Product release brief

E1707 G6 PROFIsafe STO

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Table of contents

1. Foreword

The goal of the E1707 project was the addition of the Safe Torque Off (STO) and SS1-t safety functions via PROFIsafe to the 6th drive controller generation.

Over the course of the project, the project scope was expanded. In addition to the implementation of PROFIsafe functions, the execution of the PROFIdrive application was newly included.

The 6th STOBER driver controller generation includes the SC6, SI6 and SD6 series, each with different safety functions.

At the start of the project, the possibility of implementing a universal PROFIsafe solution for all drive controller series was tested. However, this was not possible from an economic viewpoint due to the different hardware and software architectures.

This product release brief describes the optional SU6 safety module as well as the implementation of PROFIdrive for SC6 and SI6 drive controller series from a sales perspective.

The optional SU6 safety module adds a hardware solution for selecting the STO and SS1-t safety functions via PROFIsafe to the STOBER product portfolio in the area of SC6 and SI6 drive controllers.

PROFIdrive is primarily a functional expansion of the drive controller firmware that is available as standard.

Figure 1: STOBER system

2. Document history

2.1. Authors

Department	Name (abbreviation)	Email contact
SPE	Markus Frei (mf)	markus.frei@stoeber.de

Table 1: Authors

2.2. Confirmations

The information provided in this document has been researched, compiled and documented to the best of our knowledge and belief.

However, we cannot rule out the possibility that mistakes nonetheless found their way into this document. We are happy to receive feedback indicating helpful or necessary additions or pointing out mistakes. To do this, please send a simple email to one of the authors named in Chapter 2.1.

2.3. Notes about the document version

Changes and additions to content are documented in this chapter of the document. Orthographic improvements and corrections are not documented.

Date	Version	Name	Comment
2021-07-08	V0.x	M. Frei	Document created
2021-07-26	V1.0	M. Frei	Document approved

Table 2: Document version

3. Project overview

3.1. ePEP project

ePEP project E1707 includes the following subprojects for the functional expansion of the SC6 and SI6 drive controller series:

- PROFIsafe STO and SS1-t
- PROFIdrive with application classes 1 and 3 (AC1, AC3)
- PROFIdrive with application class 4 (AC4, IRT)

3.2. ePEP project team

In accordance with the principles of the ePEP process, the project team consists of the following roles and members:

ePEP project role	Project member	Email contact
Market Manager (MV)	Daniel Lohse	daniel.lohse@stoeber.de
Product Manager (PV)	Markus Frei	markus.frei@stoeber.de
Development Manager (EV)	Elmar Senneka	elmar.senneka@stoeber.de
Project Manager (PM)	See PV	

Table 3: Project team

The project members are happy to answer any questions about the product or project according to their role in the ePEP process.

3.3. Development goal(s)

3.3.1. PROFIsafe STO and SS1-t

- STO and SS1-t safety functions via PROFIsafe
- Economically optimized solution

3.3.2. PROFIdrive AC1 and AC3

- PROFIdrive device profile for application classes AC1 and AC3 based on PROFINET RT

3.3.3. PROFIdrive AC4 (IRT)

- PROFIdrive device profile for application class AC4 based on PROFINET IRT

3.4. Project history

Time frame	Action
2017	Project start
…	Market analysis and product definition of PROFIsafe
2018	Start of development for PROFIsafe STO and SS1-t
2019	Addition of PROFIdrive AC1 and AC3
2020	Addition of PROFIdrive AC4 (IRT)
4th Q 2021	End of development for PROFIsafe
2nd Q 2021	End of development for PROFIdrive AC1 and AC3
2nd Q 2021	PROFIsafe and PROFIdrive AC1 and AC3 field test phase
2nd Q 2021	Successful type-examination for PROFIsafe
2021-07	SU6 development, warehouse stock (100 units)
2021-08	Official market release at SAT for PROFIdrive AC1 and AC3
2021-08	Official market release at SAT for PROFIsafe
2021-11	Official product presentation of PROFIsafe and PROFIdrive at SPS 2021 fair
1st Q 2022	Planned market launch for PROFIdrive AC4 (IRT)

Table 4: Project history

4. PROFIsafe subproject

The SU6 safety module arose in the course of the E1707 project based on the hardware of SY6, in which PROFIsafe firmware was integrated in place of the FSoE firmware.

4.1. Start of sales

The safety module is officially available from STOBER as of 2021-08-02. The SU6 was unlocked in the SAP system for a gross sales price of €150 and has been available from the warehouse from this point.

Presentation of the SU6 safety module is officially planned at SPS 2021 –
Smart Production Solutions in Nuremberg. Promotional activities are planned in the run-up to the fair.

Note

Due to the pandemic, plans may be changed.

4.2. Market situation

In principle, the product is a "me-too" product. Most notable manufacturers of drive controllers offer solutions for STO and SS1-t via PROFIsafe.

Often, only one solution is available that also includes advanced safety technology like SLS and SOS. As a result, if only STO or SS1-t is needed, these solutions are generally at a disadvantage in terms of price.

4.2.1. Target market

National and international machine and systems engineering, particularly in the area of process technology.

4.2.2. Target applications.

Simple PROFIsafe applications in combination with Siemens SIMATIC controllers of the S7-1200(F) and S7-1500(F) series.

4.2.3. Product advantages

No.	Keyword	Comment
1	Availability	Not all market players offer a solution for PROFIsafe STO/SS1-t
2	Easy-to-use	Project configuration and commissioning of the product in combination with a Siemens controller is very easy
3	Safety level	SIL 3/PL e (cat. 4) Some of the solutions on the market are limited to SIL 2/PL d (cat. 3)
4	Price / performance	The safety module offered makes STO and SS1-t very affordable in the context of PROFIsafe controllers
5	STOBER system modules	Consistency of STOBER products and product variants up to standardized interface of the PROFIsafe controller

Table 5: Product advantages

4.2.4. Product limitations

With the development goal of an economically optimized solution, the following compromises needed to be made in the course of development:

No.	Keyword	Comment
1	Axiality	The selection of STO/SS1-t always applies to all axes in the drive controller
2	Reaction time	The worst case response time is approx. 60 ms; this is not expected to pose a problem in practice, however, since SS1-t times are generally much longer

Table 6: Product limitations

4.3. Principal function

The safety module locks the pulse width modulation (PWM) in the power unit of the drive controller on request or in case of error. This ensures that the drive controller cannot generate any torque or force on the motor.

Set value changes or limitations in the drive controller are not made by the safety module. Upon selection of the SS1-t safety function, for example, the drive is not stopped automatically.

Attention!

Deactivating the power unit using STO does not protect against electric shock!

4.4. Interface(s)

PROFIsafe uses the PROFINET interface of the drive controller that is available as standard.

For easy addressing of the PROFIsafe address, eight mechanical DIP switches are provided to the customer. This guarantees a simple device exchange in case of service.

In accordance with the PROFIsafe specification, the safety functions can be operated and diagnosed by a PROFIsafe controller using standard telegram 30.

Note

In the course of development, external acceptance was carried out and passed successfully for the correct implementation of the interface.

4.5. Type-examination

By definition, components from the area of safety technology are subject to the Machinery Directive. This includes our drive controllers with integrated safety technology.

Therefore, we require a type-examination certificate to be able to bring our drive controllers to market in accordance with regulations. The type-examination was performed by the Institut für Arbeitsschutz (IFA) der Deutschen Gesetzlichen Unfallversicherung (DGUV) (Institute for Occupational Safety and Health of the German Social Accident Insurance) at the start of 2021, which we passed.

The type-examination certificate can be downloaded from the download center on our website as needed.

Note

At the planned market launch on 2021-08-02, we will have the test documents of the successful type-examination.

The official representative document that we typically post on the website is currently being create by the IFA.

4.6. Documentation

A separate manual is available for the safety module, as is typical at STOBER.

At market launch, the manual will be available in German (_de). The English (_en) and French translations are in progress and should be available over the course of August.

4.7. Application area

The safety module is available as an optional accessories for the SC6 and SI6 drive controllers. The operational environment corresponds to that of the base devices.

The optional SU6 safety module replaces the SZ6 option module without safety functions, integrated in the drive controllers in the standard version.

The safety module can be used with all motor types supported by the drive controller, such as synchronous, asynchronous or Lean motors.

The safety module can be used with all applications available in the drive controller used in combination with PROFINET.

Note

The SU6 safety module cannot be used with the SD6 drive controller series from STOBER.

4.8. Assembly/installation

The safety module is installed in the drive controller during the production process and checked for proper functioning by the production test system during the quality control test.

In addition to testing for correct integration, the serial number of the safety module is also linked with that of the base device here, for example, for complete traceability of its location.

Note

For organizational reasons, later installation of the safety module in the field by a customer or by a STOBER employee is not possible.

4.9. Service concept

The safety module is maintenance-free.

In case of a defect, the safety module can be exchanged during repair at our main facility.

Replacement or repair on site is not possible!

Note

Like all other safety modules, the maximum operating life is limited to 20 years.

4.10. Firmware update

A firmware update of the safety module in the field is not possible.

Note

A firmware or application update for the base device is always possible, independent of the safety module.

4.11. Configuration

The safety module is available for customers in the commissioning software in DriveControlSuite V 6.5-D or later.

The configuration and actuation of the safety module are carried out by the PROFIsafe controller.

Note

The safety module supports PROFIsafe standard telegram 30 for PROFIsafe V 2.4 and PROFIsafe V 2.6.1.

For the tests during development, the safety module was operated on Siemens controllers of the S7-1200(F) and S7-1500(F) series using TIA Portal V 15 and V 16.

4.12. Validation and verification

Prior to delivery and following any modifications, as is typical for safety components, our customers must verify and document that the machine's safety functions are working properly. This also includes validating and verifying the safety functions in which the safety module is involved.

The safety functions can be checked using the scope analysis tool in DriveControlSuite. The customer can include any scope images that are made in the corresponding documents (safety check, safety acceptance report, etc.).

4.13. Training activities

A PROFIsafe training for technical employees in Sales is planned as part of the PROFIdrive training activities in fall 2021.

Note

Due to the pandemic, plans may be changed.

4.14. Safety level

The safety module fulfils the SIL 3/ PL e (category 4) requirements for all safety functions.

The SIL classification is based on the product standard for drive controllers, DIN EN 61800-5-2. SIL 3 is the highest possible classification in this standard.

The PL classification is derived from DIN EN ISO 13849-1, which is to be used for 99% of our customers. PL e is the highest safety level described in it.

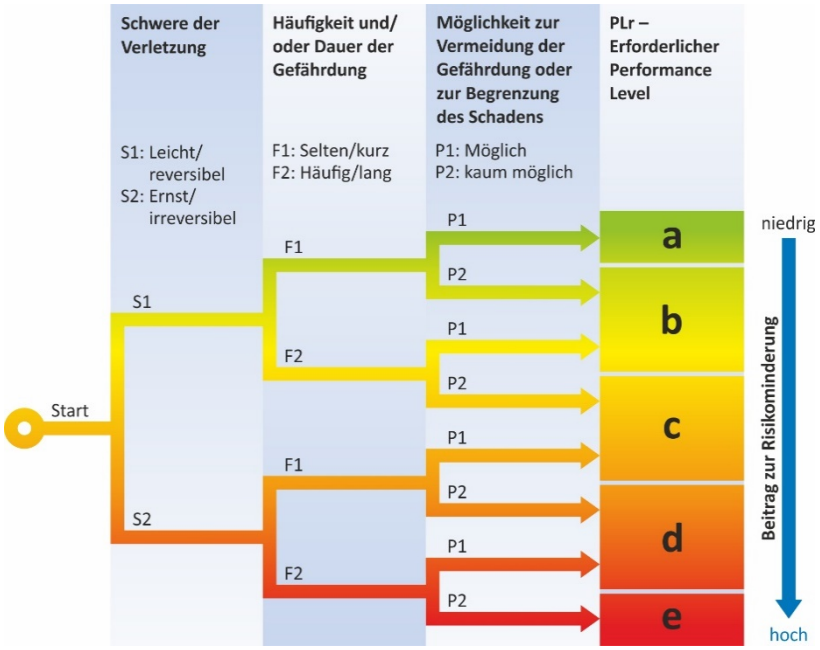

Figure 2: Risk graph of DIN EN ISO 13849-1

4.15. Worst case response time

Between the arrival of the STO activation on the drive controller and the safe locking of the power unit, a maximum of 60 ms may pass.

In case of SS1-t, the time needed to stop the drive must also be taken into account. The time needed to stop the drive depends on the application. This depends on the drive mechanism, its load and the possible brake ramps. In practice, typical values for this range from 100 ms to several seconds.

Note

A wide range of times are advertised on the market. For example, Beckhoff advertises a 31.25 µs reaction time for FSoE. The times listed are generally best-case times, which are irrelevant for safety considerations.
The FSoE watchdog monitoring time in the Beckhoff system, just as the PROFIsafe monitoring time in the Siemens system, is 100 ms in the default configuration. In both systems, values under 50 ms can lead to problems in the system in the event of telegram failures.

4.16. Safety functions

Drive-integrated safety functions are described in DIN EN 61800-5-2 "Adjustable speed electrical power drive systems - Part 5-2: Safety requirements - Functional".

When implementing the safety functions and their interfaces, attention was given not only to fulfilling the requirements of EN 61800-5-2 (Safety Integrity Level (SIL)), but also to implementing the safety functions such that our customers can also use these in accordance with the requirements of DIN EN ISO 13849-1 "Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design" based on the Performance Level (PL).

Thanks to the safety functions implemented, it is also possible to fulfill the requirements of other standards not explicitly mentioned here, such as DIN EN ISO 13850 "Safety of machinery - Emergency stop function – Principles for design" or DIN EN ISO 14118 "Safety of machinery - Prevention of unexpected start-up".

Note

Only the safety functions implemented in the E1707 project are mentioned in this chapter.

4th16th1st Normative safety functions based on DIN EN 60204-1

DIN EN 60204-1 "Safety of machinery – Electrical equipment of machines – Part 1: General requirements" is one of the most foundational standards in mechanical engineering. In addition to the requirements for basic electrical safety, it also describes stop categories for stopping movements.

Note

Many of our customers use the terms of EN 60204 because they are not familiar with the EN 61800-5-2 standard relevant to drive controllers. This sometimes leads to misunderstandings regarding the term "category".

Safety function in acc. with DIN EN 60204-1	Description
Stop category 0	Corresponds to the STO safety function of DIN EN 61800-5-2
Stop category 1	Corresponds to the SS1 safety function of DIN EN 61800-5-2

Table 7: Normative safety functions based on DIN EN 60204-1

4th16th2nd Normative safety functions based on DIN EN 61800-5-2

DIN EN 61800-5-2 is the basic standard for the safety of drive controllers and frequency inverters. In addition to the safe stop functions, this standard also describes other safety functions for limiting and monitoring movements, as well as added functions such as Safe Brake Control.

4.16.2.1. Safe stop functions

Implemented safety functions for safely stopping movements:

Safety function	Description	Response to detection of a limit value violation
STO	Safe Torque Off	–
SS1	Safe Stop 1: Controlled or monitored transition into STO	STO

Table 8: Safe stop functions based on EN 61800-5-2

The most important available safety functions are briefly explained in the following sections. If necessary, details of the functions can be found in the manual.

4.16.2.2. Safe Torque Off (STO)

When the STO safety function is selected by the STO_ACT (STO_ACTIVATE) control signal, the power unit of the drive controller is immediately locked. The drive may coast down.

The STO_ACK (STO_ACKNOWLEDGE) status signal reports the state to the safety controller.

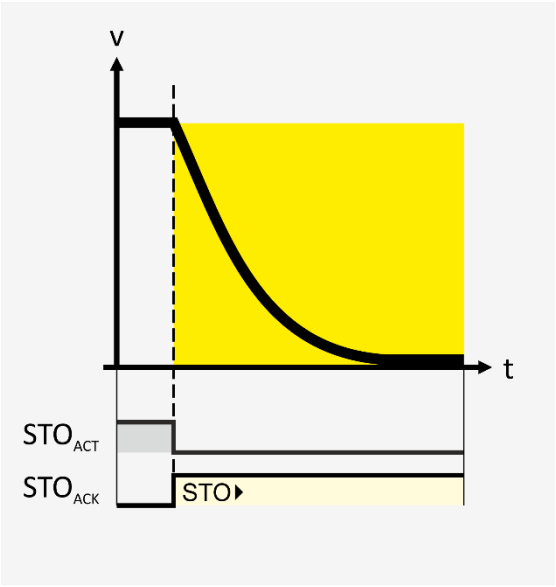

Figure 3: Safe Torque Off (STO)

4.16.2.3. Safe Stop 1 (SS1)

For the SS1 safety function, three possible implementation variants are described in standards.

1. SS1-d with controlled deceleration
2. SS1-r with monitored deceleration ramp
3. SS1-t with time control

The SS1-t variant is available on the safety module, since it does not depend on safe position measurement.

Unlike the STO safety function, using SS1-t, the power unit of the drive controller is only safely locked after a configurable time has expired, known as the SS1-t time. The braking process itself does not have safe monitoring.

The actuation is carried out by the SS1_ACT (SS1_ACTIVATE) control signal, and feedback is provided using the SS1_ACK (SS1_ACKNOWLEDGE) and STO_ACK (STO_ACKNOWLEDGE) status signals.

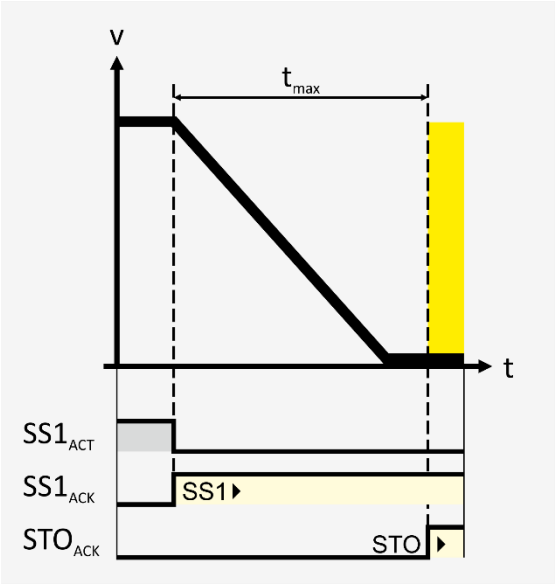

Figure 4: Safe Stop 1 (SS1)

4.16.2.4. Safe movement functions

The safety module does not support any safe movement functions, such as Safely-Limited Speed (SLS) or Safe Operating Stop (SOS).

The expanded safety functions for the SC6 and SI6 drive controllers are part of the E1903 project.

4.17. FAQ

Frequently asked questions we hear when talking with our customers are addressed in this chapter.

Note
We welcome feedback about "Frequently Asked Questions" so that we can improve our documentation.

4.17.1. Questions about hardware

1. How long can the SU6 safety module be used?

   The safety module can be used for a maximum of 20 years, as is typical for safety modules in the context of the Machinery Directive.

2. Can the safety module be used in modified drive controllers, e.g. IT network devices?

   No, the type-examination of the drive controllers is based on the intended use defined in the drive controller manual.

4.17.2. Questions about software

1. Can PROFIsafe also be used in combination with traditional STOBER applications or does PROFIsafe only work in combination with PROFIdrive?

   PROFIsafe is application-independent and can theoretically be combined with all available applications in the drive controller. In practice, PROFINET is required for fieldbus communication.

4.17.3. Questions about handling

1. When is an STO needed?

   DIN EN ISO 13850 describes the requirements for an emergency stop. The description there mentions only SS1 and STO as possible functions for stopping.

   The STO can also be used as the basis for a restart lockout based on EN ISO 14118 to protect against unexpected start-up.

2. When is SS1 needed?

   DIN EN ISO 13850 describes the requirements for an emergency stop. The description there mentions only SS1 and STO as possible functions for stopping.

   The Institut für Arbeitsschutz (IFA) der Deutschen Gesetzlichen Unfallversicherung (DGUV) (Institute for Occupational Safety and Health of the German Social Accident Insurance) recommends a controlled stop by SS1.

5. PROFIdrive AC1 and AC3 subproject

In the course of the E1707 project, PROFIdrive application classes AC1 and AC3 were added to the drive controller firmware. Neither application class requires isochronous real-time communication (IRT).

The communication between drive controller and controller is not isochronous in the implemented application classes. As a result, the application classes are not suitable for the implementation of isochronous set value specification. Movement profile generation, which can be implemented with CIA 402 operating modes Cyclic synchronous torque (cst), Cyclic synchronous velocity (csv) or Cyclic synchronous position (csp), is not possible.

Not all functions of the application classes described for PROFIdrive or the associated telegrams have been implemented. When the implemented functions were selected, we oriented ourselves around TIA Portal, the popular automation software for programming Siemens controllers.

If other features are required after market launch, please notify the project team.

5.1. Start of sales

PROFIdrive is officially available at STOBER with the release of DriveControlSuite V 6.5-D starting from 2021-08-02.

Presentation of the functions is officially planned at SPS 2021 – Smart Production Solutions in Nuremberg. Promotional activities are planned in the run-up to the fair.

Note

Due to the pandemic, plans may be changed.

5.1.1. Additional sales information

The presentation "STOBER goes PROFIsafe/PROFIdrive" was created to support Sales and will be available in German and English at the market launch of the subproject. The presentation contains the system advantages and customer benefits for the feature presentation at customer locations.

It will be translated into other languages as needed.

5.2. Market situation

In principle, PROFIdrive is a "me-too" product. Most notable manufacturers of drive controllers offer comparable solutions.

5.2.1. Target market

National and international machine and systems engineering, particularly in the area of process technology.

5.2.2. Target applications

Simple PROFIdrive applications in combination with Siemens SIMATIC controllers of the S7-1500(T) series.

5.2.3. Product advantages

No.	Keyword	Comment
1	Availability	Not all market players offer a PROFIdrive solution
2	Easy-to-use	The project configuration and commissioning of the product in combination with a Siemens controller are very easy
3	Price / performance	The PROFIdrive functions offered make SC6/SI6 drive controllers an economically attractive solution for PROFIdrive-capable controllers
4	STOBER system modules	Consistency of STOBER products and product variants up to standardized interface of the PROFIdrive controller

Table 9: Product advantages

5.2.4. Product limitations

With the development goal of an economically optimized solution, the following compromises needed to be made in the course of development:

No.	Keyword	Comment
1	Application classes (AC)	Not all application classes described by PNO have been implemented
2	Telegrams	Not all telegrams described by PNO for operating the application classes have been implemented

Table 10: Product limitations

5.3. Principal function

After integrating the drive controllers into the device configuration of the controller using a GSD file, the controller programmer can access drive controllers conveniently using Siemens technology objects or Siemens function blocks and control their movements.

5th3rd1st Supported application classes and standard telegrams

Class	Applications	Examples	Telegrams
AC1	Standard drives Speed control with set speed value	Pumps, fans, stirrers, conveyor belts	1,2,3
AC3	Positioning drives Drive-based positioning	Position control without interpolation	111
AC4[1]	*Motion control* *Controller-based positioning*	*Positioning, synchronous speed operation*	*3*

Table 11: Application classes and telegrams

[1] Application class AC4 is part of the subproject "PROFIdrive AC4 (IRT)"

5.4. Interface(s)

PROFIdrive uses the PROFINET interface of the drive controller that is available as standard.

In accordance with the PROFIdrive specification, the drive controllers can be operated and diagnosed using various telegrams depending on the application class.

5.5. Documentation

In addition to the general PROFINET manual, a separate application manual is created for PROFIdrive, which documents the integration into TIA Portal, for example.

At market launch, the manual will be available in German, English and French.

Note

The manual is being created; an initial release is planned for 2021-09.

5.6. Configuration

Project configuration and parameterization are performed in the automation software (e.g. Siemens TIA Portal) and in DriveControlSuite commissioning software.

5.7. Training activities

5.7.1. Internal

A PROFIdrive training for technical employees in Sales is planned as part of the 2021 Technical Meeting in fall 2021.

Note

Due to the pandemic, plans may be changed.

5.7.2. External

No customer training activities are planned for market launch.

If need for this arises during market introduction, please notify the project team.

5.8. FAQ

Frequently asked questions we hear when talking with our customers are addressed in this chapter.

Note
We welcome feedback about "Frequently Asked Questions" so that we can improve our documentation.

5.8.1. Questions about hardware

1. Which PROFINET cycle times are supported by SC6/SI6 drive controllers?

   As usual, the cycle time of the drive controllers is freely selectable (250 µs to 8 ms). Communication with the controller with PROFINET RT is not isochronous.

5.8.2. Questions about software

1. Starting from which firmware version are PROFIdrive application classes AC1 and AC3 supported?

   The functions are visible for customers in V 6.5-D and later.

2. Is the PROFIdrive application also planned for the SD6 series?

   Currently, functional expansion for the SD6 drive controller series is not planned.

5.8.3. Questions about handling

1. Can we substitute other PROFIdrive drive controllers 1:1?

   No general statement can be made about this. PROFIdrive provides manufacturer-specific expansion options in addition to the basic functions.

   If need for this arises during or after market introduction, please notify the project team.

2. Is connection to Siemens SIMOTION or SINUMERIC possible?

   No definitive statement can be made at the time of market introduction because there are still no experience values regarding this.

   At STOBER, testing was conducted with SIMATIC controllers of the S7-1500 series.

   Since both Siemens motion control platforms are based primarily on central motion control and isochronous communication via PROFINET IRT, this suggests that connection with the AC1 and AC3 application classes is not possible.

   If insights into this arise during or after market introduction, please notify the project team.

3. Can PROFIdrive be used with classic Siemens S7-300/400 controllers?

   Theoretically yes, although only the current S7-1500 controller was tested at STOBER.

4. Is a SIMATIC Technology CPU (e.g. S7-1515F) absolutely necessary?

   No, the basic functions of PROFIdrive are already provided in the standard controllers.

6. PROFIdrive AC4 (IRT) subproject

In the course of the E1707 project, PROFIdrive application class AC4 is also added to the drive controller firmware.

The communication between drive controller and controller is isochronous for this application class. As a result, the application class is suitable for the implementation of isochronous set value specification. Movement profile generation, which can be implemented with CIA 402 operating modes Cyclic synchronous torque (cst), Cyclic synchronous velocity (csv) or Cyclic synchronous position (csp), is possible.

Not all functions of the application class described for PROFIdrive or the associated telegrams have been implemented.

When the implemented functions were selected, we oriented ourselves around Siemens TIA Portal, the automation software for programming Siemens controllers.

If other features are required after market launch, please notify the project team.

As of 2021-07, this application class is still under development. The market introduction is planned for the 1st quarter of 2022.

List of figures

List of tables

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