APPLICATION NOTE

IRC5 ROBOT CONTROLLER AND CI502 WITH SAFETY I/O MODULES

SETTING UP THE IRC5 WITH “PREPARED FOR ABB CI502”

Contents

1 Introduction

1.1 Scope

This application note describes how to configure S500 safety I/O modules that are connected to an IRC5 controller with the “Prepared for ABB CI502” option (Product ID: 3HAC064043-001). It gives a detailed description of the I/O channel configuration of DX581-S and DI581-S safety I/O modules using ABB RobotStudio.

This documentation is intended for qualified personnel familiar with functional safety. You must read and understand the safety concepts and requirements presented in the referenced documentation before you operate an IRC5 system with safety I/O modules.

This application note is relevant for:

- Personnel responsible for the installation and configuration of the fieldbus hardware and software of IRC5 systems.
- Personnel that configure IRC5 I/O systems.
- System integrators who use IRC5 robot controllers.

1.2 Terms and abbreviations

The table below explains the abbreviations used in the document.

Abbreviation	Description
CI502	ABB CI502-PNIO PROFINET IO Bus Module / Communication interface module, Product ID: 1SAP220700R0001. A PROFINET IO device module used to connect to a PROFINET IO controller. Up to 10 S500 I/O modules (standard and/or safety) can be attached to it.
CRC	Cyclic redundancy check. A number derived from and stored or transmitted with a block of data to detect data corruption.
DC	Configurable digital input or output. It can be used as an input and/or an output.
I/O	Input/Output
IP	Internet protocol
OSSD	Output Signal Switching Device
Passivation	A special state of safety I/O modules which leads to the delivery of safe substitute values, which are “0” values for S500 safety I/O modules.
PLC	Programmable logic controller
PROFINET	An industrial technical standard for data communication over Industrial Ethernet.
Reintegration	The process of switching from substitute values “0” to the process data.
RW	RobotWare (Firmware of IRC5 controller)
S500	ABB I/O modules which can be used with the ABB IRC5 robot controller
TU	Terminal Unit

1.3 References

The table below shows the related documents with the download links.

Ref	Type, Title, Document-ID, Download-Link, Version
[1]	AC500-S Unbundled S500 Safety I/Os, 3ADR024128K0201, http://search.abb.com/library/Download.aspx?DocumentID=3ADR024128K0201&LanguageCode=en&DocumentPartId=&Action=Launch or newer version 3ADR024128K02** (** = sequential version number)
[2]	AC500-S Safety User Manual, 3ADR025091M0207, http://search.abb.com/library/Download.aspx?DocumentID=3ADR025091M0207&Language-Code=en&DocumentPartId=&Action=Launch or newer version 3ADR025091M02** (** = sequential version number)
[3]	CI502-PNIO (-XC) Description, 3ADR024127K0201, http://search.abb.com/library/Download.aspx?DocumentID=3ADR024127K0201&Language-Code=en&DocumentPartId=&Action=Launch, or newer version 3ADR024127K02** (** = sequential version number)
[4]	Functional Safety and SafeMove2, 3HAC052610-001 http://search.abb.com/library/Download.aspx?DocumentID=3HAC052610-001&LanguageCode=en&DocumentPartId=&Action=Launch G (RW6.07) or newer
[5]	Usage of unbundled S500 safety I/Os and AC500-S F_iPar_CRC Calculator, 3ADR020122K0201 http://search.abb.com/library/Download.aspx?DocumentID=3ADR020122K0201&LanguageCode=en&DocumentPartId=&Action=Launch
[6]	Operating manual of RobotStudio, 3HAC032104-001 http://search.abb.com/library/Download.aspx?DocumentID=3HAC032104-001&LanguageCode=en&DocumentPartId=&Action=Launch Revision D or newer
[7]	PROFINET Controller/Device I/O Configurator, 3HAC065546-001, http://search.abb.com/library/Download.aspx?DocumentID=3HAC065546-001&LanguageCode=en&DocumentPartId=&Action=Launch to be found in RobotStudio Help in “Additional Resources” section. Revision B or newer
[8]	User Documentation DVD for all IRBs, 3HAC032875-001 https://new.abb.com/products/3HAC032875-001/userdoc-dvd-for-all-irbs

2 Setup overview

This manual focuses on the configuration of ABB S500 safety I/O modules connected to an IRC5 controller via PROFINET, using the IRC5 “Prepared for ABB CI502” option, as shown in Fig. 1.

Fig. 1: IRC5 controller with SafeMove2 and ABB safety I/Os configured using the “Prepared for ABB CI502” option

The solution with the “Prepared for ABB CI502” robot controller option described in this application note offers:

- Connection of safety sensors such as light curtains, laser scanners, safety mats, etc. directly to the SafeMove2 safety controller, for example, for installations without safety fieldbus equipped PLCs.
- Prepared in terms of software support (that is, no hardware, wiring, and so on) in ABB RobotStudio.
- Replacement of SafeMove1 functionality.
- “Prepared for ABB CI502” offers the same functionality as F-Host, but is limited to ABB safety I/O modules from ABB Automation Products.
- A CI502 PROFINET IO communication interface module with on-board standard I/Os is used to attach ABB safety I/O modules.

Key characteristics of the solution with the “Prepared for ABB CI502” robot controller option:

- No explicit need for the PROFIsafe F-Host robot controller option.
- Higher flexibility and productivity with SafeMove2 features and the “Prepared for ABB CI502” option.
- Smaller safety distances due to faster safety response times.

3 Installation and configuration

This chapter describes the prerequisites, hardware and PROFINET setup to connect ABB DI581-S and DX581-S safety I/O modules and the CI502 communication interface module. The configuration and special parameters of the DX581-S and DI581-S safety I/O modules are described in detail. This includes the description of how to use the diagnostic signals of the DX581-S and DI581-S safety I/O modules to reintegrate passivated safety channels, for example, in the case of detected cross-talk wiring errors, and so on.

3.1 Prerequisites

To complete the tasks described in this application note, the reader must have expertise of:

- Mechanical and electrical installation work with the IRC5 robot controller.
- The system and fieldbus parameter configuration of the IRC5 robot controller.
- The configuration of the SafeMove2 option in the IRC5 robot controller.

For more information, refer to [4], [6] and [7].

3.1.1 Hardware

The following hardware is needed:

Hardware name	Comments
IRC5 robot controller with options: • **1241-1 “Prepared for ABB CI502”** • **888-2 “PROFINET Controller Device”** • **996-1 “Safety Module“**	Refer to the ABB Robotics catalog from 2018 (or newer)
CI502-PNIO	CI502-PNIO (V3): S500, PROFINET IO communication interface module with 8 DI, 8 DO and 8 DC channels, Order code: 1SAP220700R0001
TU508-ETH	TU508-ETH: S500, ETH terminal unit, spring terminals, Order code: 1SAP214000R0001
DI581-S	DI581-S: S500, Safety digital input module 16SDI, Order code: 1SAP284000R0001
DX581-S	DX581-S: S500, Safety digital I/O module 8SDI/SDO, Order code: 1SAP284100R0001
TU582-S	TU582-S: S500, Safety I/O terminal unit, spring terminals, 24V DC, Order code: 1SAP281200R0001

3.1.2 Software and firmware versions

The functionality described in this application note was tested with the following component software versions:

Component	Software/firmware version	Comments
IRC5 Robot Controller	RW 6.08.01	Additional options are required: • 1241-1 “Prepared for ABB CI502” • 888-2 “PROFINET Controller/Device” • 996-1 “Safety Module” These can be ordered from ABB Robotics.
CI502-PNIO	3.2.6	PROFINET IO communication interface module It can be ordered from ABB Automation Products.
DX581-S	1.0.0	Safety digital input/output module It can be ordered from ABB Automation Products.
DI581-S	1.0.0	Safety digital input module It can be ordered from ABB Automation Products.
RobotStudio	6.08	Download link: https://new.abb.com/products/robotics/de/robotstudio/downloads
AC500-S F_iPar_CRC Calculator	1.0.0.0	This software tool is needed to calculate CRC for individual safety I/O module parameters. Download link: http://search.abb.com/library/Download.aspx?DocumentID=9AKK106713A4484&LanguageCode=en&DocumentPartId=&Action=Launch

3.2 Hardware setup

This section gives references to the hardware setup of IRC5 robot controller with S500 safety I/O modules using the “Prepared for ABB CI502” option.

The hardware setup of the IRC5 robot controller and related components is described in [8].

The installation instructions for S500 safety I/O modules are listed in the “References” section in [1]. A note on connections:

- Connect +24V DC to terminals 1.8 (UP) and 3.8 (UP3) on TU508-ETH.
- Connect 0V to terminal 1.9 (ZP) on TU508-ETH.
- Connect +24V DC and 0V separately to the attached DI581-S and/or DX581-S safety I/O modules, respectively, to 1.8 (UP) and 1.9 (ZP) on TU582-S.

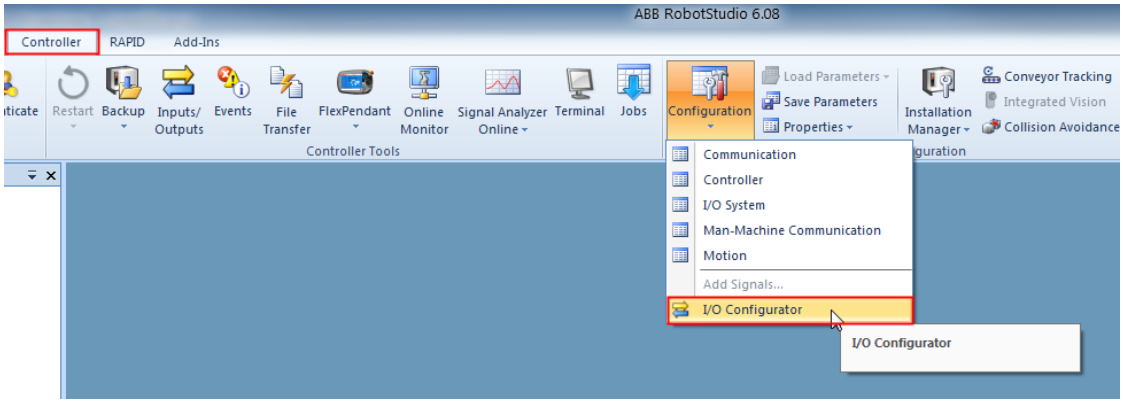
Examples of possible sensor and actor connections to the DI581-S and DX581-S safety I/O modules are listed in the “Circuit examples” sections in [2].

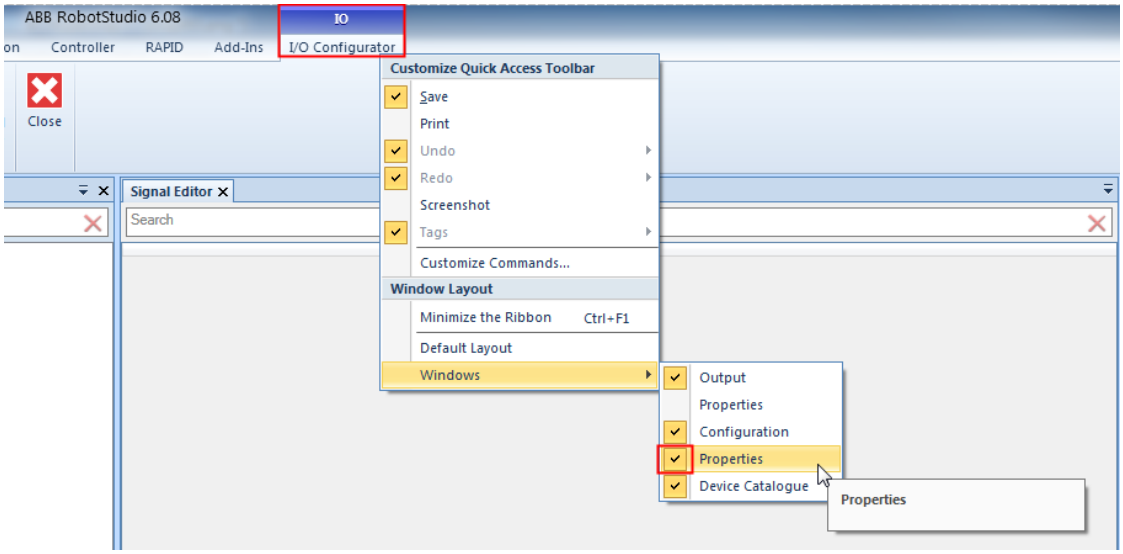
3.3 PROFINET setup

The S500 safety I/O modules are attached to the CI502 PROFINET IO communication interface module, which is used as a communication interface for connectivity to the IRC5 robot controller. This section describes how to setup the PROFINET parameters of the CI502 module.

3.3.1 PROFINET configuration

1. Open RobotStudio and connect to the IRC5 controller.
2. Open the I/O Configurator: Select “Controller” → “Configuration” → “I/O Configurator”.

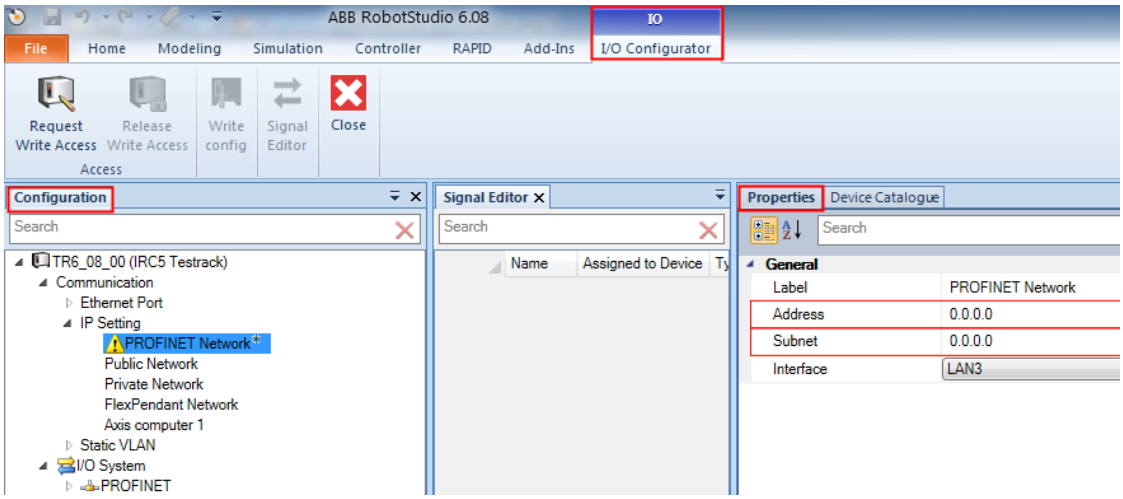




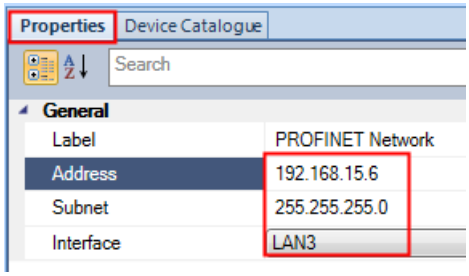
Note that you may have to change the window settings to see the “Properties” view. To do so, right-click on “I/O Configurator” → “Windows” and then select “Properties”.

3. Configure the PROFINET properties.

   Open the PROFINET controller properties in the “Configuration” tab using “Communication” → “IP Setting” → “PROFINET Network”.



   Enter the “IP-Address”, “Subnet” and the LAN “Interface” in the “Properties” tab (refer to the example below).

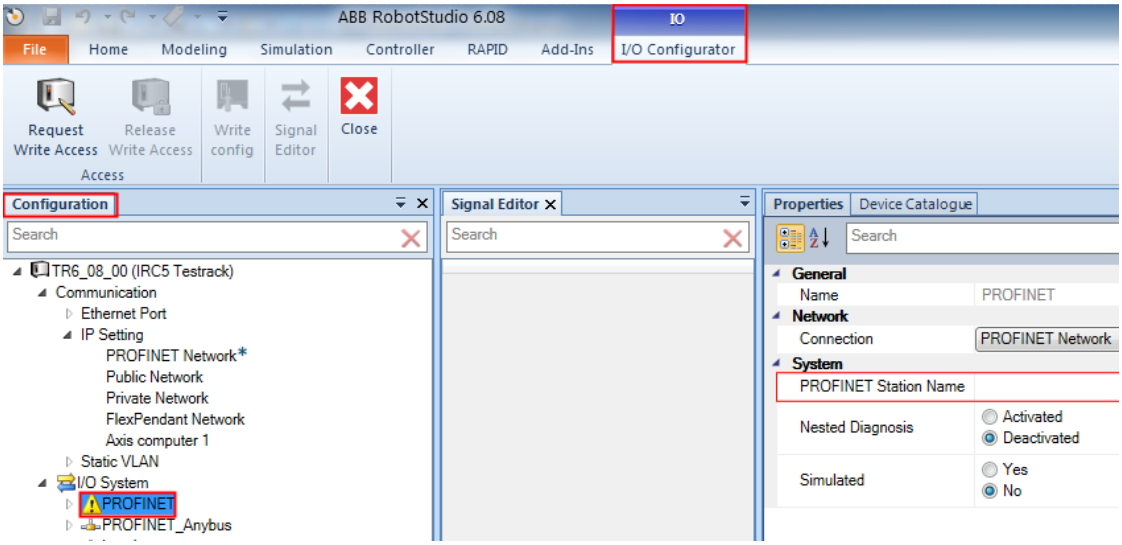


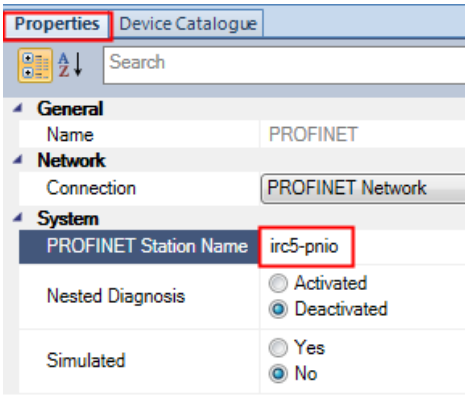
   After this step, the warning sign on the “PROFINET Network” node in the tree disappears.

4. Enter a PROFINET Station Name.

   Open the PROFINET properties in the “Configuration” tab using “I/O System” → “PROFINET”.

In the “Configuration” tab, enter a valid PROFINET name, for example, “irc5-pnio”. PROFINET names can only consist of small letters and/or numbers and/or “-”.

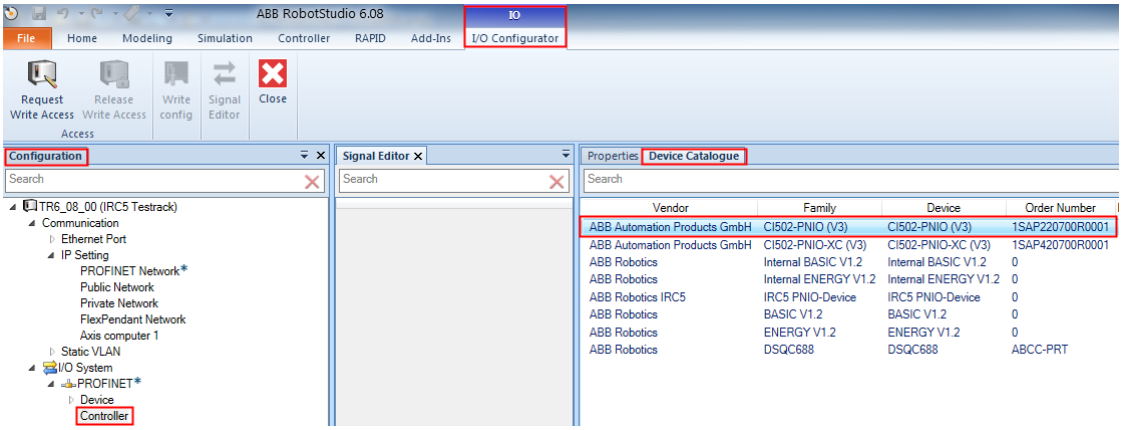




After this step, the warning sign on the “PROFINET” node in the tree below “I/O System” disappears.

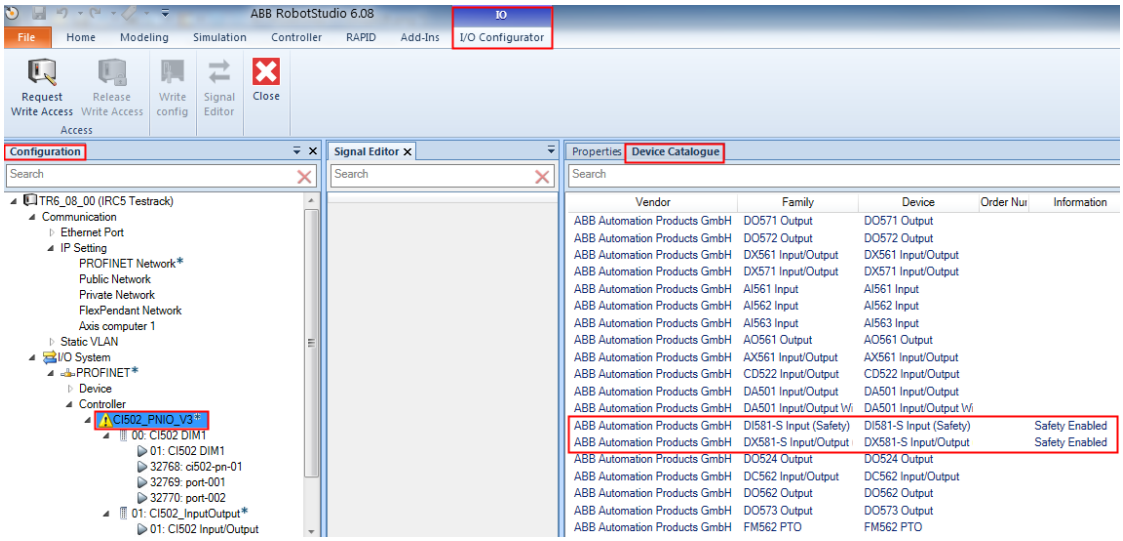
5. Add the CI502 PROFINET IO communication interface module and the DX581-S and/or DI581-S safety I/O modules in the RobotStudio project.

   In the “Configuration” tab, select “I/O System” → “PROFINET” → “Controller”, open “Device Catalogue” and select the “CI502-PNIO (V3)” device.

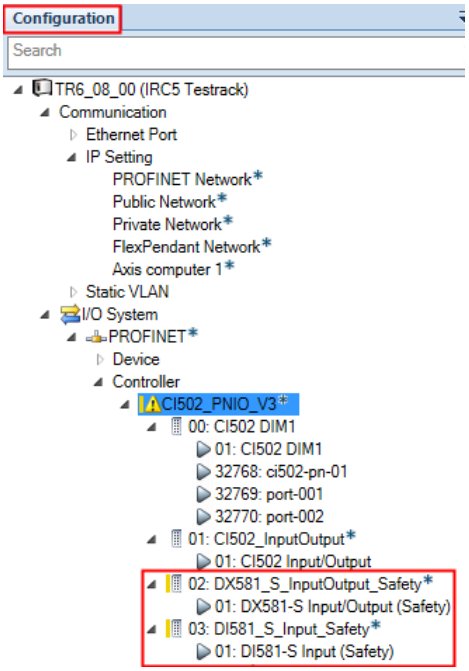


Double-click on “CI502-PNIO (V3)” to add the CI502 module to the robot PROFINET Controller.

Select the “CI502_PNIO_V3” node in the “Configuration” tab and the “Device Catalogue” tab will show all S500 devices which can be attached to the CI502 module. Add “DX581-S Input/Output (Safety)” and/or “DI581-S Input (Safety)” devices from the device catalogue by double-clicking the devices.

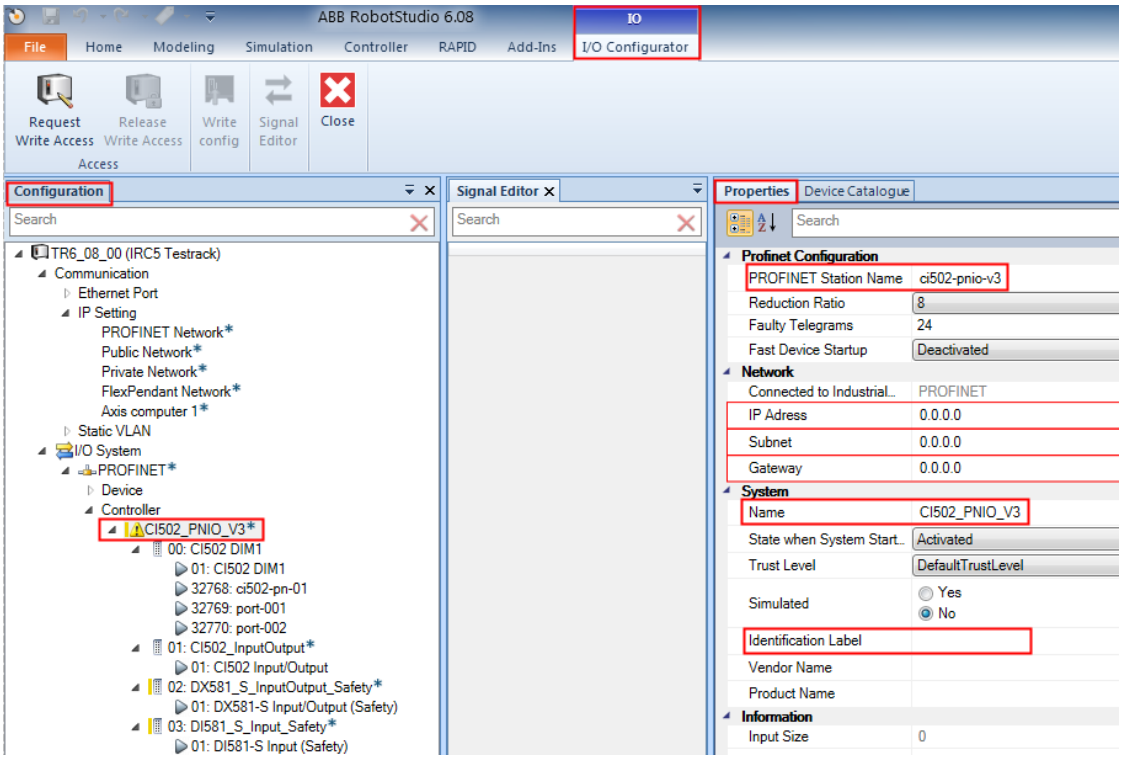


The selected devices appear as nodes under the “CI502_PNIO_V3” node.

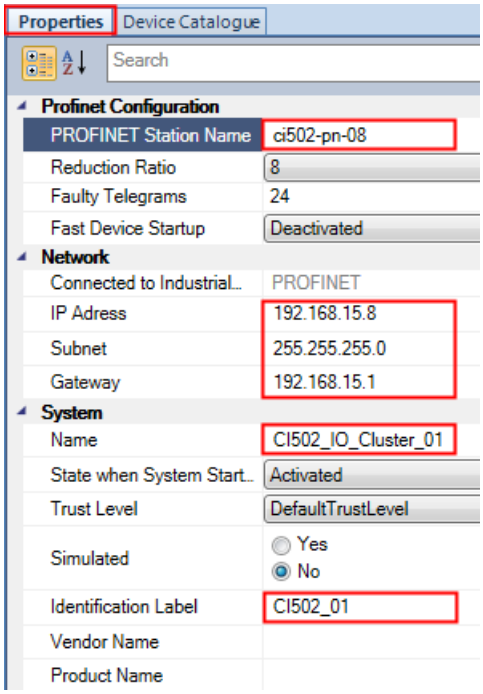


3.3.2 CI502 PROFINET configuration

To configure the CI502 PROFINET parameters, select the “CI502-PNIO_V3” device in the “Configuration” tab and activate the “Properties” tab as shown below.



Configure the parameters in the “Properties” tab as required.



The key parameters are explained in the table below. For more information on CI502 parameters, refer to [3].

Parameter	Description
PROFINET Station name	This parameter defines the PROFINET name for the PROFINET IO device. There are two options to set the PROFINET IO device name for CI502 modules: Option 1, “Allocation of the Device Name via DCP”: The allocation of the device name via DCP is standard for PROFINET networks. For this method of allocation, you must set both rotary address switches to "0" on the CI502 module.  Option 2, “Allocation of the Device Name via Address Switches”: The CI502 has 2 rotary switches to set an explicit name to the PROFINET IO device before commissioning. No engineering tool is needed. The device gets its name (including the fixed part of the device name) directly from the switch settings (01h...FFh). This name can be used directly within the device configuration: **“ci502-pn-xx”** Note: "ci502-pn-” is the fixed part of the device name and xx represents the position of the rotary switch (0..FFh or 0..255d). **The rotary switches have hexadecimal values.** For example, to set the name to “ci502-pn-08”, set the upper rotary switch to “0” and the lower switch to “8”. For the detailed descriptions of the options and how to set the “PROFINET Station name” for CI502, refer to “Allocation of the Device Name” in [3].
Network parameters (“IP Address”, “Subnet” and “Gateway”)	Set the “IP Address” as required. It must be in the range of the PROFINET, which is configured under “Communications” → “IP Settings” → “PROFINET Network”, for example: IP Address: 192.168.15.6 Subnet: 255.255.255.0 Gateway: 192.168.15.1

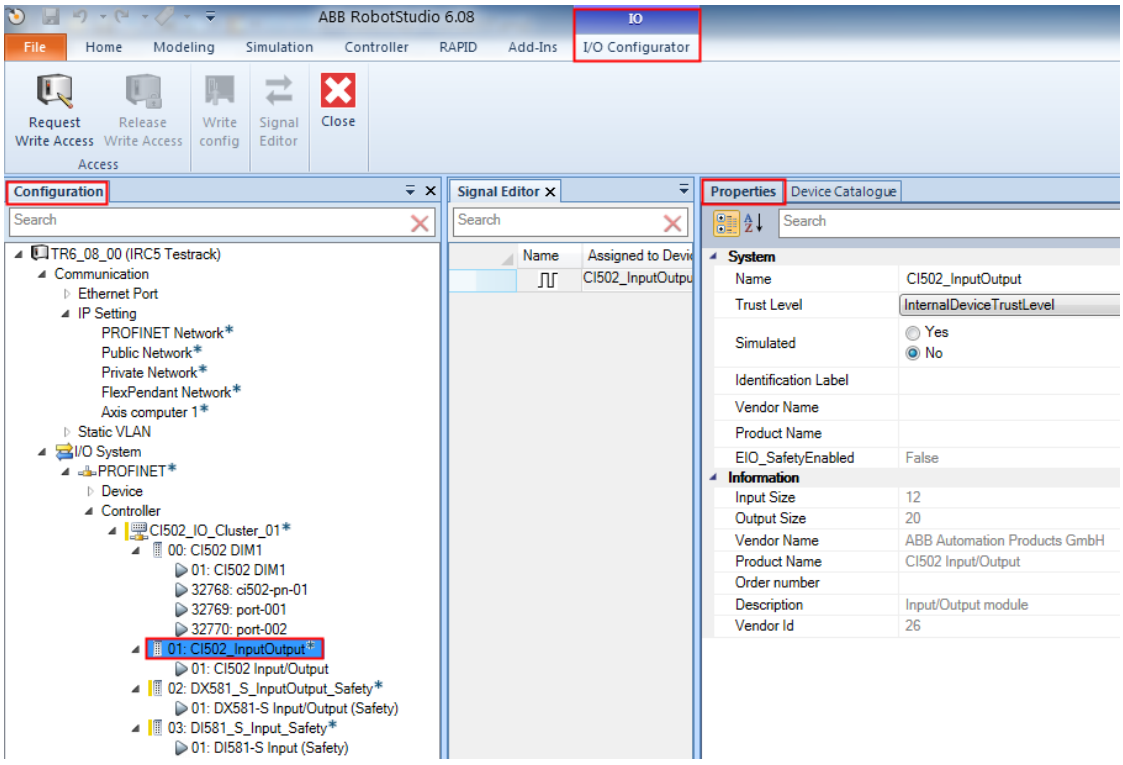
Parameter	Description
Name	Default value: CI502_PNIO_V3 The name can be set as required, for example, to reflect the function of the I/O cluster.
Identification Label	It can be set as required to identify the module.

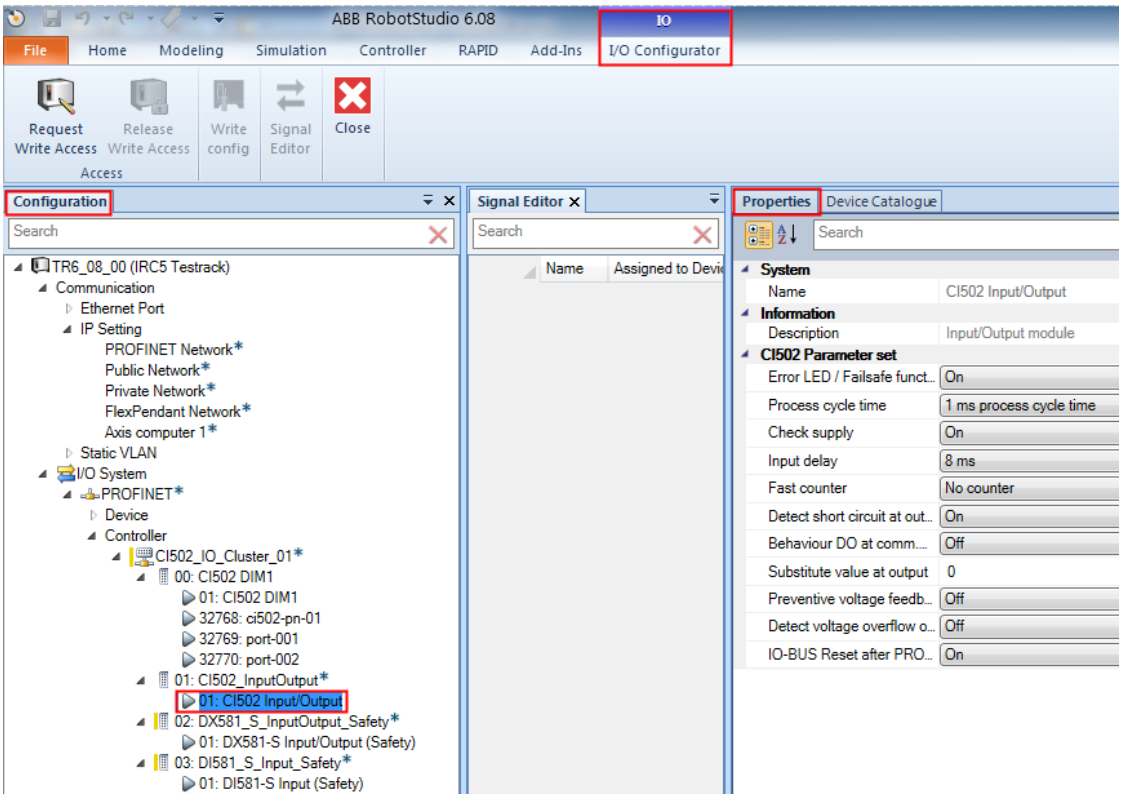
3.4 CI502 module configuration

You can configure the behavior of the inputs and outputs in the “Properties” tab of the CI502 module and its sub-element, respectively.

For the detailed descriptions of all CI502 parameters, refer to “Parameterization” of CI502 in [3].

To complete the configuration tasks described in this application note, you do not need to change the default values. The default configuration of CI502 module parameters is shown below.

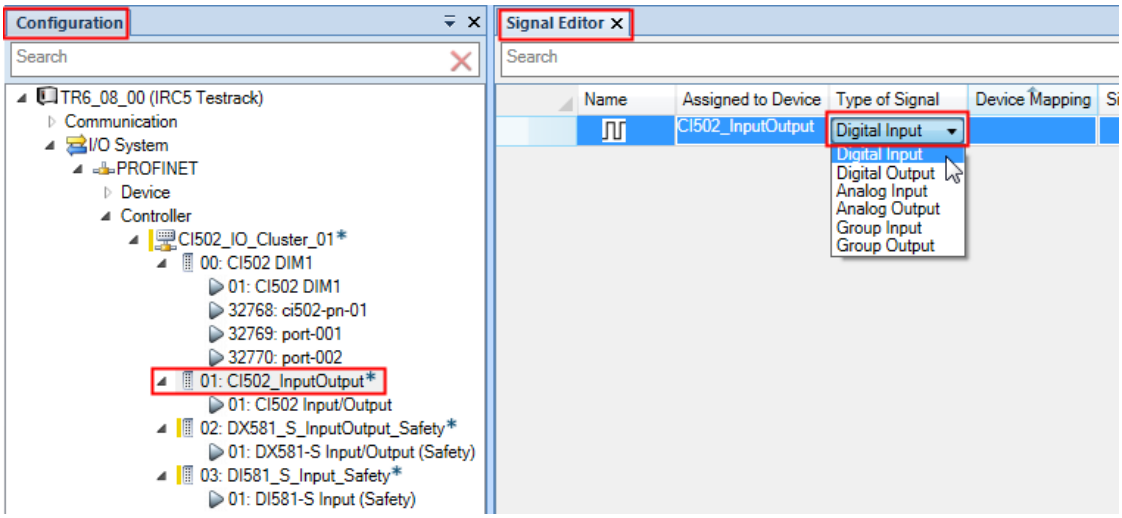




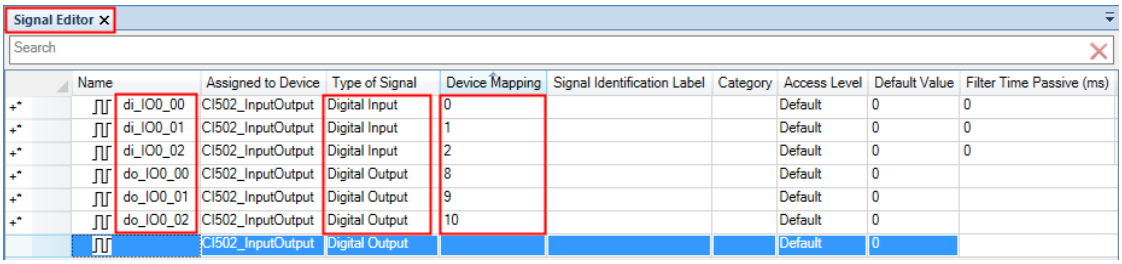
3.4.1 CI502 standard I/O channels

In addition to PROFINET IO device functionality, the CI502 has 8 reserved configurable digital input/outputs, 8 digital inputs and 8 digital outputs, which can be used, for example, for error acknowledgement on the IRC5 robot controller and/or CI502 with its I/O modules.

For example, to add standard signals in the IRC5 robot controller and map them to the CI502 I/O channels, select “CI502_InputOutput” in the “Configuration” tab and change the “Type of Signal” to Digital Input in “Signal Editor” tab:



Enter a signal name in the “Name” field and configure the “Device Mapping” according to the tables in Sections 3.4.1.1 and 3.4.1.2. Press “Enter” to insert a new line for the next signal.



3.4.1.1 CI502 input channels

The following table shows the offset values for signal mapping CI502 input channels in the RobotStudio “Signal Editor”.

Channel/Signal	Offset (Mapping)	Remark/Description
Digital inputs DC0-DC7	0-7	Group input (Byte) – Digital inputs DC0-DC7
Digital input DC0	0	
Digital input DC1	1	
Digital input DC2	2	
Digital input DC3	3	
Digital input DC4	4	
Digital input DC5	5	
Digital input DC6	6	
Digital input DC7	7	
Digital inputs DI8-DI15	8-15	Group input (Byte) – Digital inputs DI8-DI15
Digital input DI8	8	
Digital input DI9	9	
Digital input DI10	10	
Digital input DI11	11	
Digital input DI12	12	
Digital input DI13	13	
Digital input DI14	14	
Digital input DI15	15	
Fast counter : Actual value 1	32-63	Group input (DWord) – reserved for fast counter
Fast counter : Actual value 2	64-95	Group input (DWord) – reserved for fast counter
Fast counter : State Byte 1	96-103	Group input (DWord) – reserved for fast counter
Fast counter : State Byte 2	104-111	Group input (DWord) – reserved for fast counter

3.4.1.2 CI502 output channels

The offset values for signal mapping the CI502 output channels in the RobotStudio “Signal Editor”:

Channel/Signal	Offset (Mapping)	Remark/Description
Digital outputs DC0-DC7	0-7	Group output (Byte) – Digital outputs DC0-DC7
Digital output DC0	0	
Digital output DC1	1	
Digital output DC2	2	
Digital output DC3	3	
Digital output DC4	4	
Digital output DC5	5	
Digital output DC6	6	
Digital output DC7	7	
Digital outputs DO8-DO15	8-15	Group output (Byte) – Digital outputs DO8-DO15
Digital output DO8	8	
Digital output DO9	9	
Digital output DO10	10	
Digital output DO11	11	
Digital output DO12	12	
Digital output DO13	13	
Digital output DO14	14	
Digital output DO15	15	
Fast counter : Start value 1	32-63	Group output (DWord) – reserved for fast counter
Fast counter : End value 1	64-95	Group output (DWord) – reserved for fast counter
Fast counter : Start value 2	96-127	Group output (DWord) – reserved for fast counter
Fast counter : End value 2	128-159	Group output (DWord) – reserved for fast counter
Fast counter : Control Byte 1	160-167	Group output (Byte) – reserved for fast counter
Fast counter : Control Byte 2	168-175	Group output (Byte) – reserved for fast counter

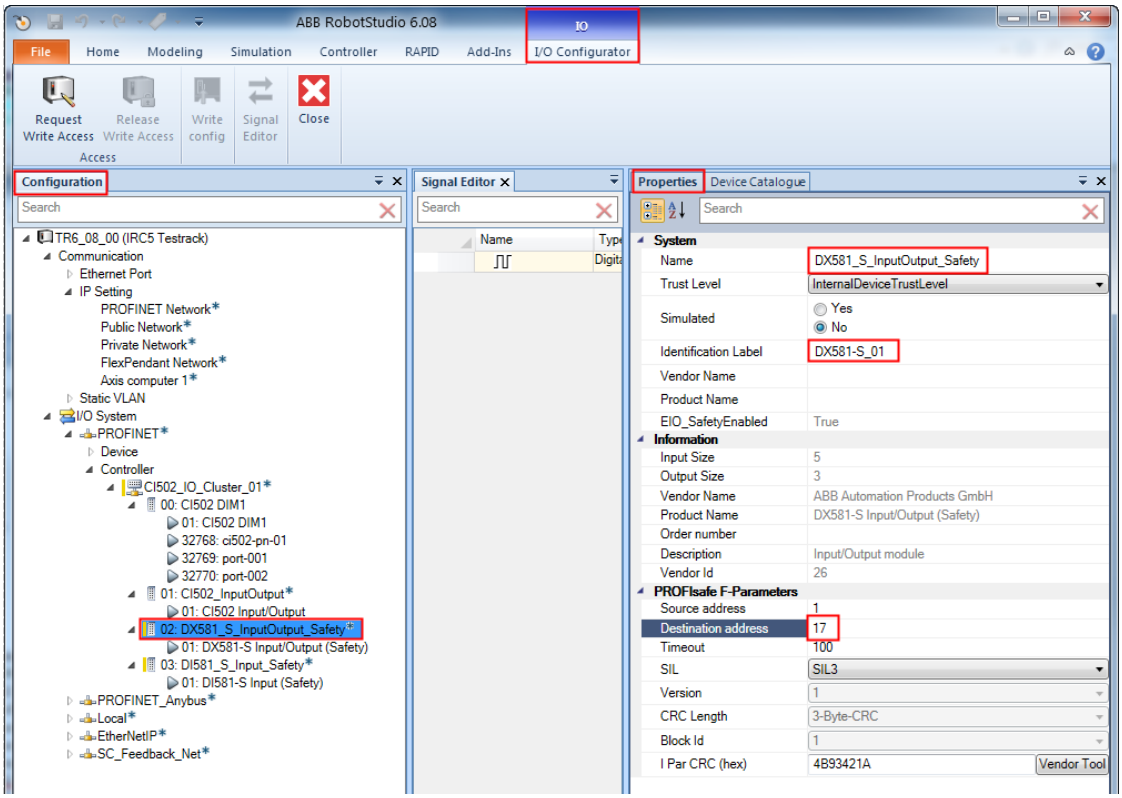
3.5 DX581-S configuration

The DX581-S safety I/O module has 8 safety digital inputs, which can be configured as 1-channel or 2-channel safety digital inputs, 8 safety digital outputs and 4 test pulse outputs. For a detailed description of all DX581-S parameters, refer to the “Parameterization” section of DX581-S in [2].

You can configure the behavior of the inputs and outputs of the DX581-S safety I/O module in the “Properties” tab:

1. Configure the generic properties of the module.

Select the “DX581_S_InputOutput_Safety” node and activate its “Properties” tab.



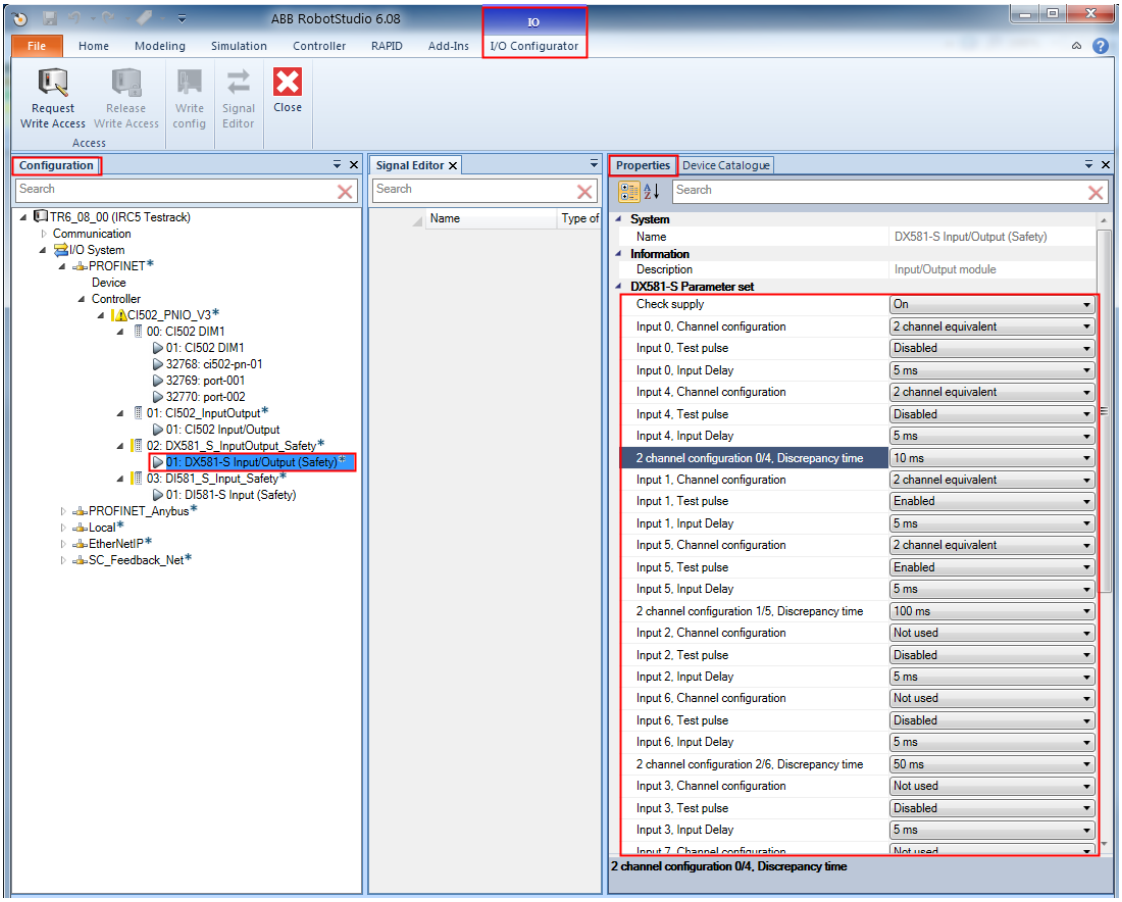
Parameter	Description
Name	The “Name” can be set as required, for example, to reflect the function of the DX581-S safety I/O module. Default value: “DX581_S_InputOutput_Safety”
Identification Label	It can be set as required to identify the module.

Parameter	Description
Destination address	The destination address is the so-called F_Dest_Add, which is used for PROFIsafe F-Device identification. Set the F_Dest_Add destination address according to the value set with the two rotary hardware switches on the DX581-S safety I/O module. Note that the F_Dest_Add destination address in the configuration must be set as a decimal value, but the rotary switches are set as hexadecimal values. The default setting of the DX581-S rotary switches is 02h (hexadecimal). For more information on F_Dest_Add, refer to [2].

For information on the other parameters listed in the “Properties” tab, refer to [2].

2. Configure the safety I/O channels.

Select the “DX581-S Input/Output (Safety)” node and its “Properties” tab:



The key parameters are explained in the table below. For a detailed description of all parameters, refer to “Parameterization” in [2].

Parameter	Description
Check supply	“On”, “Off” Default value: “On” The parameter setting defines whether diagnosis messages are generated for this device in case of a missing power supply on “UP” terminals.
Input, Channel configuration	“Not used”, “1 channel”, “2 channel equivalent”, “2 channel antivalent” Default value: “Not used” Note that if channels are used as “2 channel equivalent” or “2 channel antivalent” inputs, the following possible channel combinations are supported: • Channels 0 and 4 • Channels 1 and 5 • Channels 2 and 6 • Channels 3 and 7 Note that in “2 channel equivalent” or “2 channel antivalent” configurations you must configure the higher channel in the same way as the lower one. In addition, only the lower channel reflects the result of both channels and must be used in the controller program. The higher channel always delivers fail-safe “0” values in the controller program.
Input, Test pulse	“Disabled”, “Enabled” Default value: “Disabled” If “Enabled” is selected, the safety input channel must be powered by the dedicated test pulse output of the DX581-S safety I/O module: • Input channels 0 and 1 shall use test pulse output T0 • Input channels 2 and 3 shall use test pulse output T1 • Input channels 4 and 5 shall use test pulse output T2 • Input channels 6 and 7 shall use test pulse output T3

Parameter	Description
Input Delay	“1 ms”, “2 ms”, “5 ms”, “10 ms”, “15 ms”, “30 ms”, “50 ms”, “100 ms”, “200 ms”, “500 ms” Default value: 5 ms Signals with a duration shorter than the input delay value are not captured by the safety module. For more information, refer to the “Functionality” section of DX581-S safety I/O module in [2].
2 channel configuration, Discrepancy time	“10 ms”, “20 ms”, “30 ms”, “40 ms”, “50 ms”, “60 ms”, “70 ms”, “80 ms”, “90 ms”, “100 ms”, “150 ms”, “200 ms”, “250 ms”, “300 ms”, “400 ms”, “500 ms”, “750 ms”, “1 s”, “2 s”, “3 s”, “4 s”, “5 s”, “10 s”, “20 s”, “30 s” Default value: 50 ms It is used in a 2-channel configuration to detect if both input channels have changed to the same state after the discrepancy time. **Note that for OSSD devices such as laser scanners, light curtains, etc. it is highly recommended to set the discrepancy time to 10 ms to avoid the reintegration procedure using dedicated acknowledge reintegration signals.** In case of mechanical position switches, mode selectors, E-Stop buttons, etc. discrepancy time values of 100 ms and above must be used depending on their properties. For more information, refer to “Functionality” section of the DX581-S safety I/O module in [2].
Output channel	“Not used”, “Used” Default value: “Not used”
Output, Detection	“Off”, “On” Default value: “On” The “Detection” parameter defines whether the internal output channel test is active. Note that the reachable SILCL (IEC 62061), SIL (IEC 61508) and PL (ISO 13849-1) levels for the safety outputs of the DX581-S safety I/O module are only valid if the parameter Detection = “On”. If the parameter detection = “Off” then contact ABB technical support to obtain proper reachable SILCL, SIL and PL levels.

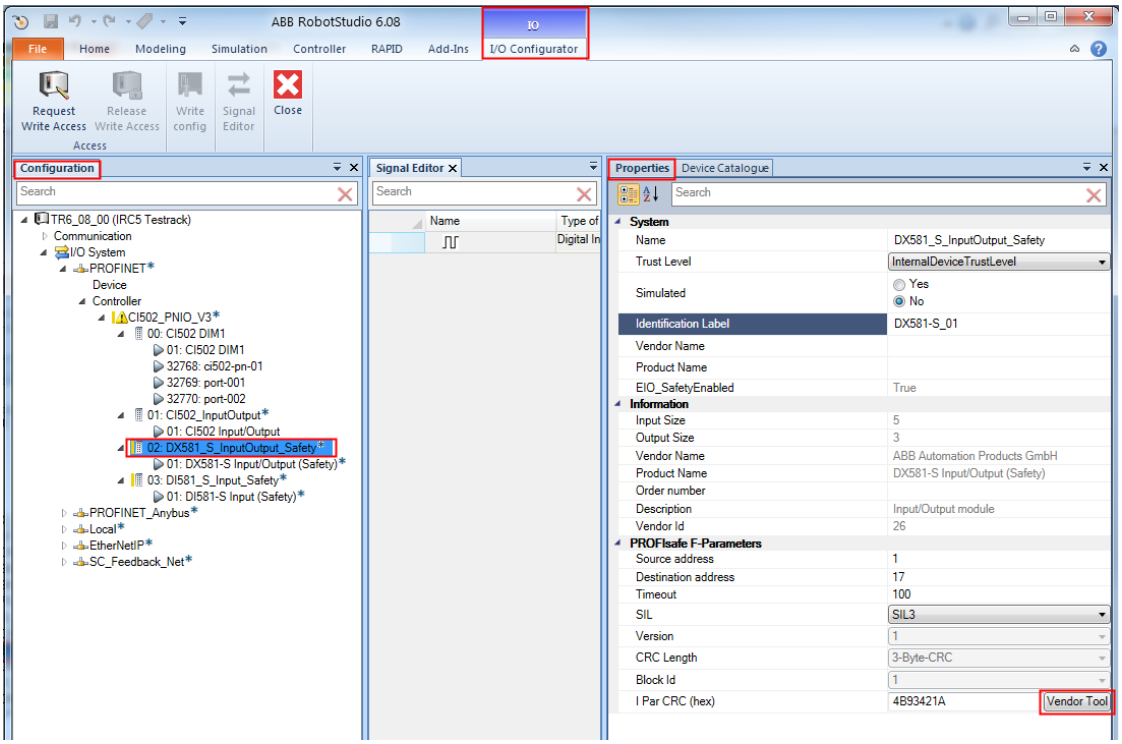
3. Calculate I Par CRC (F_iPar_CRC) for the DX581-S parameters.

The I Par CRC (F_iPar_CRC according to PROFIsafe definition) parameter is a special parameter which defines a checksum and is used for the safe transfer of DX581-S safety I/O parameters to physical DX581-S safety I/O modules.

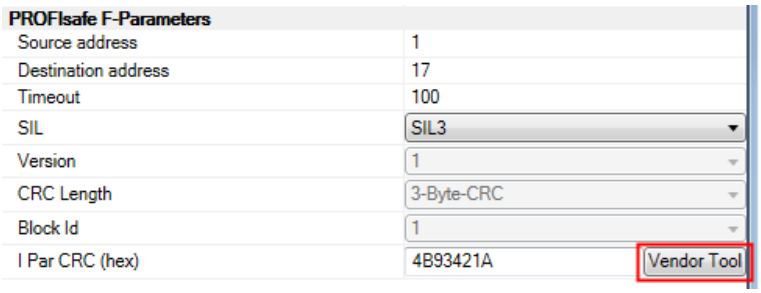
The checksum I Par CRC must be calculated and entered after the parameter configuration of the DX581-S safety I/O module (for example, “Destination address” parameter) and its I/O channels (for example, “Input delay” parameter) is complete. If DX581-S parameters are changed later, the I Par CRC calculation must be done again.

Note that to configure I Par CRC, you have to install the vendor tool “AC500-S F_iPar_CRC Calculator” beforehand using this link: http://search.abb.com/library/Download.aspx?DocumentID=9AKK106713A4484&LanguageCode=en&DocumentPartId=&Action=Launch

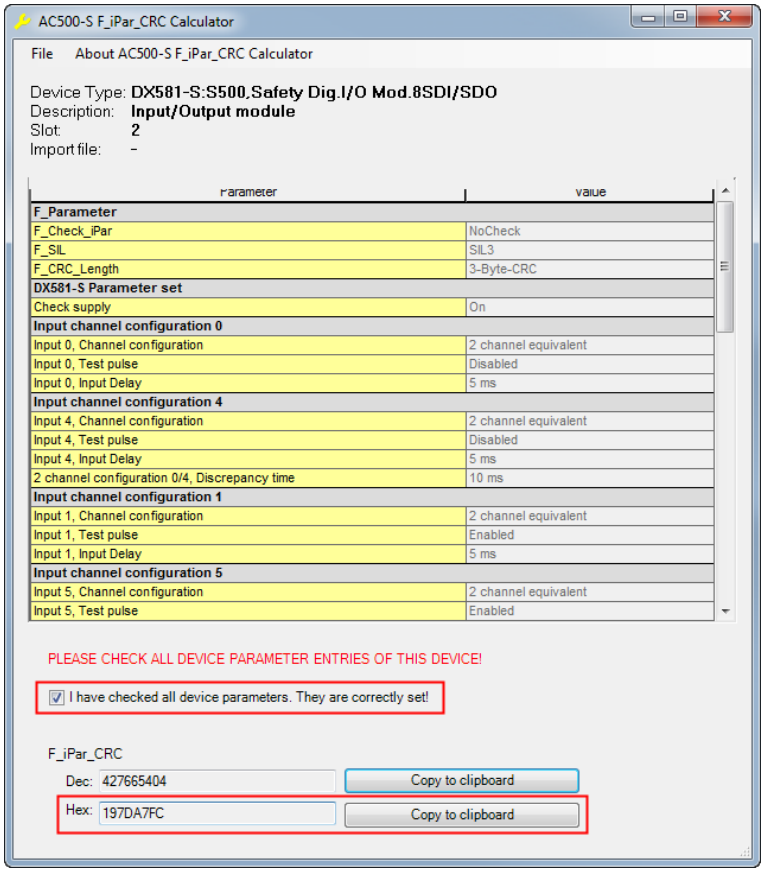
Select the “DX581_S_InputOutput_Safety” node and its “Properties” tab:



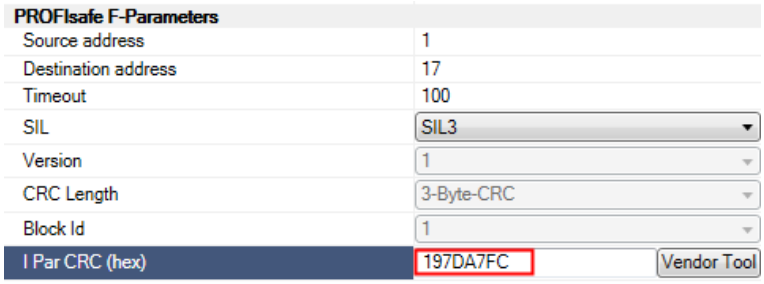
Call the “Vendor Tool” by clicking on the button right to the “I Par CRC” value.



The “AC500-S F_iPar_CRC Calculator” is launched. Verify all entries, which are DX581-S parameters, in the “AC500-S F_iPar_CRC Calculator” tool and acknowledge them using the checkbox.



Copy the hexadecimal value of the I Par CRC (F_iPar_CRC) from “AC500-S F_iPar_CRC Calculator” to the clipboard and paste it to the I Par CRC parameter field of the DX581-S safety I/O module in RobotStudio.



3.5.2 DX581-S signals

To add signals to the IRC5 robot controller using the I/O configurator in RobotStudio, you must enter the offset values for signal mapping of the DX581-S safety I/O channels. The tables in sections 3.5.2.1 and 3.5.2.2 show the offset values for the signal mappings of the DX581-S safety I/O channels.

3.5.2.1 DX581-S input signal mapping

The offset values for input signal mapping of the DX581-S safety I/O module:

Channel/Signal	Offset (Mapping)	Remark/Description
Safety digital inputs I0-I7	0-7	Group input (Byte) – Safety digital inputs I0-I7
Safety digital input I0	0	Safety DI0. If used as a 2-channel configuration: value of the 2-channel evaluation (I0 and I4)
Safety digital input I1	1	Safety DI1. If used as a 2-channel configuration: value of the 2-channel evaluation (I1 and I5)
Safety digital input I2	2	Safety DI2. If used as a 2-channel configuration: value of the 2-channel evaluation (I2 and I6)
Safety digital input I3	3	Safety DI3. If used as a 2-channel configuration: value of the 2-channel evaluation (I3 and I7)
Safety digital input I4	4	Safety DI4. If used as a 2-channel configuration: value is always FALSE. See Safety DI0.
Safety digital input I5	5	Safety DI5. If used as a 2-channel configuration: value is always FALSE. See Safety DI1.
Safety digital input I6	6	Safety DI6. If used as a 2-channel configuration: value is always FALSE. See Safety DI2.
Safety digital input I7	7	Safety DI7. If used as a 2-channel configuration: value is always FALSE. See Safety DI3.
Safe diagnostic I0-I7	8-15	Group input (Byte) – Safety input signals to indicate the use of fail-safe values on safety DI channels
Safe_Diag – Input I0	8	Indication of fail-safe value used on Safety DI0
Safe_Diag – Input I1	9	Indication of fail-safe value used on Safety DI1
Safe_Diag – Input I2	10	Indication of fail-safe value used on Safety DI2
Safe_Diag – Input I3	11	Indication of fail-safe value used on Safety DI3
Safe_Diag – Input I4	12	Indication of fail-safe value used on Safety DI4
Safe_Diag – Input I5	13	Indication of fail-safe value used on Safety DI5
Safe_Diag – Input I6	14	Indication of fail-safe value used on Safety DI6
Safe_Diag – Input I7	15	Indication of fail-safe value used on Safety DI7
Safe diagnostic O0-O7	16-23	Group input (Byte) – Safety input signals to indicate the use of fail-safe values on Safety DO channels
Safe_Diag – Output O0	16	Indication of fail-safe value used on Safety DO0
Safe_Diag – Output O1	17	Indication of fail-safe value used on Safety DO1
Safe_Diag – Output O2	18	Indication of fail-safe value used on Safety DO2
Safe_Diag – Output O3	19	Indication of fail-safe value used on Safety DO3
Safe_Diag – Output O4	20	Indication of fail-safe value used on Safety DO4

Channel/Signal	Offset (Mapping)	Remark/Description
Safe_Diag – Output O5	21	Indication of fail-safe value used on Safety DO5
Safe_Diag – Output O6	22	Indication of fail-safe value used on Safety DO6
Safe_Diag – Output O7	23	Indication of fail-safe value used on Safety DO7
Reintegration request I0-I7	24-31	Group input (Byte) – Indication that safety input channels can be reintegrated to deliver safety process values instead of fail-safe “0” values
Rei_Req – Input I0	24	Safety DI0 channel can be reintegrated
Rei_Req – Input I1	25	Safety DI1 channel can be reintegrated
Rei_Req – Input I2	26	Safety DI2 channel can be reintegrated
Rei_Req – Input I3	27	Safety DI3 channel can be reintegrated
Rei_Req – Input I4	28	Safety DI4 channel can be reintegrated
Rei_Req – Input I5	29	Safety DI5 channel can be reintegrated
Rei_Req – Input I6	30	Safety DI6channel can be reintegrated
Rei_Req – Input I7	31	Safety DI7 channel can be reintegrated
Reintegration request O0-O7	32-39	Group input (Byte) – Indication that safety output channels can be reintegrated to deliver safety process values instead of fail-safe “0” values
Rei_Req – Output O0	32	Safety DO0 channel can be reintegrated
Rei_Req – Output O1	33	Safety DO1 channel can be reintegrated
Rei_Req – Output O2	34	Safety DO2 channel can be reintegrated
Rei_Req – Output O3	35	Safety DO3 channel can be reintegrated
Rei_Req – Output O4	36	Safety DO4 channel can be reintegrated
Rei_Req – Output O5	37	Safety DO5 channel can be reintegrated
Rei_Req – Output O6	38	Safety DO6 channel can be reintegrated
Rei_Req – Output O7	39	Safety DO7 channel can be reintegrated
PROFIsafe Protocol inputs – Byte 0	40-47	Group input – only for internal use
PROFIsafe Protocol inputs – Byte 1	48-55	Group input – only for internal use
PROFIsafe Protocol inputs – Byte 2	56-63	Group input – only for internal use
PROFIsafe Protocol inputs – Byte 3	64-71	Group input – only for internal use

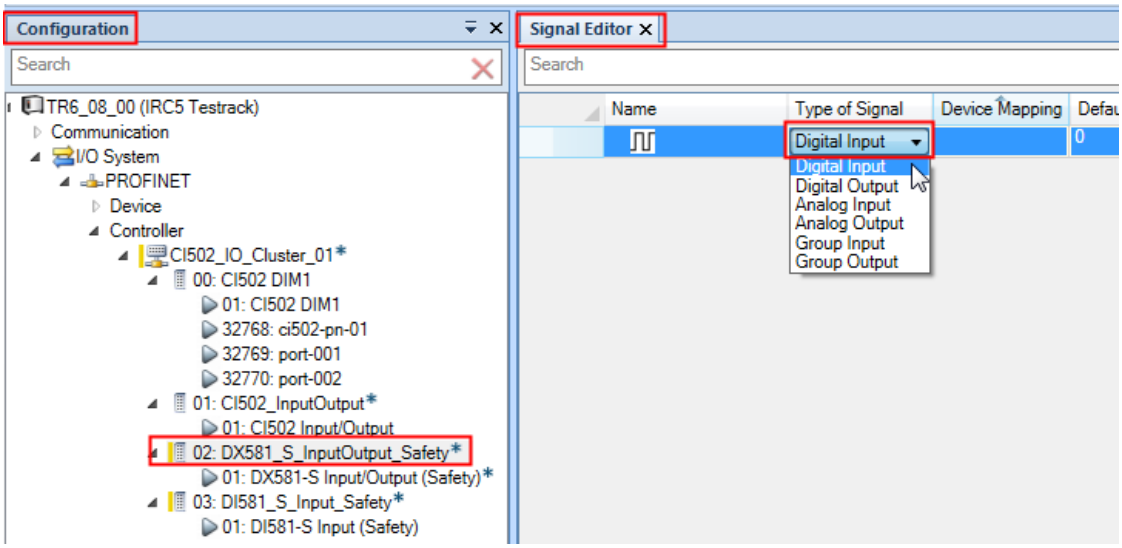
3.5.2.2 DX581-S output signal mapping

The offset values for output signal mapping of the DX581-S safety I/O module:

Channel/Signal	Offset (Mapping)	Remark/Description
Safety digital outputs O0-O7	0-7	Group output (Byte) – Safety digital outputs O0-O7
Safety digital output O0	0	Safety DO0
Safety digital output O1	1	Safety DO1
Safety digital output O2	2	Safety DO2
Safety digital output O3	3	Safety DO3
Safety digital output O4	4	Safety DO4
Safety digital output O5	5	Safety DO5
Safety digital output O6	6	Safety DO6
Safety digital output O7	7	Safety DO7
Acknowledge reintegration I0-I7	8-15	Group output (Byte) – Safety outputs to reintegrate safety digital inputs I0-I7
Ack_Rei – Input I0	8	Output to reintegrate safety DI0
Ack_Rei – Input I1	9	Output to reintegrate safety DI1
Ack_Rei – Input I2	10	Output to reintegrate safety DI2
Ack_Rei – Input I3	11	Output to reintegrate safety DI3
Ack_Rei – Input I4	12	Output to reintegrate safety DI4
Ack_Rei – Input I5	13	Output to reintegrate safety DI5
Ack_Rei – Input I6	14	Output to reintegrate safety DI6
Ack_Rei – Input I7	15	Output to reintegrate safety DI7
Acknowledge reintegration O0-O7	16-23	Group output (Byte) – Safety outputs to reintegrate safety digital outputs O0-O7
Ack_Rei – Output O0	16	Output to reintegrate safety DO0
Ack_Rei – Output O1	17	Output to reintegrate safety DO1
Ack_Rei – Output O2	18	Output to reintegrate safety DO2
Ack_Rei – Output O3	19	Output to reintegrate safety DO3
Ack_Rei – Output O4	20	Output to reintegrate safety DO4
Ack_Rei – Output O5	21	Output to reintegrate safety DO5
Ack_Rei – Output O6	22	Output to reintegrate safety DO6
Ack_Rei – Output O7	23	Output to reintegrate safety DO7
PROFIsafe Protocol outputs – Byte 0	24-31	Group output – only for internal use
PROFIsafe Protocol outputs – Byte 1	32-39	Group output – only for internal use
PROFIsafe Protocol outputs – Byte 2	40-47	Group output – only for internal use

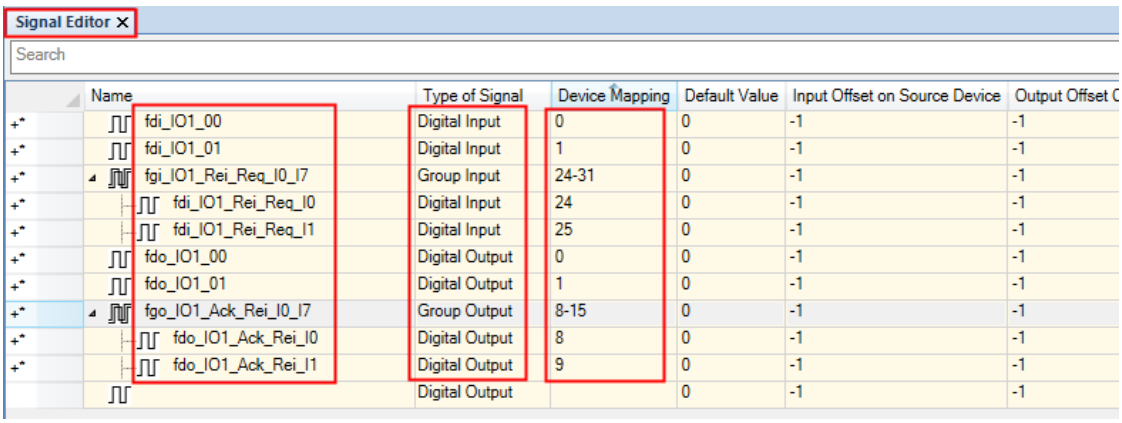
Channel/Signal	Offset (Mapping)	Remark/Description
PROFIsafe Protocol outputs – Byte 3	48-55	Group output – only for internal use

To use the safety signals of the DX581-S safety I/O module in the IRC5 safety control program, assign symbolic names to them. Select “DX581_S_InputOutput_Safety” in the “Configuration” tab and add new signals by changing the “Type of Signal”, for example, to “Digital Input” in the “Signal Editor” tab.



Enter a signal name in the “Name” field and adapt the “Device Mapping” using the offset values listed in tables from Sections 3.5.2.1 and 3.5.2.2.

Press “Enter” to insert a new line for the next signal to fill the list of safety signals for the DX581-S safety I/O module. For example, you can create a list of signals as shown below.



The created safety signals for DX581-S safety I/O module can be later used (refer to Section 3.8) in the IRC5 safety controller to realize the required safety functions, as described in [4].

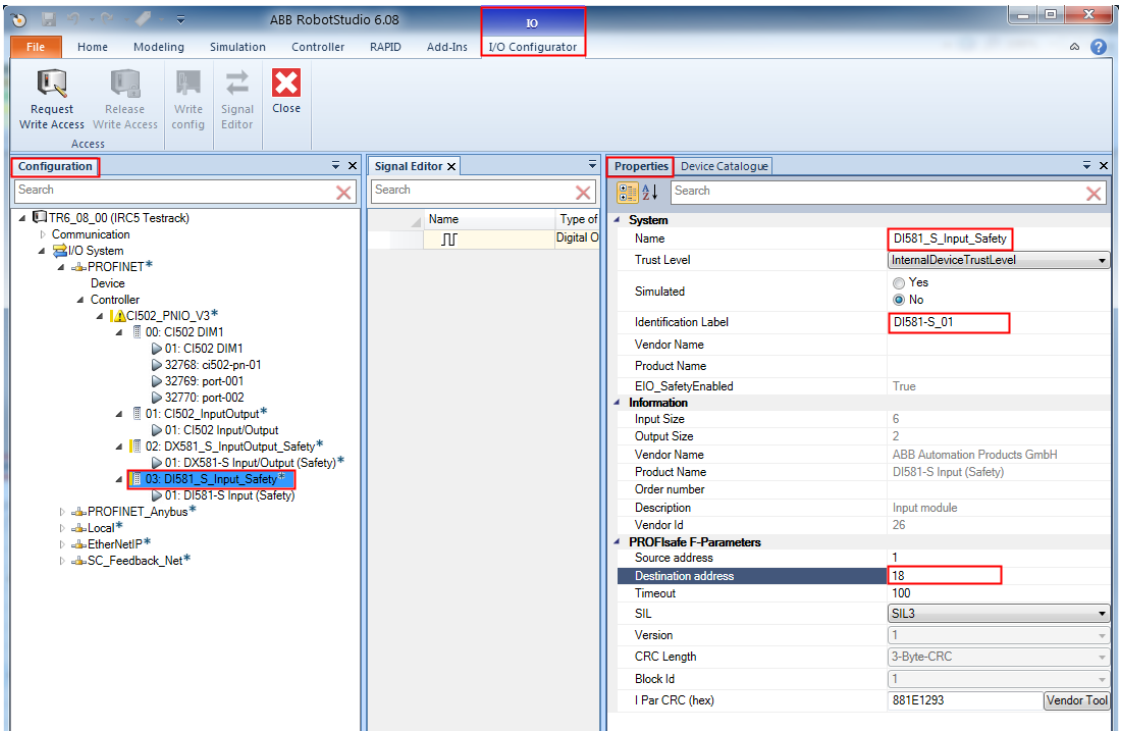
3.6 DI581-S configuration

DI581-S safety I/O module has 16 safety digital inputs, which can be configured as 16 1-channel or as 8 2-channel safety digital inputs, and 8 test pulse outputs. For a detailed description of all DI581-S parameters, refer to the “Parameterization” section of DI581-S in [2].

You can configure the behavior of the inputs of the DI581-S safety I/O module in the “Properties” tab:

1. Configure the generic properties of the module.

Select the “DI581_S_Input_Safety” node and activate its “Properties” tab:



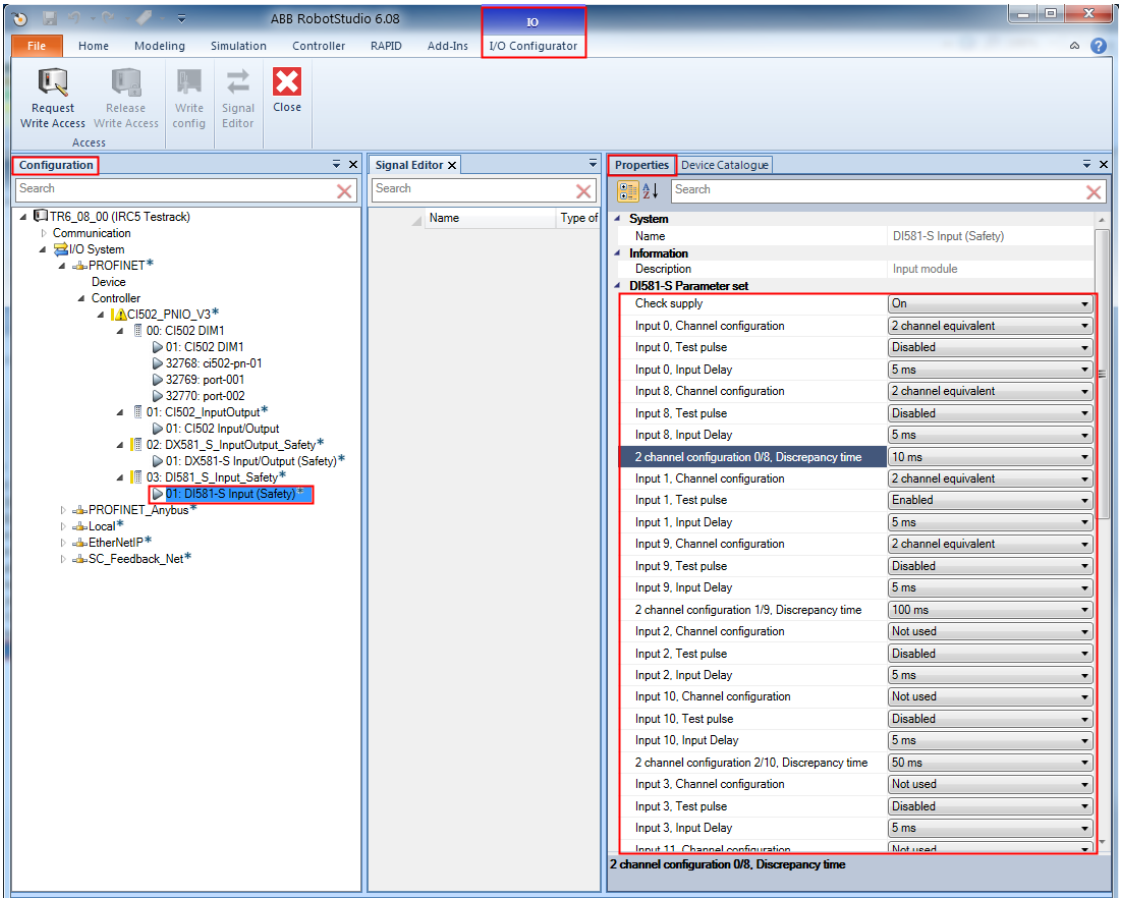
Parameter	Description
Name	The “Name” can be set as required, for example, to reflect the function of the DI581-S safety I/O module. Default value: “DI581_S_Input_Safety”
Identification Label	It can be set as required to identify the module.

Parameter	Description
Destination address	The destination address is the so-called F_Dest_Add, which is used for PROFIsafe F-Device identification. Set the F_Dest_Add destination address according to the value set with the two rotary hardware switches on the DI581-S safety I/O module. Note that the F_Dest_Add destination address in the configuration must be set as a decimal value, but the rotary switches are set as hexadecimal values. The default setting of the DI581-S rotary switches is 02h (hexadecimal). For more information on F_Dest_Add, refer to [2].

Refer to [6] for information on all other parameters listed in the “Properties” tab.

2. Configure the safety I/O channels.

Select the “DI581-S Input (Safety)” node and its “Properties” tab:



The key parameters are explained in the table below. For information on all parameters, refer to the “Parameterization” section in [2].

Parameter	Description
Check supply	“On”, “Off” Default value: “On” The parameter setting defines whether diagnosis messages are generated for this device in case of a missing power supply on the “UP” terminals.
Input, Channel configuration	“Not used”, “1 channel”, “2 channel equivalent”, “2 channel antivalent” Default value: “Not used” Note that if the channels are used as “2 channel equivalent” or “2 channel antivalent” inputs, the following possible channel combinations are supported: • Channels 0 and 8 • Channels 1 and 9 • Channels 2 and 10 • Channels 3 and 11 • Channels 4 and 12 • Channels 5 and 13 • Channels 6 and 14 • Channels 7 and 15 Note that in “2 channel equivalent” or “2 channel antivalent” configurations you must configure the higher channel in the same way as the lower one. In addition, only the lower channel reflects the result of both channels and must be used in the controller program. The higher channel always delivers fail-safe “0” values in the controller program.

Parameter	Description
Input, Test pulse	“Disabled”, “Enabled” Default value: “Disabled” If “Enabled” is selected, the safety input channel must be powered by the dedicated test pulse output of the DI581-S safety I/O module: • Input channels 0 and 1 shall use test pulse output T0 • Input channels 2 and 3 shall use test pulse output T1 • Input channels 4 and 5 shall use test pulse output T2 • Input channels 6 and 7 shall use test pulse output T3 • Input channels 8 and 9 shall use test pulse output T4 • Input channels 10 and 11 shall use test pulse output T5 • Input channels 12 and 13 shall use test pulse output T6 • Input channels 14 and 15 shall use test pulse output T7
Input Delay	“1 ms”, “2 ms”, “5 ms”, “10 ms”, “15 ms”, “30 ms”, “50 ms”, “100 ms”, “200 ms”, “500 ms” Default value: 5 ms Signals with a duration shorter than the input delay value are not captured by the safety module. For more information, refer to the “Functionality” section of the DI581-S safety I/O module in [2].
2 channel configuration, Discrepancy time	“10 ms”, “20 ms”, “30 ms”, “40 ms”, “50 ms”, “60 ms”, “70 ms”, “80 ms”, “90 ms”, “100 ms”, “150 ms”, “200 ms”, “250 ms”, “300 ms”, “400 ms”, “500 ms”, “750 ms”, “1 s”, “2 s”, “3 s”, “4 s”, “5 s”, “10 s”, “20 s”, “30 s” Default value: 50 ms It is used in 2-channel configuration to detect whether both input channels have changed to the same state after the discrepancy time. **Note that for OSSD devices such as laser scanners, light curtains, etc. it is highly recommended to set the discrepancy time to 10 ms to avoid the reintegration procedure using dedicated acknowledge reintegration signals.** In case of mechanical position switches, mode selectors, E-Stop buttons, etc. Discrepancy time values of 100 ms and above must be used depending on their properties. For more information, refer to the “Functionality” section of the DI581-S safety I/O module in [2].

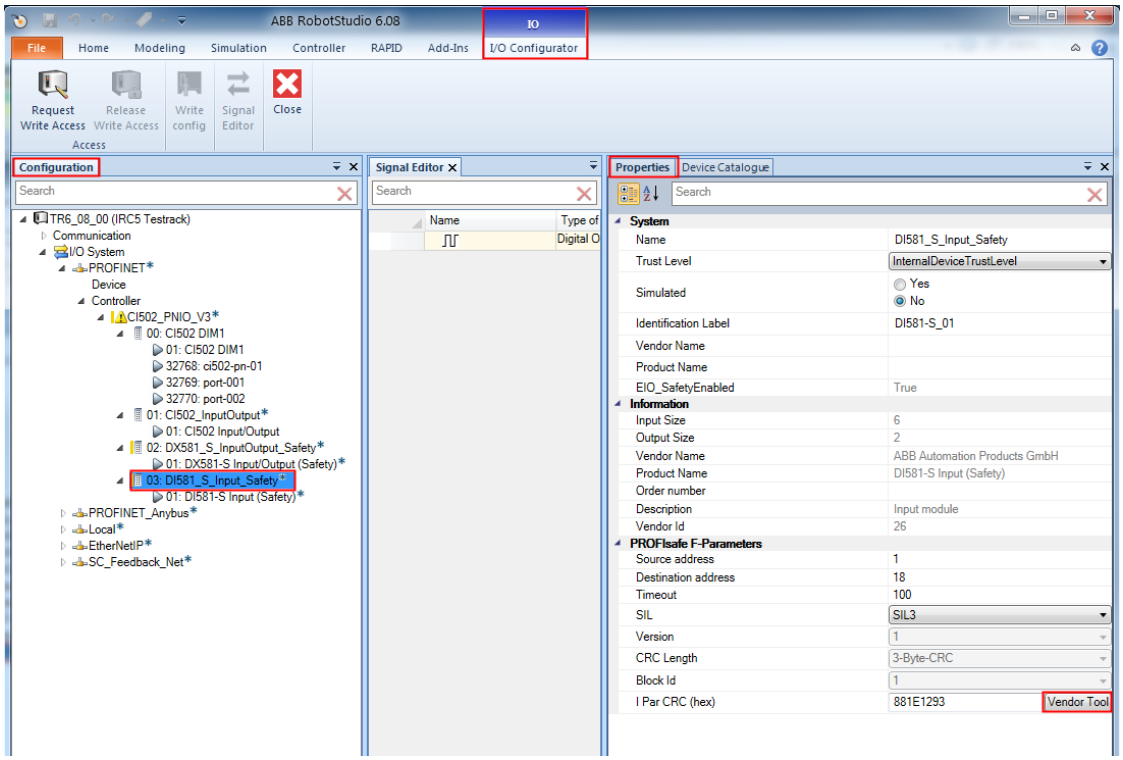
3. Calculate the I Par CRC (F_iPar_CRC) for DI581-S parameters.

The I Par CRC (F_iPar_CRC according to the PROFIsafe definition) parameter is a special parameter which defines a checksum and is used for a safe transfer of the DI581-S safety I/O parameters to physical DI581-S safety I/O modules.

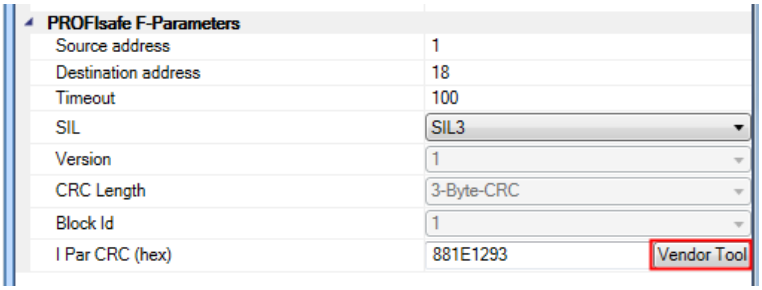
The checksum I Par CRC must be calculated and entered after the parameter configuration of the DI581-S safety I/O module (for example, “Destination address” parameter) and its I/O channels (for example, “Input delay” parameter) is complete. If DI581-S parameters are changed later, the I Par CRC calculation must be done again.

Note that to configure I Par CRC, you have to install the vendor tool “AC500-S F_iPar_CRC Calculator” beforehand using this link: http://search.abb.com/library/Download.aspx?DocumentID=9AKK106713A4484&LanguageCode=en&DocumentPartId=&Action=Launch

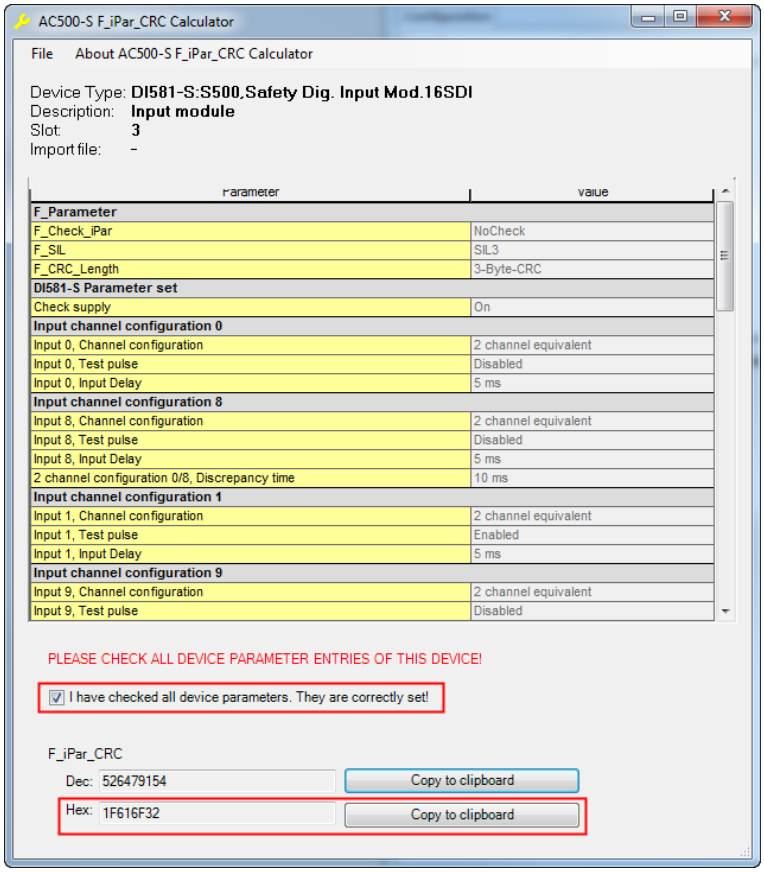
Select the “DI581_S_Input_Safety“ node and its “Properties” tab:



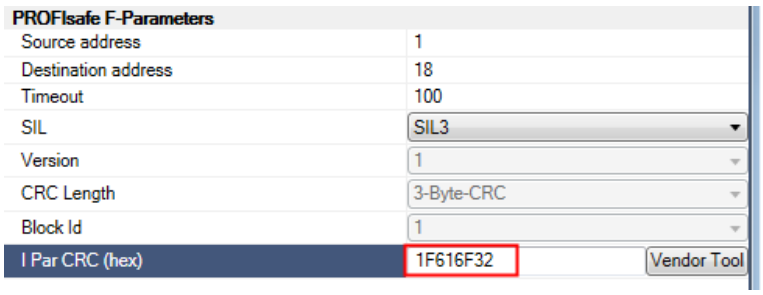
Call the “Vendor Tool” by clicking on the button right to the “I Par CRC” value.



“AC500-S F_iPar_CRC Calculator” tool is launched. Verify all entries, which are DI581-S parameters, in the “AC500-S F_iPar_CRC Calculator” tool and acknowledge them using the checkbox.



Copy the hexadecimal value of the I Par CRC (F_iPar_CRC) from the “AC500-S F_iPar_CRC Calculator” to the clipboard and paste it to the I Par CRC parameter field of the DI581-S safety I/O module in RobotStudio.



3.6.2 DI581-S signals

To add signals to the IRC5 robot controller using the safety I/O configurator in RobotStudio, enter the offset values for signal mapping of the DI581-S safety I/O channels. The tables in sections 3.6.2.1 and 3.6.2.2 show the offset values for the signal mappings of DI581-S safety I/O channels.

3.6.2.1 DI581-S input signal mapping

The offset values for the input signal mapping of the DI581-S safety I/O module:

Channel/Signal	Offset (Mapping)	Remark/Description
Safety digital inputs I0-I15	0-15	Group input (Word) – Safety digital inputs I0-I15
Safety digital input I0	0	Safety DI0. If used as a 2-channel configuration: value of the 2-channel evaluation (I0 and I8)
Safety digital input I1	1	Safety DI1. If used as a 2-channel configuration: value of the 2-channel evaluation (I1 and I9)
Safety digital input I2	2	Safety DI2. If used as a 2-channel configuration: value of the 2-channel evaluation (I2 and I10)
Safety digital input I3	3	Safety DI3. If used as a 2-channel configuration: value of the 2-channel evaluation (I3 and I11)
Safety digital input I4	4	Safety DI4. If used as a 2-channel configuration: value of the 2-channel evaluation (I4 and I12)
Safety digital input I5	5	Safety DI5. If used as a 2-channel configuration: value of the 2-channel evaluation (I5 and I13)
Safety digital input I6	6	Safety DI6. If used as a 2-channel configuration: value of the 2-channel evaluation (I6 and I14)
Safety digital input I7	7	Safety DI7. If used as a 2-channel configuration: value of the 2-channel evaluation (I7 and I15)
Safety digital input I8	8	Safety DI8. If used as a 2-channel configuration: value is always FALSE. See Safety DI0.
Safety digital input I9	9	Safety DI9. If used as a 2-channel configuration: value is always FALSE. See Safety DI1.
Safety digital input I10	10	Safety DI10. If used as a 2-channel configuration: value is always FALSE. See Safety DI2.
Safety digital input I11	11	Safety DI11. If used as a 2-channel configuration: value is always FALSE. See Safety DI3.
Safety digital input I12	12	Safety DI12. If used as a 2-channel configuration: value is always FALSE. See Safety DI4.
Safety digital input I13	13	Safety DI13. If used as a 2-channel configuration: value is always FALSE. See Safety DI5.
Safety digital input I14	14	Safety DI14. If used as a 2-channel configuration: value is always FALSE. See Safety DI6.
Safety digital input I15	15	Safety DI15. If used as a 2-channel configuration: value is always FALSE. See Safety DI7.
Safe diagnostic I0-I15	16-31	Group input (Word) – Safety input signals to indicate the usage of fail-safe values on safety DI channels
Safe_Diag – Input I0	16	Indication of fail-safe value used on Safety DI0
Safe_Diag – Input I1	17	Indication of fail-safe value used on Safety DI1

Channel/Signal	Offset (Mapping)	Remark/Description
Safe_Diag – Input I2	18	Indication of fail-safe value used on Safety DI2
Safe_Diag – Input I3	19	Indication of fail-safe value used on Safety DI3
Safe_Diag – Input I4	20	Indication of fail-safe value used on Safety DI4
Safe_Diag – Input I5	21	Indication of fail-safe value used on Safety DI5
Safe_Diag – Input I6	22	Indication of fail-safe value used on Safety DI6
Safe_Diag – Input I7	23	Indication of fail-safe value used on Safety DI7
Safe_Diag – Input I8	24	Indication of fail-safe value used on Safety DI8
Safe_Diag – Input I9	25	Indication of fail-safe value used on Safety DI9
Safe_Diag – Input I10	26	Indication of fail-safe value used on Safety DI10
Safe_Diag – Input I11	27	Indication of fail-safe value used on Safety DI11
Safe_Diag – Input I12	28	Indication of fail-safe value used on Safety DI12
Safe_Diag – Input I13	29	Indication of fail-safe value used on Safety DI13
Safe_Diag – Input I14	30	Indication of fail-safe value used on Safety DI14
Safe_Diag – Input I15	31	Indication of fail-safe value used on Safety DI15
Reintegration request I0-I15	32-47	Group input (Word) – Indication that safety input channels can be reintegrated to deliver safety process values instead of fail-safe “0” values
Rei_Req – Input I0	32	Safety DI0 channel can be reintegrated
Rei_Req – Input I1	33	Safety DI1 channel can be reintegrated
Rei_Req – Input I2	34	Safety DI2 channel can be reintegrated
Rei_Req – Input I3	35	Safety DI3 channel can be reintegrated
Rei_Req – Input I4	36	Safety DI4 channel can be reintegrated
Rei_Req – Input I5	37	Safety DI5 channel can be reintegrated
Rei_Req – Input I6	38	Safety DI6 channel can be reintegrated
Rei_Req – Input I7	39	Safety DI7 channel can be reintegrated
Rei_Req – Input I8	40	Safety DI8 channel can be reintegrated
Rei_Req – Input I9	41	Safety DI9 channel can be reintegrated
Rei_Req – Input I10	42	Safety DI10 channel can be reintegrated
Rei_Req – Input I11	43	Safety DI11 channel can be reintegrated
Rei_Req – Input I12	44	Safety DI12 channel can be reintegrated
Rei_Req – Input I13	45	Safety DI13 channel can be reintegrated
Rei_Req – Input I14	46	Safety DI14 channel can be reintegrated
Rei_Req – Input I15	47	Safety DI15 channel can be reintegrated

Channel/Signal	Offset (Mapping)	Remark/Description
PROFIsafe Protocol inputs – Byte 0	48-55	Group input – only for internal use
PROFIsafe Protocol inputs – Byte 1	56-63	Group input – only for internal use
PROFIsafe Protocol inputs – Byte 2	64-71	Group input – only for internal use
PROFIsafe Protocol inputs – Byte 3	72-79	Group input – only for internal use

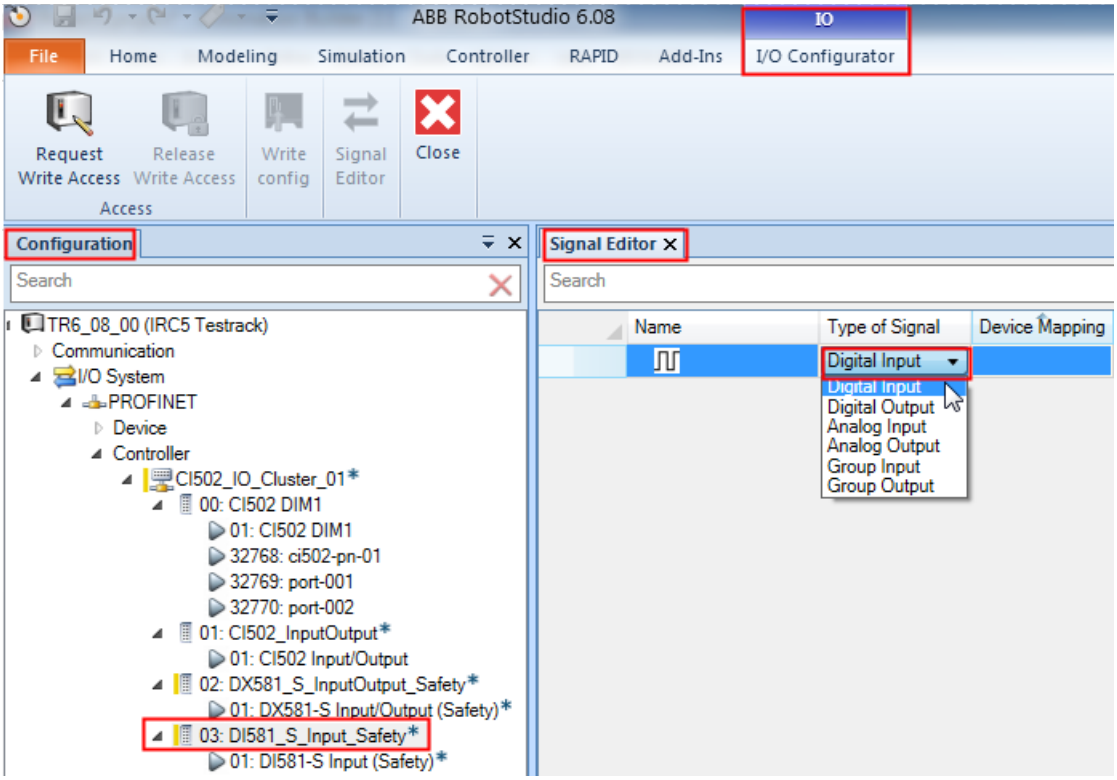
3.6.2.2 DI581-S output signal mapping

The offset values for the output signal mapping of the DI581-S safety I/O module:

Channel/Signal	Offset (Mapping)	Remark/Description
Acknowledge reintegration I0-I15	0-15	Group output (Word) – Safety outputs to reintegrate safety digital inputs I0-I17
Ack_Rei – Input I0	0	Output to reintegrate safety DI0
Ack_Rei – Input I1	1	Output to reintegrate safety DI1
Ack_Rei – Input I2	2	Output to reintegrate safety DI2
Ack_Rei – Input I3	3	Output to reintegrate safety DI3
Ack_Rei – Input I4	4	Output to reintegrate safety DI4
Ack_Rei – Input I5	5	Output to reintegrate safety DI5
Ack_Rei – Input I6	6	Output to reintegrate safety DI6
Ack_Rei – Input I7	7	Output to reintegrate safety DI7
Ack_Rei – Input I8	8	Output to reintegrate safety DI8
Ack_Rei – Input I9	9	Output to reintegrate safety DI9
Ack_Rei – Input I10	10	Output to reintegrate safety DI10
Ack_Rei – Input I11	11	Output to reintegrate safety DI11
Ack_Rei – Input I12	12	Output to reintegrate safety DI12
Ack_Rei – Input I13	13	Output to reintegrate safety DI13
Ack_Rei – Input I14	14	Output to reintegrate safety DI14
Ack_Rei – Input I15	15	Output to reintegrate safety DI15
PROFIsafe Protocol outputs – Byte 0	16-23	Group output – only for internal use
PROFIsafe Protocol outputs – Byte 1	24-31	Group output – only for internal use
PROFIsafe Protocol outputs – Byte 2	32-39	Group output – only for internal use
PROFIsafe Protocol outputs – Byte 3	40-47	Group output – only for internal use

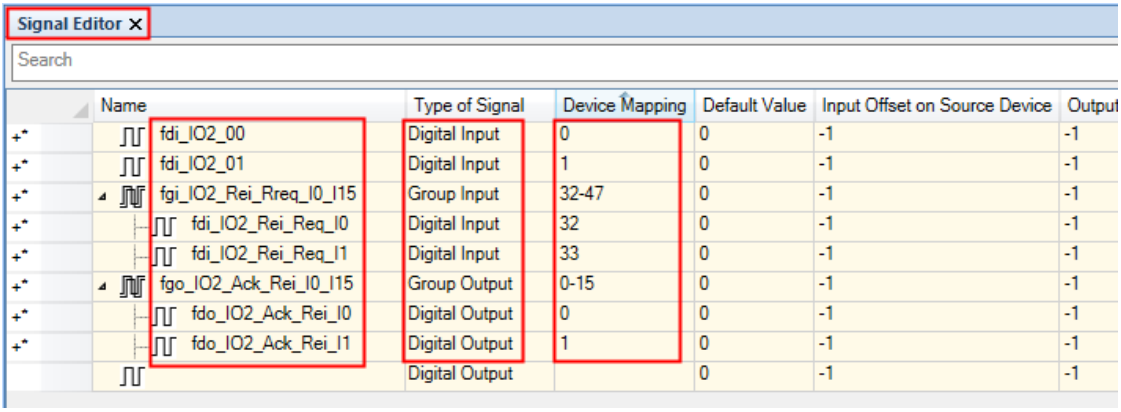
To use the safety signals of the DI581-S safety I/O module in the IRC5 safety control program, assign symbolic names to them.

Select the “DI581_S_Input_Safety” in the “Configuration” tab and add new signals by changing the “Type of Signal”, for example, to “Digital Input” in the “Signal Editor” tab.



Enter a signal name in the “Name” field and configure the “Device Mapping” using the offset values listed in Sections 3.6.2.1 and 3.6.2.2.

Press “Enter” to insert a new line for the next signal to fill the list of safety signals for the DI581-S safety I/O module. For example, you can create a list of signals as shown below.



Name	Type of Signal	Device Mapping	Default Value	Input Offset on Source Device	Output
fdi_IO2_00	Digital Input	0	0	-1	-1
fdi_IO2_01	Digital Input	1	0	-1	-1
fgi_IO2_Rei_Rreq_I0_I15	Group Input	32-47	0	-1	-1
fdi_IO2_Rei_Req_I0	Digital Input	32	0	-1	-1
fdi_IO2_Rei_Req_I1	Digital Input	33	0	-1	-1
fgo_IO2_Ack_Rei_I0_I15	Group Output	0-15	0	-1	-1
fdo_IO2_Ack_Rei_I0	Digital Output	0	0	-1	-1
fdo_IO2_Ack_Rei_I1	Digital Output	1	0	-1	-1
	Digital Output		0	-1	-1

3.7 Reintegration of safety I/O channels

If the safety channels of DX581-S and/or DI581-S safety I/O modules get passivated, for example, due to wiring errors such as a short circuit to +24V DC, a discrepancy time error, and so on, there are two ways to reintegrate safety channels after the causes of the errors are remedied (that is, the cause of the passivation is no longer present):

1. Power cycle the CI502 module off and then on with the DX581-S and/or DI581-S safety I/O modules (refer to the UP terminals on the modules).

   After power off/on cycle safety I/O modules are passivated and have to be reintegrated using either restart of IRC5 robot controller or use the “F-Host Op. Ack” button (Login as “Safety User” on FlexPendant and select “Control Panel” → “Safety Controller” → “Configuration”) on the FlexPendant.

2. Use safety “Post-Logic” procedures, which have to be programmed for the IRC5 safety controller, and the “Acknowledge reintegration” signals from DI581-S and/or DX581-S, respectively, to reintegrate the module channels. This avoids unnecessary downtime due to power cycling.

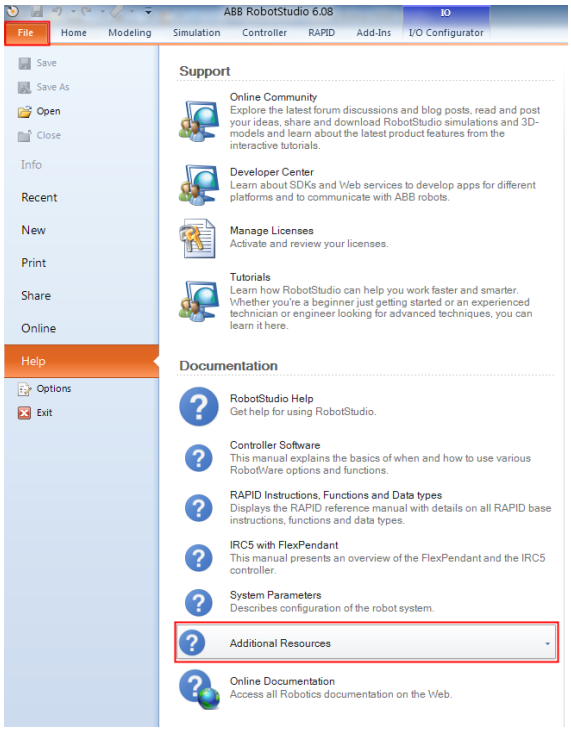
The channel passivation of DI581-S and DX581-S safety I/O modules can be detected by monitoring “Safe diagnostic” input signals in the IRC5 safety controller program. If the cause for the channel passivation is no longer present, the “Reintegration request” input signal of the given channel is set to TRUE. The acknowledgement can be performed in the IRC5 robot controller application by setting the “Acknowledge reintegration” output signal of the given channel to TRUE and later to FALSE (using the rising edge scenario). If “Group inputs” (Bytes/Words) and “Group outputs” (Bytes/Words) are used for the DI581-S and DX581-S safety I/O module channels, all channels of the given safety I/O module can be simultaneously reintegrated.

For more information on DI581-S and DX581-S safety I/O module passivation and reintegration, refer to [2].

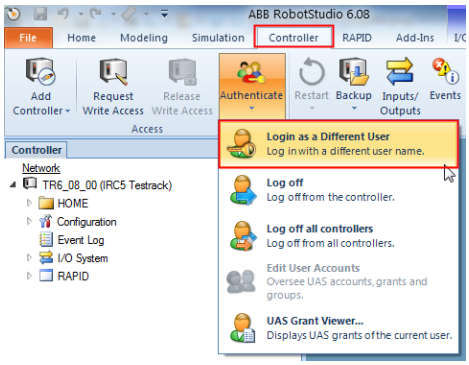
3.8 SafeMove2 configuration

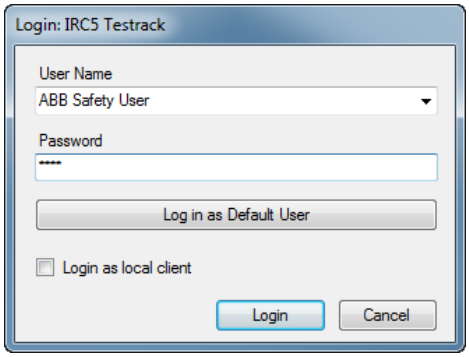
After the configuration of the CI502 module and S500 safety I/O modules as well as signals in the RobotStudio “IO configurator”, you can use the safety signals in the “Visual SafeMove” editor of the RobotStudio.

For a detailed description of how to use the “SafeMove” editor, refer to [4], which can be called, for example, from RobotStudio, as shown below.

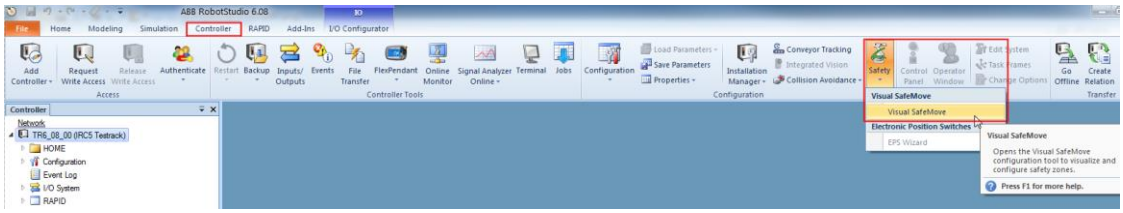


To use the CI502 and safety I/O signals, you have to open the “Visual SafeMove” editor, navigate to “Controller” tab and login as a “Safety User” first:

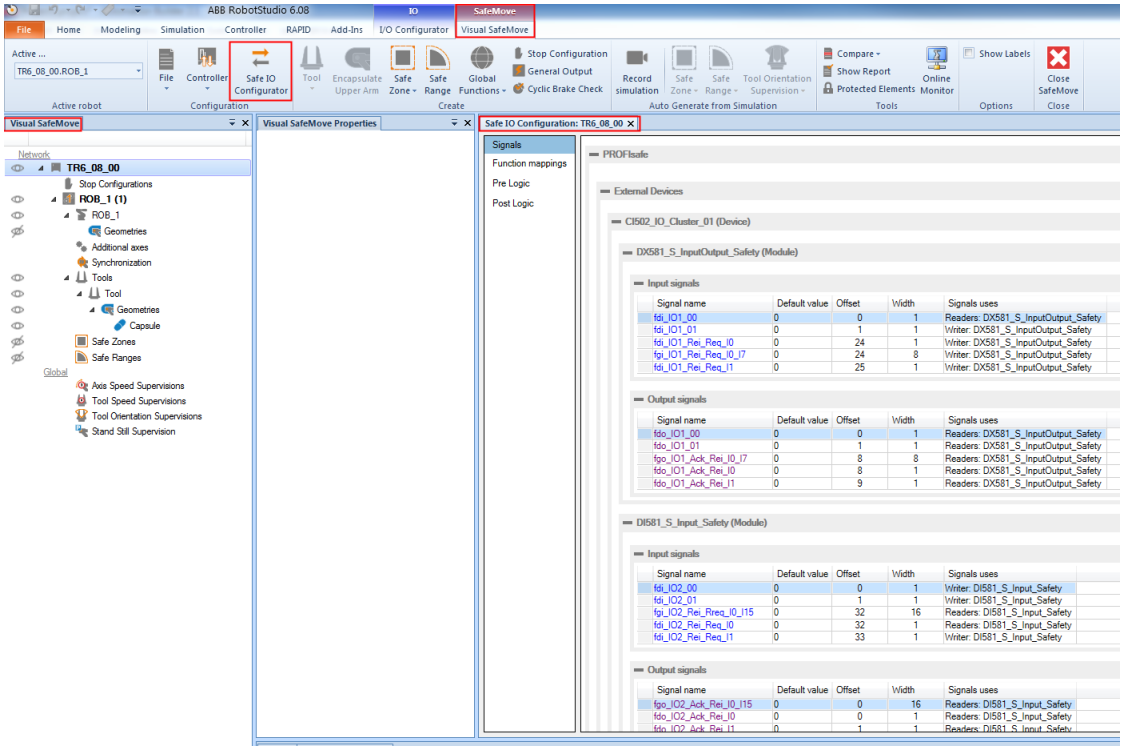




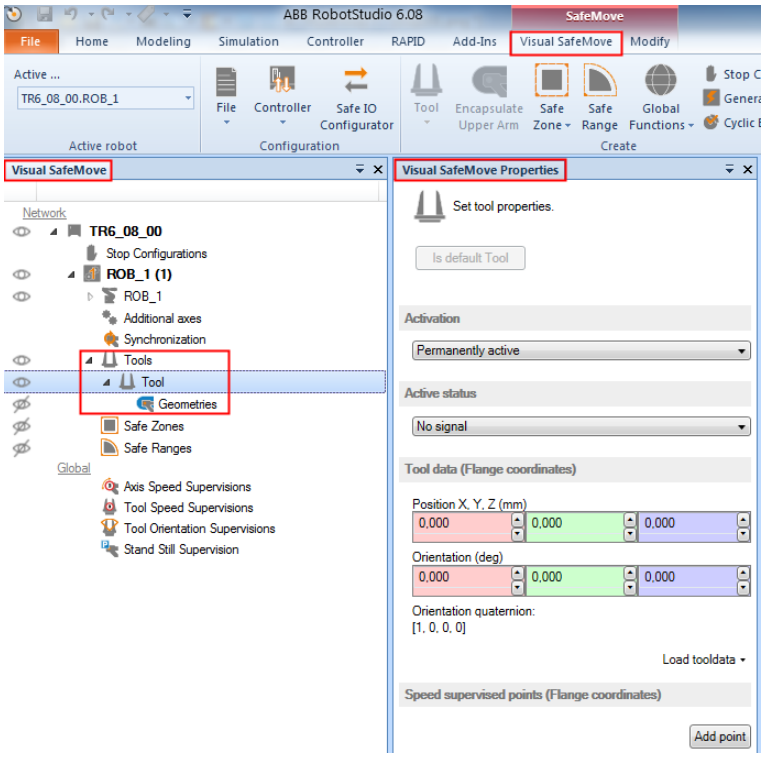
After this, open the “Visual SafeMove” editor using “Safety” → “Visual SafeMove”:



The defined safety signals from the DX581-S and DI581-S safety I/O modules on the CI502 module become available and you can use them to configure the safety functions of the robot application, as shown below.



At least one robot tool must be configured in Visual SafeMove, to be able to download the configuration.

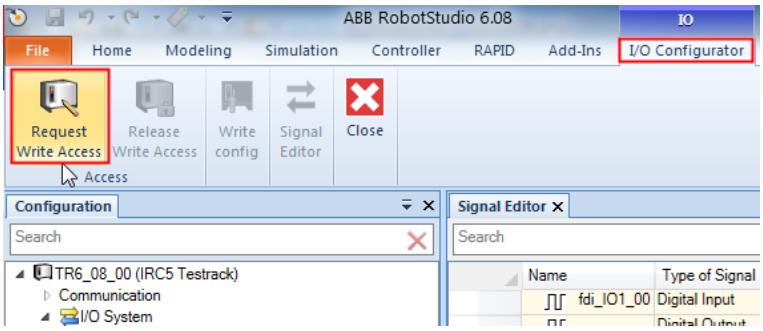


3.9 Downloading the configuration to IRC5

The configuration created in RobotStudio has to be downloaded to the IRC5 controller.

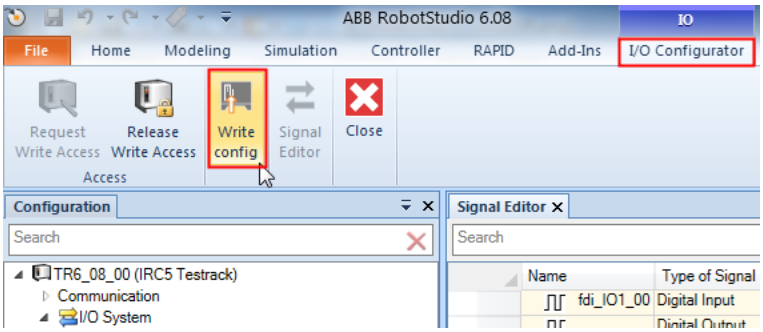
To download the configuration:

1. Set the IRC5 controller to the “Manual mode”.
2. Log in as a “Safety User”.
3. Request Write Access.

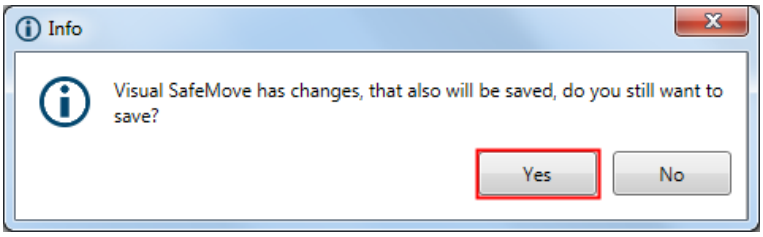


The request needs to be granted on the FlexPendant.

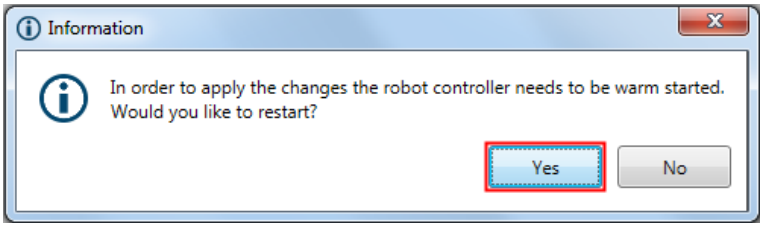
4. Write the configuration to the IRC5 robot controller.



5. Answer “Yes” to the following question:



6. Answer “Yes” to the following question:



The IRC5 robot controller starts again.

7. Make a backup of the changed system for later use, if required.

4 Summary

This application note provided details on the configuration of ABB S500 safety I/O modules connected to an IRC5 controller via PROFINET using the IRC5 “Prepared for ABB CI502” option. For related information, such as checklists for the ABB S500 safety I/O module and IRC5 safety controller commissioning, safety function response time calculation, safety values, and so on, refer to [2] and [4].

REVISION HISTORY

Rev.	Description of version / Changes	Date / Who
A	First release	2019-02-22 / ABB

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ABB Automation Products GmbH
Eppelheimer Straße 82
69123 Heidelberg, Germany
Phone: +49 62 21 701 1444
Fax : +49 62 21 701 1382
E-Mail: plc.support@de.abb.com
www.abb.com/plc