KUKA

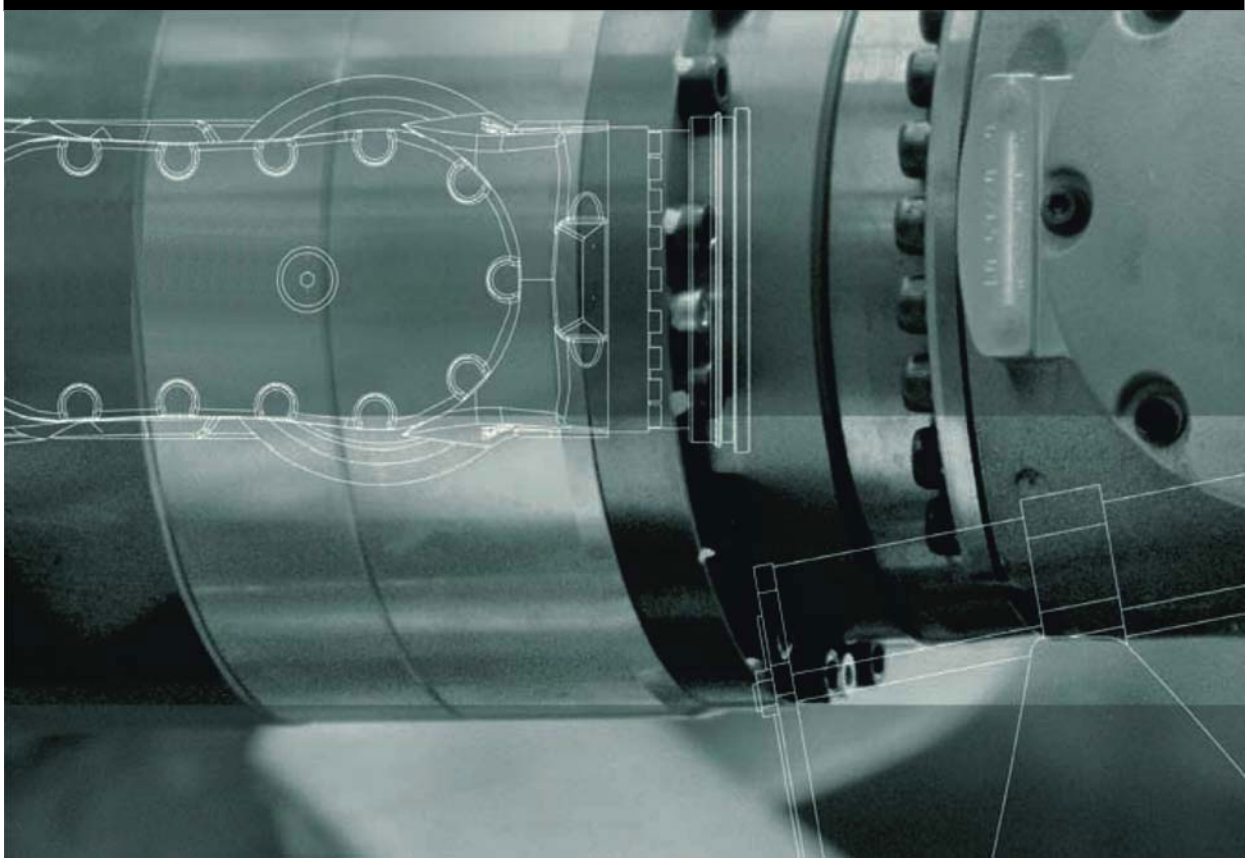
Controller Option

KUKA Roboter GmbH

KUKA.ProfiNet Controller/Device 3.1
KUKA.ProfiNet Device 3.1

For KUKA System Software 8.3

For VW System Software 8.3



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Other functions not described in this documentation may be operable in the controller. The user has no claims to these functions, however, in the case of a replacement or service work.

We have checked the content of this documentation for conformity with the hardware and software described. Nevertheless, discrepancies cannot be precluded, for which reason we are not able to guarantee total conformity. The information in this documentation is checked on a regular basis, however, and necessary corrections will be incorporated in the subsequent edition.

Subject to technical alterations without an effect on the function.

Translation of the original documentation

KIM-PS5-DOC

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Contents

1 Introduction

1.1 Target group

This documentation is aimed at users with the following knowledge and skills:

- Advanced KRL programming skills
- Advanced knowledge of the robot controller system
- Advanced knowledge of field buses
- Knowledge of WorkVisual
- Knowledge of the software Step 7 from Siemens or PC WORX from Phoenix Contact

1.2 Industrial robot documentation

The industrial robot documentation consists of the following parts:

- Documentation for the manipulator
- Documentation for the robot controller
- Operating and programming instructions for the control software
- Instructions for options and accessories
- Parts catalog on storage medium

Each of these sets of instructions is a separate document.

1.3 Representation of warnings and notes

Safety

These warnings are relevant to safety and **must** be observed.

⚠ DANGER	These warnings mean that it is certain or highly probable that death or severe injuries **will** occur, if no precautions are taken.
⚠ WARNING	These warnings mean that death or severe injuries **may** occur, if no precautions are taken.
⚠ CAUTION	These warnings mean that minor injuries **may** occur, if no precautions are taken.
NOTICE	These warnings mean that damage to property **may** occur, if no precautions are taken.
⚠	These warnings contain references to safety-relevant information or general safety measures. These warnings do not refer to individual hazards or individual precautionary measures.

This warning draws attention to procedures which serve to prevent or remedy emergencies or malfunctions:

SAFETY INSTRUCTIONS	Procedures marked with this warning **must** be followed exactly.

Notes

These hints serve to make your work easier or contain references to further information.

Tip to make your work easier or reference to further information.

1.4 Trademarks

Windows is a trademark of Microsoft Corporation.

Step 7 is a trademark of Siemens AG.

PC WORX is a trademark of Phoenix Contact.

1.5 Terms used

Term	Description
GSDML	Device description file for PROFINET
Industrial Ethernet	Ethernet is a data network technology for local area networks (LANs). It allows data to be exchanged between the connected devices in the form of data frames.
PC WORX	Configuration software from Phoenix Contact
PLC	Programmable Logic Controller
Step 7	Configuration software from Siemens
IRT	Isochronous Real Time Cycle-synchronous communication
CBA	Component Based Automation Component-based automation
Subnet	Subnetwork in the Internet Protocol (IP)
Subnet mask	Defines which IP addresses a device looks for in its own network and which addresses can be reached in other networks.
Controller	Higher-level controller that controls all the components of a system.
Device	Field device subordinated to a controller.
PROFIsafe	PROFIsafe is a PROFINET-based safe interface for connecting a safety PLC to the robot controller. (PLC = master, robot controller = slave)
CSP	Controller System Panel. Display element and connection point for USB and network
SIB	Safety Interface Board

2 Product description

2.1 Overview of PROFINET

PROFINET is an Ethernet-based field bus. Data exchange is carried out on a client-server basis.

PROFINET is installed on the robot controller.

Compatibility

KUKA.ProfiNet 3.1 is compatible with the following field buses:

- KR C4 PROFIBUS
- KR C4 PROFIBUS CP 5614 2.0
- KR C4 Interbus 2.0
- KR C4 EtherCAT

Limitations

Only PROFINET IO Class A, Fast Startup, PROFIsafe Device and PROFIenergy are supported.

The following device classes/functions are not supported, for example:

- PROFINET IO Class B
- PROFINET IO Class C (includes the function IRT)
- PROFINET CBA
- PROFIsafe Controller
- Profiles, e.g. PROFIdrive
- Gateway devices (for converting PROFIBUS to other field buses)

Configuration software

PROFINET is configured on a laptop or PC. The following software is required for configuration:

- WorkVisual 3.0 or higher
- Depending on the selected procedure, additional configuration software may be required:
  - Step 7 from Siemens
  - Or PC WORX from Phoenix Contact

For configuration of a higher-level controller, the corresponding configuration software from the manufacturer is also required, e.g. Step 7 from Siemens.

Device types

The following device types are used with PROFINET:

- Controller: A higher-level controller that controls all the components of a system.
- Device: A field device subordinated to a controller. A device consists of a number of modules and submodules.
- Supervisor: Can be a programming device or industrial PC. Parallel to the controller, this has access to all process and parameter files.

The 3 device types have relationships for transferring configuration data and process data.

A physical device, e.g. the robot controller, can be a controller and/or a device. The configuration of communication relationships is carried out solely in the controller.

PROFIenergy

PROFIenergy enables control of the energy consumption via a PROFINET network. For this, commands are used by means of which the energy-consuming devices react to planned and unplanned interruptions.

The PROFINET device supports PROFIenergy. If PROFIenergy is used, the robot controller comunicates with the higher-level controller via the PROFIenergy protocol.

3 Safety

This documentation contains safety instructions which refer specifically to the product described here. The fundamental safety information for the industrial robot can be found in the “Safety” chapter of the operating or assembly instructions for the robot controller.

⚠ WARNING The “Safety” chapter in the operating instructions or assembly instructions of the robot controller must be observed. Death to persons, severe injuries or considerable damage to property may otherwise result.

4 Installation

4.1 System requirements

Robot controller

Hardware:

- KR C4
- Or KR C4 compact

Software:

- KUKA System Software 8.3.2 or higher
- Or VW System Software 8.2.17 or higher

Laptop/PC

Software:

- WorkVisual 3.0 or higher

  The requirements for installation of WorkVisual are contained in the WorkVisual documentation.
- Step 7 or PC WORX (optional)

  The requirements for installation of Step 7 or PC WORX are contained in the documentation for this software.

4.2 Routing the data cables

- The Industrial Ethernet cables are routed to the devices from the controller or from the switch using a star or ring topology.

4.3 Installing or updating PROFINET (KSS)

Description

There are 2 option CDs for PROFINET:

- **KUKA.ProfiNet Controller / Device 3.1**: Includes **Profinet Controller**, **Profinet Device** and **Profisafe Device**.
- **KUKA.ProfiNet Device 3.1**: Includes **Profinet Device** and **Profisafe Device**.

The option CDs must not be installed at the same time, otherwise malfunctions may result.

On updating PROFINET, the existing configuration is automatically adopted. If this is not desired, the existing version must first be uninstalled.

It is advisable to archive all relevant data before updating a software package.

Preparation

- Copy software from CD to KUKA USB stick.

  Copy the software onto the stick with the file Setup.exe at the highest level (i.e. not in a folder).

NOTICE Recommendation: Use a KUKA stick. Data may be lost if any other stick is used.

Precondition

- “Expert” user group

Procedure

1. Connect the USB stick to the robot controller or smartPAD.

2. In the main menu, select **Start-up** > **Additional software**.
3. Press **New software**. The entry **Profinet KRC-Nexxt** or **Profinet ProfiSafe Device** must be displayed in the **Name** column and drive **E:** or **K:** in the **Path** column.

   If not, press **Refresh**.
4. If the specified entries are now displayed, continue with step 5.

   If not, the drive from which the software is being installed must be configured first:
   - Press the **Configuration** button. A new window opens.
   - Select a line in the **Installation paths for options** area.

     Note: If the line already contains a path, this path will be overwritten.
   - Press **Path selection**. The available drives are displayed.
   - Select **E:**. (If stick connected to the robot controller.)

     Or select **K:**. (If stick connected to the smartPAD.)
   - Press **Save**. The window closes again.

   The drive only needs to be configured once and then remains saved for further installations.
5. Select the entry **Profinet KRC-Nexxt** or **Profinet ProfiSafe Device** and press **Install**. Answer the request for confirmation with **Yes**.
6. Confirm the reboot prompt with **OK**.
7. Remove the stick.
8. Reboot the robot controller.

LOG file A LOG file is created under C:\KRC\ROBOTER\LOG.

4.4 Installing PROFINET (VSS)

PROFINET is included in VSS 8.3. It includes **Profinet Controller**, **Profinet Device** and **Profisafe Device**.

To install PROFINET, the relevant check box must be activated during the set-up for VSS 8.3.

4.5 Uninstalling PROFINET (KSS)

It is advisable to archive all relevant data before uninstalling a software package.

Precondition
- “Expert” user group

Procedure
1. In the main menu, select **Start-up** > **Additional software**.
2. Select the entry **Profinet KRC-Nexxt** or **Profinet ProfiSafe Device** and press **Uninstall**. Reply to the request for confirmation with **Yes**. Uninstallation is prepared.
3. Reboot the robot controller. Uninstallation is resumed and completed.

LOG file A LOG file is created under C:\KRC\ROBOTER\LOG.

5 Configuration

5.1 Overview

Step	Description
1	Configure the higher-level controller with Step 7. **Note:** This step only needs to be carried out if a higher-level controller is being used.
2	Make GSDML files available. ■ For configuration with WorkVisual (>>> 5.2 "Making GSDML files available for configuration with WorkVisual" Page 13) ■ For configuration with Step 7 or PC WORX (>>> 5.3 "Making GSDML files available for configuration with Step 7 / PC WORX" Page 14)
3	Name the devices. (>>> 5.4 "Naming the device" Page 14)
4	Configure PROFINET. ■ Configure the bus with WorkVisual. (>>> 5.5 "Configuring the bus with WorkVisual" Page 16) ■ Or: Configure the bus with Step 7 or PC WORX. (>>> 5.6 "Configuring the bus with Step 7 or PC WORX" Page 29)
5	Map the inputs and outputs in WorkVisual. (>>> 5.7 "PROFIBUS signal names in WorkVisual" Page 30)
6	Transfer the bus configuration from WorkVisual to the robot controller.
7	Reboot the robot controller. **Note:** If a change has been made in the **Profinet version:** box on the **Communication settings** tab, the robot controller must be rebooted with the following settings: ■ With a cold start ■ With the option **Reload files**
8	Safety interface via PROFIsafe (optional) (>>> 5.8 "Safety interface via PROFIsafe (optional)" Page 31)

Information about procedures in WorkVisual is contained in the WorkVisual documentation. Information about procedures in Step 7 or PC WORX can be found in the documentation for this software.

5.2 Making GSDML files available for configuration with WorkVisual

If the robot controller is the controller and a different device is to be added as the device, WorkVisual requires the GSDML file of this device for the configuration. The GSDML file must be obtained from the manufacturer of the device.

Precondition

- There is no project open.

Procedure

1. Select the menu sequence **File** > **Import / Export**.

The **Import/Export Wizard** window is opened.

2. Select **Import device description file** and click on **Next >**.
3. Click on **Browse…** and specify a directory.
4. Confirm with **Next >**.
   A list is displayed of the devices that are to be imported.
5. Click on **Finish**.
   The devices are imported.
6. Close the **Import/Export Wizard** window.

5.3 Making GSDML files available for configuration with Step 7 / PC WORX

Description

If a KUKA robot controller is added as a device in Step 7 or PC WORX, this software requires the GSDML file for the KUKA robot controller. A distinction must be made between whether the robot controller is running KSS 8.3 or VSS 8.3.

Procedure

1. Copy the GSDML file of the KUKA robot controller.
   The file can be found on the WorkVisual CD-ROM, in the following directory: DeviceDescriptions\GSDML
   - For KSS 8.3: […]**KUKA-Roboter-GmbH-KR C4-Device**[…]
   - For VSS 8.3: […]**KUKA-Roboter-GmbH-VKR C4-Device**[…]
2. Insert the file in Step 7 or PC WORX.
   If, until now, a file for KSS 8.1 or VSS 8.1 has been used, it is not necessary to delete it.

Depending on whether a device description file for KSS/VSS 8.1, 8.2 or 8.3 has been used for configuration of the higher-level controller, the setting that has to be selected in the **Profinet version** box on the **Communication settings** tab in WorkVisual varies:

- KSS/VSS 8.1: **v8.1**
- KSS/VSS 8.2: **v8.2**
- KSS/VSS 8.3: **v8.3 or higher**

(>>> 5.5.1.1 "“Communication settings” tab" Page 17)

5.4 Naming the device

Description

A PROFINET device is delivered without a name. In order to be able to use the device, it must first be assigned a unique name. This procedure is referred to as “Device naming”.

It is advisable to assign a logical name to the device. For example, if the device belongs to a certain tool, this should be obvious from the name.

The assigned device name must conform to the naming convention for PROFINET devices:

- Length of name: 1 … 240 characters
- The name must consist of at least 1 label.
- Labels are separated from each other by means of the symbol “.”.
- Length of a label: 1 … 63 characters
- A label can consist of letters (a-z), numbers (0-9) and the symbol “-”.
- A label must not begin or end with the symbol “-”.
- The 1st label must not start with the character string “port-xyz-” or “port-xyz-abcde” (a, b, c, d, e, x, y, z = 0 … 9).
- The name must not have the form “n.n.n.n” (n = 0 … 999).

As an alternative to the procedure in WorkVisual, the device can be renamed in Step 7 or any other software with a device naming function.

NOTICE The following address ranges are used by default by the robot controller for internal purposes. IP addresses from this range must not therefore by assigned when naming the device.
This applies to naming of the device with WorkVisual or any other software.

- 192.168.0.0 … 192.168.0.255
- 172.16.0.0 … 172.16.255.255
- 172.17.0.0 … 172.17.255.255

Precondition

- A robot controller has been added and set as active.
- The device is not in cyclical communication with a controller.

Procedure

1. Expand the tree structure of the robot controller on the **Hardware** tab in the **Project structure** window.
2. Right-click on **Bus structure** and select **Add…** from the context menu.
3. A window opens. Select the entry **PROFINET** in the **Name** column and confirm with **OK**. The entry is inserted in the tree structure.
4. Right-click on **PROFINET** in the tree structure and select **Settings** from the context menu.
5. A window opens. Select the **Communication settings** tab.
   (>>> 5.5.1.1 ""Communication settings" tab" Page 17)
6. Select the network adapter and confirm with **OK**.
7. Right-click on **PROFINET** and select **Connect** from the context menu.
8. Right-click on **PROFINET** and select **Functions** > **Device list and PROFINET names...** from the context menu.
   A window opens. The **Available devices** tab is displayed.
9. Double-click on the name of the desired device and change the name.
10. If required: Assign an IP address to the device.
    The device will subsequently be assigned an IP address by the robot controller. This will cause the address assigned here to be overwritten. It may nonetheless be useful to assign the device an address here, e.g. for diagnostic purposes, as it is not otherwise possible to communicate with the device.
11. Save the changes with **Name devices**.

5.4.1 Identifying the device

Precondition

- A robot controller has been added and set as active.
- The **PROFINET** node is inserted into the bus structure and linked.

Procedure

1. Expand the tree structure of the robot controller on the **Hardware** tab in the **Project structure** window.
2. Right-click on **PROFINET** and select **Functions** > **Device list and PROFINET names...** from the context menu.
   A window opens. The **Available devices** tab is displayed.
3. Select the desired device and click on **Signal**.
   One or more LEDs on the device flashes. A description of which LEDs flash can be found in the device manufacturer documentation.

In the case of the robot controller, LEDs 4 to 6 on the CSP flash. LED 1 is lit up permanently.

4. To stop the flashing, click on **Stop signaling**.

5.4.2 Resetting the device configuration to factory settings

Precondition

- A robot controller has been added and set as active.
- The **PROFINET** node is inserted into the bus structure and linked.

Procedure

1. Expand the tree structure of the robot controller on the **Hardware** tab in the **Project structure** window.
2. Right-click on **PROFINET** and select **Functions** > **Device list and PROFINET names** from the context menu.
   A window opens. The **Available devices** tab is displayed.
3. Select the desired device and click on **Reset**.
4. Answer the request for confirmation with **Yes**.
   The configuration of the device is reset to the factory settings.

5.5 Configuring the bus with WorkVisual

5.5.1 Configuring a PROFINET device

Precondition

- A robot controller has been added and set as active.
- The **PROFINET** node is inserted into the bus structure.

Procedure

1. Expand the tree structure of the robot controller on the **Hardware** tab in the **Project structure** window.
2. Right-click on **PROFINET** in the tree structure and select **Settings** from the context menu.
3. A window opens. Select the **Communication settings** tab.
   (>>> 5.5.1.1 ""Communication settings" tab" Page 17)
4. Activate the check box **Activate PROFINET device stack**.
5. Fill out the following boxes:
   - **Device name**; **Number of safe I/Os**; **Number of I/Os**; **Profinet version**; **Display diagnostic alarm as message**; **Transmit device alarms to PLC**
6. Save the setting with **Apply**.
7. Select the **Device Diagnostic** tab.
   (>>> 5.5.1.2 ""Device Diagnostic" tab" Page 18)
8. If, in the case of a bus error, a maintenance request, a need for maintenance or a diagnostic alarm, a status bit is to be sent to the PLC, activate the **Use status bit** check box in the corresponding range and enter the bit number.
9. If PROFIenergy is to be used: Activate the **Enable PROFIenergy** check box on the **PROFIenergy** tab and fill out the following boxes for the "Hibernate","Drive bus OFF" and "Brakes applied" states:
   - **Time to pause**; **Time min length of stay**; **Time to operate**

   (>>> 5.5.1.3 ""PROFIenergy" tab" Page 20)
10. Save the settings by selecting **OK**.

5.5.1.1 “Communication settings” tab

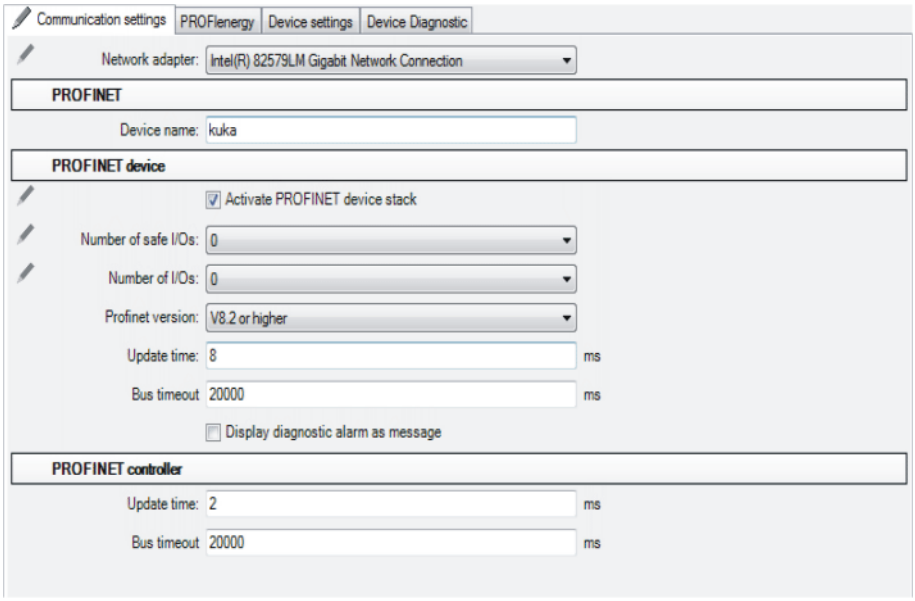

Fig. 5-1: “Communication settings” tab

Box	Description
Network adapter:	Select the network adapter used.
PROFINET	
Device name:	Enter the name of the device.
PROFINET device	
Activate PROFINET device stack	■ **Activated:** PROFINET is used as device. ■ **Deactivated:** PROFINET is used as controller.
Number of safe I/Os:	Select the number of safe inputs and outputs that the device has. ■ **0**: The safety interface via SIB is used. ■ **64**:The safety interface via PROFIsafe is used.
Number of I/Os:	Select the number of non-safe inputs and outputs that the device has.
Profinet version:	Select the version of the GSDML file that is used in the PLC project.
Bus cycle time	Enter the cycle time. Cycle time: The I/O data of the devices are updated in the robot controller memory every *x* ms. **Note**: The lower the value for the bus cycle time, the greater the CPU utilization. The PROFINET reaction time is the sum of the bus cycle time and the update time. This calculation does not take into account the reaction times of the applications which need these data (e.g. submit interpreter).

Box	Description
Bus timeout	If the robot controller cannot establish the connection to the PLC within this time, it generates an error message. (If the connection is then established subsequently, the message changes to an acknowledgement message.) Unit: ms
Display diagnostic alarm as message	■ **Activated:** Diagnostic messages are displayed in the message window of the KUKA smartHMI. ■ **Deactivated:** No diagnostic messages are displayed in the message window of the KUKA smartHMI.
Transmit device alarms to PLC	■ **Activated:** If a device signals an alarm to the robot controller, the robot controller informs the PLC that a device has sent an alarm. The PLC can read the IP address and the PROFINET name of the device in an acyclic mode. For this purpose, the PLC must use the corresponding diagnostic address of the robot controller. ■ **Deactivated:** The robot controller does not inform the PLC when a device sends an alarm. **Note:** Further information can be found in the PROFINET specification.
PROFINET controller	
Bus cycle time	Enter the cycle time. Cycle time: The I/O data of the PROFINET device are updated in the PLC memory every *x* ms. **Note**: The lower the value for the bus cycle time, the greater the CPU utilization. The PROFINET reaction time is the sum of the bus cycle time and the update time. This calculation does not take into account the reaction times of the applications which need these data (e.g. submit interpreter).
Bus timeout	If the robot controller cannot establish the connection to the device within this time, it generates an error message. (If the connection is then established subsequently, the message changes to an acknowledgement message.) Unit: ms

5.5.1.2 “Device Diagnostic” tab

The forwarding of messages from PROFINET devices to the higher-level controller can be activated on this tab. The messages are collected and forwarded to the device part of the robot controller. The availability of the messages depends on the specific device.

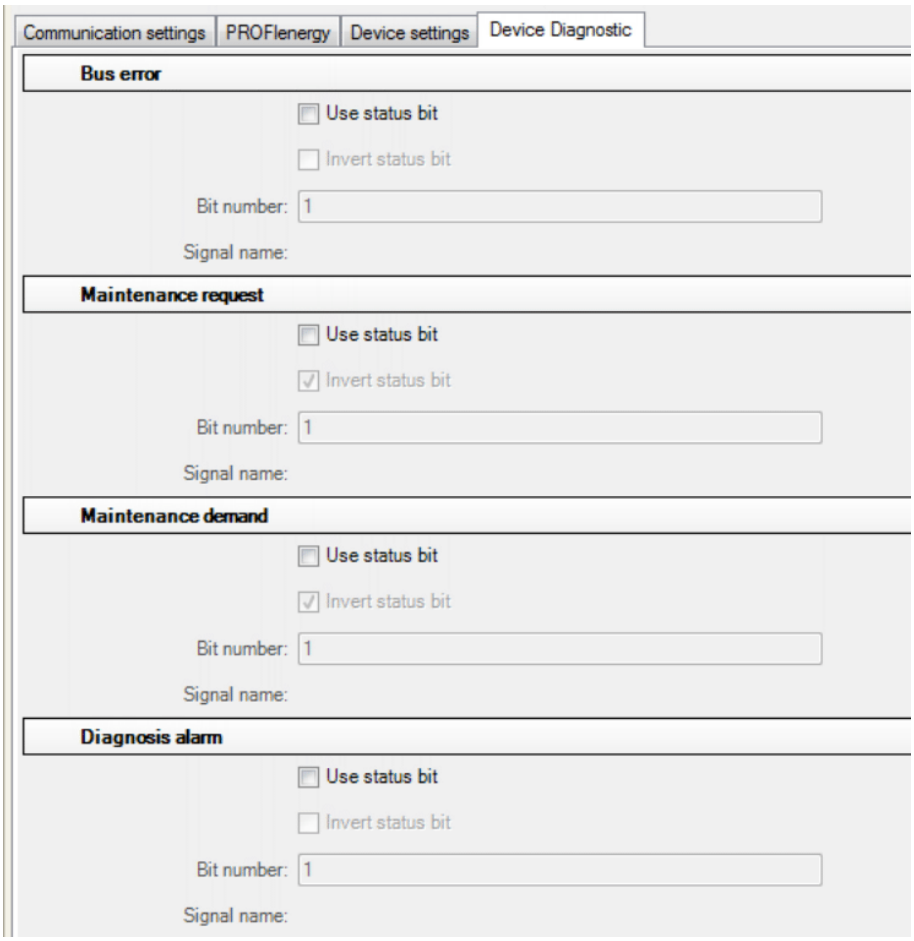

Fig. 5-2: "Device Diagnostic" tab

Box	Description
Bus error	
Use status bit	■ **Activated:** In the case of a bus error, a status bit is sent to the PLC. ■ **Deactivated:** No status bit is sent to the PLC.
Invert status bit	■ **Activated:** In the case of a bus error, the status bit is inverted and sent to the PLC. ■ **Deactivated:** The status bit is not inverted.
Bit number:	Enter the number of the status bit in the address range of the PLC. ■ **1 ... Number of device I/Os** **Note**: The bit number must differ from the bit numbers of the other diagnostic bits.
Signal name:	The signal name depends on the entered bit number.
Maintenance request	
Use status bit	■ **Activated:** If maintenance is to be carried out on the device, a status bit is sent to the PLC. It is not necessary for the maintenance to be carried out immediately; the wear limit has not yet been reached. ■ **Deactivated:** No status bit is sent to the PLC.

Box	Description
Invert status bit	■ **Activated:** If maintenance is to be carried out on the device, the status bit is inverted and sent to the PLC. ■ **Deactivated:** The status bit is not inverted.
Bit number	Enter the number of the status bit in the address range of the PLC. ■ **1 ... Number of device I/Os**
Signal name:	The signal name depends on the entered bit number.
Maintenance demand	
Use status bit	■ **Activated:** If maintenance must be carried out on the device, a status bit is sent to the PLC. The maintenance must be carried out immediately; the wear limit has been reached. ■ **Deactivated:** No status bit is sent to the PLC.
Invert status bit	■ **Activated:** If maintenance must be carried out on the device, the status bit is inverted and sent to the PLC. ■ **Deactivated:** The status bit is not inverted.
Bit number	Enter the number of the status bit in the address range of the PLC. ■ **1 ... Number of device I/Os**
Signal name:	The signal name depends on the entered bit number.
Diagnosis alarm	
Use status bit	■ **Activated:** If a diagnostic alarm is active for a device, a status bit is sent to the PLC. ■ **Deactivated:** No status bit is sent to the PLC.
Invert status bit	■ **Activated:** If a diagnostic alarm is active for a device, the status bit is inverted and sent to the PLC. ■ **Deactivated:** The status bit is not inverted.
Bit number:	Enter the number of the status bit in the address range of the PLC. ■ **1 ... Number of device I/Os** **Note**: The bit number must differ from the bit numbers of the other diagnostic bits.
Signal name:	The signal name depends on the entered bit number.

If, in the case of **Maintenance request** or **Maintenance demand**, the same bit number is entered, these are linked by a logic OR operation. In this case, both must be either inverted or not inverted.

The current status of a status bit can be found in the diagnostic data (>>> 8.1 "Displaying diagnostic data" Page 57).

5.5.1.3 “PROFIenergy” tab

The robot controller supports the following PROFIenergy states:

- **Ready_To_Operate**: The controller is ready for operation.
- **Drive bus OFF**: The drives are switched off.
- **Hibernate**: The controller is in the rest state and only reacts to the Wake-OnLan packet.
- **Brakes applied**: The brakes have been applied and only react to the next motion command.

If the break in production is too short to use the **Drive bus OFF** state, energy can be saved with the **Brakes applied** state. However, the robot controller can only activate the **Brakes applied** state if it is in a programmed stop.

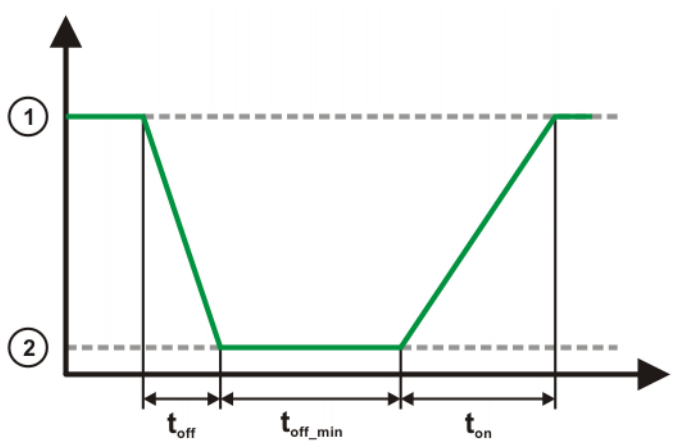

Fig. 5-3: PROFIenergy states

1 **Ready_To_Operate** state
2 **Drive bus OFF**, **Hibernate** or **Brakes applied** state

The PROFIenergy states have the following properties:

Name	Description
Time_to_Pause (t_{off})	Time until the controller has reached the **Drive bus OFF**, **Hibernate** or **Brakes applied** state from the **Ready_To_Operate** state.
Time_min_length_of_stay (t_{off_min})	Time in which the controller remains in the **Drive bus OFF**, **Hibernate** or **Brakes applied** state. For the **Drive bus OFF** and **Hibernate** states, it should be possible to shut down all connected devices completely in this time before the controller reboots.
Time_to_operate (t_{on})	Time until the controller has reached the **Ready_To_Operate** state from the **Drive bus OFF**, **Hibernate** or **Brakes applied** state.

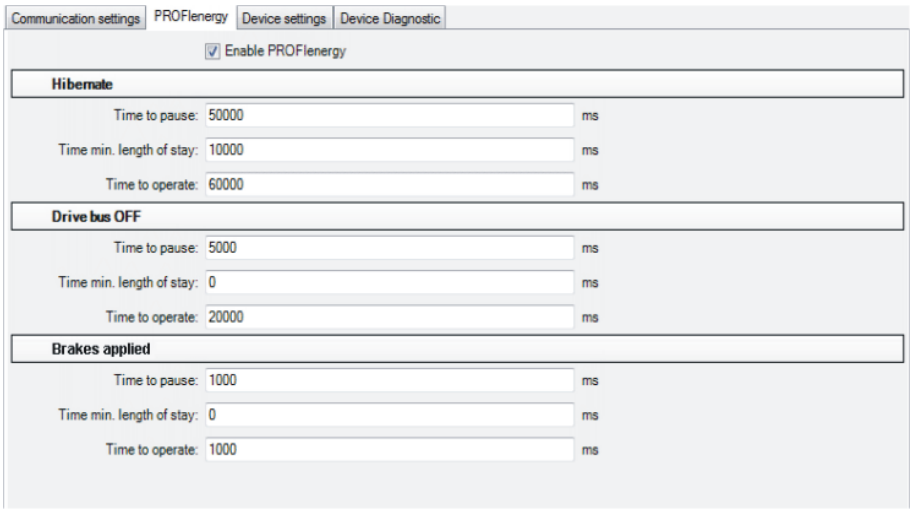

Fig. 5-4: “PROFIenergy” tab

The default values of the break times correspond to the minimum values. The defaults must not fall below these values.

Box	Description
Enable PROFIenergy	■ **Activated:** PROFIenergy is used. ■ **Deactivated:** PROFIenergy is not used. By default, the check box is deactivated.
Hibernate	
Time to pause:	Enter the time that the controller may take before the “Hibernate” state is reached. Default value: 50000 ms
Time min. length of stay:	Enter the minimum time for which the controller is to remain in the “Hibernate” state. Default value: 10000 ms
Time to operate:	Enter the time that the controller may take before the “Ready_To_Operate” state is reached. Default value: 60000 ms
Drive bus OFF	
Time to pause:	Enter the time that the controller may take before the “Drive bus OFF” state is reached. Default value: 5000 ms
Time min. length of stay:	Enter the minimum time for which the controller is to remain in the “Drive bus OFF” state. Default value: 0 ms
Time to operate:	Enter the time that the controller may take before the “Ready_To_Operate” state is reached. Default value: 20000 ms
Brakes applied	
Time to pause:	Enter the time that the controller may take before the “Brakes applied” state is reached. Default value: 1000 ms

Box	Description
Time min. length of stay:	Enter the minimum time for which the controller is to remain in the “Brakes applied” state. Default value: 0 ms
Time to operate:	Enter the time that the controller may take before the “Ready_To_Operate” state is reached. Default value: 1000 ms

5.5.2 Configuring PROFINET Controller

Precondition

- A robot controller has been added and set as active.
- The **PROFINET** node is inserted into the bus structure.

Procedure

1. Expand the tree structure of the robot controller on the **Hardware** tab in the **Project Structure** window.
2. Right-click on **PROFINET IO** and select **Add…** from the context menu.
3. A window opens with a list of devices. Select the device used and confirm with **OK**. The device is inserted in the tree structure.

NOTICE The inserted device must correspond to the actual device used in reality. Substantial damage to property may otherwise result.

4. Right-click on the device in the tree structure and select **Settings…** from the context menu. A window with the device data is opened.

   On the **Network** tab, fill out the following boxes:

   - **IP address**; **Subnet mask**; **Use a gateway**; **Gateway**
   - **Device name**; **Always available**; **User ID**; **Display diagnostic alarm as message**

   (>>> 5.5.2.1 "Device settings" Page 24)
5. The **Modules** tab displays the slots on the device. Assign the slots to the modules used.
6. If necessary, repeat steps 4 to 7 for further devices.
7. Save the device data with **OK**.

5.5.2.1 Device settings

Network settings

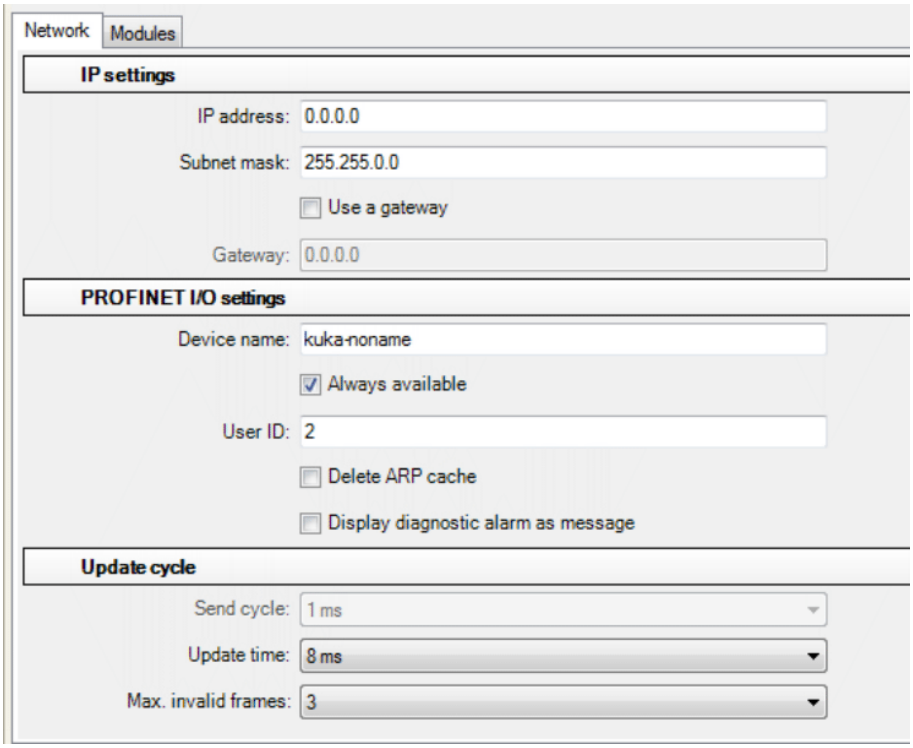

Fig. 5-5: "Network" tab

Box	Description
IP settings	
IP address:	Enter the IP address of the device.
Subnet mask:	The controller is delivered with the subnet mask 255.255.0.0 set; that is why this address is already entered. If the subnet mask has been changed, enter the changed address.
Use a gateway	■ **Activated:** A gateway is used. ■ **Deactivated:** No gateway is used.
Gateway:	Enter the IP address of the gateway. The address only needs to be entered if a gateway is to be used.
PROFINET I/O settings	
Device name:	Enter the name of the device. This must be identical with the name assigned during the naming of the device.
Always available	■ **Activated:** The robot controller expects the device to be active when the controller boots up. If the device is not active, the robot controller issues an error message. ■ **Deactivated:** The robot controller does not check whether the device is active when the controller boots up.
User ID:	Enter the ID of the device. The ID must be unambiguous and must not be less than 2. **Note**: The ID is required for coupling and decoupling devices.

Box	Description
Delete ARP cache	■ **Activated:** The ARP cache is deleted. ■ **Deactivated:** The ARP cache is not deleted. **Note**: It is recommended to activate the check box if the devices are configured as in the example “Reduced scope”. In the case of a configuration as in the example “Normal scope”, the check box should not be activated. (>>> 5.5.2.4 "Reducing the amount of configuration work" Page 28)
Display diagnostic alarm as message	■ **Activated:** Diagnostic messages are displayed in the message window of the KUKA smartHMI. ■ **Deactivated:** No diagnostic messages are displayed in the message window of the KUKA smartHMI.
Update cycle	
Update time:	Enter the update time. Update time: The current I/O data are exchanged between the robot controller and the devices every *x* ms. **Note**: The lower the value for the update time, the greater the CPU utilization. The PROFINET reaction time is the sum of the bus cycle time and the update time. This calculation does not take into account the reaction times of the applications which need these data (e.g. submit interpreter).
Max. invalid frames:	Enter the maximum number of data packets that may be lost before the robot controller generates an error message.

Slot configuration

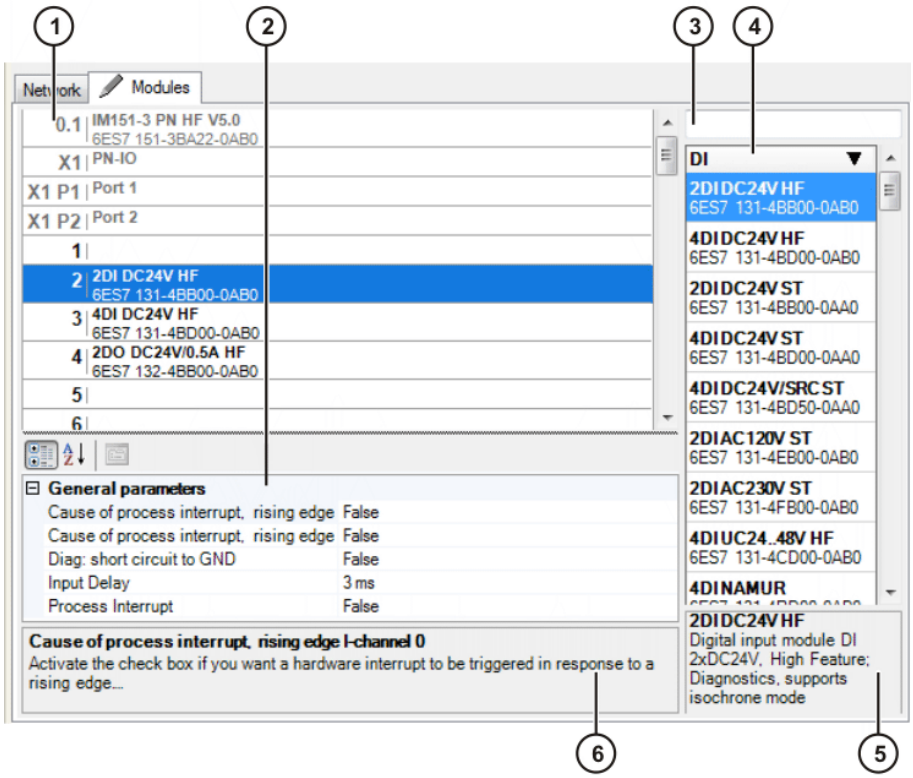

Fig. 5-6: “Modules” tab

1	Slot	4	Module window
2	Parameter window	5	Parameter description
3	Search box	6	Module description

All the windows can be resized as desired.

Element	Description
Slot	Number of slots on the device The number of slots displayed depends on the device selected. The number of slots displayed is always the maximum number possible for the device. Some devices have predefined slots. These cannot be modified. The lines of these slot numbers are grayed out. There are several possible methods for assigning a module to a slot: ■ Select the desired group in the module window. Click on the desired module in the group and drag it onto the slot. ■ Click on the slot. Select the desired group in the module window and double-click on the desired module. ■ Right-click on the slot and select **Paste** from the context menu. Select the desired module via the module group.
Parameter window	The parameter window displays module-specific parameters, which can be set via a selection menu.
Search box	The search box can be used to search for modules. The search is a full-text search.
Module window	The modules are divided into groups.

Element	Description
Parameter description	Describes the parameters that can be set in the parameter window.
Module description	Describes the module type and properties.

5.5.2.2 Using a shared device

Description

Shared device allows 2 controllers to access the same device. In this way, the number of PROFINET interfaces required for an application can be reduced. By default, full access is activated for every slot of a device. Only 1 controller may have full access to each slot. In order to enable another controller to access the slots, full access must be deactivated for these slots.

Shared device can only be used if the factory settings of these devices support this function.

Procedure

1. Right-click on the device in the tree structure and select **Settings…** from the context menu. A window opens with the device settings.
2. On the **Modules** tab, click on a slot that is to be used by a different controller.
   (>>> 5.5.2.1 "Device settings" Page 24)
3. Set the parameter **Full access** to **False** in the **Shared device** section of the parameter window.
4. Repeat steps 2 to 3 for all slots that are to be used by the other controller.
5. Save the settings by selecting **OK**.
6. Configure the slots the other way round in the configuration of the other controller.

5.5.2.3 Activating fast startup

Description

When a PROFINET device is coupled or run up, the device must reach its operational state as quickly as possible. A normal device can require up to 10 seconds to run up. Fast startup enables devices to reach their operational state in less than a second. This allows tools to be changed more quickly.

Fast startup can only be used if the couplable/decouplable device and the factory settings of the device description file support this function.

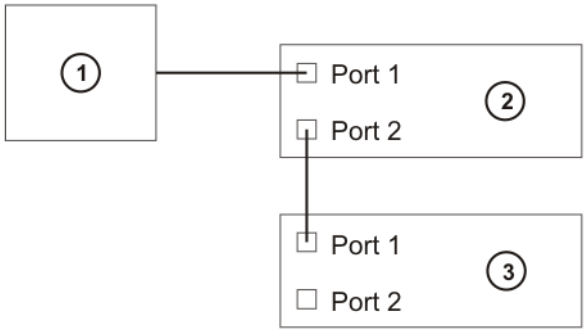

Fig. 5-7: Fast startup (schematic representation)

1 KRC controller
2 Coupling device
3 Couplable / decouplable device

Precondition

- There is an additional PROFINET device between the controller and the device that is to be decoupled.

Procedure

The procedure is described using the example of a device with 2 ports (port 1: slot **X1 P1**, port 2: slot **X1 P2**).

1. Right-click on the couplable/decouplable device in the tree structure and select **Settings…** from the context menu. A window opens with the device settings.
   (>>> 5.5.2.1 "Device settings" Page 24)
2. On the **Modules** tab, click on the slot **X1 (PN-IO)**.
3. In the **Start-up Behavior** area of the parameter window, set the parameter **Start-up prioritized** to **True**.
4. Click on the slot **X1 P1 (Port 1)**.
5. Select the transmission medium in the **Media access** area of the parameter window. In the case of copper as the medium, the setting **100 MBit/s, twisted pair (TX), Fullduplex** is normally used.
6. Save the settings by selecting **OK**.
7. Right-click on the coupling device in the tree structure and select **Settings…** from the context menu. A window opens with the device settings.
   (>>> 5.5.2.1 "Device settings" Page 24)
8. On the **Modules** tab, click on the slot **X1 P2 (Port 2)**.
9. Select the transmission medium in the **Media access** area of the parameter window. In the case of copper as the medium, the setting **100 MBit/s, twisted pair (TX), Fullduplex** is normally used.
10. Save the settings by selecting **OK**.

The setting for the transmission medium must be identical for the couplable/decouplable device and for the coupling device. The setting must not be set to **auto negotiate**.

The port settings must be carried out on the ports used for the couplable PROFINET connection. In the example, these are port 2 for the coupling device and port 1 for the couplable/decouplable device.

5.5.2.4 Reducing the amount of configuration work

Description

It is possible to reduce the amount of configuration work required and still retain the fast startup setting when exchanging devices. For this, the devices must have the same device type, the same IP address and the same device name. This means that only one device exists for the controller, thereby reducing the number of inputs and outputs which need to be mapped.

Example: Normal scope

In the following example, 3 devices are configured in WorkVisual as PROFINET devices (grippers A, B and C). Each one has a different name and a different IP address. During configuration, inputs and outputs need to be configured for each device here. For 3 devices, this amounts to a total of 192 inputs and outputs in this example.

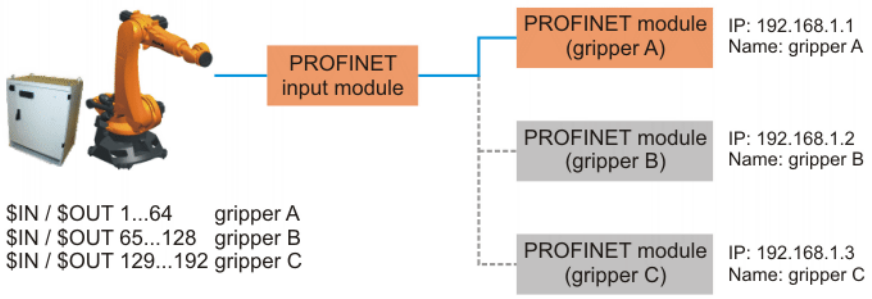

Fig. 5-8: Example: Normal scope of configuration work

Example: Reduced scope

In the following example, only 1 device is configured in WorkVisual as a PROFINET device (gripper X). In actual fact, however, there are 3 devices with the same device name and the same IP address. In this case, inputs and outputs need to be configured for only one device. That means a total of 64 inputs and outputs in this example.

If this example is applied, only one of the identically configured devices may be coupled at a time.

It is advisable to activate the **Delete ARP cache** check box on the **Network** tab if using this example.
(>>> 5.5.2.1 "Device settings" Page 24)

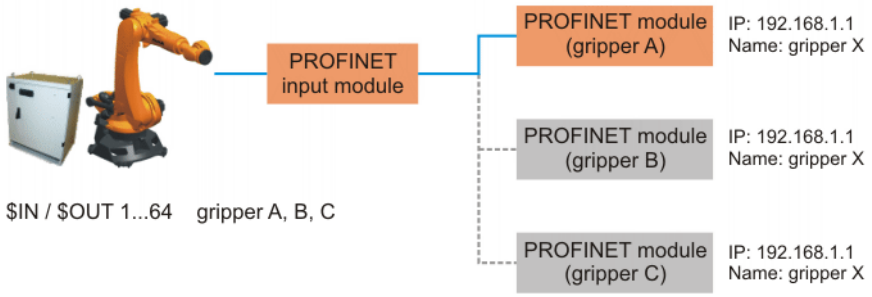

Fig. 5-9: Example: Reduced scope of configuration work

5.6 Configuring the bus with Step 7 or PC WORX

Procedure

1. Configure the bus with Step 7 or PC WORX.
2. Export the configuration from Step 7 or PC WORX.
3. Import the configuration into WorkVisual.

Configuration

It is not possible to assign devices to a KUKA robot controller in Step 7 and PC WORX.

Remedy in **Step 7**:

1. Define a CP1616 as a controller.
2. Assign the required devices to the CP1616.

Remedy in **PC WORX**:

1. Create a project ILC 350 PN.
2. Assign the required devices to the project.

When a configuration of this type is imported into WorkVisual, WorkVisual ignores the CP1616/ILC 350 PN and takes the KUKA robot controller as the controller.

Export

To enable the configuration from Step 7 or PC WORX to be imported into WorkVisual, the following options must be set for the export:

- Exporting from **Step 7**:
  - Activate the checkboxes **Export default values**, **Export symbols**, **Export subnets**.
  - Activate the radiobox **Readable**.
- Exporting from **PC WORX**:
  - Select **Export PLCopen xml file**.

Import

On importing the configuration into WorkVisual, only the following settings are transferred:

- IP address
- Subnet mask
- Gateway (if used)
- Device name
- Slot allocation

All other settings (e.g. fast startup, parameters of modules and ports) must be performed again in WorkVisual.

5.7 PROFIBUS signal names in WorkVisual

Description

PROFINET signal names have the following structure in WorkVisual:

Example **03:01:0002 Output**

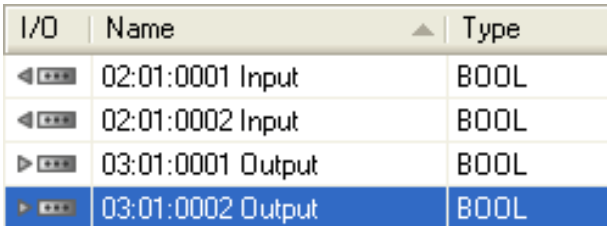

Fig. 5-10: PROFINET signal names in WorkVisual

Name	Meaning	In the example
1st value from left	Slot number **Note**: Modules without inputs/outputs, e.g. power supply modules, have a number but are not displayed in the list.	03
2nd value from left	Subslot number (generally 01)	01
3rd value from left	Index number (consecutive ascending numbering of the individual inputs/outputs)	0002
Input/Output	Direction of processing	Output

If the robot controller is used as the PROFINET device, the safe signals are located in slot 1 and the non-safe signals are located in slot 2. The number of safe inputs and outputs can be set on the **Communication settings** tab.
(>>> 5.5.1.1 ""Communication settings" tab" Page 17)

5.8 Safety interface via PROFIsafe (optional)

5.8.1 Safety functions via PROFIsafe (KR C4)

Description

The exchange of safety-relevant signals between the controller and the system is carried out via PROFIsafe. The assignment of the input and output states in the PROFIsafe protocol is listed below. In addition, non-safety-oriented information from the safety controller is sent to the non-safe section of the higher-level controller for the purpose of diagnosis and control.

Reserved bits

Reserved safe inputs can be pre-assigned by a PLC with the values **0** or **1**. In both cases, the manipulator will move. If a safety function is assigned to a reserved input (e.g. in the case of a software update) and if this input is preset with the value **0**, then the manipulator would either not move or would unexpectedly come to a standstill.

KUKA recommends pre-assignment of the reserved inputs with **1**. If a reserved input has a new safety function assigned to it, and the input is not used by the customer's PLC, the safety function is not activated. This prevents the safety controller from unexpectedly stopping the manipulator.

The 64 safe inputs and outputs described below are indicated in yellow in the WorkVisual mapping editor.

Input byte 0

Bit	Signal	Description
0	RES	Reserved 1 The value **1** must be assigned to the input.
1	NHE	Input for external Emergency Stop **0** = external E-STOP is active **1** = external E-STOP is not active
2	BS	Operator safety **0** = operator safety is not active, e.g. safety gate open **1** = operator safety is active
3	QBS	Acknowledgement of operator safety Precondition for acknowledgement of operator safety is the signal "Operator safety assured" set in the BS bit. **Note:** If the "BS" signal is acknowledged by the system, this must be specified under **Hardware options** in the safety configuration. Information is contained in the Operating and Programming Instructions for System Integrators. **0** = operator safety has not been acknowledged Edge **0** ->**1** = operator safety has been acknowledged

Bit	Signal	Description
4	SHS1	Safety STOP 1 (all axes) ■ FF (motion enable) is set to **0**. ■ Voltage US2 is switched off. ■ AF (drives enable) is set to **0** after 1.5 s. Cancelation of this function does not require acknowledgement. This function is not permissible for the EMERGENCY STOP function. **0** = safety stop is active **1** = safety stop is not active
5	SHS2	Safety STOP 2 (all axes) ■ FF (motion enable) is set to **0**. ■ Voltage US2 is switched off. Cancelation of this function does not require acknowledgement. This function is not permissible for the EMERGENCY STOP function. **0** = safety stop is active **1** = safety stop is not active
6	RES	-
7	RES	-

Input byte 1

Bit	Signal	Description
0	US2	Supply voltage US2 (signal for switching the second supply voltage, US2, without battery backup) If this output is not used, it should be set to 0. **0** = switch off US2 **1** = switch on US2 **Note:** Whether and how input US2 is used must be specified under **Hardware options** in the safety configuration. Information is contained in the Operating and Programming Instructions for System Integrators.
1	SBH	Safe operational stop (all axes) Precondition: All axes are stationary Cancelation of this function does not require acknowledgement. This function is not permissible for the EMERGENCY STOP function. **0** = safe operational stop is active. **1** = safe operational stop is not active.
2	RES	Reserved 11 The value **1** must be assigned to the input.
3	RES	Reserved 12 The value **1** must be assigned to the input.

Bit	Signal	Description
4	RES	Reserved 13 The value **1** must be assigned to the input.
5	RES	Reserved 14 The value **1** must be assigned to the input.
6	RES	Reserved 15 The value **1** must be assigned to the input.
7	SPA	System Powerdown Acknowledge The system confirms that it has received the power-down signal. A second after the “SP” (System Power-down) signal has been set by the controller, the requested action is executed, without the need for confirmation from the PLC, and the controller shuts down. **0** = confirmation is not active **1** = confirmation is active

Output byte 0

Bit	Signal	Description
0	NHL	Local E-STOP (local E-STOP triggered) **0** = local E-STOP is active **1** = local E-STOP is not active
1	AF	Drives enable (the internal safety controller in the KRC has enabled the drives so that they can be switched on) **0** = drives enable is not active (the robot controller must switch the drives off) **1** = drives enable is active (the robot controller must switch the drives to servo-control)
2	FF	Motion enable (the internal safety controller in the KRC has enabled robot motions) **0** = motion enable is not active (the robot controller must stop the current motion) **1** = motion enable is active (the robot controller may trigger a motion)
3	ZS	One of the enabling switches is in the center position (enabling in test mode) **0** = enabling is not active **1** = enabling is active
4	PE	The signal “Peri enabled” is set to 1 (active) if the following conditions are met: ■ Drives are switched on. ■ Safety controller motion enable signal present. ■ The message “Operator safety open” must not be active. (>>> "Signal “Peri enabled” (PE)" Page 34)
5	AUT	The manipulator is in AUT or AUT EXT mode. **0** = AUT or AUT EXT mode is not active **1** = AUT or AUT EXT mode is active

Bit	Signal	Description
6	T1	The manipulator is in Manual Reduced Velocity mode. **0** = T1 mode is not active **1** = T1 mode is active
7	T2	The manipulator is in Manual High Velocity mode. **0** = T2 mode is not active **1** = T2 mode is active

Output byte 1

Bit	Signal	Description
0	NHE	External E-STOP has been triggered. **0** = external E-STOP is active **1** = external E-STOP is not active
1	BS	Operator safety **0** = operator safety is not assured **1** = operator safety is assured (input BS = 1 and, if configured, input QBS acknowledged)
2	SHS1	Safety stop 1 (all axes) **0** = Safety stop 1 is not active **1** = Safety stop 1 is active (safe state reached)
3	SHS2	Safety stop 2 (all axes) **0** = Safety stop 2 is not active **1** = Safety stop 2 is active (safe state reached)
4	RES	Reserved 13
5	RES	Reserved 14
6	PSA	Safety interface active Precondition: The Ethernet interface PROFINET must be installed on the controller. **0** = safety interface is not active **1** = safety interface is active
7	SP	System Powerdown (controller will be shut down) One second after the SP signal has been set, the PSA output is reset by the robot controller, without confirmation from the PLC, and the controller is shut down. **0** = controller on safety interface is active. **1** = controller will be shut down

Signal “Peri enabled” (PE)

The signal “Peri enabled” is set to 1 (active) if the following conditions are met:

- Drives are switched on.
- Safety controller motion enable signal present.
- The message “Operator safety open” must not be active.
  This message is only active in the modes T1 and T2.

“Peri enabled” in conjunction with the signal “Safe operational stop”

- In the case of activation of the signal “Safe operational stop” during the motion:

  - Error -> braking with Stop 0. “Peri enabled” eliminated.
- Activation of the signal “Safe operational stop” with the manipulator stationary:

  Release the brakes, switch drives to servo-control and monitor for restart. “Peri enabled” remains active.
  - Signal “Motion enable” remains active.
  - US2 voltage (if present) remains active.
  - Signal “Peri enabled” remains active.

“Peri enabled” in conjunction with the signal “Safety stop 2”

- In the case of activation of the signal “Safety stop 2”:
  - Stop 2 of the manipulator.
  - Signal “Drive enable” remains active.
  - Brakes remain released.
  - Manipulator remains under servo-control.
  - Monitoring for restart active.
  - Signal “Motion enable” is deactivated.
  - US2 voltage (if present) is deactivated.
  - Signal “Peri enabled” is deactivated.

5.8.2 Safety functions via PROFIsafe (VKR C4)

Description

The exchange of safety-relevant signals between the controller and the system is carried out via PROFIsafe. The assignment of the input and output states in the PROFIsafe protocol is listed below. In addition, non-safety-oriented information from the safety controller is sent to the non-safe section of the higher-level controller for the purpose of diagnosis and control.

Reserved bits

Reserved safe inputs can be pre-assigned by a PLC with the values **0** or **1**. In both cases, the manipulator will move. If a safety function is assigned to a reserved input (e.g. in the case of a software update) and if this input is preset with the value **0**, then the manipulator would either not move or would unexpectedly come to a standstill.

KUKA recommends pre-assignment of the reserved inputs with **1**. If a reserved input has a new safety function assigned to it, and the input is not used by the customer’s PLC, the safety function is not activated. This prevents the safety controller from unexpectedly stopping the manipulator.

The 64 safe inputs and outputs described below are indicated in yellow in the WorkVisual mapping editor.

Input byte 0

Bit	Signal	Description
0	RES	Reserved 1 The value **1** must be assigned to the input.
1	NHE	Input for external Emergency Stop **0** = external E-STOP is active **1** = external E-STOP is not active

Bit	Signal	Description
2	BS	Operator safety Input for access to the safety zone. The signal triggers a Stop 1 in the Automatic operating modes. Cancellation of this function must be acknowledged, as the manipulator must not be allowed to resume motion if, for example, a safety gate accidentally closes itself. **0** = operator safety is not active, e.g. safety gate open **1** = operator safety is active
3	QBS	Acknowledgement of operator safety Precondition for acknowledgement of operator safety is the signal "Operator safety assured" set in the BS bit. **Note:** If the “BS” signal is acknowledged by the system, this must be specified under **Hardware options** in the safety configuration. Information is contained in the Operating and Programming Instructions for System Integrators. **0** = operator safety has not been acknowledged Edge **0** ->**1** = operator safety has been acknowledged
4	SHS1	Safety STOP 1 (all axes) ■ FF (motion enable) is set to **0**. ■ Voltage US2 is switched off. ■ AF (drives enable) is set to **0** after 1.5 s. Cancelation of this function does not require acknowledgement. This function is not permissible for the EMERGENCY STOP function. **0** = safety stop is active **1** = safety stop is not active
5	SHS2	Safety STOP 2 (all axes) ■ FF (motion enable) is set to **0**. ■ Voltage US2 is switched off. Cancelation of this function does not require acknowledgement. This function is not permissible for the EMERGENCY STOP function. **0** = safety stop is active **1** = safety stop is not active

Bit	Signal	Description
6	E2	E2 keyswitch (customer-specific signal for mode selection) **0** = E2 keyswitch is not active **1** = E2 keyswitch is active
7	E7	E7 keyswitch (customer-specific signal for mode selection) **0** = E7 keyswitch is not active **1** = E7 keyswitch is active

Input byte 1

Bit	Signal	Description
0	US2	Supply voltage US2 (signal for switching the second supply voltage, US2, without battery backup) If this output is not used, it should be set to 0. **0** = switch off US2 **1** = switch on US2 **Note:** Whether and how input US2 is used must be specified under **Hardware options** in the safety configuration. Information is contained in the Operating and Programming Instructions for System Integrators.
1	SBH	Safe operational stop (all axes) Precondition: All axes are stationary Cancelation of this function does not require acknowledgement. This function is not permissible for the EMERGENCY STOP function. **0** = safe operational stop is active. **1** = safe operational stop is not active.
2	RES	Reserved 11 The value **1** must be assigned to the input.
3	RES	Reserved 12 The value **1** must be assigned to the input.
4	RES	Reserved 13 The value **1** must be assigned to the input.
5	RES	Reserved 14 The value **1** must be assigned to the input.

Bit	Signal	Description
6	RES	Reserved 15 The value **1** must be assigned to the input.
7	SPA	System Powerdown Acknowledge The system confirms that it has received the power-down signal. A second after the “SP” (System Power-down) signal has been set by the controller, the requested action is executed, without the need for confirmation from the PLC, and the controller shuts down. **0** = confirmation is not active **1** = confirmation is active

Output byte 0

Bit	Signal	Description
0	NHL	Local E-STOP (local E-STOP triggered) **0** = local E-STOP is active **1** = local E-STOP is not active
1	AF	Drives enable (the internal safety controller in the KRC has enabled the drives so that they can be switched on) **0** = drives enable is not active (the robot controller must switch the drives off) **1** = drives enable is active (the robot controller must switch the drives to servo-control)
2	FF	Motion enable (the internal safety controller in the KRC has enabled robot motions) **0** = motion enable is not active (the robot controller must stop the current motion) **1** = motion enable is active (the robot controller may trigger a motion)
3	ZS	One of the enabling switches is in the center position (enabling in test mode) **0** = enabling is not active **1** = enabling is active
4	PE	The signal “Peri enabled” is set to 1 (active) if the following conditions are met: ■ Drives are activated. ■ Safety controller motion enable signal present. ■ The message “Operator safety open” must not be active. (>>> "Signal “Peri enabled” (PE)" Page 34)
5	EXT	The manipulator is in AUT EXT mode. **0** = AUT EXT mode is not active **1** = AUT EXT mode is active

Bit	Signal	Description
6	T1	The manipulator is in Manual Reduced Velocity mode. **0** = T1 mode is not active **1** = T1 mode is active
7	T2	The manipulator is in Manual High Velocity mode. **0** = T2 mode is not active **1** = T2 mode is active

Output byte 1

Bit	Signal	Description
0	NHE	External E-STOP has been triggered. **0** = external E-STOP is active **1** = external E-STOP is not active
1	BS	Operator safety **0** = operator safety is not assured **1** = operator safety is assured (input BS = 1 and, if configured, input QBS acknowledged)
2	SHS1	Safety stop 1 (all axes) **0** = Safety stop 1 is not active **1** = Safety stop 1 is active (safe state reached)
3	SHS2	Safety stop 2 (all axes) **0** = Safety stop 2 is not active **1** = Safety stop 2 is active (safe state reached)
4	RES	Reserved 13
5	RES	Reserved 14
6	PSA	Safety interface active Precondition: The Ethernet interface PROFINET must be installed on the controller. **0** = safety interface is not active **1** = safety interface is active
7	SP	System Powerdown (controller will be shut down) One second after the SP signal has been set, the PSA output is reset by the robot controller, without confirmation from the PLC, and the controller is shut down. **0** = controller on safety interface is active. **1** = controller will be shut down

5.8.3 SafeOperation via PROFIsafe (optional)

Description

The components of the industrial robot move within the limits that have been configured and activated. The actual positions are continuously calculated and monitored against the safety parameters that have been set. The safety controller monitors the industrial robot by means of the safety parameters that have been set. If a component of the industrial robot violates a monitoring limit or a safety parameter, the manipulator and external axes (optional) are

stopped. The PROFIsafe interface can be used, for example, to signal a violation of safety monitoring functions.

In the case of an encoder error, monitoring spaces are regarded as not violated. All associated output signals and system variables are set accordingly.

Examples:

- Signal outputs switch to “logic 1”.
- $SR_RANGE_OK[] switches to TRUE.

Reserved bits

Reserved safe inputs can be pre-assigned by a PLC with the values **0** or **1**. In both cases, the manipulator will move. If a safety function is assigned to a reserved input (e.g. in the case of a software update) and if this input is preset with the value **0**, then the manipulator would either not move or would unexpectedly come to a standstill.

KUKA recommends pre-assignment of the reserved inputs with **1**. If a reserved input has a new safety function assigned to it, and the input is not used by the customer’s PLC, the safety function is not activated. This prevents the safety controller from unexpectedly stopping the manipulator.

Input byte 2

Bit	Signal	Description
0	JR	Mastering test (input for the reference switch of the mastering test) **0** = reference switch is active (actuated). **1** = reference switch is not active (not actuated).
1	VRED	Reduced axis-specific and Cartesian velocity (activation of reduced velocity monitoring) **0** = reduced velocity monitoring is active. **1** = reduced velocity monitoring is not active.
2 … 7	SBH1 … 6	Safe operational stop for axis group 1 ... 6 Assignment: Bit 2 = axis group 1 … bit 7 = axis group 6 Signal for safe operational stop. The function does not trigger a stop, it only activates the safe standstill monitoring. Cancelation of this function does not require acknowledgement. **0** = safe operational stop is active. **1** = safe operational stop is not active.

Input byte 3

Bit	Signal	Description
0 … 7	RES	Reserved 25 ... 32 The value **1** must be assigned to the inputs.

Input byte 4

Bit	Signal	Description
0 … 7	UER1 … 8	Monitoring spaces 1 … 8 Assignment: Bit 0 = monitoring space 1 … bit 7 = monitoring space 8 **0** = monitoring space is active. **1** = monitoring space is not active.

Input byte 5

Bit	Signal	Description
0 … 7	UER9 … 16	Monitoring spaces 9 … 16 Assignment: Bit 0 = monitoring space 9 … bit 7 = monitoring space 16 **0** = monitoring space is active. **1** = monitoring space is not active.

Input byte 6

Bit	Signal	Description
0 … 7	WZ1 … 8	Tool selection 1 … 8 Assignment: Bit 0 = tool 1 … bit 7 = tool 8 **0** = tool is not active. **1** = tool 1 is active. Exactly one tool must be selected at all times.

Input byte 7

Bit	Signal	Description
0 … 7	WZ9 … 16	Tool selection 9 … 16 Assignment: Bit 0 = tool 9 … bit 7 = tool 16 **0** = tool is not active. **1** = tool 1 is active. Exactly one tool must be selected at all times.

Output byte 2

Bit	Signal	Description
0	SO	Safety option active SafeOperation activation status **0** = safety option is not active **1** = safety option is active
1	RR	Manipulator referenced Mastering test display **0** = mastering test required. **1** = mastering test performed successfully.
2	JF	Mastering error Space monitoring is deactivated because at least one axis is not mastered. **0** = mastering error. Space monitoring has been deactivated. **1** = no error.

Bit	Signal	Description
3	VRED	Reduced axis-specific and Cartesian velocity (activation status of reduced velocity monitoring) **0** = reduced velocity monitoring is not active. **1** = reduced velocity monitoring is active.
4 … 7	SBH1 … 4	Activation status of safe operational stop for axis group 1 ... 4 Assignment: Bit 4 = axis group 1 … bit 7 = axis group 4 **0** = safe operational stop is not active. **1** = safe operational stop is active.

Output byte 3

Bit	Signal	Description
0 … 1	SBH5 … 6	Activation status of safe operational stop for axis group 5 ... 6 Assignment: Bit 0 = axis group 5 … bit 1 = axis group 6 **0** = safe operational stop is not active. **1** = safe operational stop is active.
2 … 7	RES	Reserved 27 ... 32

Output byte 4

Bit	Signal	Description
0 … 7	MR1 … 8	Alarm space 1 … 8 Assignment: Bit 0 = alarm space 1 (associated monitoring space 1) … bit 7 = alarm space 8 (associated monitoring space 8) **0** = space is violated. **1** = space is not violated. **Note**: The signal is only set to 1 in the event of a workspace violation if the corresponding monitoring space is active, i.e. it must have been configured as “always active” or switched to active by means of the corresponding PROFIsafe input (input byte 4).

Output byte 5

Bit	Signal	Description
0 … 7	MR9 … 16	Alarm space 9 … 16 Assignment: Bit 0 = alarm space 9 (associated monitoring space 9) … bit 7 = alarm space 16 (associated monitoring space 16) **0** = space is violated. **1** = space is not violated. **Note**: The signal is only set to 1 in the event of a workspace violation if the corresponding monitoring space is active, i.e. it must have been configured as “always active” or switched to active by means of the corresponding PROFIsafe input (input byte 5).

Output byte 6

Bit	Signal	Description
0 … 7	RES	Reserved 49 ... 56

Output byte 7

Bit	Signal	Description
0 … 7	RES	Reserved 57 ... 64

5.8.4 Schematic circuit diagram of PROFIsafe enabling switch

Description

An external enabling switch can be connected to the higher-level safety controller. The signals (ZSE make contact and External panic break contact) must be correctly linked to the PROFIsafe signals in the safety controller. The resulting PROFIsafe signals must then be routed to the PROFIsafe of the KR C4. The response to the external enabling switch is then identical to that for a discretely connected X11.

Signals

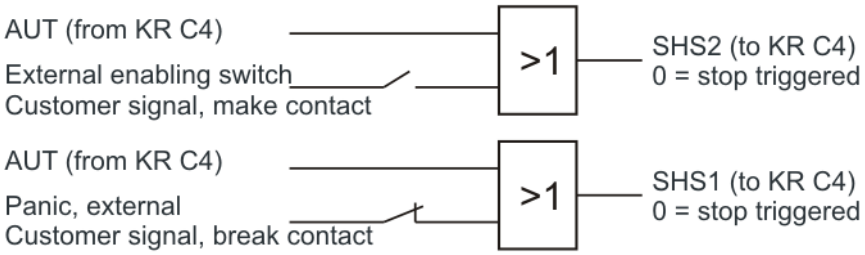

Fig. 5-11: Schematic circuit diagram of external enabling switch

- Enabling switch center position (make contact closed (1) = enabled) OR AUT at SHS2
- Panic (break contact open (0) = panic position) = AND not AUT at SHS1

5.8.5 Logging off the higher-level safety controller

Description

On switching off the robot controller, the connection to the higher-level safety controller is terminated. This termination is announced so that an E-STOP does not have to be triggered for the entire system. When the robot controller is shutting down, it sends the signal Shutdown PROFIsafe [SP=1] to the higher-level safety controller, triggering a Stop 1. The higher-level safety controller confirms the request with the signal Shutdown PROFIsafe Acknowledge [SPA=1]. Once the controller is restarted and communication is re-established with the higher-level safety controller, the signal PROFIsafe aktiv [PSA=1] is set. The following diagrams show the behavior on switching on and off.

Shutdown

The following example shows shutdown of the robot controller by a higher-level controller using the KS signal. The robot controller sets the signals “Drive bus deactivated [AB]” and “Controller operational readiness [BBS]” accordingly and logs off from the PROFIsafe Bus via safety-oriented signals.

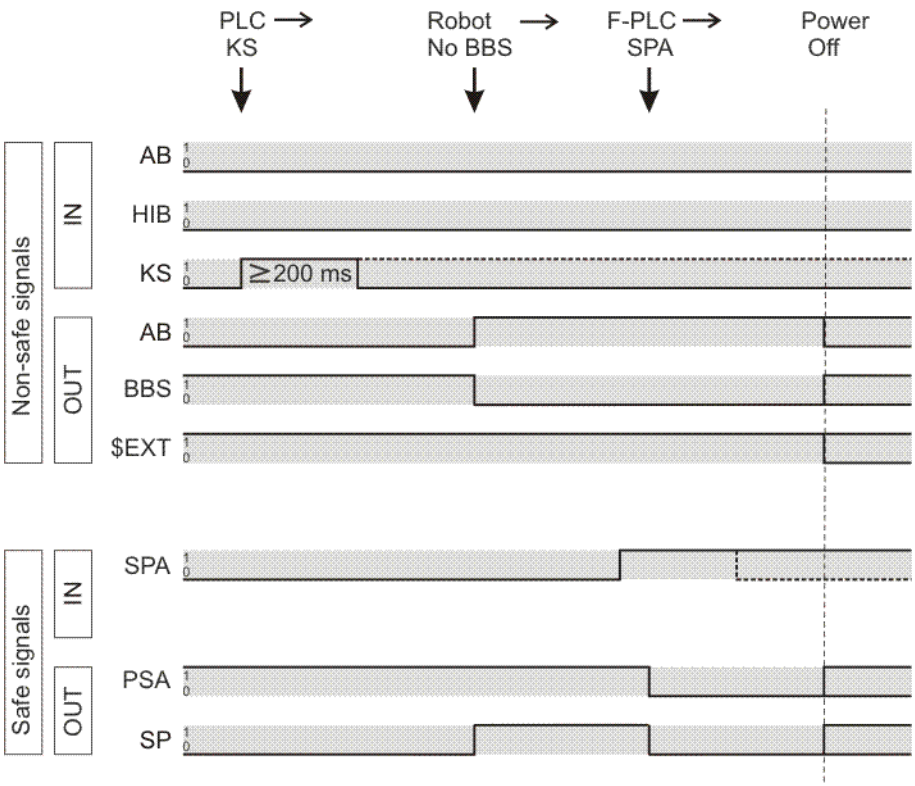

Fig. 5-12: Logging off systems from the higher-level controller

Shutdown to power save mode 0 - Hibernate is carried out in accordance with the timing shown. Instead of the KS signal, the HIB signal must be activated by the higher-level controller for at least 200 ms.

Power save mode

The following example shows how the robot controller is put into power save mode 2 and back into the operating state by a higher-level controller using the AB signal. The robot controller remains logged on to the PROFINET/PROFIsafe Bus.

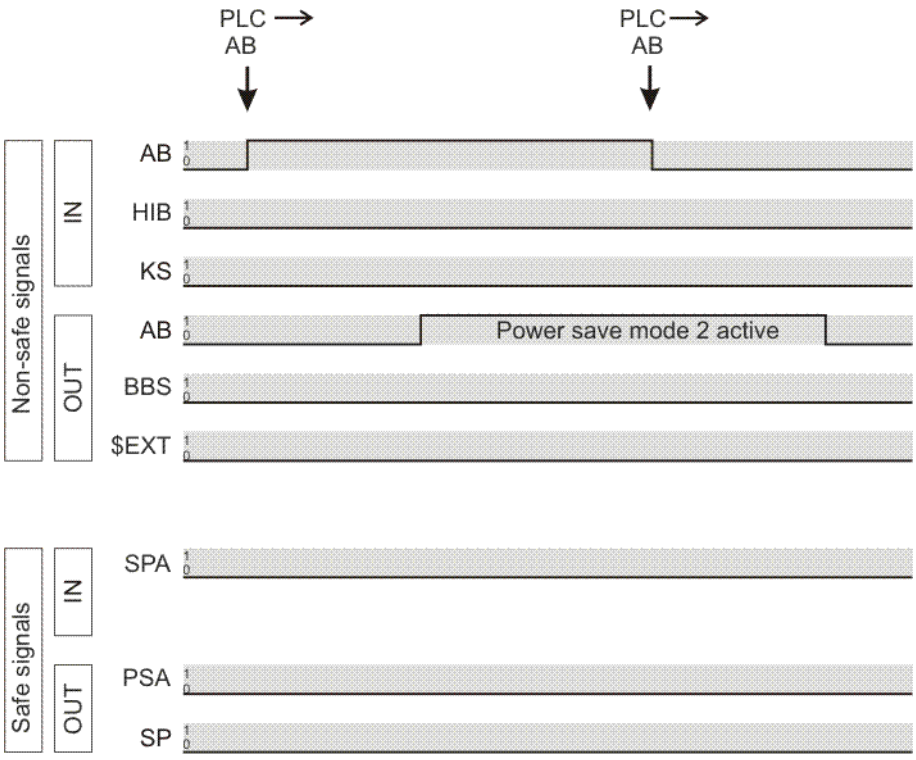

Fig. 5-13: Power save mode 2

Switching on via WakeOnLAN

The following example shows switch-on of the robot controller by a higher-level controller via WakeOnLAN. After receiving a Magic Packet for WakeOnLAN, the robot controller signals operational readiness via BBS. The PROFIsafe status is indicated via safety-oriented signals via PSA.

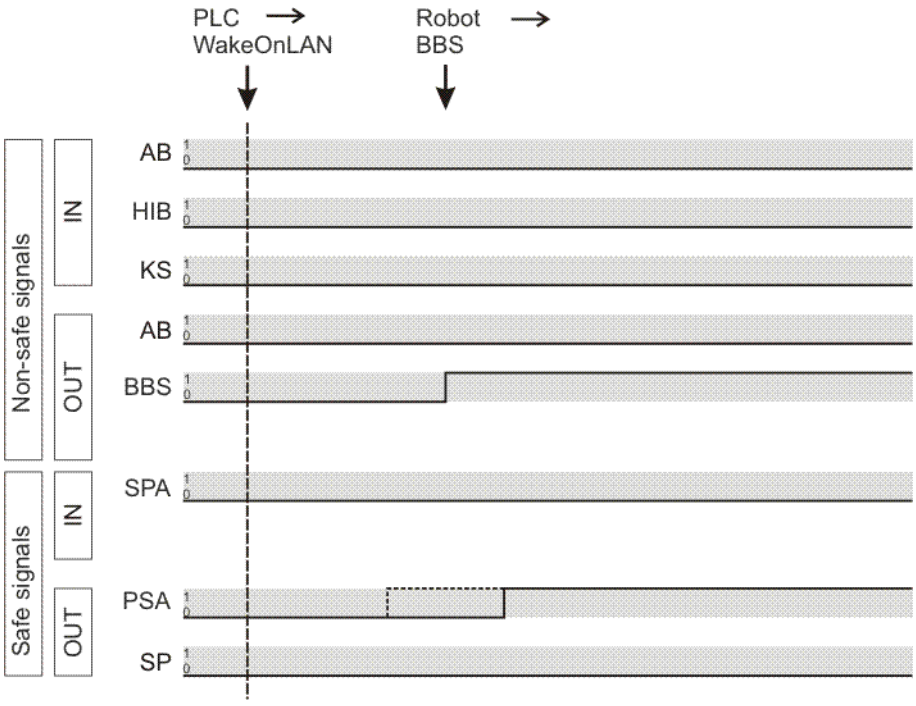

Fig. 5-14: Switching on via WakeOnLAN

6 Operation

6.1 Coupling/decoupling devices

For certain applications, e.g. tool change, it is necessary to couple and decouple devices. Coupling and decoupling can be carried out via the HMI or in KRL.

Decoupling

Properties of decoupled devices:

- If decoupled devices are disconnected from PROFINET or the power supply, no error is triggered.
- All I/O operations on decoupled devices remain without effect.
- Decoupled devices cannot carry out error treatment in the case of read/write errors.
- The device inputs are set to zero on decoupling.

Coupling

The IOCTL function is executed synchronously. It only returns when the device is functional and can be written to once again.

If a coupled device is not functional, e.g. because it is disconnected from the bus or supply voltage, a message is displayed after a default timeout of 10 s.

Always available

The option **Always available** affects the way the robot controller reacts to a decoupled device in the event of a cold start or I/O reconfiguration. **Always available** can be set in the device data in WorkVisual.

(>>> 5.5.2.1 "Device settings" Page 24)

	Always available: activated	**Always available**: deactivated
Device coupled	No error message	No error message
Device decoupled	Error message	No error message

If the option **Always available** is not activated for a device, the device is automatically decoupled in the case of a reboot or reconfiguration of the I/O driver. In order to establish a connection with the device, it must be recoupled using the IOCTL function.

6.1.1 Coupling/decoupling devices via the HMI

Procedure

1. Select the menu sequence **Display** > **Variable** > **Single**.
2. In the **Name** box, enter:
   - To decouple: =IOCTL("PNIO-CTRL",60,*[user ID]*)
   - To couple: =IOCTL("PNIO-CTRL",50,*[user ID]*)
3. Confirm by pressing the Enter key. The device is coupled or decouple.

Description

[User ID]: The user ID is displayed in WorkVisual in the **User ID** box in the device settings.

(>>> 5.5.2.1 "Device settings" Page 24)

6.1.2 Coupling/decoupling devices via KRL

KRL syntax

Decoupling:

```
RET =IOCTL("PNIO-CTRL",60,[user ID])
```

Coupling:

```
RET =IOCTL("PNIO-CTRL",50,[user ID])
```

Description

[User ID]: The user ID is displayed in WorkVisual in the **User ID** box in the device settings.

(>>> 5.5.2.1 "Device settings" Page 24)

Return values for RET:

Value	Meaning
0	IOCTL was executed successfully.
1	Timeout
2	IOCTL contains an incorrect parameter.

Examples

Here the device with the ID 3 is decoupled, depending on the tool used.

```
...
IF (NEXT_TOOL == GRIPPER_1) THEN
  RET = IOCTL("PNIO-CTRL",60,3)
ENDIF
...
```

The timeout for coupling/decoupling is set by default to 10 s. This default value can be changed. Here the value is set to 5000 ms:

```
RET = IOCTL("PNIO-CTRL",1001,5000)
```

6.2 PROFIenergy commands

Using PROFIenergy commands, the PLC can signal to the robot controller to change the state or query information.

Example

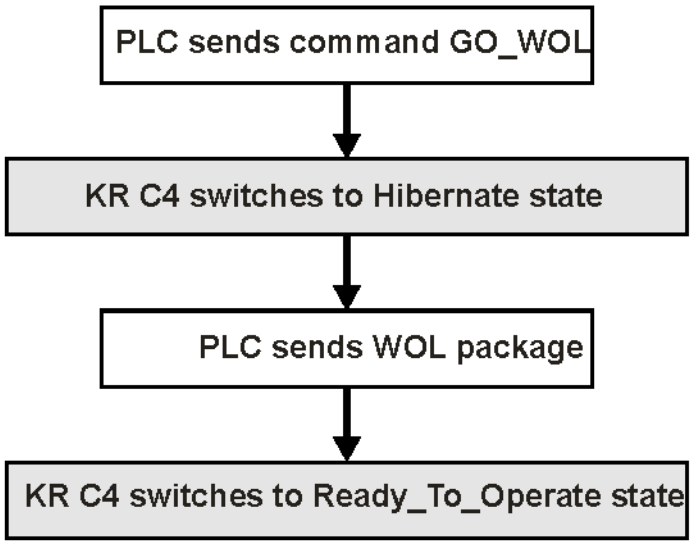

Fig. 6-1: Using commands (schematic sequence)

Description

The following PROFIenergy commands are supported:

Command	Description
Start_Pause	The robot controller switches to the Drive bus OFF state.
End_Pause	The robot controller comes back out of Hibernate / Drive bus OFF.
Start_Pause_with_time_response	Queries the total time required by the robot controller to switch state (t_{off}, t_{on} and t_{off_min}).

Command	Description
Info_Sleep_WOL	Determines information about the PE_sleep_mode_WOL state from the device.
Go_WOL	Switches a device to the PE_sleep_mode_WOL state (Hibernate).
Query_Version	Queries the version of the PROFIenergy protocol.
List_Modes	Displays a list of energy-saving modes supported by the controller.
Get_Mode	Queries information about a specific energy-saving mode.
Get_Measurement_List	Polls the IDs of all supported measurements. The KR C4 provides 3 measurement values: ■ ID = 1: Current energy consumption – average value in kW over 100 ms ■ ID = 2: Energy consumption of last hour in kW/h ■ ID = 3: Energy consumption in kW/h between start and stop of measurement
Get_Measurement_Values	Polls the measurement values using the IDs from Get_Measurement_List.

PLC manufacturers provide modules for controlling the commands. Some commands are executed automatically by the PLC; they cannot be executed by the user.

The use of PROFIenergy commands is described and additional information about them are provided in the Siemens documentation **Common Application Profile PROFIenergy**.

6.3 Querying the power save mode of the robot controller

The IOCTL function can be used to query the energy save mode of the robot controller.

KRL syntax

```
RET = IOCTL("PNIO-CTRL",1001,5000)
```

Return values for RET:

Value	Meaning
-1	Fault
1	The robot controller is in the “Drive bus OFF” state.
2	The robot controller is in the “Brakes applied” state.
255	The robot controller is in the “Ready_To_Operate” state.
256	PROFIenergy is not initialized.
257	The robot controller is in a transitional state.

6.4 Power management via PROFINET

Description

The following signals are available for activating or deactivating different power save modes and for detecting the states of the robot controller. These functions are only executed in EXT mode, not in T1 or T2.

Input byte 0

KUKA recommends pre-assignment of the reserved inputs with **1**. If a reserved input has a new safety function assigned to it, and the input is not used by the customer's PLC, the safety function is not activated. This prevents the safety controller from unexpectedly stopping the manipulator.

Bit	Signal	Description
0	AB	Drive bus **0** = activate drive bus, condition: HIB = 0 and KS = 0 **1** = deactivate drive bus, condition: HIB = 0 and KS = 0
1	HIB	Hibernate **0** = no function **1** = initiate Hibernate on the controller, condition: AB = 0 and KS = 0
2	KS	Cold start **0** = no function **1** = initiate cold start on the controller, condition: AB = 0 and HIB = 0
3 … 7	RES	Spare

Output byte 0

Bit	Signal	Description
0	AB	Drive bus **0** = drive bus activated **1** = drive bus deactivated
1	BBS	Operational readiness of the robot controller **0** = robot controller not ready **1** = robot controller ready
2 … 7	RES	Spare

7 Programming

7.1 Acyclic communication

In addition to typical I/O communication, asynchronous communication may also be necessary between applications and the I/O driver.

Examples:

- Requesting data from the higher-level controller.
- Parameterizing I/O modules during operation. (Only possible for modules with the relevant functionality.)

7.1.1 Acyclic data to the devices (controller ring)

Commands for acyclic transfer of data:

Command	Description
MASTER_READ	Command ID: 1 The controller stack requests data from a lower-level device.
MASTER_WRITE	Command ID: 2 The controller stack writes data to a lower-level device.
MASTER_RD_CONFIRMATION	Command ID: 1 The device responds to the read command from the controller stack.
MASTER_WR_CONFIRMATION	Command ID: 2 The device responds to the write command from the controller stack.

All commands are structure types. They consist of the following components:

Component	Description
CommandID	Command ID
CommandLen	Command length. The length of all parameters from “TransactionNum” (in bytes)
TransactionNum	Unique designation for the data exchange (e.g. “packet counter”)
User ID	Unambiguous ID for the device
SlotNumber	Slot number **Note:** Not for MASTER_RD_CONFIRMATION and MASTER_WR_CONFIRMATION.
SubSlotNumber	Subslot number **Note:** Not for MASTER_RD_CONFIRMATION and MASTER_WR_CONFIRMATION.
Index	Index for data exchange (0x0000 - 0x7FFF)
UserDataLen	Length of user data (in bytes) **Note:** Not for MASTER_WR_CONFIRMATION.

Component	Description
UserData[4096]	User data **Note:** Only for MASTER_WRITE and MASTER_RD_CONFIRMATION.
ErrorCode	Error code **Note:** Only for MASTER_RD_CONFIRMATION and MASTER_WR_CONFIRMATION.

All components except UserData[4096] are of the data type INT and have a length of 4 bytes.

The component UserData[4096] is of data type BYTE and has the length specified in the component UserDataLen.

It is advisable to take the values for the components SlotNumber, SubSlotNumber, Index, UserDataLen and UserData[4096] from the device manufacturer's data sheet or the PROFINET specification.

7.1.1.1 Configuring the record index

If acyclic communication is used, the following must be observed when configuring the higher-level controller:

The record index range that is not already reserved for PROFINET must, in part, be reserved for KUKA. The user must reserve this range when configuring the record index.

The record index has 16 bits.

Range	Description	
0x0000 to 0x7FFF	For adaptation by the user	
	0x[..]00 to 0x[..]FF	The range [..] is freely available to the user for adaptation.
	0x00[..] to 0x7F[..]	Range used by KUKA. In the range [..], the user must enter "00". **Note:** Do not enter "80". 00 = acyclic data of the KUKA robot controller (KR C) 80 = PROFIsafe F parameter
0x8000 to 0xFFFF	Reserved by PROFINET. It cannot be influenced by the user.	

7.1.2 Acyclic data to the higher-level controller (device ring)

Commands for acyclic transfer of data:

Command	Description
SPS_READ	Command ID: 3 The higher-level controller requests data from the robot controller via a read command.
SPS_WRITE	Command ID: 4 The higher-level controller writes data to the robot controller via a write command.

Command	Description
SPS_RD_CONFIRMATION	Command ID: 3 The robot controller responds to the read command from the higher-level controller.
SPS_WR_CONFIRMATION	Command ID: 4 The robot controller responds to the write command from the higher-level controller.

All commands are structure types. They consist of the following components:

Component	Description
CommandID	Command ID
CommandLen	Command length. The length of all parameters from “TransactionNum” (in bytes)
TransactionNum	Unique designation for the data exchange (e.g. “packet counter”)
ARID	Unique designation for “Application Relation”
SlotNumber	Slot number
SubSlotNumber	Subslot number
Index	Index for data exchange (0x0000 - 0x7FFF)
UserDataLen	Length of user data (in bytes) **Note:** Not for SPS_WR_CONFIRMATION.
UserData[4096]	User data **Note:** Only for SPS_WRITE and SPS_RD_CONFIRMATION.
ErrorCode	Error code **Note:** Only for SPS_RD_CONFIRMATION and SPS_WR_CONFIRMATION.

All components except UserData[4096] are of the data type INT and have a length of 4 bytes.

The component UserData[4096] is of data type BYTE and has the length specified in the component UserDataLen.

It is advisable to take the values for the components CommandID, TransactionNum, ARID, SlotNumber, SubSlotNumber and Index from the PLC command.

7.2 Example of acyclic communication

Example of acyclic communication in the program SPS.SUB:

```
...
 1  COPEN (:LD_EXT_OBJ1, nHandle)
 2  Wait for (nHandle>0)
 3  WMode=#SYNC
 4  RMode=#ABS
 5  TimeOut=1
 6
 7     WAIT FOR NOT($POWER_FAIL)
 8     TORQUE_MONITORING()
 9
10    ;FOLD USER PLC
11    ;Make your modifications here
12;-----------------------------------------
13  Offset=0
14
15  CRead (nHandle, Stat, RMode, TimeOut, Offset, "%r",Buffer[]);
16  If ( Stat.Ret1==#DATA_END ) then
17
18  Offset=0
19  CAST_FROM(Buffer[],Offset, CmdID)
20  CAST_FROM(Buffer[],Offset, CmdLen)
21
22  if (CmdID == 3) then
23        CAST_FROM(Buffer[],Offset, Transaction)
24        CAST_FROM(Buffer[],Offset, ARID)
25        CAST_FROM(Buffer[],Offset, Slot)
26        CAST_FROM(Buffer[],Offset, SubSlot)
27        CAST_FROM(Buffer[],Offset, Index)
28        CAST_FROM(Buffer[],Offset, DataLen)
29
30        Offset=0
31        wait for strClear(TMPSTR[])
32        SWRITE(TMPSTR[],STAT,Offset,"CmdId=%d CmdLen=%d TNum=%d
          ARID=%d Slot=%d SubSlot=%d Index=%d DataLen=%d", CmdID,
          CmdLen, Transaction, ARID, Slot, SubSlot, Index, DataLen)
33        $loop_msg[]=TMPSTR[]
34
35        wait sec 1
36
37        CmdLen = 32 ;-- User Data has 4 Bytes + 7*4 = 32
38        ErrCode=0
39        DataLen=4
40        UserData=255
41        Offset=0
42
43        CAST_TO(Buffer[],Offset,CmdID)
44        CAST_TO(Buffer[],Offset,CmdLen)
45        CAST_TO(Buffer[],Offset,Transaction)
46        CAST_TO(Buffer[],Offset,ARID)
47        CAST_TO(Buffer[],Offset,Slot)
48        CAST_TO(Buffer[],Offset,SubSlot)
49        CAST_TO(Buffer[],Offset,Index)
50        CAST_TO(Buffer[],Offset,ErrCode)
51        CAST_TO(Buffer[],Offset,DataLen)
52        CAST_TO(Buffer[],Offset,UserData)
53
54        CWrite (nHandle,Stat,WMode,"%1.40r",Buffer[])
55        Wait for (Stat.Ret1==#DATA_OK)
56
57  endif
...
```

Line	Description
15	The robot controller waits for a command from the higher-level controller.
22	`CmdID == 3`: The higher-level controller requests data from the robot controller via a read command.
23 … 28	The robot controller reads the request.
37 … 55	The robot controller replies to the higher-level controller.

Detailed information about the following commands is contained in the documentation CREAD/CWRITE.

- CHANNEL
- CIOCTL
- CAST_FROM; CAST_TO
- COPEN; CCLOSE
- CREAD; CWRITE
- SREAD; SWRITE

8 Diagnosis

8.1 Displaying diagnostic data

> The diagnostic data can also be displayed in WorkVisual. Information about procedures in WorkVisual is contained in the WorkVisual documentation.

Procedure

1. Select **Diagnosis** > **Diagnostic monitor** in the main menu.
2. Select the desired module in the **Module** box.
   Diagnostic data are displayed for the selected module.

Description

Diagnostic data can be displayed for the following modules:

- **Profinet Controller Stack (PNIO-CTRL)**
- **Profinet Device Stack (PNIO-DEV)**
- **Profinet Device (device name)**
- **Profinet IO Driver (PNIODriver)**
- **PROFIenergy (PROFIenergy)**

8.1.1 Profinet Controller Stack (PNIO-CTRL)

Name	Description
Bus cycle error	Number of non-compliant cycles
Applications logged on for acyclic data	Names of the applications logged on for the service “acyclic data”
Read request counter Write request counter	The robot controller sends Read or Write commands to the devices. The counter indicates the number of packets.
Read request transaction number Write request transaction number	Transaction number
Read request AR User ID Write request AR User ID	Application Relation User ID of PROFINET device The user is to issue this ID at the following point in WorkVisual: in the device settings on the **Network** tab, in the **User ID:** box.
Read request index Write request index	Record index for the acyclic data
Read request slot number Write request slot number	Number of the slot from which data are read (Read) or to which they are written (Write)
Read request subslot number Write request subslot number	Number of the subslot from which data are read (Read) or to which they are written (Write)
Read response counter Write response counter	The robot controller receives Read or Write commands from the devices. The counter indicates the number of packets.
Read response transaction number Write response transaction number	Transaction number
Read response ARID Write response ARID	Application Relation ID of PROFINET device ID issued by the master on booting

Name	Description
Read response AR User ID Write response AR User ID	Application Relation User ID of PROFINET device The user is to issue this ID at the following point in WorkVisual: in the device settings on the **Network** tab, in the **User ID:** box.
Read request index Write request index	Record index for the acyclic data
Read response error code Write response error code	0 = no error
Read response error decode Write response error decode	
Read response error code 1 Write response error code 1	
Read response error code 2 Write response error code 2	

8.1.2 Profinet Device Stack (PNIO-DEV)

Name	Description
AR ID	PROFINET Application Relation ID
Input length in bytes	Input length of the I/O image of the configured PROFINET device in bytes
Output length in bytes	Output length of the I/O image of the configured PROFINET device in bytes
Ready	■ **YES**: Communication between the PLC and device instance is working. ■ **NO**: No communication between the PLC and device instance.
Indication message number	HMI message number of the displayed indication message
Read status	■ **0**: Status OK ■ **1**: No new data are present for reading. ■ All other values: Internal error
Write status	■ **0**: Status OK ■ ≠0: Internal error
Abort indication counter	Internal error counter
Data status	PROFINET data status byte; see PROFINET specifications
AR Status	PROFINET Application Relation Status
Bus cycle error	Number of non-compliant cycles
Controller bus error bit active	■ **YES**: Bus errors are signaled to the PLC. ■ **NO**: Bus errors are not signaled to the PLC.
Controller bus error bit inverted	■ **YES**: The device is OK. ■ **NO**: Bus error.
Controller Maintenance Request bit active	■ **YES**: Maintenance request is signaled to the PLC. ■ **NO**: Maintenance request is not signaled to the PLC.
Controller Maintenance Request bit inverted	■ **YES**: The device is OK. ■ **NO**: There is a maintenance request.
Controller Maintenance Demand bit active	■ **YES**: Need for maintenance is signaled to the PLC. ■ **NO**: Need for maintenance is not signaled to the PLC.

Name	Description
Controller Maintenance Demand bit inverted	■ **YES**: The device is OK. ■ **NO**: Maintenance must be carried out on the device.
Controller Diagnosis bit active	■ **YES**: Diagnostic alarms are signaled to the PLC. ■ **NO**: Diagnostic alarms are not signaled to the PLC.
Controller Diagnosis bit inverted	■ **YES**: The device is OK. ■ **NO**: A diagnostic alarm is active.
Trigger application	■ [blank]: The driver accesses the PROFINET devices cyclically. ■ [*ApplicationName*]: Access by the driver to the PROFINET devices is controlled by *ApplicationName*.
Applications logged on for acyclic data	Names of the applications logged on for the service “acyclic data”
Read request counter Write request counter	The robot controller receives Read or Write commands from the PLC. The counter indicates the number of packets.
Read request transaction number Write request transaction number	Transaction number
Read request ARID Write request ARID	Application Relation ID of PROFINET device ID issued by the master on booting
Read request index Write request index	Record index for the acyclic data
Read request slot Write request slot	Number of the slot from which data are read (Read) or to which they are written (Write)
Read request subslot number Write request subslot number	Number of the subslot from which data are read (Read) or to which they are written (Write)
Read response counter Write response counter	The robot controller sends Read or Write commands to the PLC. The counter indicates the number of packets.
Read response timeout counter Write response timeout counter	A timeout occurs if the KUKA PROFINET device has not yet sent the Read or Write packet to the PLC after 5 seconds. After the timeout, the robot controller sends a default response meaning “feature not supported” to the PLC.
Read response transaction number Write response transaction number	Transaction number
Read response ARID Write response ARID	Application Relation ID of PROFINET device ID issued by the master on booting
Read response index Write response index	Record index for the acyclic data
Read response slot Write response slot	Number of the slot from which data are read (Read) or to which they are written (Write)
Read response subslot Write response subslot number	Number of the subslot from which data are read (Read) or to which they are written (Write)

Name	Description
Read response error code Write response error code	0 = no error
Read response error decode Write response error decode	
Read response error code 1 Write response error code 1	
Read response error code 2 Write response error code 2	

8.1.3 Profinet Device

Name	Description
Name	Profinet name of the device
AR User ID	Profinet Application Relation User ID (User ID in WorkVisual)
ARID	Profinet Application Relation ID
Input length in bytes	Input length of the I/O image of the configured PROFINET device in bytes
Output length in bytes	Output length of the I/O image of the configured PROFINET device in bytes
AR State	Profinet Application Relation status
Should be connected	■ **YES**: The setting was made during configuration that the device should be coupled during start-up. ■ **NO**: The setting was made during configuration that the device should not be coupled during start-up.
Ready	■ **YES**: Communication with the device is working. ■ **NO**: No communication with the device.
Read status	■ **0**: Status OK ■ **1**: No new data are present for reading. ■ All other values: Internal error
Write status	■ **0**: Status OK ■ ≠0: Internal error
Alarm message number	HMI message number of the displayed alarm message
Indication message number	HMI message number of the displayed indication message
Abort counter	Internal error counter
Data status byte	Profinet data status byte

8.1.4 Profinet IO Driver (PNIODriver)

Name	Description
IP address	Data that are assigned to the robot controller during device naming.
Profinet Subnetmask	
Profinet Standard Gateway	
Profinet MAC Address	Address of the network adapter via which the Profinet communicates with controllers, devices, etc.
Device Stack Name	PROFINET name of the device instance
Profinet Device Stack Vendor ID	Manufacturer ID of the PROFINET device stack

Name	Description
Profinet Device Stack ID	Internal ID of the PROFINET device stack
Profinet Flashing	■ **ON**: Flashing is active if ON and OFF are displayed alternately. ■ **OFF**: Flashing is not active.

8.1.5 PROFIenergy (PROFIenergy)

Name	Description
PE state	Internal PROFIenergy state ■ **Not initialized/present**: PROFIenergy has not been initialized or is not present. ■ **No active commands**: No PROFIenergy commands are active. ■ **Command being executed**: A PROFIenergy command is being executed. ■ **Error state**: An error has occurred. ■ **Start_Pause done**: The command Start_Pause has been executed. ■ **Start_Pause_Time_Info done**: The command Start_Pause_Time_Info has been executed. ■ **End_Pause done**: The command End_Pause has been executed. ■ **Info_Sleep_WOL done**: The command Info_Sleep_WOL has been executed. ■ **Go_WOL done**: The command Go_WOL has been executed. ■ **Query_Version done**: The command Query_Version has been executed. ■ **List_Modes done**: The command List-Modes has been executed. ■ **Get_Mode done**: The command Get_Mode has been executed. ■ **PEM_Status done**: The command PEM_Status has been executed. ■ **PE_Identity done**: The command PE_Identity has been executed.
Current PE mode	PROFIenergy mode to which the controller is currently set.
Start PE mode	PROFIenergy mode to which the controller is set before a change of mode.
Target PE mode	PROFIenergy mode to which the controller is set after a change of mode.
PE mode name	Name of the PROFIenergy mode
PE mode ID	ID of the PROFIenergy mode
PE mode attribute	Attribute of the PROFIenergy mode **Note**: Information about the attributes can be found in the PROFIenergy specifications.
Minimum pause time	Minimum time required by the controller to switch to a different mode.
Minimum time in this mode	Minimum time the controller stays in one mode.

Name	Description
Maximum time in this mode	Maximum time the controller stays in one mode.
Power consumption	Power consumption of the controller in a specific mode

8.2 Topology diagnosis

Precondition

- The laptop/PC with WorkVisual is connected to the PROFINET network with a valid IP address.
- The network card in the PROFINET network has been selected in the communication settings .
- The devices to be diagnosed are connected and active.

Procedure

1. Expand the tree structure of the robot controller on the **Hardware** tab in the **Project structure** window.
2. Right-click on **PROFINET** in the tree structure and select **Connect** from the context menu.
3. Right-click on **PROFINET** and select **Functions** > **Topology...** from the context menu. The **Topology** tab is displayed.

Description

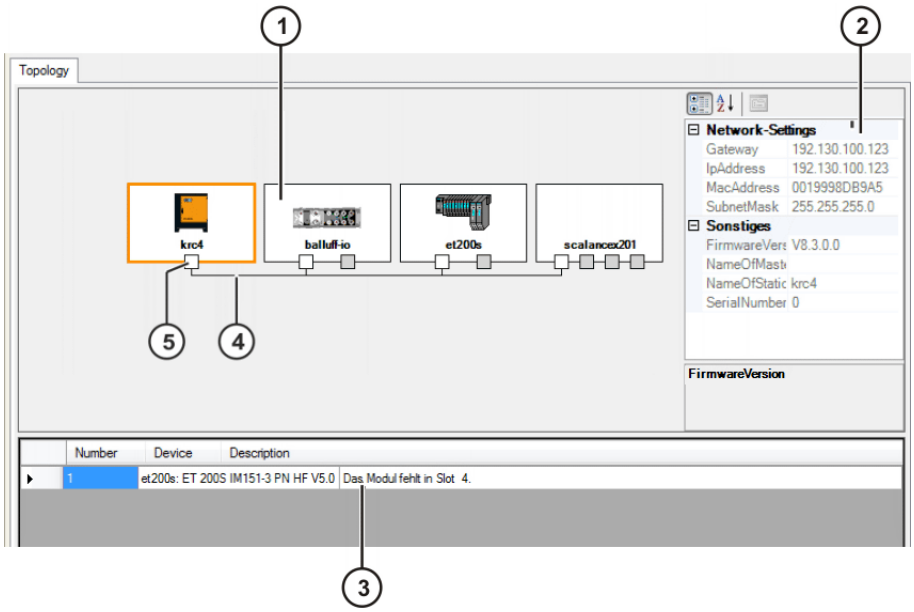

Fig. 8-1: “Topology” tab

Item	Description
1	PROFINET device If the device is displayed in white, there is a connection to the device. If it is displayed in gray, there is no connection to the device.
2	Parameter window Various parameters are displayed for the selected module.
3	Message window If a device signals an error, this is displayed in the message window.
4	Connecting cable
5	Connection Connected connections are indicated by the color white, non-connected ones by gray.

8.3 Advanced device diagnosis

Precondition

- The device to be diagnosed is connected and active.

Procedure

1. Expand the tree structure of the robot controller on the **Hardware** tab in the **Project structure** window.
2. Right-click on **PROFINET** in the tree structure and select **Connect** from the context menu.
3. Right-click on the device and select **Connect** from the context menu.
4. Right-click on the device and select **Diagnosis...** from the context menu. A window is displayed with the tabs **Device diagnosis**, **Connections** and **Process data**.

Description

General information about the device is displayed on the **Device diagnosis** tab:

- Device name
- IP settings
- MAC address
- Location
- Designation
- Firmware version
- Device version
- Hardware version
- Order number
- Serial number

The following information about the connections is displayed on the **Connections** tab:

- Name
- Type
- State
- Transmission speed
- Connected devices

The inputs and outputs visualized over time are displayed on the **Process data** tab. A scaling factor and a color can be selected for each device.

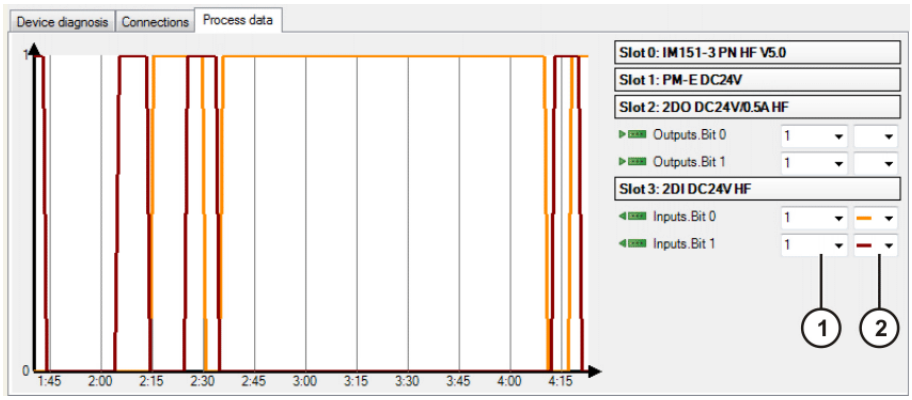

Fig. 8-2: “Process data” tab

1 Scale factor 2 Color

8.4 Displaying the connection list

Precondition

- The device to be diagnosed is connected and active.

Procedure

1. Expand the tree structure of the robot controller on the **Hardware** tab in the **Project structure** window.
2. Right-click on **PROFINET** in the tree structure and select **Connect** from the context menu.
3. Right-click on **PROFINET** and select **Functions** > **Connection list...** from the context menu. The **Connection list** tab is displayed.

Description

The following information is displayed for each connected device:

- Name
- IP address
- MAC address
- Order number
- Serial number
- Firmware version
- Connection
- Connection type
- State
- Transmission speed
- Remaining residual attenuation reserve (only in the case of fiber-optic cable connections)

8.5 Diagnostic signals via PROFINET

Description

Some signal states are extended to ensure that they can be detected reliably. In the case of extended signal states, the minimum duration of the extension is specified in square brackets. Values are specified in milliseconds, e.g. [200].

Output byte 0

Bit	Signal	Description
0	DG	Validity for non-safety-oriented signals and data on this interface **0** = data are not valid **1** = data are valid
1	IFS	Internal error in safety controller **0** = no error **1** = error [200]
2	FF	Motion enable **0** = motion enable not active [200] **1** = motion enable active
3	AF	Drives enable **0** = drives enable not active [200] **1** = drives enable active
4	IBN	Start-up mode Start-up mode enables jogging of the manipulator without a higher-level controller. **0** = Start-up mode is not active. **1** = Start-up mode is active.

Bit	Signal	Description
5	US2	Peripheral voltage **0** = US2 switched off **1** = US2 switched on
6 … 7	RES	Reserved

Output byte 1

Bit	Signal	Description
0	SO	Activation status of the safety option **0** = safety option is not active **1** = safety option is active
1	JF	Mastering error (optional) **0** = no error **1** = mastering error, space monitoring deactivated.
2	VRED	Reduced velocity (optional) **0** = reduced velocity monitoring is not active. **1** = reduced velocity monitoring is active.
3	VKUE	At least one Cartesian velocity limit exceeded (optional) **0** = no error **1** = velocity exceeded [200]
4	VAUE	At least one axis velocity limit exceeded (optional) **0** = no error **1** = velocity exceeded [200]
5	ZBUE	Cell area exceeded (optional) **0** = no error **1** = cell area exceeded [200]
6 … 7	RES	Reserved

Output byte 2

Bit	Signal	Description
0	SHS1	Safety stop (all axes) STOP 0 or STOP 1 **0** = safety stop is not active. **1** = safety stop is active.
1	ESV	External stop request violated Safe operational stop SBH1, SBH2 or safety stop SHS1, SHS2 violated Braking ramp was not maintained or a monitored axis has moved. **0** = no error **1** = violated
2	SHS2	Safety stop 2 **0** = safety stop is not active. **1** = safety stop is active.

Bit	Signal	Description
3	SBH1	Safe operational stop (axis group 1) (optional) **0** = safe operational stop is not active. **1** = safe operational stop is active.
4	SBH2	Safe operational stop (axis group 2) (optional) **0** = safe operational stop is not active. **1** = safe operational stop is active.
5	WFK	Tool error (no tool) (optional) **0** = no error **1** = no tool selected.
6	WFME	Tool error (more than one tool) (optional) **0** = no error **1** = more than one tool selected.
7	RES	Reserved

Output byte 3

Bit	Signal	Description
0	JR	Mastering test (optional) **0** = mastering test is not active. **1** = mastering test is active.
1	RSF	Reference switch error (optional) **0** = reference switch OK **1** = reference switch defective [200]
2	JRA	Mastering test request (optional) **0** = mastering test not requested. **1** = mastering test requested.
3	JRF	Mastering test failed (optional) **0** = mastering test OK. **1** = mastering test failed.
4	RS	Reference stop (optional) Reference run only possible in operating modes T1 and CRR. **0** = no error **1** = reference stop due to impermissible operating mode
5	RIA	Referencing interval (optional) **0** = no reminder **1** = reminder interval expired [200]
6 … 7	RES	Reserved

Output byte 4

Bit	Signal	Description
0 … 7	WZNR	Tool number (8-bit word) (optional) **0** = error (see WFK and WFME) **1** = tool 1 **2** = tool 2, etc.

Output byte 5

Bit	Signal	Description
0 … 7	UER1 … 8	Monitoring spaces 1 … 8 (optional) Assignment: Bit 0 = monitoring space 1 … bit 7 = monitoring space 8 **0** = monitoring space is not active. **1** = monitoring space is active.

Output byte 6

Bit	Signal	Description
0 … 7	UER9 … 16	Monitoring spaces 9 … 16 (optional) Assignment: Bit 0 = monitoring space 9 … bit 7 = monitoring space 16 **0** = monitoring space is not active. **1** = monitoring space is active.

Output byte 7

Bit	Signal	Description
0 … 7	UERV1 … 8	Stop in the event of a violation of monitoring spaces 1 … 8 (optional) Assignment: Bit 0 = monitoring space 1 … bit 7 = monitoring space 8 **0** = monitoring space is not violated, or monitoring space is violated but “Stop at boundaries” has not been configured. **1** = monitoring space is violated and robot stops with a safety stop [200]. Precondition: “Stop at boundaries” has been configured.

Output byte 8

Bit	Signal	Description
0 … 7	UERV9 … 16	Stop in the event of a violation of monitoring spaces 9 … 16 (optional) Assignment: Bit 0 = monitoring space 9 … bit 7 = monitoring space 16 **0** = monitoring space is not violated, or monitoring space is violated but “Stop at boundaries” has not been configured. **1** = monitoring space is violated and robot stops with a safety stop [200]. Precondition: “Stop at boundaries” has been configured.

8.6 I&M data sets

During installation of PROFINET, the I&M data sets 1 to 4 are created. The I&M data sets are used for unambiguous identification of a device. The data sets are saved remanently and can only be read or written with a higher-level controller or configuration software, e.g. Step 7.

- **I&M 1**: Contains the arrays **IM_Tag_Function** and **IM_Tag_Location**
- **I&M 2**: Contains the array **IM_Tag_Date**
- **I&M 3**: Contains the array **IM_Descriptor**
- **I&M 4**: Contains the array **IM_Signature**

Further information on the I&M data sets can be found in the PROFINET specification.

9 Messages

No.	Message	Description
11000	*Device {Name} could not be started within {Timeout} ms*	Cause: The PROFINET communication with the device has failed.
11001	*Connection to device {Name} terminated.*	Cause: Power supply and/or network connection was interrupted.
11003	*Alarm from device {Name} received with alarm type {Alarm}.*	See description of the alarm types.
11005	*Alarm from device {Name} received with alarm type {Alarm}.*	See description of the alarm types.
11006	*Connection between PLC and {Name} could not be established in {Timeout} ms*	Possible causes: ■ Bus timeout is too low. ■ The configuration of the Profinet device section on the controller does not match the configuration on the PLC. ■ The device is defective.
11007	*The configured device differs from the real device {Name}, Slot {Slot}, Subslot {Subslot}*	Cause: The configuration does not correspond to the connected device.
11008	*Connection between PLC and {Name} terminated.*	Possible causes: ■ Power supply and/or network connection was interrupted. ■ Performance problems (number of devices, cycle times).
11015	*PROFIenergy cannot connect to Cabinet Control.*	Cause: Cabinet Control has not been loaded or is not functioning correctly. Remedy: 1. Check system for faults. 2. Reboot the system. 3. If the message remains displayed: re-install system.
11016	*PROFIenergy cannot log onto Cabinet Control.*	Possible causes: ■ KUKA System Software version not supported by PROFIenergy. ■ Cabinet Control has not been loaded or is not functioning correctly.
11021	*Short circuit at device {Name}, channel {Slot} {Subslot}*	Further information is contained in the device manufacturer documentation.
11022	*Undervoltage at device {Name}, channel {Slot} {Subslot}*	Further information is contained in the device manufacturer documentation.
11023	*Overvoltage at device {Name}, channel {Slot} {Subslot}*	Further information is contained in the device manufacturer documentation.
11024	*Overload at device {Name}, channel {Slot} {Subslot}*	Further information is contained in the device manufacturer documentation.
11025	*Overtemperature at device {Name}, channel {Slot} {Subslot}*	Further information is contained in the device manufacturer documentation.
11026	*Open circuit at device {Name}, channel {Slot} {Subslot}*	Further information is contained in the device manufacturer documentation.
11027	*Upper limit exceeded at device {Name}, channel {Slot} {Subslot}*	Further information is contained in the device manufacturer documentation.

No.	Message	Description
11028	*Lower limit exceeded at device {Name}, channel {Slot} {Subslot}*	Further information is contained in the device manufacturer documentation.
11029	*Unknown error at device {Name}, channel {Slot} {Subslot}*	Further information is contained in the device manufacturer documentation.
11030	*Device {Name} requests immediate maintenance work soon*	Possible cause: The transmission quality is greatly reduced. It is advisable to carry out the necessary maintenance work immediately, as the device may otherwise fail.
11031	*Device {Name} requires maintenance work soon*	Possible cause: The transmission quality is significantly reduced. It is advisable to carry out the necessary maintenance work soon, as the device may otherwise fail.
13037	*Profinet controller stack cannot be started, error code: {Code}*	Cause: The PROFINET firmware is incorrectly parameterized. (bas_cm_api.xml)
13038	*Profinet device stack cannot be started, error code: {Code}*	Cause: The file pndev1.xml is faulty.
13039	*Error initializing the Profinet firmware*	Cause: The Profinet software stack or the file bas_cm_api.xml is faulty.
13040	*Error reading file {Configuration file}*	Cause: A configuration file is faulty. (IPPNIO.xml, PNIODriver.xml or bas_cm_api.xml)
13041	*Error reading the MAC address from the KLI*	Cause: The KLI configuration is faulty.

Alarm types

Alarm type	Description
ALARM_TYPE_DIAG_APPEARS	A diagnostic alarm has arrived.
ALARM_TYPE_DIAG_DISAPPEARS	A diagnostic alarm has been withdrawn.
ALARM_TYPE_PULL	An I/O module has been unplugged from the device.
ALARM_TYPE_PLUG	An I/O module has been plugged into the device.

10 KUKA Service

10.1 Requesting support

Introduction

This documentation provides information on operation and operator control, and provides assistance with troubleshooting. For further assistance, please contact your local KUKA subsidiary.

Information

The following information is required for processing a support request:

- Model and serial number of the manipulator
- Model and serial number of the controller
- Model and serial number of the linear unit (if present)
- Model and serial number of the energy supply system (if present)
- Version of the control software
- Optional software or modifications
- Diagnostic package **KrcDiag**:

  Additionally for KUKA Sunrise: Existing projects including applications

  For versions of KUKA System Software older than V8: Archive of the software (**KrcDiag** is not yet available here.)
- Application used
- External axes used
- Description of the problem, duration and frequency of the fault

10.2 KUKA Customer Support

Availability

KUKA Customer Support is available in many countries. Please do not hesitate to contact us if you have any questions.

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