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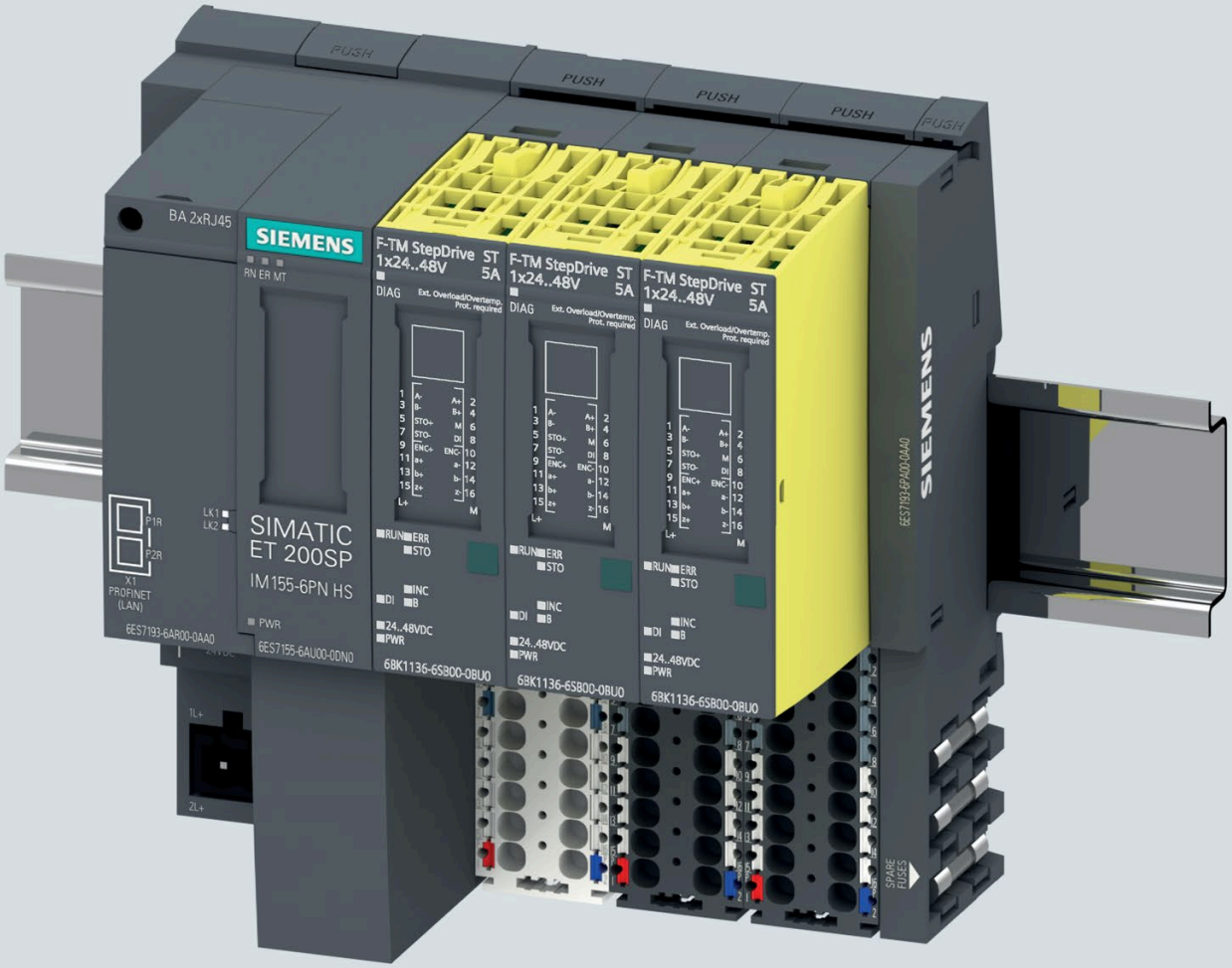

Equipment Manual

SIMATIC

ET 200SP

F-TM StepDrive ST 1x24..48V 5A
6BK1136-6SB00-0BU0

Edition 04/2021

siemens.com/micro-drive

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SIMATIC

ET 200SP
F-TM StepDrive ST 1x24..48V 5A

Equipment Manual

04/2021
A5E50747356-AA

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

DANGER

indicates that death or severe personal injury **will** result if proper precautions are not taken.

WARNING

indicates that death or severe personal injury **may** result if proper precautions are not taken.

CAUTION

indicates that minor personal injury can result if proper precautions are not taken.

NOTICE

indicates that property damage can result if proper precautions are not taken.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

WARNING

Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

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Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Ⓟ 03/2021 Subject to change

Preface

Purpose of the documentation

This equipment manual supplements the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the central modules of the S7-1500 automation system, the S7-1200 automation system, as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

Note

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

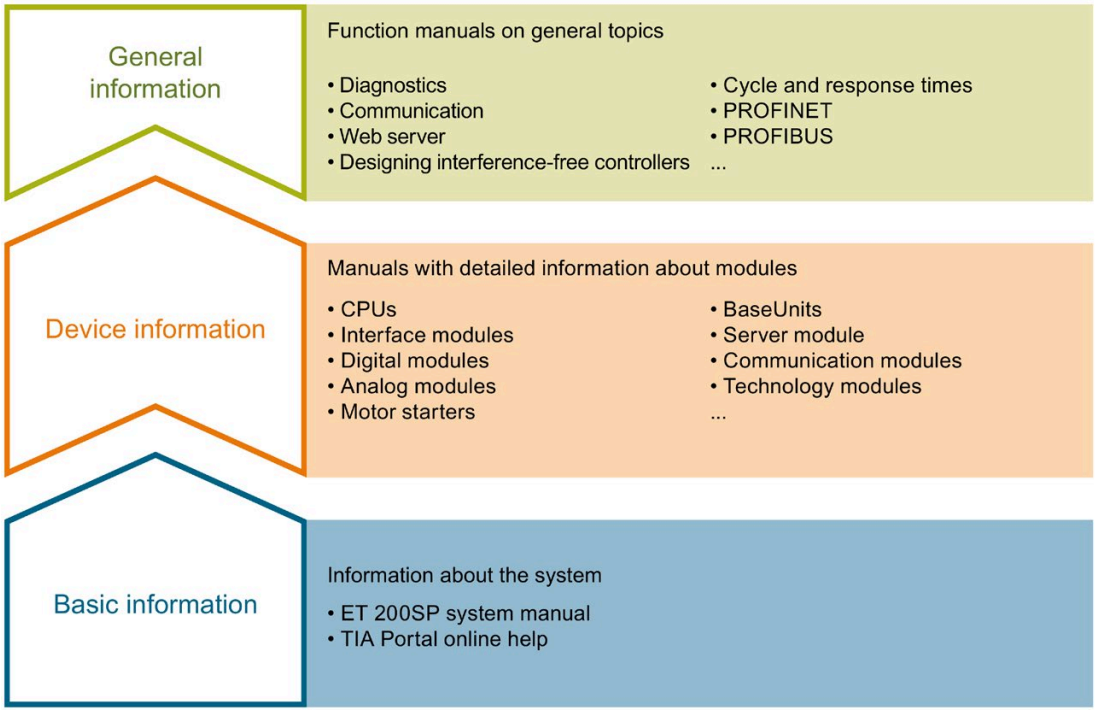
To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

Table of contents

ET 200SP Documentation Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.



Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

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"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://new.siemens.com/global/en/productservices/automation/topics/tia/tia-selection-tool.html).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Safety Evaluation Tool (SET)

You can quickly and easily evaluate the safety functions of your machine using the Safety Evaluation Tool (SET) for the IEC 62061 and ISO 13849-1 standards. You receive the results as a standard-compliant report that can be integrated in the machine documentation as proof of safety.

The free Safety Evaluation Tool is available on the Internet (https://new.siemens.com/global/en/products/automation/topic-areas/safety-integrated/factory-automation/support/safety-evaluation-tool.html).

Basic safety information

2

Basic safety information

Observe the safety information.

Note

When operating on a PELV/SELV power supply, no leakage currents are to be expected that could trigger an ground fault circuit interrupter upstream of the power supply.

Electric shock when an unsuitable power supply is connected

⚠ WARNING

Electric shock when an unsuitable power supply is connected

If an unsuitable power supply is connected, exposed parts may carry hazardous voltages. Contact with hazardous voltages can result in severe injuries or death.

- Only use power supplies that provide SELV (Safety Extra Low Voltage) or PELV (Protective Extra Low Voltage) output voltages for all connections and terminals of the electronics modules.

Electric shock with damaged devices

⚠ WARNING

Electric shock with damaged devices

Incorrect handling can damage devices. Hazardous voltages can be created at the housing or at exposed components if devices are damaged, and can cause death or serious injury if parts are touched.

- Ensure compliance with the limits specified in the technical data during transport, storage and operation.
- Never use damaged devices.

Danger to life in the event of inadequate enclosures

WARNING

Spread of fire with built-in units

In the event of a fire, the enclosures of the built-in units cannot prevent fire and smoke from escaping. This can result in severe injuries or material damage.

- Install built-in units in a suitable metal control cabinet so that personnel are protected from fire and smoke, or protect personnel by other appropriate measures.
- Make sure that smoke can only escape via controlled routes.

Unexpected movement of machines due to wireless devices or cell phones

WARNING

Unexpected movement of machines due to wireless devices or cell phones

Using wireless devices or cell phones with a transmitter power > 1 W in the immediate vicinity of the components can cause the devices to malfunction. The malfunctions can affect the functional safety of machinery and can therefore pose a risk to people or cause material damage.

- Switch off wireless devices or mobile phones if you come within 2 m of the components.
- Only use the "SIEMENS Industry Online Support app" on a device that is switched off.

Fire due to insufficient ventilation clearances

WARNING

Fire due to insufficient ventilation clearances

Insufficient ventilation clearances can lead to components overheating, resulting in fire with production of smoke. This could cause severe physical injury or death. It can also result in increased downtimes and reduced service lives of devices/systems.

- Adhere to the minimum clearances specified for the respective component.

Industrial Security

⚠ WARNING

Risk of unsafe operating states due to manipulation of the software

Software manipulations (e.g. viruses, Trojans, malware and worms) can cause unsafe operating states in your plant, which may result in death, serious injury or material damage.

- Keep the software up-to-date.
- Integrate the automation and drive components into a holistic, state-of-the-art Industrial Security concept for the plant or machine.
- In your comprehensive Industrial Security concept, take all products used into account.
- Protect files stored on removable media from malware with appropriate protective measures, e.g. virus scanner.
- Protect the drive from unauthorized changes by using a suitable safety password.

Product overview

3

3.1 Area of application

Broad range of control applications

The SIMATIC ET 200SP distributed I/O system provides the flexibility and power required for a wide range of control applications.

The F-TM StepDrive ST is a product from the range of TM Drive modules in the ET 200SP network. In this manual, the term TM Drive is used as a synonym for F-TM StepDrive ST.

The F-TM StepDrive technology module offers you the following possible applications:

- Variable speed control
- Positioning tasks in combination with higher-level controller
- In the area of safety extra-low voltage ≤ 60 V DC with integrated hardware Safety function Safe Torque Off (STO)

Areas of application

The TM Drives have proven to be an ideal and compact drive in many applications.

Examples of applications:

- Packaging machines
- Automatic assembly machines
- Electronics and battery production
- Printing and labeling machines
- Winders/unwinders, e.g. in the textile, packing and printing and solar industries
- Driving of shuttles for storage and retrieval machines and storage rack systems
- Automated guided vehicle systems
- Battery-powered applications

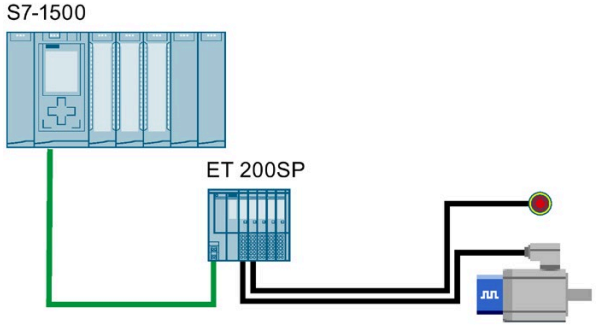


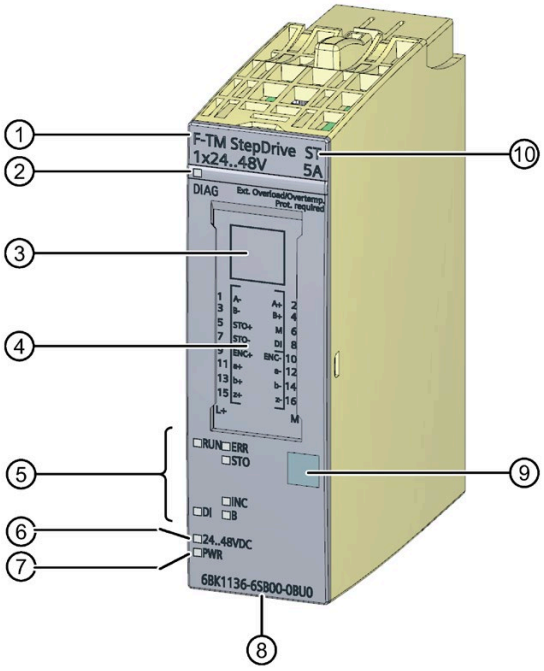
Figure 3-1 Overview of standard variant with standard CPU

3.2 Properties

Article number

6BK1136-6SB00-0BU0

View of the module



①	Module type and designation	⑥	LED for supply voltage
②	LED for diagnostics	⑦	LED for power
③	2D matrix code	⑧	Article number
④	Wiring diagram	⑨	Color coding of module type
⑤	LEDs for motor control	⑩	Function class

Figure 3-2 View of the module F-TM StepDrive ST

Properties

The F-TM StepDrive ST has the following properties:

- Operation on ET 200SP PROFINET IMs as of V4.0
- Operation on CPU 151x as of V2.0, S7-1200, OpenController and CPU 151xSP
- Speed-controlled single-axis drive with PROFIdrive profile
- Nominal voltage of the drive module: 24 to 48 V DC (safety extra-low voltage)
- Support of incremental encoders (with A, B, Z track)
- 24 V digital input
- Support of individually configurable bipolar stepper motors
- Controller parameter determination possible using HSP
- Thermal monitoring of the motor and the power end stage
- Cyclic overload capability
- Safety function STO hardwired
- Motor holding brake external via the process image
- Integrated engineering in STEP 7 (TIA Portal) via Hardware Support Package HSP0311 V16 or higher

Accessories

The following accessories, which are not included in the scope of delivery of this module, can be used with the module:

- Labeling strips
- Color-coded labels
- Reference identification labels
- Shield connection

A BaseUnit of the type U0 (6ES7193-6BP00-0DU0 oder 6ES7193-6BP00-0BU0) is needed for operation of the TM Drive. You can find an overview of the BaseUnits that you can use with the technology module in the manual SIMATIC ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/109751716).

For more information on accessories, refer to the system manual SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

3.3 Supported functions

System functions

The TM Drive supports the following PROFINET IO functions:

- Firmware update via PROFINET IO

The TM Drive supports the function:

- Identification data I&M 0 to 3

PROFIdrive communication types

TheTM Drive supports the following types of communication:

- Cyclic data exchange via a cyclic data channel

  Motion control systems require cyclically updated data during operation for open-loop and closed-loop control. This data must be sent as setpoints to the drive devices or read as actual values from the drive devices via the communication system. The transfer of this data is normally time-critical.

- Acyclic data exchange via an acyclic data channel

  An acyclic parameter channel for exchange of parameters between the CPU or supervisor and the drive devices is additionally available. Access to this data is not time-critical.

- Alarm channel

  Alarms are output event-triggered and indicate incoming and outgoing error states.

PROFIdrive application classes

The TM Drive supports Application Classes 1 and 4 of the PROFIdrive profile as of V4.2.

- Class 1 (AC1)

  The drive is controlled via a speed setpoint using PROFINET.

  The closed-loop speed control takes place entirely in the drive.

  Typical applications are, for example, simple frequency converters for pump and fan control.

- Class 4 (AC4)

  This PROFIdrive application class defines a speed setpoint interface with the closed-loop speed control taking place in the drive and the closed-loop position control taking place in the CPU, as is required for robot and machine tool applications with coordinated motion sequences on multiple drives.

Wiring

4

4.1 Pin assignment

Specific application

Observe the safety and accident prevention regulations applicable for specific applications, e.g. "Safety of Machinery EN ISO 13849-1".

During wiring and maintenance work, the TM Drive must be disconnected from the power supply.

EMERGENCY OFF equipment

EMERGENCY OFF devices according to IEC 60204 (corresponds to DIN VDE 0113) must remain in effect in all operating modes of the plant or system.

The drive-integrated safety function STO of the TM Drive does not replace the EMERGENCY OFF mechanism of the plant.

Excluding hazardous plant states

Hazardous operating states must not occur when

- The plant restarts up after a voltage dip or voltage failure
- Bus communication resumes after a fault

If necessary, the EMERGENCY OFF must be forced!

An uncontrolled or undefined startup must not occur after the EMERGENCY OFF is unlocked.

You can find a description on how to prevent uncontrolled startup in the section Safety Integrated functions (Page 34).

Potential group

Up to a continuous input current of up to max. 10 A for each potential group, up to 3 TM Drive can be connected together to form a drive group.

No other ET 200SP components may be located within a potential group consisting of one or more TM Drive.

A TM Drive potential group can be supplied as follows:

- With a separate power supply unit
- With a common power supply that also supplies other components. In this case, use a DC line filter (TDK Electronics 2-wire filter series B84113C) before the TM Drive potential group.
- If you are using a power supply unit with a rated current of more than 10 A or batteries/rechargeable batteries, then it is imperative to connect a circuit breaker of characteristic B with max. 10 A rated current, approved for direct current and the corresponding SELV / PELV voltage, upstream of the TM Drive potential group.
  For a potential group with only one TM Drive we recommend using an appropriate miniature circuit breaker with 6 A fuse and characteristic B.
- You must not use voltage sources with low impedances (such as supercaps) without adequate current-limiting protective measures.

Short circuits

The power outputs of the TM Drive are short-circuit proof. If the module detects a short circuit, it is still imperative to rectify the fault before switching it on again. Otherwise the module can be damaged.

Disturbance of radio communication services due to radio-frequency interferences in residential environments

The TM Drive can cause radio frequency interference which requires measures for interference suppression. This system is not designed for liberal use in the first environment (residential area) and must not be used there without appropriate radio interference suppression measures. Have the installation and commissioning performed with appropriate radio interference suppression measures by experts.

Protection from external electrical effects

You can find information on interference-proof design in the function manual Designing interference-free controllers (https://support.industry.siemens.com/cs/ww/en/view/59193566).

Overload

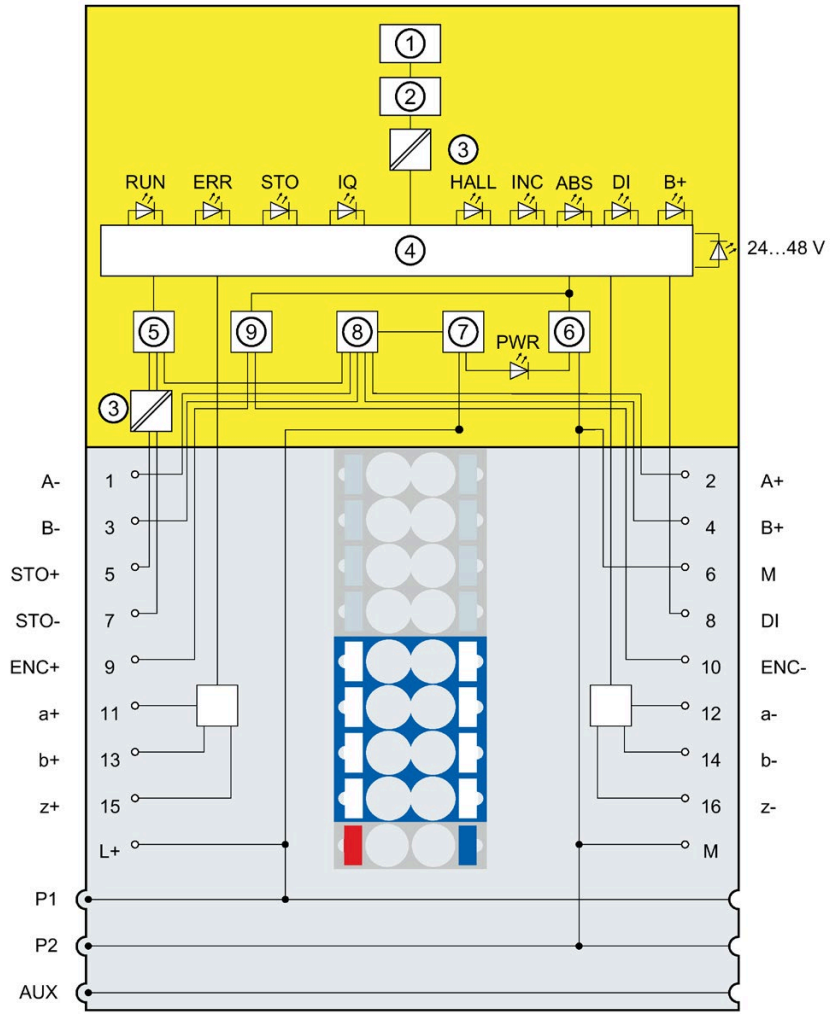
The TM Drive is overload-capable. The load of the power end stage is automatically limited by the drive.

With automatic overload limiting, the output current is automatically reduced on reaching the rated load of the power end stage to effectively prevent an overload of the power unit.

4.2 Block diagram

WARNING
Fuse for the load circuit In general, use a suitable overcurrent protection device to protect the TM Drive.

Schematic circuit diagram



①	Backplane bus	**Stepper motor**
②	Backplane bus interface module of the technology controller	A-
③	Galvanic isolation	A+
④	Technology controller	B-
⑤	Safe Torque Off circuitry	B+

⑥ Digital input circuit
⑦ Power supply/Preparation
⑧ Reverse polarity protection
⑨ Power electronics
⑩ Encoder power supply

Power supply

L+ Power supply 24 - 48 V
M Power supply GND

Inputs

STO+ STO+ input (24 V)
M Negative terminal
STO- Negative STO input
DI Digital input

Encoder supply

ENC+ Power supply encoder 5 V
ENC- Power supply encoder, negative connection

Incremental encoder

a+ Differential encoder signal a+
a- Differential encoder signal a-
b+ Differential encoder signal b+
b- Differential encoder signal b-
z+ Differential encoder signal z+
z- Differential encoder signal z-

Figure 4-1 Schematic circuit diagram

Cable lengths and cable types

If you do not use an "all-in-one" plug-in cable, the following cable lengths and cable types are permitted for the interfaces:

Table 4- 1 Wiring rules for the interfaces

Pins	Function	Maximum cable length	Cable type
ENC+/ENC-	Incremental encoder signals and supply	10 m	Shielded For differential wiring, one twisted pair per signal pair
A+/A-/B+/B-	Motor phases	10 m	Shielded
DI, M	Input	10 m	≥ 2 m shielded
	Ground	10 m	-
L+/M	Power supply, power unit	10 m	-
a, b, z	Encoder connectors	10 m	Shielded For differential wiring, one twisted pair per signal pair
STO	Safe Torque Off	10 m	-

Permissible cable cross-sections depend on the BaseUnit used. See ET 200SP BaseUnits Equipment Manual (https://support.industry.siemens.com/cs/ww/en/view/59753521)

CABLE SPEC.	Note that connected power lines must be designed according to the expected current value at maximum ambient temperature and installation type in accordance with applicable standards.

Note

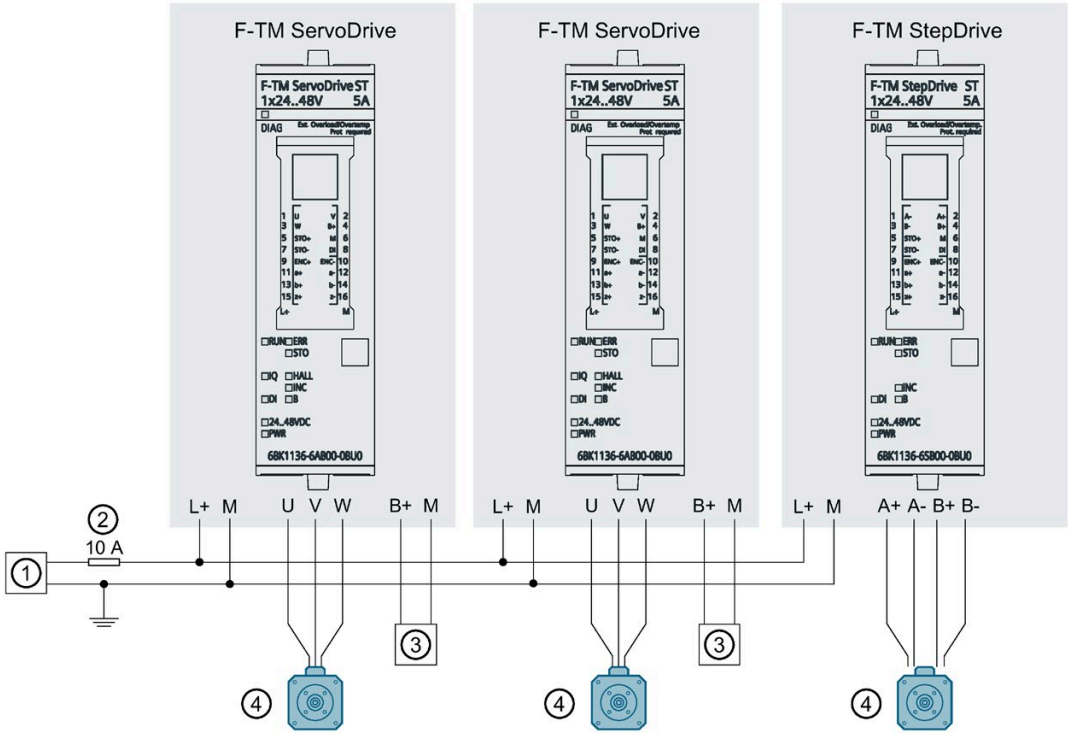
In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor/encoder side.

4.3 Wiring of multiple TM Drive

In a potential group

You can connect multiple TM Drive to form a potential group (drive line-up). The following figure shows you the TM Drive with different motors.

Wiring of multiple TM Drive to form a drive line-up



① Power supply unit
② Protective device
③ Braking resistor
④ Motor

Figure 4-2 Wiring of multiple TM Drive to form a drive line-up

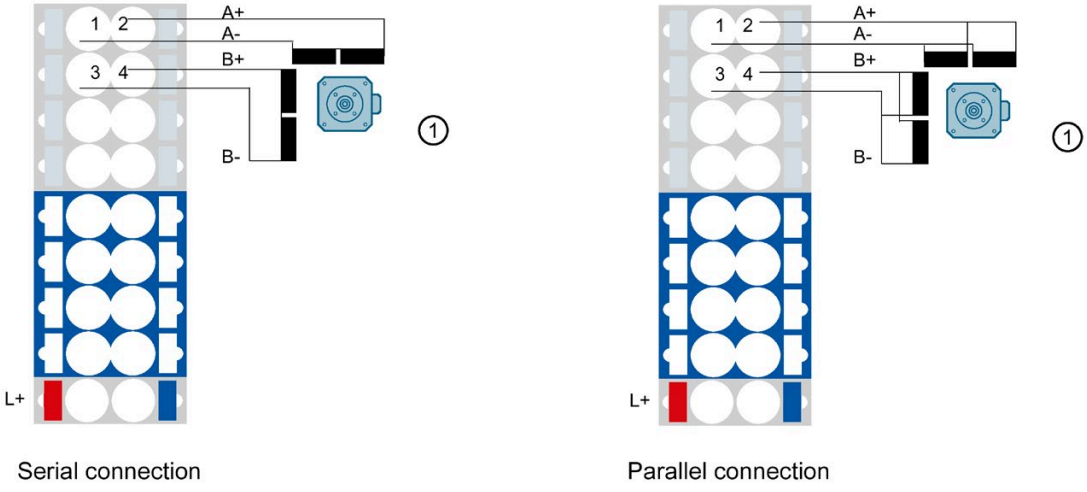
4.4 Connecting the motor

Overview

The F-TM StepDrive supports bipolar interconnected stepper motors.

4.4.1 Wiring the motor phases (stepper motor)

The following figure shows the connection of the motor phases to the BaseUnit:



①	Stepper motor
A+, A-, B+, B-	Motor phases

Figure 4-3 Connecting the motor

Note

In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor side.

Pin assignment

Pin	Designation	Function
1	A+	Motor phase A+
2	A-	Motor phase A-
3	B+	Motor phase B+
4	B-	Motor phase B-

4.5 Connecting an encoder

4.5.1 Connecting an incremental encoders

You can connect motors with a 3-channel incremental encoder to the TM Drive. The A and B tracks and a reference track Z are required for evaluation. You connect all signals as "single-ended" or "differential".

The following figure shows the connection of an incremental encoder to the BaseUnit.

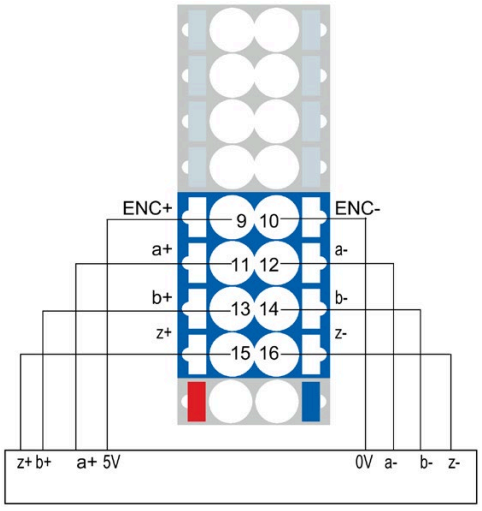


Figure 4-4 Connection of incremental encoder with differential signals

Pin assignment of incremental encoder

Pin	Designation	Function
9	ENC+	Power supply encoder 5 V
10	ENC-	Power supply encoder, negative connection
11	a+	Differential encoder signal a+
12	a-	Differential encoder signal a-
13	b+	Differential encoder signal b+
14	b-	Differential encoder signal b-
15	z+	Differential encoder signal z+
16	z-	Differential encoder signal z-

Table 4- 2 Power supply and signal processing conditions of the incremental encoder

Encoder circuit	Range
TTL bipolar 5 V or differential	High 2 V .. 5.5 V
	Low -5.5 V ... -2 V
TTL unipolar 5 V	High 4 V .. 5.5 V
	Low 0 V .. 1 V
Encoder supply voltage	5 V ... 5.3 V
Maximum current consumption of the encoder	150 mA
Maximum signal frequency that can be processed (per signal A and B)*	500 kHz

*The quadrature interface results in a maximum step resolution of 2000 kHz

Note

In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example with a metal clip on the control cabinet rear panel. The cable shield must be applied on the encoder side.

4.5.2 Connecting safe torque off (Hardware STO)

Safe Torque Off (STO)

The safety function Hardware STO is activated via an exclusive safe input (STO+ and STO-). The TM Drive safely switches off the control of the motor. As long as Hardware STO is active, the motor does not generate any torque.

The safe state "Safe Torque Off" corresponds to the de-energized state at STO+/STO- (closed-circuit current principle).

The Hardware STO function meets the specification of a digital input according to EN 61131-2 Type 1 without limitation. In addition, this input has an increased leakage current resistance of 5 mA. That is, at leakage currents below 5 mA, the safe state is always selected.

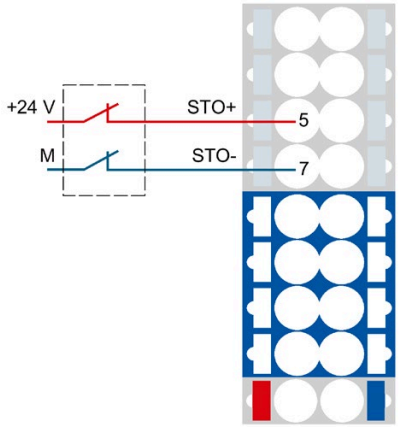
WARNING

Danger to life due to coasting down of the drive with STO

The Category 0 stop function according to EN 60204-1 (STO according to Safety Integrated) means that the drives are not braked but instead coast down for an amount of time corresponding to the kinetic energy.

- You must take this behavior into account, for example, in the logic for the protective door interlock.

Wiring the Hardware STO



STO+ STO input 24 V
STO- STO input, negative connection

Figure 4-5 Connection of Hardware STO

Note

The supply voltage for the STO inputs must be different from that of the power supply.

Table 4- 3 Pin assignment

Pin	Designation	Function
5	STO+	STO input 24 V
7	STO-	STO input, negative connection

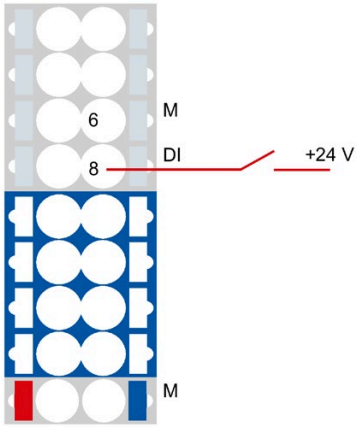
The cables of the hardware STO (STO+/STO-) must be routed separately from other cables, especially power cables.

The risk of crushing and short-circuits against earth connections must be minimized by appropriate routing.

Premature aging of the cables due to continuous UV radiation must be ruled out.

4.5.3 Connecting the 24 V digital input

Connecting a 24 V digital input



DI 24 V digital input
M Ground

Figure 4-6 24 V digital input connection

Table 4- 4 Pin assignment

Pin	Designation	Function
6	M	Ground, internally connected to ground of 24 - 48 V power supply
8	DI	24 V digital input

Safety functions integrated in the drive 5

5.1 Basic safety information

5.1.1 General safety information

WARNING

Danger to life if the safety instructions and residual risks are not taken into consideration

The non-observance of the safety instructions and residual risks stated in the associated F-TM StepDrive documentation can result in accidents causing severe injuries or death.

- Observe the safety instructions given in the F-TM StepDrive documentation.
- Consider the residual risks for the risk evaluation.

WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings

As a result of incorrect or changed parameter settings, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameter assignment against unauthorized access.
- Respond to possible malfunctions by implementing suitable measures (e.g. EMERGENCY STOP or EMERGENCY OFF).

WARNING

Validity of safety features

The safety features of the product are guaranteed only for intended use within the intended ambient conditions (see section Technical specifications (Page 112)).

The safety features only apply when operating with a BaseUnit of the U0 type (6ES7193-6BP00-0DU0 or 6ES7193-6BP00-0BU0).

5.1.2 Warranty and liability for application examples

Application examples are non-binding and do not claim to be complete regarding configuration and equipment as well as all eventualities. Application examples do not represent customer-specific solutions. They are only intended to provide support for typical tasks.

As user, you are responsible for ensuring that the products described are used correctly. Application examples do not relieve you of the responsibility to use safe practices in application, installation, operation and maintenance.

5.1.3 Fundamental safety instructions for Safety Integrated

Additional safety instructions and residual risks are provided outside of this section at the relevant points of this system manual.

⚠ DANGER

Risk minimization through Safety Integrated

Safety Integrated can be used to minimize the risk associated with machines and plants. However, safe operation of the machine or system with Safety Integrated is only possible if the machine manufacturer:

- Knows and complies with this technical user documentation, including the documented constraints, safety instructions and residual risks
- Carefully constructs and configures the machine/plant and verifies it through a carefully implemented and documented acceptance test by qualified personnel
- Implements and validates all the measures required in accordance with the system/machine risk analysis by means of the programmed and configured Safety Integrated functions or by other means

The use of Safety Integrated does not replace the machine/plant risk assessment carried out by the machine manufacturer as required by the CE Machinery Directive.
In addition to using Safety Integrated functions, further risk reduction measures must be implemented.

⚠ WARNING

Danger to life as a result of undesirable motor movement when automatically restarting

An emergency stop must be performed according to Stop Category 0 (STO) (EN 60204-1). The emergency stop must be ensured by external measures.
It is not permissible that the motor automatically restarts after an Emergency Stop, as this represents danger to life as a result of the associated undesirable motor motion.
If individual safety functions are deactivated, an automatic restart is permitted under certain circumstances depending on the risk analysis (except when Emergency Stop is reset). An automatic start is possible when a protective door is closed, for example.

- Ensure that no automatic restart takes place in the indicated cases.

WARNING

Danger to life as a result of undesirable motor motion when the system powers up and the drives are activated after hardware and/or software is changed or replaced

After hardware and/or software components have been modified or replaced, or after drive parameters are changed or parameter backups are loaded, it is only permissible for the system to run up and the drives to be activated with the protective devices closed. Personnel shall not be present within the danger zone during this time.

- It may be necessary to carry out a partial or complete acceptance test or a simplified functional test after making certain changes or replacements.
- Before personnel may re-enter the hazardous area, all of the drives should be tested to ensure that they exhibit stable control behavior by briefly moving them in both the plus and minus directions (+/-).

5.1.4 Safety Integrated functions

This section gives you a quick insight into the functioning of the safety functions.

The description of the safety functions starts in each case with the definition in IEC/EN 61800-5-2 and simple examples of the use of the function.

The description of the functions is simplified as far as possible so that the essential properties and setting options are made clear.

Response time

You can find additional information on the response time of the listed safety functions in section Response times (Page 118).

Examples of safety devices and 3 F-TM StepDrive

Note

The supply voltage for the STO inputs must be different from that of the power supply.

The following figure shows various safety devices that are connected to 3 F-TM StepDrive.

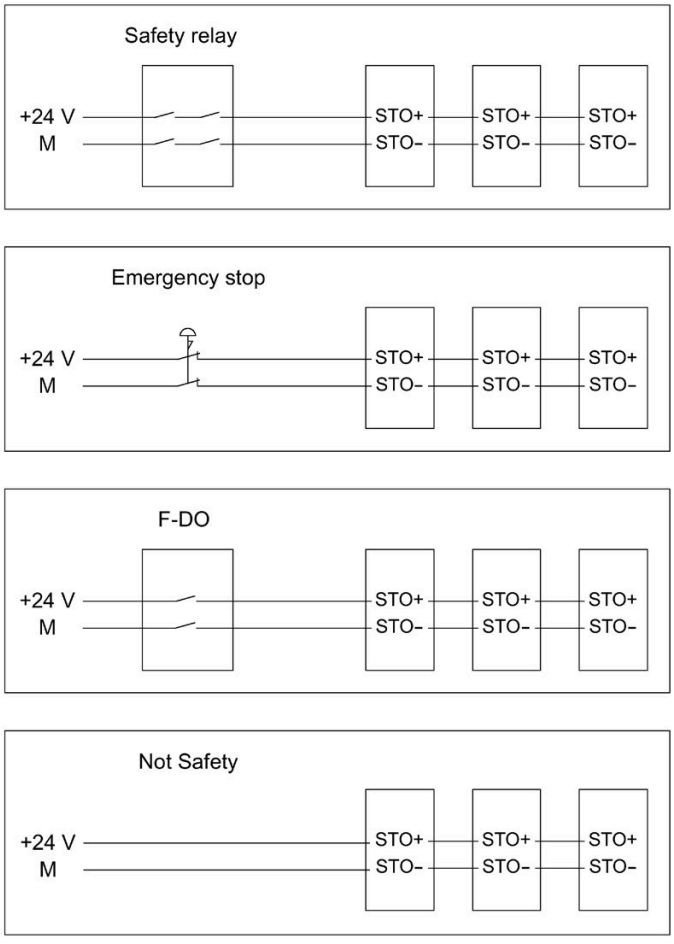


Figure 5-1 Safety devices and 3 F-TM StepDrive

Note

The F-TM StepDrive does not support startup protection.

Measure:

Startup protection via additional safety relay or in higher-level controller, depending on the safety requirements.

Operating voltage range

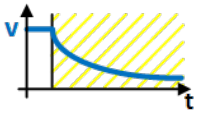
Operate input STO+ as intended with 19.2 to 28.8 V DC for the active enable or lower 5 V DC for the disable.

Connect the input STO- for enabling or disabling the connection to ground.

Switching on again after power off

An On delay of more than 2 s must be observed between tripping and restarting the module, for example switching the power supply off and on. Otherwise the module can register an internal STO error and the module switches off in a safety-oriented manner.

5.1.4.1 Safe Torque Off (STO)



Safe Torque Off (STO) is a safety function that directly stops torque- or force-producing energy from being supplied to the motor. This function corresponds to Stop Category 0 according to EN 60204-1.

The F-TM StepDrive complies with the definition of the STO function in IEC/EN 61800-5-2: "The STO function prevents torque-producing energy from being supplied to the motor."

If the motor is still rotating when STO is selected, the motor will coast to a standstill.

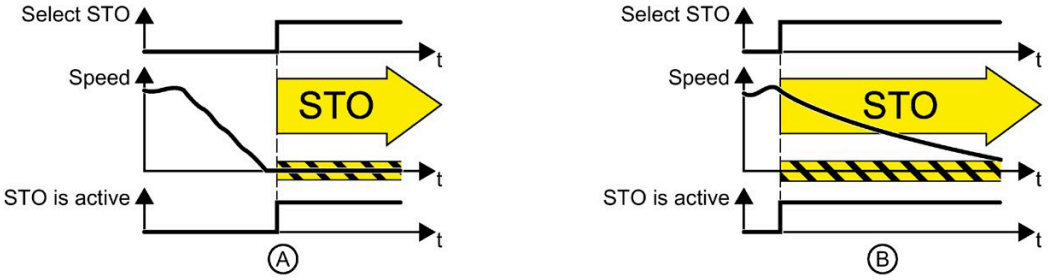


Figure 5-2 Functioning of STO (A) when motor is at stopped and (B) when motor is rotating

Functional characteristics

⚠WARNING

Danger to life due to coasting down of the drive with STO

The Category 0 stop function according to EN 60204-1 (STO according to Safety Integrated) means that the drives are not braked but instead coast down for an amount of time corresponding to the kinetic energy.

- You must take this behavior into account, for example, in the logic for the protective door interlock.

STO is a drive-specific function and must be wired individually for each drive.

The following applies when the "Safe Torque Off" function is selected:

- An unwanted startup of the motor cannot take place.
- The torque-producing energy supply to the motor is safely interrupted.
- An electrical isolation between the power unit and motor does not occur.

The stop function category 0 (selection of STO according to Safety Integrated) is only active when selected at the STO terminals. In order to meet the requirements of an EMERGENCY STOP in accordance with EN 60204-1, you need to ensure that the STO function at the STO terminals in the system can only be deselected by means of conscious manual operation. This prevents electrically driven machine components from restarting unintentionally.

Selection

The STO safety function is always enabled and cannot be disabled via parameter assignment.

You can select the STO function via the fail-safe digital input at STO+ and STO- terminals. The selection of the STO function is enabled directly as a response to safety messages (e.g. when a defect is detected in a monitoring channel).

Range of application

You can use the STO safety function without restrictions for a bipolar connected two-phase stepper motor. A special encoder concept suitable for safety is not required.

Applications

Application areas are all machines or systems with moving axes (e.g. conveyor systems, handling systems).

STO can be used in which the motor is already at a standstill or comes to a standstill safely due to friction in a short time.

STO allows safe working while a protective door is open. A conventional Emergency Stop with electromechanical unlocking is not required. The converter remains connected to the supply system and has full diagnostics capability.

Note

Difference between EMERGENCY OFF and EMERGENCY STOP

EMERGENCY OFF and EMERGENCY STOP are commands that mitigate different risks in the machine or plant. The STO function is suitable for implementing an EMERGENCY STOP, but not an EMERGENCY OFF.

Hardware STO

The F-TM StepDrive internally monitors the fail-safe digital input at STO+ and STO- terminals for discrepancies.

Discrepancy monitoring

Due to the design of the Hardware STO circuit, a discrepancy cannot occur at STO+ and STO- terminals. As long as the STO terminal is de-energized, STO is selected. The Hardware STO signal is read in internally via two channels.

To comply with the requirements for timely error detection from EN 61800-5-2, the switch-off signal paths of the end stage in both monitoring channels are also cyclically tested. Errors when testing the shutdown paths trigger STO. A manual forced checking procedure (test stop) for testing the shutdown paths of the F-TM StepDrive is therefore not needed.

WARNING

Forced checking procedure

You should nevertheless examine its necessity for diagnosing the utilized sensors or for performing a test stop in the context of the overall system.

5.1.5 Overview of the Safety Integrated functions

Compared to standard drive functions, safety functions have an especially low error rate. Performance Level (PL) and Safety Integrity Level (SIL) as defined in the corresponding standards are a measure for the error rate.

For this reason, safety functions are suitable for use and for risk reduction in safety-related applications. An application is safety-related when the risk analysis of the machine or plant has identified a particular risk potential in the application.

Safety Integrated means that the safety functions are integrated in the drive and can be executed without additional external components.

Conformity of Safety Integrated functions

The Safety Integrated functions comply with:

- Safety Integrity Level (SIL) 3 according to IEC 61508 Part 1-3
- Category 3 according to ISO 13849-1
- Performance Level (PL) d according to ISO 13849-1

For functional safety of variable-speed drives, the standard IEC 61800-5-2, in which the Safety Integrated functions are defined, applies.

Function groups

The safety functions are divided into the following function groups for the F-TM StepDrive:

- Safety Integrated stop function (hardware STO)

5.1.6 Supported safety functions

The supported safety functions are included in the standard scope of the F-TM StepDrive and can be used without an additional license.

Stop functions

The stop functions do not pose any special requirements on the utilized encoder and do not need actual value acquisition. The stop functions include the following Safety Integrated functions:

- Safe Torque Off (STO)

  Safe Torque Off is a safety function for prevention of unexpected startup according to EN 60204-1. STO prevents torque-producing energy from being supplied to the motor and corresponds to Stop Category 0.

5.1.7 Examples of using the safety functions

Table 5- 1 Examples of using the safety functions

Safety function	Application examples	Possible solution
Safe Torque Off (STO)	It is only permissible to open a protective door if the motor torque has been switched off.	Activate STO in the F-TM StepDrive via the STO inputs. The pulses are suppressed and the motor coasts to a standstill.
	A central Emergency Stop button ensures that multiple drives cannot start unintentionally.	Evaluate the emergency stop button in a central controller. Use a two-channel connection to the STO inputs on the F-TM StepDrive.

5.1.8 Safety concept

The safety concept of the drive controller is based on a 2-channel system structure. Each channel has the possibility of bringing about the safe state, and the two channels monitor each other through a corresponding cross-comparison and cyclic diagnostics.

Safe state

The safe state of the system exists when the motor bridge is **de-energized**.

The safe state is reached in the following cases:

- Switch-off or failure of the external power supply to L+/M
- Missing enable signal at STO+ and STO-
- Detection of an internal HW fault

Safe state of Safety Integrated functions

The safe state of the STO input terminal is reached when at least one of the two STO supply terminals is disconnected from the energy supply.

Note

The safe state means the absence of torque in the sense of functional safety, but not necessarily the absence of voltage in the sense of electrical safety.

5.2 Acceptance of the safety functions

Responsibilities

The machine manufacturer is responsible for the performance and documentation of the acceptance test. In this section, you will find a recommendation for how to perform and document the acceptance tests for the individual safety functions.

Note

The performance and documentation of the acceptance tests are plant-specific and must be adapted appropriately and performed.

5.2.1 General information on acceptance

Why is acceptance required?

The EU machinery directive and ISO 13849-1 stipulate:

- You must test safety-relevant functions and machine parts after commissioning.

  See "Acceptance test" below in this section.

  For the F-TM StepDrive Safety Integrated functions (SI functions), this means:
  The acceptance test is used to check the functionality of the safety functions used in the drive. Correct implementation of the defined safety functions is examined for this.

- You must create an "acceptance report" that describes the test results.

  See "Documentation" further on in this section.

Note

Purpose of the acceptance test

The measured values (e.g. speed, time) and the system behavior identified (e.g. initiation of a specific stop) serve to check the plausibility of the configured safety functions. The objective of an acceptance test is to identify potential configuration errors and/or to document the correct function of the configuration. The measured values are typical values (not worst case values). They represent the behavior of the machine at the time of measurement. These measurements cannot serve as the basis for deriving real values (e.g. maximum values for over-travel distances).

Requirements

The requirements for an acceptance test (configuration test) for safety functions of electric drives come from EN 61800-5-2, section 7.1, paragraph f). The acceptance test is called "configuration test" in this standard.

- Description of the application including an image
- Description of the safety-related components (including software versions) that are used in the application
- List of the utilized safety functions of the PDS(SR) [Power Drive System(Safety Related)]
- Results of all tests of these safety functions using the specified test procedure

Necessity of an acceptance test

An acceptance test is required (again) when the Safety Integrated functionality of a machine is commissioned or changed. The acceptance tests must be performed for each individual drive. Safety-related function extensions, transfer of commissioning to other series machines, hardware changes, software upgrades and the like may allow a partial performance test to be performed.

The conditions determining the necessity and recommendations for the test depth required in each case are summarized below.

Requirements for the acceptance test

- The machine is correctly wired.
- All safety equipment (e.g. protective door monitoring devices, light barriers, emergency limit switches) are connected and ready for operation.
- The commissioning of open-loop and closed-loop control must be complete; otherwise, the over-travel distance may be changed due to a changed dynamic response of the drive control, for example. This includes:
  - Settings of the setpoint channel
  - Position control in the higher-level CPU
  - Drive control

Acceptance test

The acceptance test comprises two parts:

- You test whether the safety functions are set correctly in the drive:
  - Does the configured safety function sufficiently reduce the residual risk at the machine/plant?
  - Do the set interfaces, timers and monitoring functions match the configuration of the machine?
- You test whether the safety-relevant functions in the machine or system function correctly.

  This part of the acceptance test goes beyond the acceptance test of the drive:
  - Is all safety equipment, such as protective door monitoring, light barriers and emergency limit switches, connected and ready for operation?
  - Do the drive settings match the configured safety-relevant function in the machine?

Documentation

The documentation consists of the following parts:

- Description of safety-relevant components and functions of the machine or system, including the program versions.
- Report of the acceptance test results.
- Report of the safety function wiring.
- The documentation must be signed off by the person who performed the acceptance test.

Authorized persons

Persons authorized by the **machine manufacturer** who, on account of their technical training and knowledge of the safety-relevant functions, can carry out the acceptance in an appropriate manner are entitled to perform the acceptance.

⚠WARNING

Unwanted movement due to faulty wiring

Incorrect wiring for Safety Integrated functions can cause unwanted motion resulting in severe injury or death.

- For Safety Integrated functions, always carry out an acceptance test for the affected function after changing the wiring.
- Record the results of the acceptance test in an acceptance report.

⚠WARNING

Unsafe operating states due to manipulation of the hardware configuration after the acceptance test

Changes to the wiring of the Safety Integrated functions after an acceptance test can cause unwanted motion resulting in severe injury or death.

- To prevent access to your machines and systems by unauthorized persons, implement access restrictions and take the precautions described in the security instructions in the preface.
- To prevent improper wiring of the Safety Integrated functions, take the precautions described in this manual.
- Review the safety change tracking of the drive at regular intervals. Make certain that no changes have been made to the wiring after the last successfully completed acceptance test.
- If intentional changes have been made, repeat the acceptance test for the Safety Integrated functions affected. The purpose of the acceptance test is to ensure and document safe operation of the system. Correct any unintentional changes back to the original values and repeat the acceptance test.

5.2.2 Content of an acceptance test

Documentation

Documentation of the machine including safety functions

- Machine description (with overview image)
- Information on controller (if available)
- Function table:
  - Active monitoring functions depending on operating mode and protective door
  - Additional sensors with protection functions
  - The table is an object or result of the configuration work.
- SI functions for each drive
- Information on the safety equipment

Function test of diagnostic/safety functions

Value-based function check of the SI functions used. You can use trace records of individual parameters, for example, to do this.

- Acceptance test for Safe Torque Off (STO)

Report completion

Reporting of the tested state of commissioning and countersignatures

- Control of the STO function as enable signal of the STO+ and STO- terminals
- Enable to control the motor is removed as soon as a connection (STO+ or STO-) is not connected
- Counter signature

5.2.3 Documentation of acceptance

Machine or system description

Describe your machine or plant using the following table. Insert a diagram of the plant, for example.

Table 5- 2 Machine description and overview image

Designation	
Type	
Serial number	
Manufacturer	
End customer	
Overview image of the machine	

Drive data

In the following table, enter information on the drive components used and add additional components as required.

Table 5- 3 Hardware components

Component	Designation	Article number	Hardware version	Type
Drive controller				
Motor				
Encoders				
Brake module				
Gearbox				

Utilized Safety Integrated functions

In the following table, describe the use of the Safety Integrated drive functions in relation to your plant or machine.

Table 5- 4 Utilized SI functions of the drive

SI function	Status/Description
Safe Torque Off (STO)	

5.2.4 Acceptance test for Safe Torque Off (STO)

Procedure

Test each configured activation of the STO function.

This test consists of the following steps:

Table 5- 5 Acceptance test for "Safe Torque Off" (STO) function

No.	Description		Status
1.	**Drive is ready for operation**		
	• No faults		
	• The enable signal is present (STO is deselected).		
2.	**Switch on motor**		
	2.1	Set speed setpoint ≠ 0	
	2.2	Switch on motor (ON command)	
	2.3	Check that the intended motor is rotating	
3.	**Select STO**		
	3.1	Selecting STO means interrupting the wire, supplying the STO from STO+ and short-circuiting STO- (if the source is current-limited)	
	3.2	Check the following points:	
		• Motor coasts down to a standstill	
		Message is implemented, but is not safety-relevant	
4.	**Deselect STO**		
	4.1	Deselection of STO (HW STO terminal)	
	4.2	Check the following points:	
		• Enable is active, motor must allow switch-on	

5.2.5 Report completion

SI change tracking (Safety logbook)

Ensure that changes to the safety function (wiring) can be traced.

Countersignatures

Commissioning engineer

Professional execution of the above-stated tests and checks is confirmed.

Table 5- 6 Report completion - Countersignature of commissioning engineer

Date	Name	Company/Department	Signature

Machine manufacturer

The correctness of the parameter assignment documented above is confirmed.

Table 5- 7 Report completion - Countersignature of machine manufacturer

Date	Name	Company/Department	Signature

5.3 System features

5.3.1 Current information

Important note for maintaining the operational safety of your system:

NOTICE
Operational safety risk from unwanted motions Systems with safety-oriented variants are subject to special operational safety requirements on the part of the operator. If information becomes known in the course of product monitoring indicating insufficient product safety, this information will be disclosed in various ways. For this reason, our website provides information on product developments and features that are (or could be) relevant to operation of systems from a safety perspective.

5.3.2 Certifications

The safety functions of the F-TM StepDrive drive system meet the following requirements:

- Safety Integrity Level (SIL) 3 according to IEC 61508 Part 1-3 and IEC 61800-5-2
- Category 3 according to ISO 13849-1
- Performance Level (PL) d according to ISO 13849-1

In addition, the safety functions of the drive are generally certified by independent institutes. A list of the components that are currently already certified in each case is available on request from your Siemens branch.

5.3.3 Failure probability of the safety functions

The probability of failure of safety functions must be specified in the form of a PFH value (Probability of Failure per Hour) according to DIN EN 61800-5-2 and ISO 13849-1. The PFH value of a safety function depends on the safety concept of the drive device, its hardware configuration and the PFH values of the other components used for the safety function. For the F-TM StepDrive drive system, PFH values are provided as a function of the hardware configuration.

Note

PFH values

The PFH value of the integrated safety function STO is 30 FIT (10^{-9}/h) and refers to a service life of 10 years.

The underlying assumption for the calculation is an average operating temperature of 40°C, an average repair time of 8 hours and an average time to recovery of 8 hours. A proof test is not necessary.

5.3.4 Response times

The response time is the time between the detection of an input signal and the change of a linked output signal. Below you will find information on the response times of the F-TM StepDrive drive system.

Note

The actual response time falls between a minimum and maximum response time. You must always assume the maximum response time when configuring your system.

The drive system is the component that provides the safety functions. The description "error-free drive system" means that the component providing the safety functions itself has no defect:

- Maximum response time in error-free drive system

  When the enable is removed at the STO+ or STO- terminals, the maximum response time in an error-free drive system is guaranteed.

Stop function (via terminals)

The following table specifies the response times for the indicated stop functions from the time of activation until occurrence of the response.

Function	Maximum response time
STOP_STO	Max. 20 ms

5.4 Safety Integrated

Important notes on the Safety Integrated system are provided in this section.

Diagnostics hardware fault

If an internally diagnosed hardware fault occurs, you can only reset the module by restarting it. Nevertheless, the replacement of the F-TM StepDrive is strongly recommended. Unwanted activation of the safety function can be an indication of a hardware fault.

Wiring the F-TM StepDrive

For information on how to perform the electrical wiring for the F-TM StepDrive, refer to section Wiring (Page 20)

STO inputs

The STO inputs are described in the section Connecting safe torque off (Hardware STO) (Page 29).

5.5 EMERGENCY OFF and EMERGENCY STOP

Difference between EMERGENCY OFF and EMERGENCY STOP

EMERGENCY OFF and EMERGENCY STOP are commands that mitigate different risks in the machine or plant.

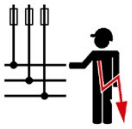
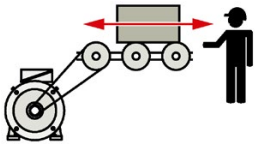
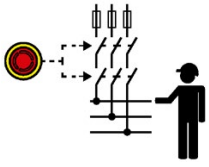
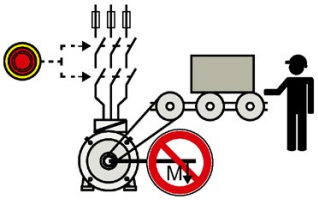
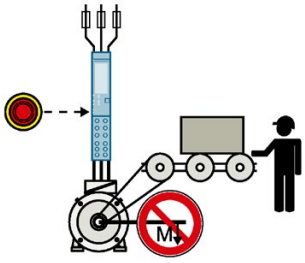
EMERGENCY OFF	**EMERGENCY STOP**
Risk of electric shock 	Risk of unexpected movement 

Table 5- 8 Measures and solutions

Command	**EMERGENCY OFF**	**EMERGENCY STOP**
Measure to minimize risk	**Safe switch off** Switching off the electric power supply for the installation, either completely or partially.	**Safely stop and safely prevent re-starting** Stopping or preventing the dangerous movement
Classic solution	Switch off the power supply. 	Switch off the drive power supply. 
Solution with the STO safety function integrated in the drive	STO is not suitable for safely switching off a voltage.	Select STO.  You may also switch off the power supply of the drive controller. However, switching off the voltage is not required as a risk-reduction measure.

Configuring

6

Configuration and parameter assignment

STEP 7 (TIA Portal) is available for configuring a ET 200SP TM Drive.

You perform the following tasks with STEP 7 (TIA Portal), for example:

- You configure the TM Drive (insertion into the project and setting the input addresses).
- You specify the desired hardware parameters for operation of the TM Drive.

Requirements

Hardware

- Supported interface modules: See Properties (Page 17)
- You have completed installation and wiring of the hardware. Take the potential group into account, see section Pin assignment (Page 20).
- You have connected the PG/PC via the PROFINET interface of the CPU.

Software

- You have installed the HSP0311. You can find the support packages for the hardware catalog in the TIA Portal (HSP) on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).

As soon as the configuration and hardware parameter assignment have been successfully completed, you can create your user program and commission the drive.

WARNING

Safety Integrated

As soon as a safety program has been created, you must perform a complete function test based on your automation task.

To accept the plant, you must use the safety summary created in accordance with this manual.

Configuring a TM Drive (minimal configuration)

To configure a TM Drive , follow these steps:

1. Create a new project.
2. Add a CPU S7-1200 or S7-1500 as a new device.
3. Add a PROFINET interface module to the project under "Devices & networks" from the ET200SP system, e.g. IM 155-6PN ST.
4. Assign the inserted IO device to the configured IO controller.
5. Switch to the device view of the interface module.
6. Add the TM Drive module from the hardware catalog to the IO device.
7. Add a server module.

6.1 Communication telegrams

Selection of a communication telegram

The selection of a communication telegram determines the process data of the drive that will be transmitted between the drive and CPU.

The following table shows the supported telegram types for the drive and sensor assignment.

Table 6- 1 Supported communication telegrams

Supported PROFIdrive telegrams	Brief description	User data
Standard telegram 1 PZD-2/2	Speed setpoint 16 bits, without sensor	• Control word STW1, status word ZSW1 • Speed setpoint 16 bits (NSET), actual speed value 16 bits (NACT)
Standard telegram 2 PZD-4/4	Speed setpoint 32 bits, without position encoder	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT)
Standard telegram 3 PZD-9/5	Speed setpoint, 32 bits with one position encoder	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT) • Encoder control word 1 (Gx_STW), encoder status word 1 (Gx_ZSW) • Actual encoder position value 1 (Gx_XIST1, Gx_XIST2)
Extension word	Status bits of the inputs	• Bit 0: DI • Bit 1: STO

A PZD (process data word) corresponds to a 16-bit word.

Selecting a telegram in STEP 7

To select the telegram for the TM Drive in STEP 7, follow these steps:

1. Select the TM Drive module in the device view.
2. Navigate to the properties of the module in the "General" tab under "TM Drive" > "Basic parameters".
3. Under "Telegram" in the drop-down list, select the desired telegram, e.g. "Standard telegram 3 (PZD length 9/5 words).
4. If needed, activate the extension word by selecting the "Telegram extension active" check box.

6.2 Structure of the encoder position actual value

Starting with standard telegram 3, the encoder position actual value is transmitted as a 32-bit value via the user data Gx_XIST1 and Gx_XIST2. These value provide the current **actual incremental position** of the encoder system and are read cyclically, for example by the "Positioning axis" technology object and further processed accordingly (see also section 8.3 (Page 100)). The layout of the encoder position actual value mainly depends on the following factors:

- Type of the encoder
- Resolution of the encoder

Regardless of the type of encoder, the actual position value is structured as follows:

- G1_XIST1 and Gx_XIST2 are right-aligned
- After it is switched on, a 32-bit counter is loaded with the current position value. Depending on the direction of rotation, this value is then only incremented or decremented. After reaching the max. position value, it starts again at 0.

Note

Dependence on the configured encoder resolution

The singleturn value ("increments / revolution") in G1_XIST1 is directly dependent on the configured encoder resolution (p408).

6.2.1 Incremental encoder

If you are using a motor with an incremental encoder and you have configured this for the type of motor encoder (p404), then the structure of the encoder position actual value is as follows:

Table 6- 2 Structure of the encoder position actual value

User data	**Contents**	
Actual encoder position value 1 (Gx_XIST1)	Increments per revolution	Depends on the parameter assignment of the encoder resolution. You can read this back under "Drive diagnostics section 10.2.3 Encoders (Page 108)".
	Bits in Gx_XIST1 "Shift factor"	2
	Encoder type	Rotary incremental

Example of an incremental encoder with 4096 "steps per revolution", this corresponds to 1024 "steps per revolution" with a fine resolution of 2:

Table 6- 3 Structure Gx_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Singleturn value (singleturn "steps per revolution")
F: Fine resolution

Table 6- 4 Structure Gx_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

6.2.2 Encoderless / calculated

If you have set encoder (0) encoderless / calculated as encoder type, the encoder position actual value is calculated. Actual encoder position value is structured as follows.

Table 6- 5 Structure of the encoder position actual value

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Increments per revolution	Depends on the parameter assignment of the encoder resolution. You can read this back under "Drive diagnostics section 10.2.3 Encoders (Page 108)".
	Bits in Gx_XIST1 "Shift factor"	2
	Encoder type	Rotary incremental

Example of a "simulated encoder" with 4096 "steps per revolution", this corresponds to 1024 "steps per revolution" with a shift factor of 2:

Table 6- 6 Structure Gx_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Singleturn value (singleturn "steps per revolution")
F: Fine resolution

Table 6- 7 Structure Gx_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

Commissioning the 7

The engineering of the TM Drive drive controller is integrated in STEP 7 (TIA Portal). You install it with the Hardware Support Package HSP0311. The graphic user interface supports you in the configuration, parameter assignment and commissioning of the drive functions of the TM Drive.

In this section you will find information on various topics including:

- Check before powering on for the first time
- Commissioning an TM Drive drive

CAUTION

Failure to comply with the instructions for Safety Integrated poses a risk of injury

Failure to comply with the instructions may result in serious injuries. Carefully read through the safety instructions in section Safety functions integrated in the drive (Page 32) before commissioning and before operation.

WARNING

Personal injury and property damage from the falling down of a suspended axis

If the drive system is used as suspended axis, the axis will fall down if the positive and negative poles of the power supply are interchanged during connection. An unexpected falling down of a hanging axis can result in personal injury and property damage.

Before commissioning, it must be ensured that a cross brace is fitted to hold the suspended axis in place and prevent it from falling down unexpectedly. Also ensure that the power supply is connected properly.

WARNING

Personal injury and property damage from the falling down of a suspended axis

An unexpected falling down of a hanging axis can result in personal injury and property damage.

- When using the STO function in conjunction with suspended axes, the axis may fall down unexpectedly and cause property damage and personal injury.

Note

Performing tests

You must ensure the safety of your plant. You therefore need to perform a complete functional test and the necessary safety checks before the final commissioning of a plant.

Also allow for any possible foreseeable errors in the tests. This avoids endangering persons or equipment during operation.

7.1 Basics

7.1.1 Engineering

You perform configuration as well as diagnostics of a TM Drive with a PG/PC or notebook (commissioning device) using the TIA Portal (Hardware Support Package HSP0311 needed).

The settings can be found in STEP 7 in the device navigation under "Ungrouped devices" > "<Name of the interface module>" > "<Name of the TM Drive>".

Overview

This drive engineering is divided into the following areas:

- Device configuration
- Online & diagnostics
- Parameters

"Device configuration" area

Contents in the "Device configuration" area of the TM Drive engineering.

- Potential group
- Basic parameters
  Define telegram, activate telegram extension
- I/O addresses

"Online & diagnostics" area

Contents in the "Online & diagnostics" area of the TM Drive engineering.

Diagnostics

- General (module information):

  Order number, firmware and hardware version, I&M data
- Diagnostic status (display of status information)

- Active messages:

  Pending faults and alarms

- Drive diagnostics
  Status bits, operating values, encoders, temperatures, inputs

Functions

- Firmware update

"Parameters" area

Contents in the "Parameters" area of the TM Drive TM engineering.

- Drive:

  Drive data record, general settings, motor, gearbox, thermal model, brake module

- Setpoint channel:

  Reference values, application limits, speed-ramp sensor

- Open-loop/closed-loop control:

  Control type, controller settings, speed controller, current controller

- Messages/monitoring

  Motor (thermal motor model), intermediate circuit voltage, braking resistor (load), power end stage (load)

7.1.2 Drive parameters

Parameter tooltips

In STEP 7 engineering of the TM Drive, all displayed drive parameters are linked with tooltips. You will find detailed information on the parameter in the tooltips, e.g. parameter name, properties, factory setting, value range, descriptions, notes and dependencies.

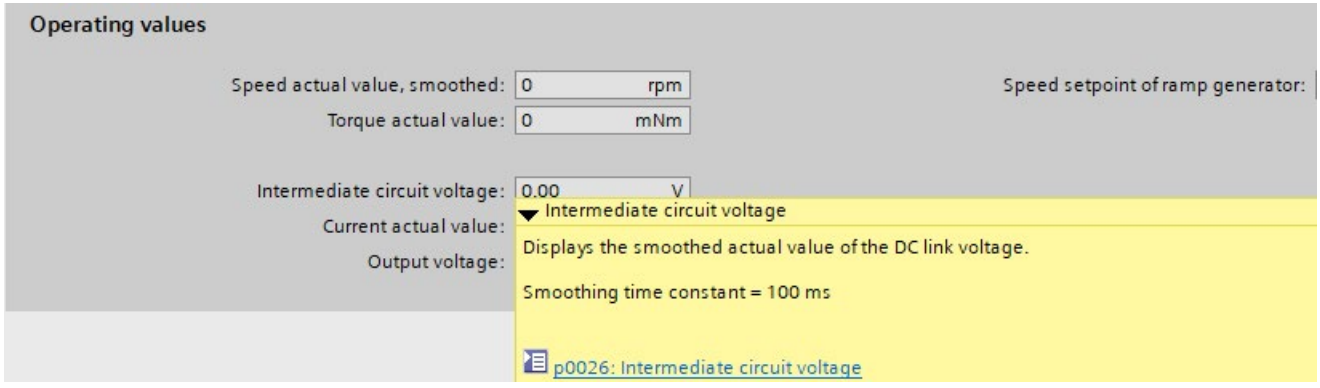


Figure 7-1 Intermediate circuit voltage tooltip

Changing a parameter

You can directly change the values of the writable adjustable parameters (p-parameters) in STEP 7.

You have the following options for this:

- You overwrite the current parameter value with the new value.

  Or

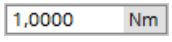
- You select a value via the drop-down list.

Invalid values are rejected.

Note

P-parameters cannot be changed online while the drive is in operation. In this case, the corresponding entry field is automatically disabled.

The following overview shows the display of an entry field, depending on the context and the properties of the drive parameter:

	Project (offline)	Parameter value can be changed and stored in the project.
	Project (offline)	The parameter value is write-protected.
	Project (online)	Parameter value is write-protected or disabled due to the drive status.

Parameter symbols and operator controls

The following overview explains additional symbols and operator controls in the TM Drive engineering:

	Drive value (online) could not be determined
	Bit parameter active (1-signal)
	Bit parameter inactive (0-signal)

Loading drive parameters

You can synchronize all p-parameter values of your project (offline) using the "Download to device" function.

Conditions

- When you load parameters into the device, a rotating drive automatically stops.
- After the parameters are loaded, the drive does not restart automatically. You must activate the drive once again using a new drive command.
- If you send an invalid parameter to the TM Drive, the module remains in parameter assignment mode. The drive cannot be activated until valid parameters are loaded.

"Download to device" function for drive parameters

You can use the "Download to device" function to transfer parameter values from your project (offline) to the drive (online).

Procedure

1. Select the drive in the project tree.
2. Click on "Download to device" in the menu bar.

Or

1. Select "Download to device" > "Software" in the shortcut menu.

You have transferred the current parameter values of your project to the drive.

7.1.3 Calling help information

To obtain information on parameters and alarms (messages) of the drive, open the information system via "Help" > "Show help" and search for the article number of the product.

You can also directly open the information system for a parameter or a message. To do so, click the online help link in the tooltip of a parameter or message .

7.2 Requirements for the commissioning

Requirements

- The TM Drive was installed according to the information in the following sections:
  - Wiring (Page 20)
  - Configuring (Page 55)
- The motor is installed in the drive train to be operated in accordance with the plant/device construction planning.

Note

Additional information concerning the requirements

You can find additional information relating to technology objects and motion control in the online help of STEP 7 under "Using technology functions" > "Motion Control".

Before powering on for the first time

Before the first power-on, check the installation and the wiring of the TM Drive.

Questions for the check

The following questions provide guidance for checking your TM Drive in the form of a checklist.

Racks

- Is the mounting rail securely mounted to the wall, in the frame or in the cabinet?
- Are the cable ducts correctly installed?
- Have the minimum clearances been observed?

Grounding and chassis concept

- Is the mounting rail connected to the protective conductor?
- Is the connection between the ground reference and ground properly established for the mounting rail?
- Has the shielding of the motor/encoder cable been applied over a large area on the device and on the motor/encoder?
- Are the required equipotential bonding cables connected with low impedance to the affected plant units?
- Are the grounding terminals correctly attached and is the motor/encoder cable correctly connected?

Module installation and wiring

- Is the TM StepDrive plugged in / installed and firmly connected or screwed according to the assembly plan and configuration with STEP 7?
- Are all connectors wired according to the circuit diagram?
- Is the PROFINET connection to the CPU and the engineering system of the STEP 7 (TIA Portal) connected?
- Is the input for Hardware STO (STO+/STO-) connected?
- Are the cables (motor connection cable, encoder cable) properly connected between the TM Drive and the motor and installed according to the guidelines?
- Is the optional digital input connected?
- Are the cables from the hardware STO (STO+/STO-) separated from the other cables, in particular from power cables?
- Have you minimized crushing hazards and short-circuits against ground connections by appropriate routing?
- Are the cables fully protected against premature aging due to continuous UV radiation?

Power supply

- Are all power supplies switched off?
- Is the power cable connector correctly wired?
- Has the connection to line voltage been made?

7.3 Procedure for commissioning the ET 200SP TM Drive

Procedure for commissioning with STEP 7

Commissioning is performed according to the steps listed below. The individual commissioning steps are optional and are to be performed as required. We recommend the following procedure for the first commissioning of a TM Drive .

Table 7- 1 Commissioning procedure

Step	Procedure	Comments	See section ...
1	Configure drive data record	Use one of the following options in the "Configure drive data record" dialog under "Parameters > Drive": • Select pre-configured drive data record from list • Custom edit drive data record	Drive data sets (Page 67)
2	Define setpoint channel	Under "Setpoint channel" you configure the following: • Reference values • Application limits • Ramp generator	Setpoint channel (Page 74)
3	Set control/closed-loop control	Have the controller parameters automatically calculated using the "Speed/current controller settings" comfort function.	Controller settings (Page 80)
4	Configure intermediate circuit voltage monitoring and optionally the brake control module	• Define limits for the intermediate circuit voltage • Motor holding brake settings	Intermediate circuit voltage (Page 85)
5	Configure messages/monitoring	• Define warning thresholds for thermal monitoring	Messages/monitoring (Page 89)

7.4 Drive data sets

Introduction

It is possible to connect motors from third-party motor manufacturers, provided that they meet the required conditions regarding motor, encoder system, connection technology, electrical safety, EMC etc., as described in this manual.

With the F-TM StepDrive ST, this also includes stepper motors which can be connected in a bipolar manner and which meet the boundary conditions explained in this manual.

Drive data record

The motor or drive of the TM Drive drive system is configured using a drive data set (DDS). A drive data record contains the settings and information for the following drive components:

- Motor
- Motor gear
- Thermal motor model

Note

The description "drive" means the combination of motor, encoder and additional built-on accessories such as a gearbox and holding brake.

Motor

You can find the settings for the motor in the "Parameters" > "Drive" > "Motor" area.

The TM Drive drive system supports stepper motors. You specify important basic data and reference data of the motor.

Observe the information and notes in the help or in the tooltips of the individual parameters.

You can also find detailed information and descriptions for the drive parameters in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

Motor encoder

The motor encoder is used for the closed-loop speed control of the drive. The encoder values are transferred to the CPU in the PROFIdrive telegram of the TM Drive, independent of the encoder type.

The following combinations are available:

Motor type: Stepper motor

- (0) No encoder / calculated
- (1) Incremental encoder (A, B, Z track)

(0) No encoder / calculated

The setting (0) encoderless / calculated is only supported in connection with a stepper motor. In this case, the rotor position is calculated and transferred to the control depending on the steps per revolution (p0408) or the steps per revolution (p0409).

(1) Incremental encoder (A, B, Z track)

When selecting the encoder type (1) incremental encoder, a 3-channel encoder with Z-track (often also referred to as I-track) can be connected.

Thermal model

The motor can be protected from thermal overload. Take section Messages/monitoring (Page 89) into consideration for this.

You define the thermal properties of the motor in the "Parameters" > "Drive" > "Thermal model" area.

7.4.1 Using the drive data set

To configure a drive, you have the following options:

- Create a user-defined drive data record and configure your motor manually.

Note

In the TM Drive engineering, the drive parameters can only be edited in the "Parameters" > "Drive" area if you are using a user-defined drive data set.

NOTICE
After a change of the drive data record, you must adapt or optimize the parameters for the current and speed controllers, if necessary. See section Controller settings (Page 80).

7.4.2 Using a user-defined drive data set

Create a user-defined drive data record and configure your motor manually.

You can also use this function to edit an existing drive data record.

WARNING

Avoiding incorrect parameter assignments

Note that incorrect or modified parameter assignments can result in drive malfunctions and damage to the drive.

Procedure

To freely configure the current drive data, follow these steps:

1. Open "Parameters" > "Drive" in the context of the drive.
2. Start the configuration wizard with the "Configure drive data record..." button in the "Drive data record" area.
3. Select the "Edit drive data record by user" option.
4. Accept the configuration with "Yes".
5. Confirm that you are changing the drive data record.
6. Adjust the motor settings for your drive.

   Observe the information and notes in the help or in the tooltips of the individual parameters.

   You can also find detailed information and descriptions for the drive parameters in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

You have selected user-defined editing of the drive and adapted the settings.

See also

Motor (Page 90)

7.4.3 Drive parameters stepper motor

Parameter number	Name	Description	Unit
Motor			
p0300	Motor type	Selection of the motor type	
p0305	Nominal current	Nominal current per coil in full step mode.	A
p0312	Hold torque	Hold torque of the stepper motor in full step mode and nominal current.	Nm
p0322	Maximum speed	Maximum speed is the mechanically permissible speed of the machine. If the speed is exceeded, the motor may be damaged.	rpm
p0372	Connection resistance	Connection resistance of a phase	Ohm
p0376	Connection inductance	Connection inductance one phase	mH
p0341	Rotor moment of inertia	The rotor moment of inertia is the mass moment of inertia of the rotor with the connecting shaft.	kgcm²
P30000	Step angle	Step angle of the stepper motor in full step mode.	-
P30001	Number of steps	The number of steps indicates the number of steps per mechanical revolution in full step mode. The value cannot be edited and is calculated from the step angle. Number of steps = 360° / step angle	-
P30014	Number of pole pairs	The number of pole pairs indicates the number of pole pairs in the motor. The value cannot be edited and is calculated from the step angle. Number of pole pairs = step angle / 4.	-
Motor gear			
P2725	Motor gear moment of inertia	Sets the motor gear moment of inertia in relation to the motor axis.	kgcm²
Thermal model			
p0611[1]	Time constant winding - environment	Setting of the thermal time constant between the winding and the environment. In nominal operation (nominal load and the ambient temperatures and installation elevation specified by the manufacturer) the limit temperature of the motor is reached after five times the time constant. Note: If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. See 7.7.1 Thermal motor monitoring	s

Parameter number	Name	Description	Unit
Motor connection			
p0352	Motor cable line resistance	Input of the motor cable resistance value for outgoing and return conductor.	Ohm
p0353	Motor series inductance (=motor cable inductance)	Input of the line inductance of the outgoing and return conductor. The value can be neglected for motor connection cables < 10 m. If a series reactor is also connected between the motor and the inverter, you need to enter the inductance value as an additive to the line inductance.	mH

7.4.4 Motor encoder

Under Encoder type configuration, select the appropriate encoder type for the motor.

Encoder type configuration			
p0404	Motor encoder selection	Selection of the motor encoder	-

7.4.4.1 Encoder parameters incremental encoder and encoderless / calculated

The encoder types incremental encoder and encoderless / calculated use the same settings.

Parameter number	Name	Description	Unit
p0408	Increments per revolution	Setting of the increments per revolution or the pulses per revolution (PPR) of the motor encoder.	-
p0409	Steps per revolution	Display of the steps per revolution or counts per revolution (CPR) of the encoder. The value cannot be edited, results from the quadrature interface and is four times the value of increments per revolution (p0408).	-

Incremental encoder

With the incremental encoder, the increments per revolution must be set.

Encoderless / calculated

With the setting encoderless / calculated, the motor is moved at low speeds in the set encoder resolution steps p0408 or p0409. The encoder resolution must be at least 4 times or a multiple of the number of pole pairs of the motor. If the values are too high, the positioning accuracy can fluctuate depending on the motor quality (ripple).

Encoderless / calculated with stepper motor

With the setting encoderless / calculated with stepper motor, the motor moves at low speeds in the set encoder resolution steps p0408 or p0409. The encoder resolution (increments per revolution (p0408)) must be at least 4 times or a multiple of the number of pole pairs of the motor. If the values are too high, the positioning accuracy can fluctuate depending on the motor quality (ripple).

It is recommended to set every integer multiple of the motor full step angle (p30001); a step division into partial steps (1/2, ¼, 1/8 ...) is not necessary but can improve the positioning accuracy, especially with multi-pole stepper motors. The following table shows how the corresponding step subdivisions are determined for this.

Table 7- 2 Determination of the step subdivisions

Step resolution	**Steps per revolution (p0409)**	**Increments per revolution (p0408)**	**Example: Step angle = 1.8 °; Number of steps = 200; Number of pole pairs = 50**	
			Steps per revolution (p0409)	**Increments per revolution (p0408)**
Full step	1 x number of steps (p30001)	1/4 x number of steps (p30001)	200	50
½ Half step	2 x number of steps (p30001)	2/4 x number of steps (p30001)	400	100
¼ quarter step	4 x number of steps (p30001)	4/4 x number of steps (p30001)	800	200
1/8 eighth step	8 x number of steps (p30001)	8/4 x number of steps (p30001)	1600	400
.	.	.	.	.
1/64 sixty-fourth of a step	64 x number of steps (p30001)	64/4 x number of steps (p30001)	12800	3200

7.4.4.2 Assign encoder counting direction parameters

With encoder type (1) incremental encoder, it may be necessary to invert the counting direction of the encoder by setting the Swap encoder counting direction parameter p0410. With incremental encoders, this may be necessary, for example, if the A and B tracks were swapped when the encoder was connected.

The following is defined as the positive direction of rotation of the encoder.

Incremental encoder:

The positive direction of rotation for an incremental encoder is defined as follows:

If the positive A edge comes before the positive B edge in terms of time, the motor with a view of the motor shaft rotates clockwise in the positive direction of rotation.

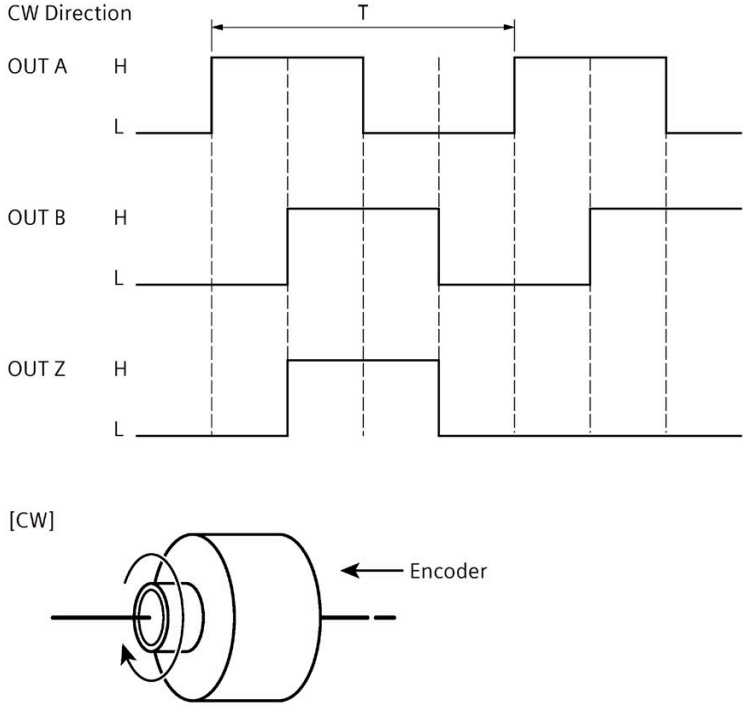


Figure 7-2 Direction of rotation for the incremental encoder

Table 7- 3 **Encoder values**

Parameter number	Name	Description	Unit
p0410	Swap encoder counting direction	This setting negates the counting direction of the encoder.	-

7.5 Setpoint channel

Overview

Setpoints from the respective setpoint source are prepared for the motor control in the setpoint channel of the drive.

You specify the setpoints via the drive telegrams to PROFIdrive.

You can find the settings for the setpoint channel in the context of the drive under "Parameters" > "Setpoint channel".

Under "Setpoint channel" you configure the following:

- Reference values (Page 75)
- Application limits (Page 76)
- Ramp generator (Page 79)

The figure below shows the processing of the speed setpoint in the drive controller.

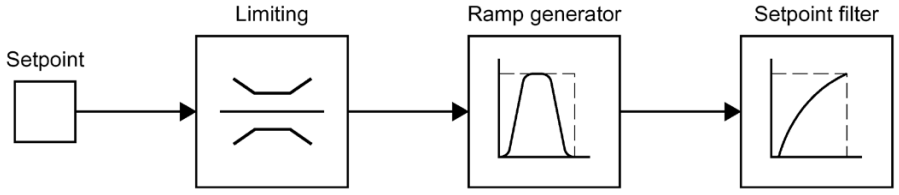


Figure 7-3 Setpoint channel

The speed setpoint from the drive telegram is limited in the setpoint channel according to the specified values, see section Reference values (Page 75).

The limited speed setpoint is fed to the ramp generator as an input signal, see section Application limits (Page 76).

The output of the ramp generator is fed to the speed controller via the speed setpoint filter, see section Ramp generator (Page 79).

7.5.1 Reference values

The physical variable speed is transmitted in the drive telegrams as a reference values.

- Speeds are normalized to the reference speed (p2000) in the drive telegram.

Here, p2000 is decisive as the reference value (telegram content = 4000 hex or 4000 0000 hex for double words if the input variable has the value p2000).

Example of the normalization of the speed:

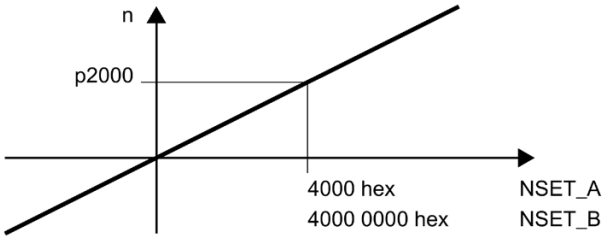


Figure 7-4 Example of normalization of the speed

Note

The speed and torque are specified in the drive telegram as a percentage of the reference speed in the range -200% to 200%.

Therefore, set the reference variables in such a way that the desired maximum value falls within the value range of the control from -200% to +200%.

Procedure

1. Configure the reference value in the context of the drive under:

   "Parameters" > "Setpoint channel" > "Reference values".

⚠ WARNING

Uncontrolled drive behavior

Note that the specification of reference values in the CPU and the drive must always match. Otherwise, uncontrolled drive behavior and rotating of the motor might occur. We therefore recommend that commissioning of the drive and thus specification of the references values be completed first before you commission the CPU and, for example, a technology object.

7.5.2 Application limits

In the "Parameters" > "Setpoint channel" > "Application values" area, you can configure limitations for the speed and torque of the drive if required and adapt them to the requirements of your mechanical system.

Speed limiting

If you need a direction-dependent speed limiting, you can define speed limits for each direction.

Torque limiting

You can specify the torque limiting as an absolute value. The limiting acts both when motoring as well as generating.

⚠ WARNING

Accuracy of torque limitation

The function of the torque limitation is not safe torque limiting in the sense of functional safety. The torque limitation refers to the calculated internal (air gap) torque of the motor.

The internal torque is a calculated value from the internal motor constant and motor current. The torque output at the shaft is the internal torque minus friction and iron losses.

Due to the following influencing factors, the deviation of the torque calculation can be in the two-digit percentage range:

- Motor parameters
- Current measurement accuracy
- Temperature dependence
- Speed and load dependence on friction, iron and additional losses of the motor

⚠ WARNING

Danger to life due to uncontrolled movement of the drive as a result of incorrect parameter assignment

Incorrect parameterization of the torque limiting can result in uncontrolled movement of the drives if there is no counter-torque, and cause death or serious injury.

Ensure the correct parameterization.

Standstill detection

Set the speed threshold for the motor standstill detection (p1226). For braking with OFF1 or OFF3, the zero speed is detected when this threshold is fallen below.

Note

A zero point calibration is only started if the speed falls below the speed threshold for standstill detection (p1226).

Note

A switch-on process of the drive via STW1 is always delayed until the speed has fallen below the speed threshold for standstill detection (p1226).

As long as the speed is still above this speed threshold, warning 2007 is issued. This can be the case, for example, if the motor shaft is driven externally.

If the switch-on command is still set despite this warning, the drive is switched on and the specified setpoint speed is adopted as soon as the speed threshold for standstill detection has been undershot.

Speed threshold values for message

Also specify the speed threshold values for the following messages of the drive status word:

- "Speed threshold 1" (p2141)

  If the speed exceeds the threshold value, bit 10 is set as feedback in ZSW 1

- "Speed threshold 4" (p2163)

  As long as the speed deviation lies within the tolerance range, bit 8 in ZSW1 is set as feedback

- "On delay time" (p2167)

  Setting the switch-on delay time for the message "Speed setpoint/actual deviation within tolerance" (see also p2163)

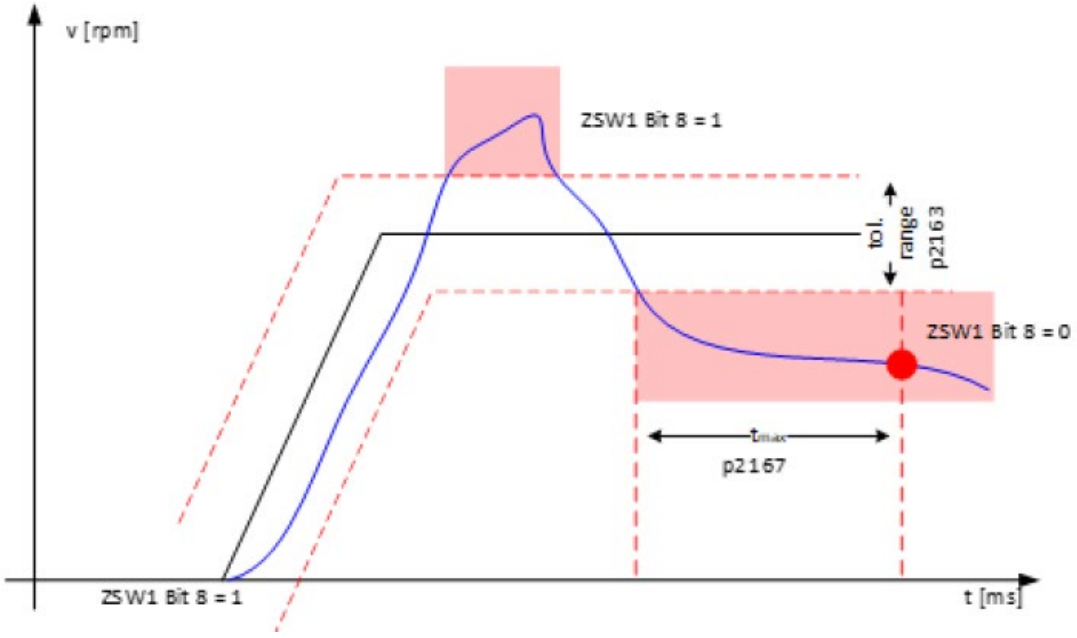


Figure 7-5 Sets the ON-delay time (p2167) and the speed threshold value 4 (p2163)

End stop detection and step loss detection with the stepper motor

If an incremental encoder and the control type [103] controlled (I = const.) are used with a stepper motor, end stop detection or step loss detection can be implemented using bit 8 in the ZSW1. The "speed threshold value 4" parameters (p2163) and the "On delay" (p2167) can be used to set the detection tolerance range.

7.5.3 Ramp generator

The TM Drive uses the speed ramp generator type "Basic ramp-function generator" p1115[0].

Speed ramp generator

The speed ramp generator is used to limit the acceleration at sudden setpoint changes and helps to prevent drive train shock loads.

An acceleration ramp and a deceleration ramp can be set independently with the ramp-up time and ramp-down time. This enables a controlled transition at setpoint changes.

The reference value for calculating the ramps from the ramp-up and ramp-down times of the speed ramp generator is the speed specified in the "Speed" dialog box.

Note

On principle, the ramp-up and ramp-down times of the ramp generator in the setpoint channel of the drive should be set only so fast that, in case of accelerations and decelerations, the motor speed can track the setpoint without damaging the machine. This ensures optimal functioning of the speed controller precontrol.

Especially with the control type [103] controlled (I = const.), the ramp-up and ramp-down times must not be set too steep, as otherwise the rotor cannot follow the controlled rotating field.

Procedure

You enter the settings for the speed ramp generator under "Parameters" > "Parameters" > "Ramp generator":

- Rampup time
- Ramp-down time
- Speed

Note

The TM Drive uses the three values entered to form the values relative to 10,000 rpm "Speed ramp generator ramp-up time" (p1120) and "Speed ramp generator ramp-down time" (p1121).

When using the GSD file, directly enter the values relative to 10,000 rpm.

7.6 Controller settings

Under "Parameters" > "Open-loop/closed-loop control", you specify the type of control, the general controller settings and the settings for speed and current controllers.

Control type

The open-loop / closed-loop control type can be selected depending on the motor type.

Motor type: Stepper motor

- [103] Controlled (I = constant)

7.6.1 Controlled (I = const.)

General controller settings

In the controlled control mode (I = const.), the speed is controlled by an angle adjuster. Depending on the respective speed, the control angle of the motor is switched faster or slower in quantified steps in the desired direction of rotation.

Speed controller

It is advisable to specify speed changes along an up and down ramp, as otherwise the drive is not able to follow the specified speed.

The internal ramp-function generator (section 7.5.3) can be used as speed ramp.

Current controller

With the control mode controlled (I = const.), the current controller applies a constant current value to the motor. The motor current is specified using two current values for travel mode (p1738 run current) and standstill mode (p1739 stop current). The current values are effective values.

- Run current p1738
- Stop current p1739

The stop current is impressed on the motor while it is at a standstill and ensures a corresponding holding torque. If a speed not equal to 0 1/min is specified, the current setpoint is switched from stop current to run current. If the motor comes to a standstill from a movement, the setpoint current is switched from run current to stop current after 1 s.

In many applications, the stop current can be reduced during standstill. As a result, energy can be saved during the stop phases and the motor is subjected to less thermal stress.

For reasons of protection, the run and stop current may not be greater than 1.5 times the rated motor current (p0305).

Note

With the closed-loop control mode (I = const.), no distinction is made between the magnetic longitudinal inductance (for Id) and transverse inductance (for Iq) of the motor. There are therefore only current controller values for the total current.

Enter the general controller settings under "Parameters" > "Control/closed-loop control" > "Controller settings".

- Moment of inertia load p1398
- Speed setpoint filter p1416

Additional important settings

The speed and current controllers can be determined in the best possible way if, in addition to the properties of the electric motor, you also specify the properties of the gearbox and the connecting cable.

- Motor cable line resistance p0352
- Motor cable/series inductance p0353
- Motor gear moment of inertia p2725

Current controller

You can either set the current controller manually or have the controller settings calculated by STEP 7.

Having controller settings calculated

To have the controller settings of STEP 7 calculated, proceed as follows:

1. Click on the "Calculate current controller settings" button in the Controller settings area. The "Controller calculation" window opens. The window displays the appropriate controller parameters.
2. Apply the controller settings by clicking the "Apply" button.

You can then continue to change the calculated controller settings manually.

Setting the controller settings manually

Enter the settings for the current controller under "Parameters" > "Control/closed-loop control" > "Current controller".

- Proportional gain
- Integral action time

Note

If you manually set the controller parameters to inappropriate values, the drive system can be damaged.

Make changes to the controller settings in small steps. Keep checking the behavior of the drive system until you have found a satisfactory setting.

7.6.2 OFF responses

OFF1 (Switch off)

By resetting bit 0 in STW1 (On), you activate OFF1 and the drive is braked to 0 in a speed-controlled manner according to the ramp generator ramp-down (p1120, p1121). If the actual speed falls below the value of the "Standstill detection" parameter (p1226) or if a timeout is detected, the pulses are blocked after the motor brake closing time p1217 has expired. "Switching on inhibited" is activated.

Timeout

With OFF1, the time is calculated in which the drive should normally stop from twice the reference speed. If the drive does not stop within 2 times of this time, the drive is de-energized and it coasts down.

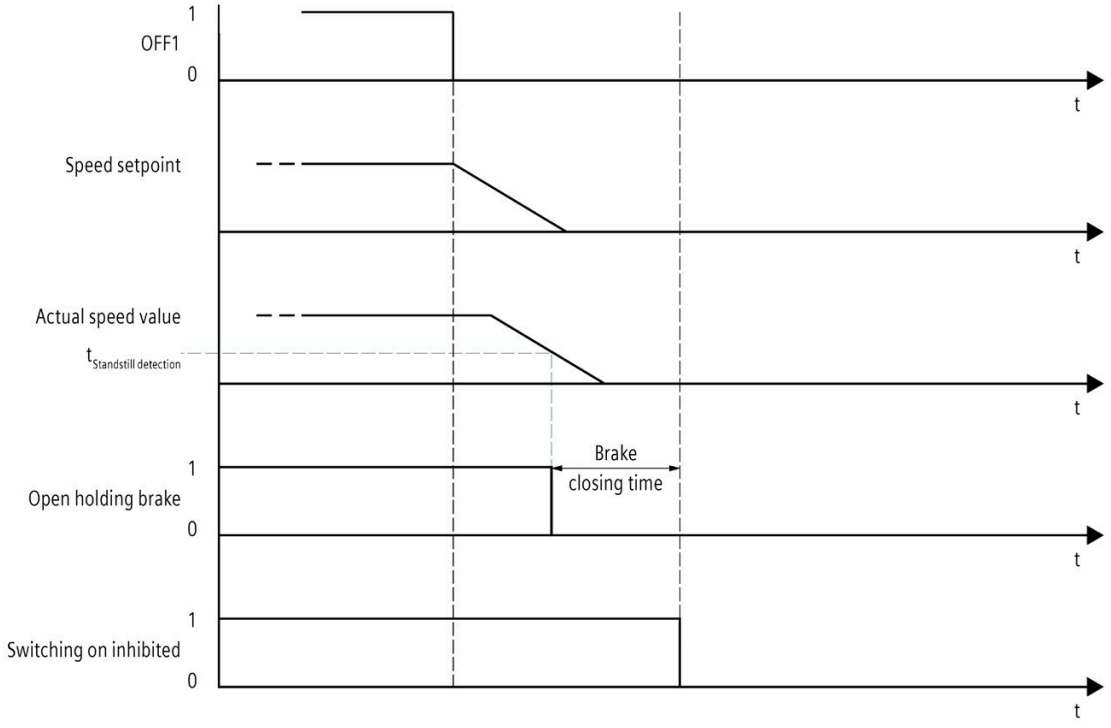


Figure 7-6 OFF1 sequence diagram

OFF2 (Coast down)

You activate OFF2 by resetting bit 1 in STW1 (NoCoastStop). The pulses are immediately canceled, any parameterized motor holding brake is applied and the drive coasts down. "Switching on inhibited" is activated.

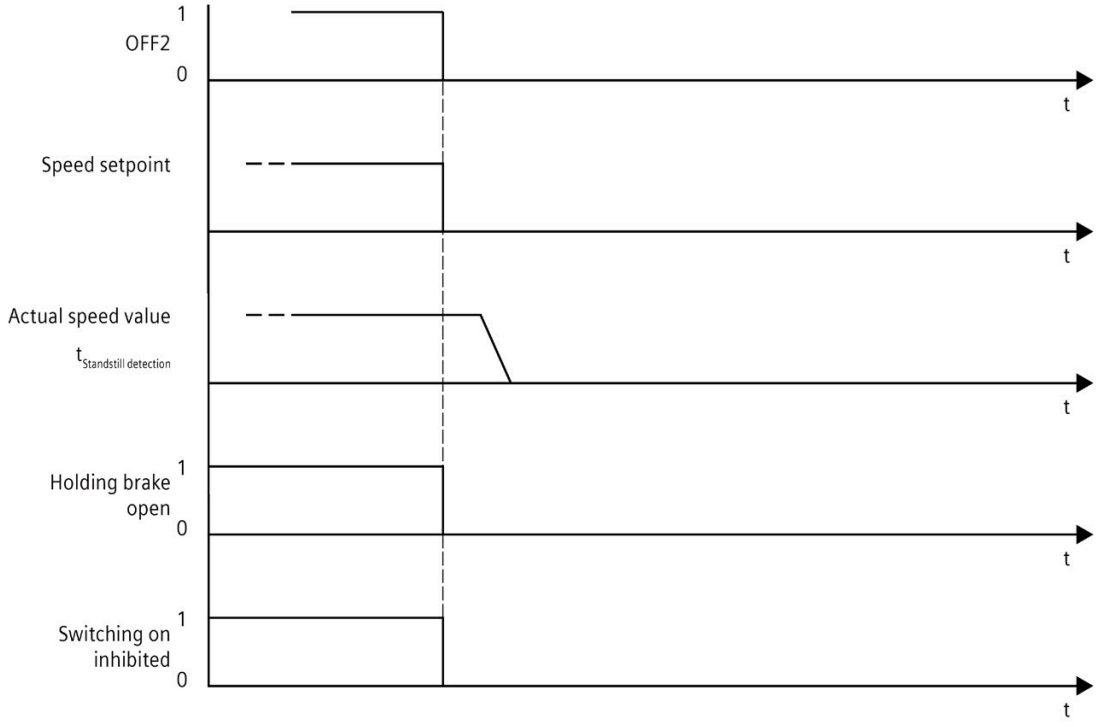


Figure 7-7 OFF2 sequence diagram

OFF3 (QuickStop)

You trigger a quick stop (OFF3) by resetting bit 2 in STW1 (NoQuickStop). The rapid stop takes into account the ramp-down time configured in the HSP ("Parameter" > "Setpoint channel" > "Speed – Ramp generator"). After the standstill is detected or the monitoring time has elapsed, any configured motor holding brake is closed and the pulses are deleted after the motor holding brake closing time p1217 has expired. "Switching on inhibited" is activated.

Note

NOTE on rapid stop (OFF3)

You trigger a quick stop (OFF3) by resetting bit 2 in STW1 (NoQuickStop). The rapid stop takes into account the ramp-down time configured in the HSP ("Parameter" > "Setpoint channel" > "Speed – Ramp generator"). The rapid stop is monitored for time and causes the motor to be energized after 6 seconds at the latest.

Timeout

The rapid stop is monitored for time and causes the motor to be energized after 6 seconds at the latest.

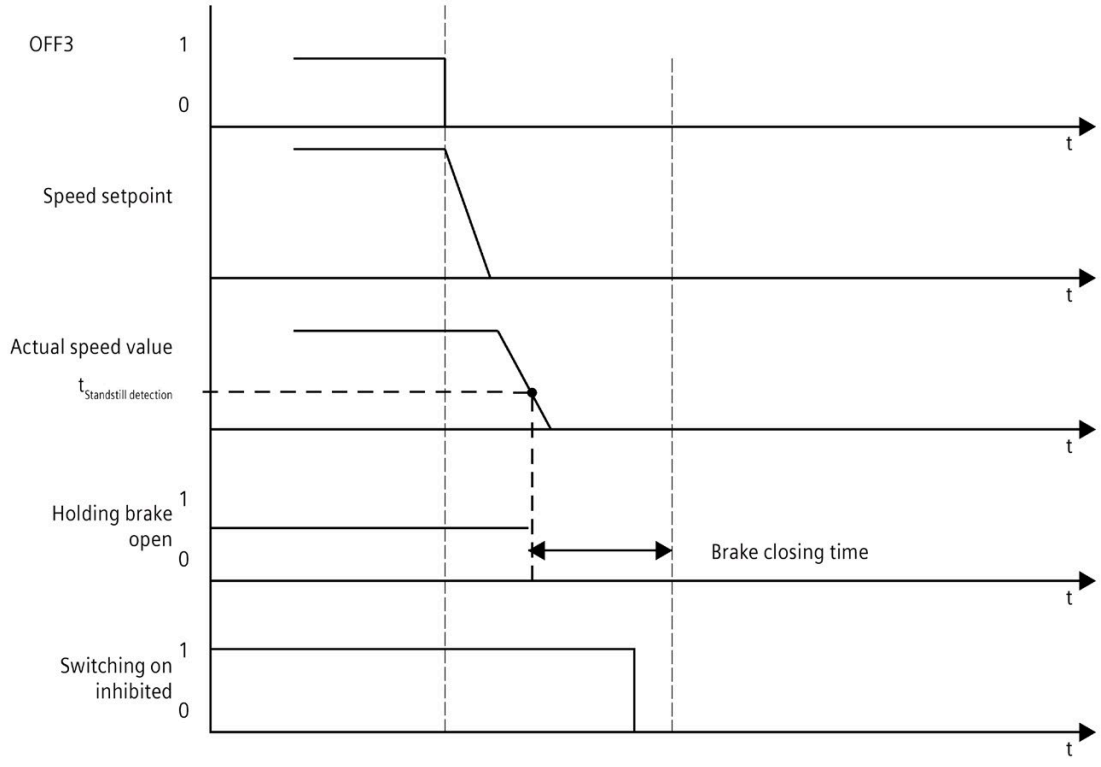


Figure 7-8 OFF3 sequence diagram

Prioritization

The OFF responses are prioritized as follows:

- OFF2 (coast down) > OFF1 (switch off)
- OFF3 (QuickStop) > OFF1 (Switch off)

7.7 Intermediate circuit voltage

The TM Drive system cyclically monitors the intermediate circuit voltage. The limit values can be set under "Alarms/Monitoring".

The following options can be selected under "Intermediate circuit voltage":

- Minimum value of the intermediate circuit voltage (p0390)
- Maximum value of the intermediate circuit voltage (p0391)

If the limit values are exceeded or not reached, the motor control is switched off. If a intermediate circuit voltage close to the limit values is detected, a corresponding warning is issued.

7.8 Brake module

The drive system TM Drive can externally control a motor holding brake via the process image using a DQ or relay module.

The following options for the stepper motor type can be selected under "Brake module":

- [0] No function
- [4] Motor holding brake externally via the process image

If stepper motors are selected, the brake chopper function cannot be used. Should a brake chopper nevertheless be required, you can install another TM Drive module with brake chopper functionality in the same potential group and connect the brake resistor there and parameterize the brake chopper.

7.8.1 External motor holding brake

The motor holding brake can be used when the drive system is disabled (e.g. when the power supply to the drive system is switched off) to prevent unwanted movements of the suspended load (e.g. falling due to gravity). The motor can move by its own weight or an external force even if the motor power supply is interrupted.

Note

- Use this brake only for "holding", which means to maintain the standstill. Do not use it for "braking", which means to stop the moving load. Use the holding brake only to hold a motor at a standstill.
- The holding brake is enabled when the motor is switched off.

If the motor holding brake function is enabled, you must configure the following settings in the area "Parameters" > "Drive" > "Brake module".

Adjust the opening and closing times of the motor holding brake:

- Motor holding brake opening time (p1216)
- Motor holding brake closing time (p1217)

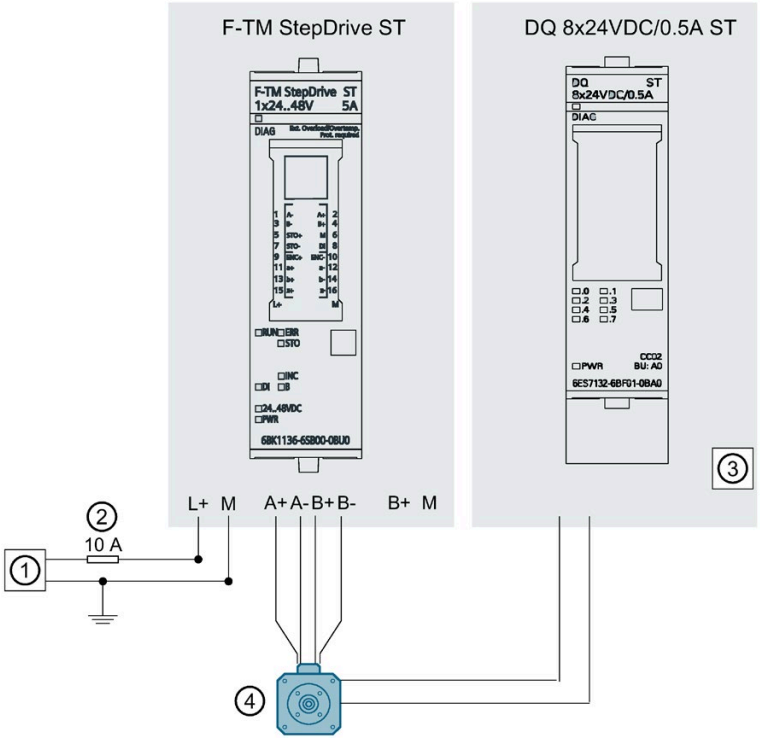
For the closing and opening times, delay times of relays may have to be taken into account and added to the times of the motor holding brake.

p1216 = motor brake opening time + relay opening time

p1217 = motor brake closing time + relay closing time

If the motor holding brake is parameterized, the drive takes the delay times into account and accordingly sets bit 12 in the process image ZSW1. This bit can be used to control a motor holding brake, for example with a DQ module or relay module.

RC circuit of a TM Drive with DQ module and motor holding brake



① Power supply unit
② Protective device
③ DQ module
④ Motor with holding brake

Figure 7-9 RC circuit of a TM Drive with DQ module and motor holding brake

Braking sequence

The sequence diagram shows an example of the behavior of the drive with OFF1.

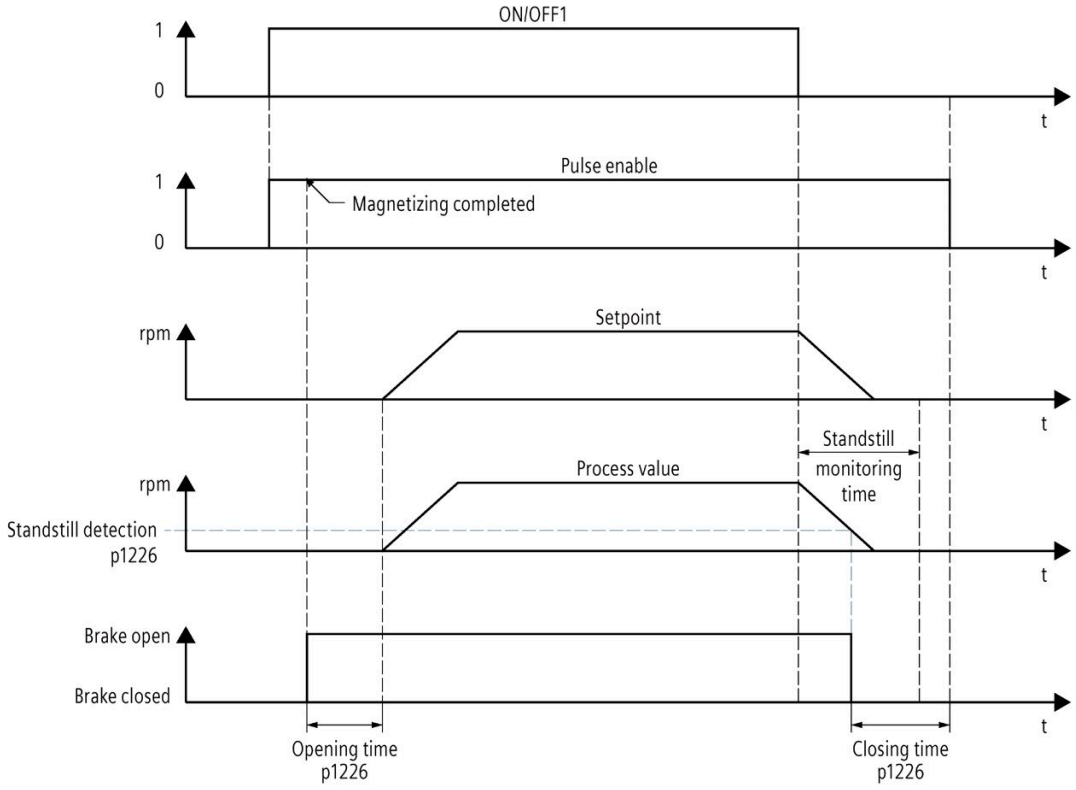


Figure 7-10 Braking sequence

The magnetizing time is calculated automatically depending on the motor parameters.

The influence of the motor holding brake on the OFF reactions is described in section 7.6.4 (Page 83) OFF reaction.

NOTICE
Improper use Improper use of the motor brake will shorten its service life. The motor brake is only intended for holding purposes. Frequent emergency stops with the motor brake shorten its service life. Unless absolutely necessary, do not use the motor brake as emergency stop.

7.9 Messages/monitoring

Thermal monitoring

The purpose of thermal monitoring is to detect critical states. Parameterizable warning thresholds are available that allow further operation of the drive (e.g. with reduced power) and prevent an immediate shutdown. However, the parameter assignment options are only interventions below the shutdown thresholds.

The following thermal monitoring options are available:

- Motor
  - Motor I^2t model
- Power end stage
  - Overload protection
  - Temperature sensor

When an overload is detected by one of these monitoring functions, a warning is output first. The respective warning thresholds (p0291) are parameterizable. The current status of the monitoring functions is displayed. If an alarm or fault limit is exceeded, the "Temperature monitoring" message is sent.

Note

All alarm and fault limits are provided with a corresponding hysteresis. The corresponding alarm or fault messages therefore remain until the threshold including hysteresis has been fallen below.

Note

Motor monitoring

The thermal motor resistance utilization is a calculated value. The values are not saved.

After a power reset, the values only match again after a sufficiently long cooling time.

Operating temperature

Note that the specified ambient temperature range for the drive must always be adhered to, see section Technical specifications (Page 112).

7.9.1 Motor

Thermal motor monitoring

The thermal motor monitoring is performed using a configurable I^2t temperature model.

WARNING

Thermal motor utilization cannot be immediately determined after initialization

The thermal model is reinitialized after changing the drive data record and when switching on the device.

After initialization, the thermal motor utilization cannot be immediately determined as the model must first settle. As a consequence, an initial utilization of 50 % is used as basis. The settling phase duration depends on the given thermal time constants; the accuracy depends on to what extent the specific installation situation deviates from the model.

During the settling time it is possible that the set alarm and/or fault threshold is reached with some delay. For the installation situation simulated in the model, a comparatively unfavorable installation was selected so that generally deviations occur on the safe side.

You can define the warning threshold under Parameters > Messages/monitoring > Motor relative to the respective shutdown threshold.

Procedure

1. Open the "Motor" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[1].

Motor I^2t model

The I^2t monitoring operates with the relative motor power loss, and in addition to the nominal motor current (p0305) as reference value, only requires the thermal time constant winding - environment (p0611[0]) to calculate the limiting integral. The 100 % shutdown threshold corresponds to the maximum continuous power loss of the motor, i.e. to the square of the nominal motor current (p0305).

WARNING

Compliance with the ambient conditions specified by the motor manufacturer

The motor may only be operated in ambient conditions such as ambient temperature, installation elevation, etc. as specified by the manufacturer.

If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. The derating behavior and the resulting lower motor performance data must be obtained from the motor manufacturer and adjusted accordingly in the motor parameters of the TM Drive.

If the motor is used outside its specification, the thermal model does not provide sufficient protection.

7.9.2 Power end stage

Thermal monitoring of power end stage

The power end stage is monitored with a temperature sensor. You can specify the warning threshold (p0291[1]) relative to the shutdown threshold "System maximum temperature power end stage".

Procedure

1. Open the "Power end stage" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[1].

Besides the temperature monitoring, the current load is also monitored. The current load of the power unit is decisive for the temperature rise. The relative load of the power end stage is calculated based on the square of the output current according to the I^2t method.

Automatic overload limiting

The TM Drive is overload-capable. The load of the power end stage is automatically limited by the drive.

The maximum overload time $t_{overload}$ is calculated depending on the temperature of the power end stage T_{PU}. When operating with cyclic overload, the rated power is not exceeded the by the time-averaged power (rms).

Stepper motor

With a stepper motor, a double overload of the rated current I_n cyclic for a duration of $t_{overload}$ = 3 s with a subsequent recovery time of 17 s at T_{PU} = 20 °C is possible. At T_{PU} = 80 °C, the overload time $t_{overload} \approx 0.75$ s.

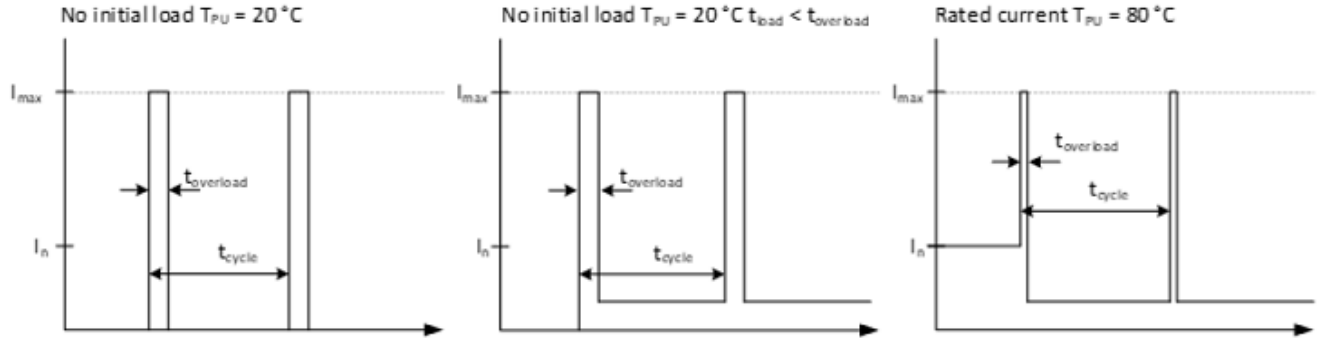


Figure 7-11 Overload behavior of TM Drive

Note the information on derating as a function of environmental conditions (e.g. temperature, mounting position) in section Derating of the ET 200SP TM Drive (Page 116).

Note

Overload capability of the power unit

Operation with a peak current of 10 A is possible temporarily if the average RMS value of the output current does not exceed the rated current of the power unit up to 5 A.

7.9.3 Intermediate circuit voltage

Monitoring of the intermediate circuit voltage

The energy recovery in the power supply cannot be suppressed. Energy is fed back when the drive brakes and the braking chopper is not connected and configured. The energy recovery results in an increase of the intermediate circuit voltage.

You can set the limits for the intermediate circuit voltage within the permissible values.

If the limits are exceeded, the module switches off. Before the module is switched off, a warning (limit - 5%) indicates that the limit has almost been exceeded. The user is responsible for ensuring compliance with the permissible voltage limits.

Procedure

1. Open the "Intermediate circuit voltage" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the minimum value (p0390) and the maximum value (p0391).

WARNING

Operation above the voltage setting range

Under the given application conditions, ensure that the motor is not operated above the voltage setting range by selecting the appropriate motor and gear unit. Otherwise, the intermediate voltage may increase when the control is inactive via 60 V DC.

Programming

8

TM Drive does not have its own control panel. A user program is required to control the motion sequences.

You have the following options for controlling the motion sequences in the user program:

- Control via the process image (Page 93)
- Control via the SINA_SPEED (Page 100) instruction
- Control with a technology object (Page 100)

8.1 Controlling TM Drive via the process image

Structure of the I/O addresses

The structure of the input addresses of the TM Drive depends on the configured communication telegram and the telegram extension.

The structure of the output addresses of the TM Drive depends on the configured communication telegram.

Standard telegram 1 Structure I/O addresses

Inputs

Bool	Data type	Offset
Status word 1	**Structure**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchOn	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6

Bool	Data type	Offset
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_A	**Word**	**2.0**
Telegram extension word (only with telegram extension)	**Structure**	**4.0**
Reserved	Byte	4.0
Telegram extension STO_Status	Bool	5.0
Telegram extension DI_Status	Bool	5.1

Outputs

Element	Data type	Offset
Control word 1	**Structure**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_A	**Word**	**2.0**

Standard telegram 2 Structure I/O addresses

Inputs

Bool	Data type	Offset
Status word 1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchOn	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word 2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Telegram extension word (only with telegram extension)	**Struct**	**8.0**
Reserved	Byte	8.0
Telegram extension STO_Status	Bool	9.0
Telegram extension DI_Status	Bool	9.1

Outputs

Element	Data type	Offset
Control word 1	**Struct**	**0.0**
Bit08_Reserved	Bool	0.0
Bit08_NoSpeedDeviation	Bool	0.1
Bit09_ControlRequested	Bool	0.2
Bit10_SpeedComparisonValueReachedExeed	Bool	0.3
Bit11_TorqueLimitNotReached	Bool	0.4
Bit12_OpenHoldingBrake	Bool	0.5
Bit13_NoMotorOvertemperature	Bool	0.6
Bit14_ActualSpeedPositive	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word 2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7

Standard telegram 3 Structure I/O addresses

Inputs

Bool	Data type	Offset
Status word 1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchON	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word 2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Encoder status word 1	**Struct**	**8.0**
Bit08_Probe1Deflected	Bool	8.0
Bit09_Probe2Deflected	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_EncoderFaultAcknowlegdeActive	Bool	8.3
Bit12_HomePositionExecuted	Bool	8.4
Bit13_AbsoluteValueCyclicallyExecuted	Bool	8.5

Bool	Data type	Offset
Bit14_ReservedParkingSensorExecuted	Bool	8.6
Bit15_ParkingSensorExecuted	Bool	8.7
Bit00_Function1Active	Bool	9.0
Bit01_Function2Active	Bool	9.1
Bit02_Function3Active	Bool	9.2
Bit03_Function4Active	Bool	9.3
Bit04_Value1Available	Bool	9.4
Bit05_Value2Available	Bool	9.5
Bit06_Value3Available	Bool	9.6
Bit07_Value4Available	Bool	9.7
Actual encoder position value 1 (Gx_XIST1)	**DWord**	**10.0**
Actual encoder position value 2 (Gx_XIST2)	**DWord**	**14.0**
Telegram extension word (only with telegram extension)	**Struct**	**18.0**
Reserved	Byte	18.0
Telegram extension STO_Status	Bool	19.0
Telegram extension DI_Status	Bool	19.1

Outputs

Element	Data type	Offset
Control word 1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word 2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5

Element	Data type	Offset
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Encoder control word 1	**Struct**	**8.0**
Bit08_Reserved	Bool	8.0
Bit09_Reserved	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_Reserved	Bool	8.3
Bit12_Reserved	Bool	8.4
Bit13_AbsoluteValueCyclically	Bool	8.5
Bit14_RequestParkingEncoder	Bool	8.6
Bit15_AcknowlegdeError	Bool	8.7
Bit00_Function1Request	Bool	9.0
Bit01_Function2Request	Bool	9.1
Bit02_Function3Request	Bool	9.2
Bit03_Function4Request	Bool	9.3
Bit04_Command0Request	Bool	9.4
Bit05_Command1Request	Bool	9.5
Bit06_Command2Request	Bool	9.6
Bit07_Mode	Bool	9.7

Basic procedure in STEP 7

1. In the project tree, create PLC data types in the CPU 2 with the appropriate structure for your configuration:
   - PLC data type for the structure of the input data (depending on PROFIdrive telegram type and telegram extension)
   - PLC data type for the structure of the output data (depending on PROFIdrive telegram type and telegram extension)
2. Create a tag from each type of the PLC data type in a tag table.
3. Assign the addresses for the tag according to the configured I/O addresses of the TM Drive.
4. Control the TM Drive by setting outputs bit-by-bit. A description of how to set the outputs to control the TM Drive can be found in the PROFIdrive standard.
   You can find the current PROFIdrive specification under (https://www.profibus.com/).

8.2 Controlling a TM Drive via the instruction SINA_SPEED

Control with the SINA_SPEED instruction

For controlling the TM Drive, you can also use the SINA-SPEED instruction from the "DriveLib" block library.

The SINA_SPEED block only works with the standard telegram 1. The telegram extension may have to be disabled. See Communication telegrams.

The "DriveLib" block library can be downloaded from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109475044).

8.3 Controlling TM Drive with a technology object

Control with a technology object

You can also use a technology object, for example "Speed-controlled axis" or "Positioning axis", to control the TM Drive.

Note that the TM Drive does not have an integrated positioning functionality and only supports speed operation.

Procedure

1. Create, for example, a "Speed axis" technology object in the CPU in the project tree in STEP 7.
2. Open the technology object.
3. Select "TM Drive" under "Configuration" > "Hardware interface" > "Drive".
4. Reference the technology object in the user program using the Motion Control technology instructions, e.g. "MC-Power".

Note

We do not recommend using the "Encoder calibration at every startup" option in conjunction with positioning technology objects (positioning axis). The calibration process can lead to undesired behavior of the drive axis.

Additional information

You can find more information about the technology objects and technology instructions in the online help of STEP 7.

Maintenance 9

9.1 Firmware update

Firmware update

A firmware update is possible via PROFINET.

See SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

9.2 Stop responses

Overview of the stop responses

Faults with safety functions and violation of limits can trigger the following stop responses:

- "Hardware STO"

  "Safe Torque Off" (STO) corresponds to Stop Category 0 in accordance with EN 60204-1. With "Safe Torque Off" (STO), the motor is switched directly to zero torque. A motor at standstill cannot be started again accidentally. A moving motor coasts to standstill.

Table 9- 1 Overview of stop responses

Stop response	Triggered ...	Action	Effect
STO	At least one signal STO+/STO- is interrupted.	Motor controllers interrupted	Drive coasts down

After the drive has been stopped, restart it with PROFIdrive.

The faults and warnings are described in the appendix Active messages (Page 107).

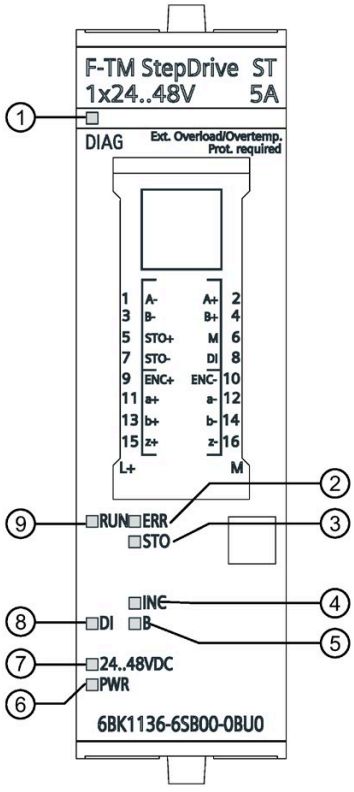
Interrupts, error messages and diagnostics and system alarms

10

10.1 Status and error displays

LED display

The figure below shows the LEDs on the TM Drive.



① DIAG (red/green)
② ERR (red)
③ STO (yellow)
Display not safety-related
④ INC (green)
⑤ B (green)
⑥ PWR (green)
⑦ 24..48V (green)
⑧ DI (green)
⑨ RUN (green)

Figure 10-1 LED display on F-TM StepDrive

Meaning of the LED displays

The following tables contain the meanings of the status and error displays.

DIAG LED

Table 10- 1 DIAG status and error display

DIAG LED	Meaning	
Off	Backplane bus supply of the ET 200SP not OK	
Flashing	Module parameters not assigned	
On	Module parameters assigned and no module diagnostics	
Flashing	0.5 Hz (slow)	Module parameters assigned and module diagnostics
	1 Hz (normal)	There is a fault. You can find detailed information via "Online & Diagnostics" > "Diagnostics" > "Active messages" or in the section Active messages (Page 107).
	2 Hz (fast)	

RUN LED

Table 10- 2 RUN status and error display

RUN LED	Meaning	
Off	Device is not yet ready for operation	
On	Device is ready for operation and error-free	
Flashing	0.5 Hz (slow)	Device is performing self-test during power-up
	1 Hz (normal)	Device performs a firmware update
	2 Hz (fast)	Device has detected a parameterization error

ERR LED

Table 10- 3 ERR status and error display

ERR LED	Meaning
Off	No fault
On	Device has a fault and needs to be restarted. This corresponds to a serious device error or the loaded firmware cannot be operated on this device version.

DI LED

Table 10- 4 DI status and error display

DI LED	Meaning
Off	Input is inactive
On	Input is active

B LED

Table 10- 5 B status and error display

B LED	Meaning
On	The motor holding brake is open / information about the process image was set

STO LED

Table 10- 6 STO status and error display

STO LED	Meaning
On	Drive ready, switch connected correctly and STO not requested
flashes (0.5 Hz)	STO requested (motor is disconnected from power)

INC LED

Table 10- 7 Status and error display INC (encoder)

INC LED	Meaning
On	Incremental speed encoder was assigned parameters/activated
Flashes (2 Hz)	Incremental speed encoder has a connection problem (A/B and/or Z track not connected)

24..48V LED

Table 10- 8 24..48V status and error display

24..48V LED	Meaning
□ Off	DC link voltage outside the configured limits
■ On	DC link voltage within the configured limits (is OK)
☼ flashes (0.5 Hz)	DC link voltage shortly before the interference threshold

PWR LEDs

Table 10- 9 PWR status and error display

PWR LED	Meaning
□ Off	Logic component supply of the converter is missing
■ On	Logic component supply of the converter is OK

10.2 Diagnostics

10.2.1 Diagnostics overview of the TM Drive

Diagnostic view of the CPU and its associated I/O

If you go online to the CPU and establish an online connection via the CPU to the TM Drive, this occurs within the project context.

Procedure

To display the diagnostic information for the TM Drive, follow these steps.

1. Select the TM Drive in the project tree, for example under "Ungrouped devices".
2. Double-click "Online & diagnostics".
   The "Diagnostics - General" window appears.
3. Navigate to the required information.

The diagnostic window is divided into the following diagnostic groups:

- **General**

  The general diagnostic information is displayed for:

  – Module
  – Module information
  – Manufacturer information

- **Diagnostics status**

  "Diagnostics status" shows the current diagnostics status of the TM Drive.

- **Active messages**

  "Active messages" displays the currently pending alarms and faults in the TM Drive module.

- **Drive diagnostics**

  The current diagnostic information of the drive is displayed for:

  – Status bits
  – Operating values
  – Encoders
  – Temperatures
  – Inputs

10.2.2 Active messages

Pending faults and alarms

"Active messages" shows the currently pending faults and alarms in the TM Drive. Faults must be acknowledged after the cause has been corrected.

Procedure

To display the active messages, follow these steps:

1. Select the TM Drive in the project tree and go to "Online & diagnostics".
2. In the "Diagnostics" folder, select the "Active messages" area.

Faults and alarms

Column	Description
Fault number	Number of the fault
Description	Description of the fault
S7 diagnostics alarm	Description of the S7 diagnostics alarm

The TM Drive supports the following faults.

Fault number	Description	S7 diagnostics alarm
1000	Overvoltage in the intermediate circuit	Undervoltage
1001	Undervoltage in the intermediate circuit	Overvoltage
1003	Shutdown due to overcurrent switch-off of a phase	Overload
1032	Temperature measured values implausible	Error
1035	Permitted temperature at the motor end stage exceeded	Overtemperature
1036	Permitted temperature at the motor winding exceeded	Overtemperature
1042	Fail-safe shutdown path (STO) defective	Safety-related shutdown
1043	Permissible temperature of the motor electronics exceeded	Overtemperature
1045	The connection to the A/B track of the incremental speed encoder is interrupted.	Wire break
1046	The connection to the Z track of the incremental speed encoder is interrupted.	Wire break
1047	An unsupported PROFIdrive speed encoder function was requested.	-
1050	A ramp/quick stop (OFF1/OFF3) could not be performed due to a timeout.	External error
1054	Permissible temperature at the motor winding when stepper motor exceeded	Overload
1300	There is an error in the parameter assignment of the motor type.	Parameter error
1340	There is an error in the parameter assignment of the encoder.	Parameter error

Fault number	Description	S7 diagnostics alarm
1360	There is an error in the parameter assignment of the controller.	Parameter error
1380	There is an error in the parameter assignment of the braking function.	Parameter error

Acknowledge faults

To acknowledge all active faults, click the "Acknowledge faults" button.

Alarms

Column	Description
Alarm number	Number of the warning
Description	Description of the warning

The TM Drive supports the following warnings.

Alarm number	Description
2000	Voltage in the intermediate circuit shortly before shutdown
2001	STO shutdown active
2002	Warning threshold when motor end stage temperature is exceeded
2003	Warning threshold when motor winding temperature is exceeded
2004	Thermal overload of the motor end stage
2200	Encoder warning in the encoder error

10.2.3 Drive diagnostics

You can find online information on important current drive diagnostics data and drive service data in the "Drive diagnostics" area under "Online & diagnostics" in the context of the drive.

Note

All drive diagnostics are only available online. They are automatically updated in the user interface.

You will find diagnostic information on the following points in the "Drive diagnostics" area:

- Status bits
- Operating values
- Encoders
- Temperatures
- Inputs

Properties of drive diagnostics

Drive diagnostics

- Show the current values of various parameters
- Are cyclically updated
- Are read-only.

Drive diagnostics: Status bits

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Status bits"

Table 10- 10 Drive diagnostics - status bits

Number	Parameter	Display/unit
Status word		
r0899	Status bits **Note**: Signal corresponds to status word 1 PROFIdrive (r0968).	• Ready for switching on • Ready for operation • Operation • Fault active • Coasting active • Rapid stop active • Switching on inhibited active • Alarm active • Speed setpoint - actual value deviation • Control by controller • n comparison value reached • Control of the motor holding brake is active **Note:** • Status word 1 is sent cyclically by the drive to the higher-level controller.

Drive diagnostics: Operating values

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Operating values"

Table 10- 11 Drive diagnostics - operating values

Number	Parameter	Display/unit
r0063	Speed actual value smoothed	rpm
r0080	Torque actual value	Nm
r1045	Speed setpoint in front of the ramp generator	rpm
r0026	DC link voltage	V
r0027	Current actual value	A_{eff}
r0072	Output voltage	V

Note

With a stepper motor and the "controlled (I = const.)" control type, the actual torque value corresponds to the current hold torque.

Drive diagnostics: Encoders

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Encoder"

Table 10- 12 Drive diagnostics - encoder

Number	Parameter	Display/unit
r7811	Position	°
r7810[0]	Single-turn steps	-
p979[2]	Increments per revolution	-
p979[3]	Fine resolution bits in actual value Gx_XIST1	Bits

Drive diagnostics: Temperatures

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Temperatures"

Table 10- 13 Drive diagnostics -temperatures

Number	Parameter	Display/unit
r0037[0]	Current microcontroller	°C
r0037[1]	Microcontroller max.	
r0037[4]	Power end stage	
r0037[5]	Power end stage max.	

Drive diagnostics: Inputs

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Inputs"

Table 10- 14 Drive diagnostics - inputs

Number	Parameter	Display/unit
-	Inputs	• Digital input • STO active

Reference

All displayed parameters have a tooltip that provides you with information and descriptions relating to the parameter as well as access to the online help.

You can find additional information on the parameters in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

Technical specifications

11

11.1 Technical specifications

Technical specifications of TM Drive

Article number	6BK1136-6SB00-0BU0
General information	
Product type designation	F-TM StepDrive 1x24 ... 48 V 5 A ST
HW function state	V1.0
Firmware version	V1.0
• FW update possible	Yes
Product description	control of stepper motors
usable BaseUnits	BU type U0
Product function	
• I&M data	Yes
• Isochronous mode	No
• Four-quadrant operation	Yes
• Safety Functions	Yes; Drive controller with hardwired STO
Protection function	
• Undervoltage protection	Yes
• Overvoltage protection	Yes
• Overload protection	Yes
• Ground-fault protection	No
• Short-circuit protection	Yes
Installation type/mounting	
Type of ventilation	Convection cooling
Supply voltage	
Design of the power supply	24 ... 48 V DC, SELV / PELV
permissible range, lower limit (DC)	16.8 V
permissible range, upper limit (DC)	57.6 V
Input current	
Current consumption (rated value)	6 A
Current consumption, max.	10 A
Current consumption for the electronics, max.	0.1 A; at 24 V
Inrush current, max.	25 A; at 24 V
Output voltage	
Rated value, min.	24 V
Rated value, max.	48 V

Article number	**6BK1136-6SB00-0BU0**
Output current	
Current output (rated value)	5 A
Output current, max.	10 A
Output frequency	1000 Hz
Encoder supply	
Number of outputs	1
Encoder	
Connectable encoders	
• Incremental encoder (symmetrical)	Yes; Up to 500 kHz per channel
5 V encoder supply	
• 5 V	Yes
• Short-circuit protection	Yes
• Output current, max.	150 mA
Power	
DC power consumption	300 W; At 50 V
Power loss	
Power loss, typ.	3.5 W
Digital inputs	
Number of digital inputs	1; + 1 input for message signal
Number of safety inputs	1; For STO, antivalent (2-pin) - 24 V DC
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	No
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
• Group error	Yes
Diagnostics indication LED	
• RUN LED	Yes
• ERROR LED	Yes
Integrated Functions	
Position detection	
• Incremental acquisition	Yes
• Absolute acquisition	No
Potential separation	
Potential separation channels	
• between the channels and backplane bus	Yes
Isolation	
Isolation tested with	DC 707 V, type Test (between backplane bus, DC input and functional ground)
Overvoltage category	2
Degree of pollution	2 according to EN 61800-5-1

Article number	**6BK1136-6SB00-0BU0**
Degree and class of protection	
IP degree of protection	IP20
Standards, approvals, certificates	
CE mark	Yes
cULus	No
RCM (formerly C-TICK)	No
KC approval	No
EAC (formerly Gost-R)	No
China RoHS compliance	Yes
Standard for EMC according to EN 61800-3	Yes, according to second environment Category C2 acc. EN 61800-3
Standard for drive acc. to EN 61800-5-1	Yes
Standard for drive acc. to EN 61800-5-2	Yes
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	Category 3, performance level d, according to EN ISO 13849-1:2015
• SIL according to IEC 61800-5-2	SIL 3 according to EN 61800-5-2:2017
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation, splash water, icing, salt spray or oil mist permitted
• horizontal installation, max.	60 °C; No condensation, splash water, icing, salt spray or oil mist permitted. Note the derating data!
• vertical installation, min.	-30 °C; No condensation, splash water, icing, salt spray or oil mist permitted.
• vertical installation, max.	50 °C; No condensation, splash water, icing, salt spray or oil mist permitted. Note the derating data!
Ambient temperature during storage/transportation	
• Storage, min.	-40 °C
• Storage, max.	70 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	3000 m
Cables	
Cable length for motor, shielded, max.	10 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	55 g
Sonstiges	
Brake design	Holding brake control via the process image
Braking chopper	No

Climatic and mechanical environmental conditions

You can find the climatic and mechanical ambient conditions here SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

If there are discrepancies between the statements in this document and the system manual, the statements in this document take priority.

Biological environmental conditions

The standards DIN EN IEC 60721-3-1:2018, DIN EN IEC 60721-3-2:2018, IEC 60721-3-3: Edition 3.0, with the classes 1B1, 2B1 and 3B1 apply for the biological environmental conditions during operation, long-term storage and transport.

Conductive dust and sand

The TM Drive must not be exposed to conductive dust or sand during operation, long-term storage and transport.

Chemical environmental conditions

The standards DIN EN IEC 60721-3-1:2018, DIN EN IEC 60721-3-2:2018, DIN EN 60721-3-3:1995, with the classes 1C2, 2C2 and 3C2 apply for the chemical environmental conditions during operation, long-term storage and transport.

11.2 Derating of the ET 200SP TM Drive

Maximum permitted output current as a function of installation altitude and ambient temperature

You must take into account the dependency on the ambient temperature and installation altitude.

Derating of the TM Drive depends on the installation elevation

For all permissible mounting types, starting from an installation altitude of 1000 m, a derating of 10% current per additional 1000 m elevation gain applies. In this case, the motor current and the output current of the digital outputs must be reduced.

All other functions do not have to be reduced up to the maximum installation altitude.

The figure below shows the maximum permitted output current as a function of the ambient air temperature for the derating.

Derating of the TM Drive depends on the ambient temperature (horizontal/vertical mounting position)

When installed horizontally (DIN rail horizontal), the TM Drive can be operated up to the maximum ambient temperature (60 °C). Note the derating curve.

With vertical mounting (vertical mounting rail), the TM Drive may be operated up to a maximum of 50 °C. Note the derating curve.

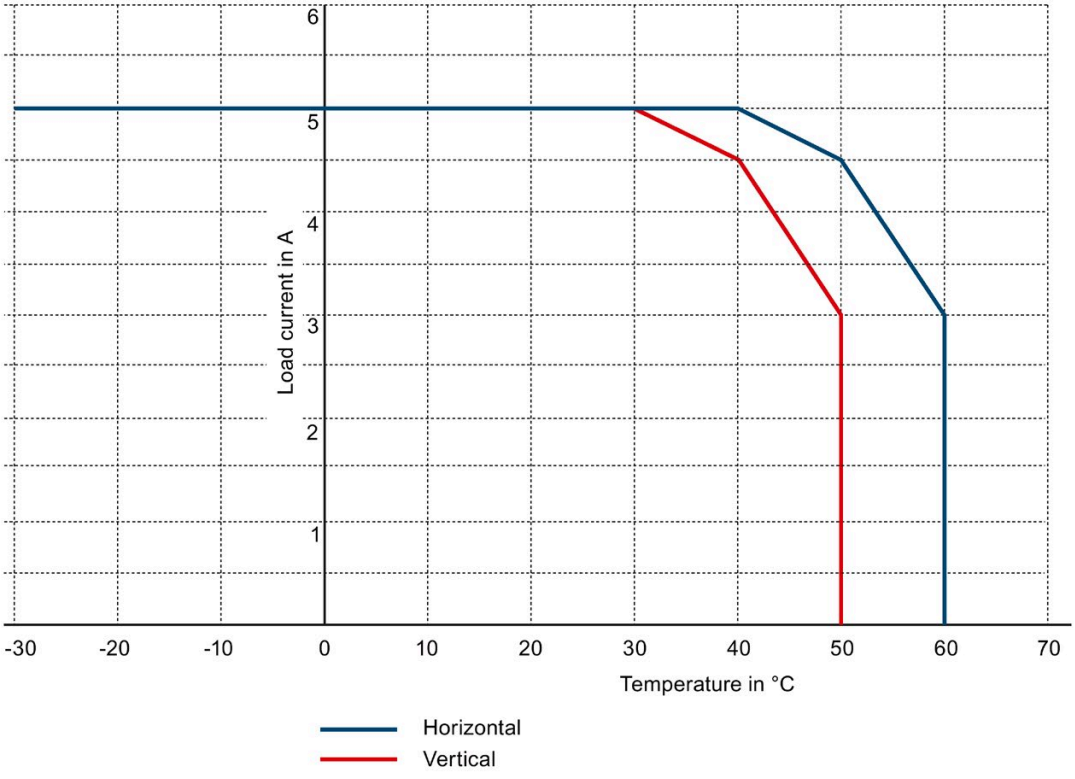


Figure 11-1 Derating the TM Drive with a stepper motor

Test signal suppression

The STO inputs can be dark tested. The dark test time is up to 1 ms.

Response times

A

A.1 Response times

Introduction

Below you can find the response time of the TM Drive in STEP7. The response times of the TM Drive are included in the calculation of the response time of the F-system.

The drive system is the component that provides the safety functions.

Definition of response time

The response time is the time between the detection of an input signal and the change of a linked output signal.

Definition of process safety time of a process

The process safety time of a process is the time between the occurrence of an error within which a process can be left unattended without risk to life and limb of the operating personnel or damage to the environment and the time of the completed reaction.

Any type of F-system control is tolerated within this process safety time, i.e. the F-system can control its processes incorrectly or even not at all. The process safety time of a process depends on the type of process and must be determined on a case-by-case basis.

Check that the process safety time of the process is not exceeded. You may need to reduce the specific monitoring times of the F-system.

Fluctuation width

The actual response time falls between a minimum and maximum response time. You must always assume the maximum response time when configuring your system.

Definition of maximum response time in an error-free scenario (worst case delay time, WCDT)

In the event of errors outside the drive system (e.g. incorrect setpoint setting by a controller, limit violations due to behavior of the motor, closed-loop control, load, etc.), the "maximum response time in an error-free scenario" is guaranteed.

Definition of maximum response time when an error is present (one fault delay time, OFDT)

In the event of a single error within the drive system (e.g. defect in a shutdown path of the power unit), the "maximum reaction time in the event of error" is guaranteed.

Times required for the calculation

Function	Maximum response time
STOP_STO via terminal	20 ms

STOP_STO:

With a STOP_STO, the drive safely switches off the torque of the connected motor immediately.

Data sets

B

You can find an overview of the data sets for the TM Drive and the structure of the data sets in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

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