

APPLICATION NOTE

AC500-S safety PLC

Unbundled S500 safety I/Os



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1. Introduction

1.1. Purpose

In this application note, we present an overview on how S500 unbundled safety I/Os DX581-S, DI581-S and AI581-S with CI501-PNIO and CI502-PNIO PROFINET IO devices can be used with PROFINET IO controllers / PROFIsafe F-Hosts.

1.2. Document history

Rev.	Description of version / changes	Who	Date
C	CI501-PNIO and AI581-S devices were added. FAQ section was added. Minor improvements in the document were made.	ABB	04.07.2022
B	Company name was changed. Various typos were corrected and various improvements in the texts and illustrations were made.	ABB	15.09.2021
A (V1.0.0)	First release	ABB	27.04.2017

1.3. Validity

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1.4. Important user information

This documentation is intended for qualified personnel familiar with functional safety. You must read and understand safety concepts and requirements presented in AC500-S safety user manual [1.] as well as further referenced documents listed in chapter 1.6 of this document prior to operating S500 safety I/O modules.

1.5. Definitions, expressions, abbreviations

AC500	ABB PLC, refer also to new.abb.com/plc for further details
AC500-S	ABB safety PLC, refer also to new.abb.com/plc for further details
CPU	Central processing unit

CRC	Cyclic redundancy check
F_iPar_CRC	Fail-safe iParameter CRC according to PROFIsafe specification
IEC	International electro-technical commission standard
I/O	Input/output
PC	Personal computer
PL	Performance level according to ISO 13849-1
PLC	Programmable logic controller
S500	I/O modules of ABB AC500 PLC and AC500-S safety PLC
SIL	Safety integrity level (IEC 61508, IEC 61511 or IEC 62061)
TU	Terminal unit
TÜV	Technischer Überwachungs-Verein (technical inspection association)
XC	Extreme condition version reliable in harsh environment, e.g., extended temperature, shock and vibration range, etc.

1.6. References / related documents

- [1.] AC500-S safety user manual, document ID: 3ADR025091M02** (** = sequential version number), <https://search.abb.com/library/Download.aspx?DocumentID=9AKK107991A4360&LanguageCode=en&DocumentPartId=&Action=Launch>
- [2.] Manual for PLC Automation with AC500 and Automation Builder, including the description of CI501-PNIO and CI502-PNIO, document ID: 3ADR010583, <https://search.abb.com/library/Download.aspx?DocumentID=3ADR010583&LanguageCode=en&DocumentPartId=&Action=Launch>
- [3.] CI501-PNIO, CI502-PNIO, TU508-ETH installation instructions, document ID: 3ADR024117M02xx, <https://search.abb.com/library/Download.aspx?DocumentID=3ADR024117M02xx&LanguageCode=en&DocumentPartId=&Action=Launch>
- [4.] DX581-S installation instructions, document ID: 3ADR010819, <https://search.abb.com/library/Download.aspx?DocumentID=3ADR010819&LanguageCode=de&LanguageCode=en&LanguageCode=es&LanguageCode=fr&LanguageCode=it&LanguageCode=ru&LanguageCode=sv&LanguageCode=zh&DocumentPartId=&Action=Launch>
- [5.] DI581-S installation instructions, document ID: 3ADR010818, <https://search.abb.com/library/Download.aspx?DocumentID=3ADR010818&LanguageCode=de&LanguageCode=en&LanguageCode=es&LanguageCode=fr&LanguageCode=it&LanguageCode=ru&LanguageCode=sv&LanguageCode=zh&DocumentPartId=&Action=Launch>
- [6.] AI581-S installation instructions, document ID: 3ADR010817, <https://search.abb.com/library/Download.aspx?DocumentID=3ADR010817&LanguageCode=de&LanguageCode=en&LanguageCode=es&LanguageCode=fr&LanguageCode=it&LanguageCode=ru&LanguageCode=sv&LanguageCode=zh&DocumentPartId=&Action=Launch>
- [7.] TU582-S installation instructions, document ID: 3ADR010816, <https://search.abb.com/library/Download.aspx?DocumentID=3ADR010816&LanguageCode=de&LanguageCode=en&LanguageCode=es&LanguageCode=fr&LanguageCode=it&LanguageCode=ru&LanguageCode=sv&LanguageCode=zh&DocumentPartId=&Action=Launch>

- [8.] PROFIsafe system description, order number 4.342
- [9.] ReadMe file - AC500-S F_iPar_CRC Calculator, document ID: 3ADR020122K0201, <http://search.abb.com/library/Download.aspx?DocumentID=3ADR020122K0201&LanguageCode=en&DocumentPartId=&Action=Launch> or newer version
- [10.] PROFINET IO GSDML data V2.3 for CI5xx-PNIO communication interface modules, document ID: 3ADR010255, <https://search.abb.com/library/Download.aspx?DocumentID=3ADR010255&LanguageCode=en&DocumentPartId=&Action=Launch> or newer version
- [11.] Software - AC500-S F_iPar_CRC Calculator, document ID: 9AKK106713A4484, <http://search.abb.com/library/Download.aspx?DocumentID=9AKK106713A4484&LanguageCode=en&DocumentPartId=&Action=Launch> or newer version
- [12.] Main catalog - PLC Automation - PLCs, control panels, engineering suite - AC500, CP600, Automation Builder, document ID: 3ADR020077C0204, <http://search.abb.com/library/Download.aspx?DocumentID=3ADR020077C0204&LanguageCode=en&DocumentPartId=&Action=Launch>
- [13.] PNO PROFINET certificate - CI501-PNIO, certificate number: Z10092, <https://search.abb.com/library/Download.aspx?DocumentID=9AKK107992A6329&LanguageCode=de&LanguageCode=en&DocumentPartId=&Action=Launch> or newer version
- [14.] PNO PROFINET certificate - CI502-PNIO, certificate number: Z10093, <https://search.abb.com/library/Download.aspx?DocumentID=9AKK107992A6327&LanguageCode=de&LanguageCode=en&DocumentPartId=&Action=Launch> or newer version
- [15.] PNO PROFIsafe certificate - DI581-S, certificate number: Z20093, <https://search.abb.com/library/Download.aspx?DocumentID=9AKK105713A7779&LanguageCode=en&DocumentPartId=&Action=Launch> or newer version
- [16.] PNO PROFIsafe certificate - DX581-S, certificate number: Z20094, <https://search.abb.com/library/Download.aspx?DocumentID=9AKK105713A7780&LanguageCode=en&DocumentPartId=&Action=Launch> or newer version
- [17.] PNO PROFIsafe certificate - AI581-S, certificate number: Z20095, <https://search.abb.com/library/Download.aspx?DocumentID=9AKK105713A7781&LanguageCode=en&DocumentPartId=&Action=Launch> or newer version
- [18.] TUV certificate - AC500-S safety PLC (-XC), document ID: 3ADR020064K0202, <https://search.abb.com/library/Download.aspx?DocumentID=3ADR020064K0202&LanguageCode=en&DocumentPartId=&Action=Launch> or newer version
- [19.] VDMA 66413 Universal Data Format for AC500-S safety PLC - safety calculation data, document ID: 9AKK106103A3319, <http://search.abb.com/library/Download.aspx?DocumentID=9AKK106103A3319&LanguageCode=en&DocumentPartId=&Action=Launch> or newer version
- [20.] Application manual - Functional safety and SafeMove, document ID: 3HAC052610-001, <http://search.abb.com/library/Download.aspx?DocumentID=3HAC052610-001&LanguageCode=en&DocumentPartId=&Action=Launch>
- [21.] Application note - IRC5 robot controller and CI502 with safety I/O module, document ID: 3ADR010316, <https://search.abb.com/library/Download.aspx?DocumentID=3ADR010316&LanguageCode=en&DocumentPartId=&Action=Launch>

2. Unbundled S500 I/O modules

2.1. Overview

Figure 1 provides an overview of ABB unbundled S500 safety and standard I/O modules:

- CI501-PNIO and CI502-PNIO are standard PROFINET IO device modules [2.];
- TU508-ETH is a terminal unit for CI501-PNIO or CI502-PNIO module [3.];
- Optional standard I/O module with a standard terminal unit from AC500 PLC (refer to [2.] for more information);
- DX581-S is a safety binary input/output module [1.] with 8 safety output channels (up to SIL 3 or PL e) and 8 safety input channels (up to SIL 2 or PL d) or 4 safety input channels (up to SIL3 or PL e) with 4 test pulse output channels;
- DI581-S is a safety binary input module [1.] with 16 safety input channels (up to SIL 2 or PL d) or 8 safety input channels (up to SIL 3 or PL e) with 8 test pulse output channels;
- AI581-S is a safety analog input module [1.] with 4 safety current input channels (up to SIL 2 or PL d) or 2 safety current input channels (up to SIL 3 or PL e).
AI581-S may not be a part of the GSDML file for CI501-PNIO and CI502-PNIO module. Contact ABB technical support for more details.
- TU582-S is a terminal unit [1.] for DX581-S, DI581-S and AI581-S modules.

WARNING



Removal / Insertion under power

S500 safety and standard I/O modules are not designed for removal or insertion under power. Because of unforeseeable consequences, it is not allowed to plug or unplug devices with the power being ON.

Make sure that all voltage sources (supply and process voltage) are switched off before you:

- connect or disconnect any signal or terminal block;
- remove, mount or replace a module.

Disconnecting any powered devices while energized in a hazardous location could result in an electric arc, which could create a flammable ignition resulting in fire or explosion.

Make sure that power is removed and that the area has been thoroughly checked to ensure that flammable materials are not present prior to proceeding.

S500 safety and standard I/O modules must not be opened when in operation.

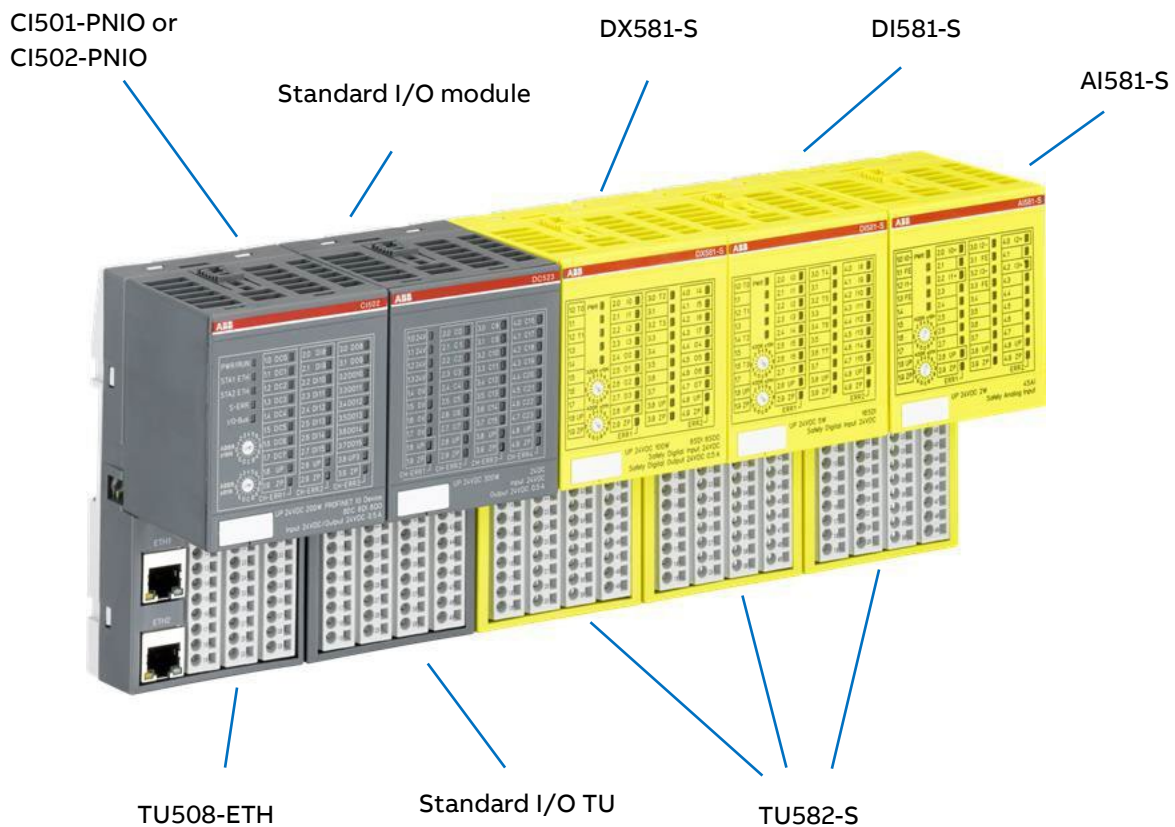


Figure 1. Overview of unbundled S500 safety and standard I/O modules

More technical details about AC500 PLC and AC500-S safety PLC can be found in [1.], [2.] and [12.].

Major benefits of using unbundled S500 safety I/Os:

- Ability to reduce wiring efforts and operation costs;
- Increase machine / cell productivity and reduce machine / cell downtime using the following S500 safety I/O features:
 - A single safety I/O channel can be individually reintegrated, which provides higher machine productivity and availability;
 - Each safety I/O channel LED not only indicates the process state but also the fault state, which saves operation costs and simplifies maintenance work;
 - Extreme condition (-XC) modules are available (see chapter 2.2), which allows cost-savings on control cabinets;
 - Front panel rotary switch for PROFIsafe address [8.], which reduces maintenance efforts because one can see all pre-set PROFIsafe addresses directly looking at the front cover of the module (no need to disassemble safety I/Os to see PROFIsafe address value or use engineering PC);
 - Ability to do wiring on safety I/O terminal units (TU582-S) even if safety I/O modules are not yet available or procured (field wiring and module placement / replacement actions are independent of each other), which results in shorter commissioning and maintenance time.

2.2. XC - eXtreme Conditions version

Extreme condition versions of CI501-PNIO, CI502-PNIO, TU508-ETH, DX581-S, DI581-S, AI581-S and TU582-S modules are:

- CI501-PNIO-XC, CI502-PNIO-XC, TU508-ETH-XC, DX581-S-XC, DI581-S-XC, AI581-S-XC and TU582-S-XC, respectively.

XC versions of S500 modules were developed for harsh environments, e.g., extended temperature, shock and vibration range, etc. More details about technical characteristics and supported standards can be found in [1.] and [12.].

2.3. Ordering data

Type	Description	Order code
CI501-PNIO	CI501-PNIO:S500, PROFINET bus module with 8DI, 8DO, 4AI and 2AO	1SAP 220 600 R0001
CI501-PNIO-XC	CI501-PNIO-XC:S500, PROFINET bus module with 8DI, 8DO, 4AI and 2AO, extreme conditions	1SAP 420 600 R0001
CI502-PNIO	CI502-PNIO:S500, PROFINET bus module with 8DI, 8DO and 8DC	1SAP 220 700 R0001
CI502-PNIO-XC	CI502-PNIO-XC:S500, PROFINET bus module with 8DI, 8DO and 8DC, extreme conditions	1SAP 420 700 R0001
TU508-ETH	TU508-ETH:S500, ETH terminal unit, spring terminals	1SAP 214 000 R0001
TU508-ETH-XC	TU508-ETH-XC:S500, ETH terminal unit, spring terminals, extreme conditions	1SAP 414 000 R0001
DI581-S	DI581-S:S500, safety digital input module 16SDI	1SAP 284 000 R0001
DI581-S-XC	DI581-S-XC:S500, safety digital input module 16SDI, extreme conditions	1SAP 484 000 R0001
DX581-S	DX581-S:S500, safety digital I/O module 8SDI/SDO	1SAP 284 100 R0001
DX581-S-XC	DX581-S-XC:S500, safety digital I/O module 8SDI/SDO, extreme conditions	1SAP 484 100 R0001
AI581-S	AI581-S:S500, safety analog I/O module 4SAI	1SAP 282 000 R0001
AI581-S-XC	AI581-S-XC:S500, safety analog I/O module 4SAI, extreme conditions	1SAP 482 000 R0001
TU582-S	TU582-S:S500, safety I/O terminal unit, 24V DC	1SAP 281 200 R0001
TU582-S-XC	TU582-S-XC:S500, safety I/O terminal unit, 24V DC, extreme conditions	1SAP 481 200 R0001

2.4. PROFINET IO device

2.4.1. CI501-PNIO

Technical information on CI501-PNIO modules:

- Installation instructions [3.];
- Technical information [2.];
- Relevant industrial standards and certifications [12.];
- PNO PROFINET certificate [13.];
- Detailed AC500/S500 platform related information [2.].

2.4.2. CI502-PNIO

Technical information on CI502-PNIO modules:

- Installation instructions [3.];
- Technical information [2.];
- Relevant industrial standards and certifications [12.];
- PNO PROFINET certificate [14.];
- Detailed AC500/S500 platform related information [2.].

2.4.3. TU508-ETH terminal unit

Technical information on TU508-ETH modules:

- Installation instructions [3.];
- Relevant industrial standards and certifications [12.];
- Detailed AC500/S500 platform related information [2.].

2.5. Safety I/O modules

2.5.1. DX581-S module

Technical information on DX581-S modules:

- Installation instructions [4.];
- Detailed technical information including functional safety aspects [1.];
- PNO PROFIsafe certificate [16.];
- TUV certificate with relevant functional safety standards [18.];
- Relevant industrial standards and certifications [12.].

2.5.2. DI581-S module

Technical information on DI581-S modules:

- Installation instructions [5.];
- Detailed technical information including functional safety aspects [1.];

- PNO PROFIsafe certificate [15.];
- TUV certificate with relevant functional safety standards [18.];
- Relevant industrial standards and certifications [12.].

2.5.3. AI581-S module

Technical information on AI581-S modules:

- Installation instructions [6.];
- Detailed technical information including functional safety aspects [1.];
- PNO PROFIsafe certificate [17.];
- TUV certificate with relevant functional safety standards [18.];
- Relevant industrial standards and certifications [12.].

2.5.4. TU582-S terminal unit

Technical information on TU582-S modules:

- Installation instructions [7.];
- Detailed technical information [1.];
- Relevant industrial standards and certifications [12.].

2.5.5. Important safety I/O module information

The following information about unbundled S500 safety I/O modules shall be taken into account in safety applications:

- Safety values for DX581-S, DI581-S and AI581-S modules (refer to chapter 2.4 in [1.]). For safety values in an electronic format, refer to [19.];
- Diagnosis data (refer to chapter 3.2.4 in [1.]);
- Safety times (refer to chapter 5 in [1.]);
- Relevant items in checklists for commissioning of safety I/Os (refer to chapters 6.3 and 6.4 in [1.]);
- System data for XC versions of DX581-S, DI581-S and AI581-S (refer to Appendix A in [1.]).

3. Module configuration

3.1. Overview

3.1.1. General

Standard configuration steps, as defined by PROFIsafe standard [8.], are needed to configure DX581-S, DI581-S and AI581-S safety I/O modules with CI501-PNIO and CI502-PNIO PROFINET IO devices.

3.1.2. Module configuration with ABB robot controller IRC5

Steps on how to configure unbundled S500 safety I/O modules with ABB Robot Controller IRC5 are described in details in a separate document [20.].

3.2. AC500-S F_iPar_CRC calculator

AC500-S F_iPar_CRC Calculator is a free-of-charge software add-on for PROFINET IO controllers / PROFIsafe F-Hosts engineering tools. AC500-S F_iPar_CRC Calculator software shall be used to calculate F_iPar_CRC value to enable safe module and channel parameter configuration of DI581-S and DX581-S modules in PROFINET IO controller / PROFIsafe F-Host engineering tools. F_iPar_CRC is defined in [8.].

AC500-S F_iPar_CRC Calculator can be downloaded from [11.] (see also ReadMe file [9.] for more information). If F_iPar_CRC calculation for AI581-S safety I/O module is needed, then contact ABB technical support.

3.3. Configuration steps

Steps on how to configure unbundled S500 safety I/O modules with PROFINET IO controllers / PROFIsafe F-Hosts engineering tools:

1. Download and install up-to-date ABB GSDML file (refer to [10.] or the download area from new.abb.com/plc) in your PROFINET IO controllers / PROFIsafe F-Hosts engineering tool.
2. Download and install AC500-S F_iPar_CRC Calculator software (refer to [11.] or the download area from new.abb.com/plc) on your engineering PC.
3. Instantiate ABB CI501-PNIO or CI502-PNIO PROFINET IO device communication module to the selected CPU with PROFINET/PROFIsafe interface in your engineering tool.
Note that on-board standard I/O channels on CI501-PNIO and CI502-PNIO modules can be used in the standard application as well.
Additional S500 standard I/O modules can be added to CI501-PNIO and/or CI502-PNIO modules, if needed.
4. Set PROFINET device name for CI501-PNIO or CI502-PNIO module (see [2.] for more details) and relevant PROFINET parameters in your engineering tool.
5. Attach DX581-S, DI581-S and/or AI581-S safety I/O module(s) to CI501-PNIO or CI502-PNIO communication module; maximum 10 safety I/O modules can be attached.
6. Set standard and safety I/O module and channel parameters (so-called iParameters, refer to [1.] for more details) for all AC500 and AC500-S I/O modules. Make sure that only valid channel configurations, as specified in [1.], are used for DX581-S, DI581-S and/or AI581-S safety I/O modules to avoid configuration errors.

7. Configure PROFIsafe F-Parameters (refer to [1.] for more details) for DX581-S, DI581-S and/or AI581-S safety I/O modules.
8. Make sure that all module and channel parameters (iParameters) and destination addresses F_Dest_Add (part of PROFIsafe F-Parameters) are correctly set; Calculate F_iPar_CRC value for given module and channel parameter configurations of DX581-S and/or DI581-S modules by starting AC500-S F_iPar_CRC Calculator software for selected DX581-S or DI581-S module, e.g., use *"Start device tool..."* option and then select *"calculate F_iPar_CRC"* or similar functions in your PROFINET IO controller / PROFIsafe F-Host engineering tool.
ABB Automation Builder (a basic license of it, which is free-of-charge, is enough) shall be used to calculate F_iPar_CRC for AI581-S modules.
9. In the *"AC500-S F-iPar_CRC Calculation"* window, check all device parameters for their correctness and activate the check box *"I have checked all device parameters. They are correctly set!"*
10. Copy the calculated F_iPar_CRC value from AC500-S F_iPar_CRC Calculator or Automation Builder (in case of AI581-S module) and paste it to the PROFIsafe F-Parameter F_iPar_CRC for the given DX581-S, DI581-S or AI581-S module in your engineering tool. Close AC500-S F_iPar_CRC Calculator. Do this operation for all DX581-S, DI581-S and/or AI581-S modules. The configuration of unbundled S500 safety I/Os is complete now.
11. Assign symbolic variables to standard and safety process data of S500 modules.
If the GSDML file data for standard or safety I/O modules is presented not as BYTE, pay attention to the BYTE order for inputs and outputs. Refer to [1.] and [2.] for more details.
12. Complete the safety and standard PLC application using safety and standard symbolic variables, respectively, and download it to the standard and safety 3rd party PLC or controller, respectively.

Various aspects to consider when S500 unbundled safety I/Os are used with PROFINET IO controllers / PROFIsafe F-Hosts:

a) Two options for usage of S500 safety I/O error codes are available:

- PROFINET process alarms;
- PROFINET standard diagnosis.

Select for CI501-PNIO or CI502-PNIO module a suitable method for error codes and diagnosis messages and implement (if required in your PROFINET IO controller, e.g., in case of PROFINET process alarms) calls of special functions or function blocks to transfer S500 safety I/O error codes to the PROFINET IO controller diagnostic buffer; Contact ABB technical support, if questions arise;

b) Take into account S500 safety I/O states like INIT, SAFE STOP, RUN (ok), RUN (user acknowledgement request), RUN (module passivation), RUN (channel passivation & reintegration), RUN (module passivation with a command) and transitions between states (refer to [1.] for more details) in your application;

c) To enable channel-granular passivation and reintegration, S500 safety I/O modules support the following additional safety data for your safety application:

- Safe diagnostic bits / bytes (refer to [1.] for more details), which can be used in your safety application with your PROFIsafe F-Host;
- Reintegration request bits / bytes and acknowledge reintegration bits / bytes for S500 safety I/O channels (refer to [1.] for more details), which can be used in your safety application with your PROFIsafe F-Host.

4. FAQ - Frequently asked questions

1. Why are S500 safety I/Os not parameterized by Siemens S7 safety CPU and, thus, do not perform a normal start?

If S500 safety I/Os are used with Siemens S7 safety CPUs, then at least one safety value from each S500 safety I/O modules connected using PROFINET/PROFIsafe shall be used in Siemens S7 safety CPU program. Only then the parameterization of S500 safety I/Os takes place. This is a feature of the Siemens S7 safety CPU.

2. Which PROFINET and PROFIsafe features are supported by S500 standard and safety I/Os?

When CI501-PNIO, CI502-PNIO and selected S500 standard and safety I/Os are used, pay attention to supported PROFINET and PROFIsafe features by these modules, as described in [1] and [3]. Contact ABB technical support if questions arise.

3. Which GSDML file versions can be used with CI501-PNIO and CI502-PNIO modules?

Refer to description files which are part of downloaded .zip files with GSDML files of CI501-PNIO and CI502-PNIO modules. There is a dedicated table with mapped GSDML file versions, product indices and/or firmware versions.

4. Why do S500 safety I/O modules go in the module passivation state during start-up with 3rd party safety CPUs?

Check PROFIsafe F_WD_Time F-Parameter of S500 safety I/O modules and make sure that it is set to the correct value, e.g., 150 ms, etc., in relation to your 3rd party PROFIsafe F-Host. This value depends on the performance of the 3rd party PROFIsafe F-Host and communication through "Black channel" [8].

5. What does "IO-BUS Reset after PROFINET reconnection" parameter on CI502-PNIO and CI501-PNIO mean?

"IO-BUS Reset after PROFINET reconnection" controls the behavior of PROFINET CI modules in relation to connected I/O modules (both safety and non-safety I/O modules).

- "IO-BUS Reset after PROFINET reconnection" = "On" resets and, thus, re-parameterizes all attached I/O modules. All internal I/O modules states are reset, including the related diagnostic information. Note that if the parameter is set to "On" then:
 - The bumpless re-start of non-safety I/O modules will not be supported. It means, for example, that non-safety output channels will go to "0" values during the re-connection and re-parameterization time and after that go to new output values.
 - Safety I/O modules will be re-parameterized and re-started as newly started modules, which may not require their PROFIsafe reintegration, depending on safety CPU state, in the safety application.
- "IO-BUS Reset after PROFINET reconnection" = "Off" will not reset all attached I/O modules. It will re-parameterize I/O modules only if parameter change is detected during the reconnection. All internal I/O module states are not reset, including the related diagnostic information. Note that if the parameter is set to "Off" then:
 - The bumpless re-start of non-safety I/O modules is supported (if no parameters are changed). It means, for example, that non-safety output channels will not go to "0" values during the re-connection and re-parameterization time, but directly to new output values.
 - Safety I/O modules will not be re-parameterized (if no parameters are changed). Thus, they may continue their operation, which may require their PROFIsafe reintegration in the safety application on the safety CPU, e.g., if PROFIsafe watchdog time for this safety I/O module

has expired. Any reintegration of such safety I/O modules will be not only application specific but also PROFIsafe specific and depends on the safety I/O handling in the safety application.

6. Shall PROFIsafe F-Host cycle time be considered before setting F_WD_Time for ABB safety I/O modules?

Yes, PROFIsafe F-Host cycle time for the given PROFIsafe safety I/O shall be at least two times smaller than the F_WD_Time setting for the given safety I/O module to avoid an unintended safety I/O module passivation.

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