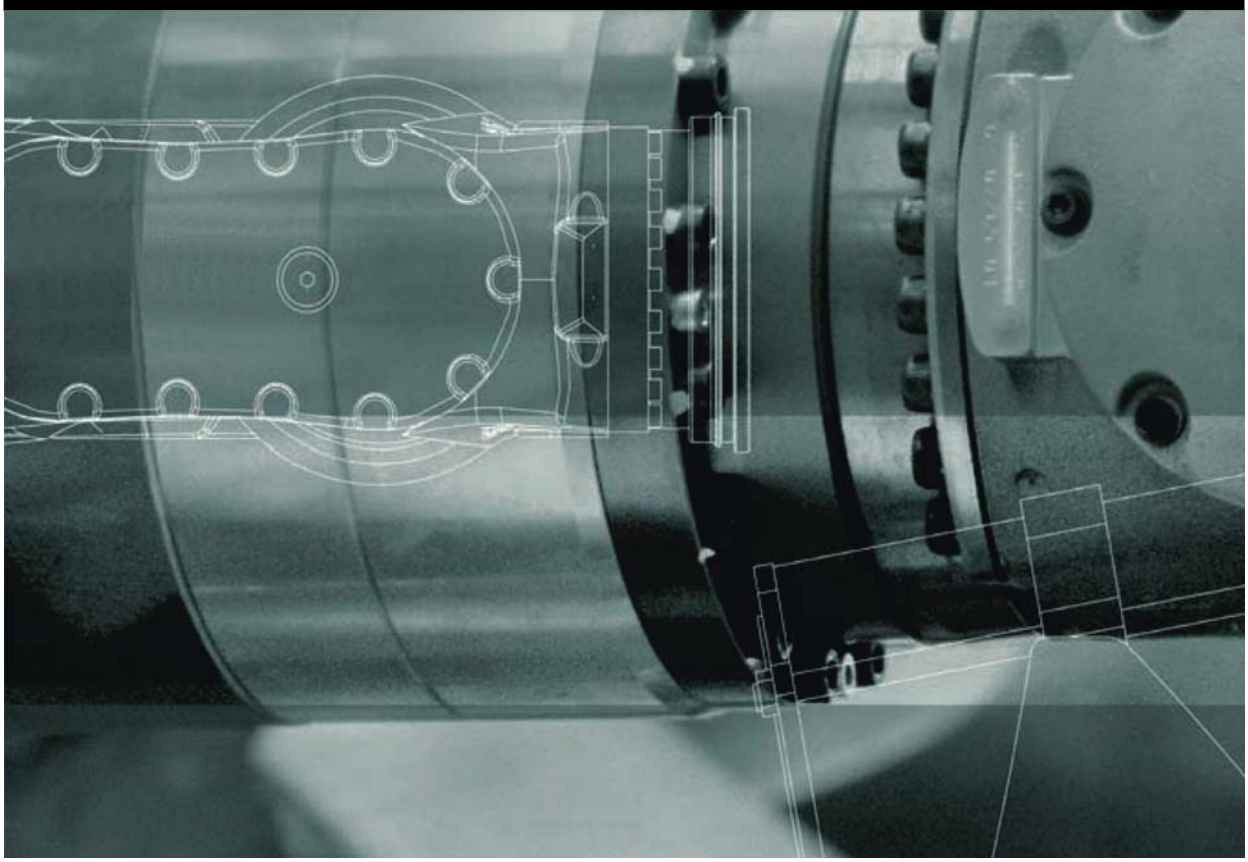
KUKA System Technology

KUKA Roboter GmbH

KUKA.CNC 2.1

For KUKA 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

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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

For optimal use of our products, we recommend that our customers take part in a course of training at KUKA College. Information about the training program can be found at www.kuka.com or can be obtained directly from our subsidiaries.

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 KUKA System Software
- Documentation relating to 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 Terms used

Term	Description
EMI	External Motion Interface EMI is an interface that enables the robot to be moved on the basis of an NC program. (That is, the robot is not moved in the conventional manner on the basis of a KRL program with taught points.)
CAD	Computer-aided design In CAD, special software is used to create a 3D model on the computer, e.g. of a workpiece. This model can then be integrated into an NC program by means of a CAM system.
CAM	Computer-aided manufacturing CAM designates the manufacturing steps leading from a CAD model to an NC program. The software used for this is independent of the CNC machine, so an NC program can be created during the work preparation phase.
G-code	Computer language for controlling CNC machines NC programs are created in G-code.
KR C	KUKA Robot Controller
KRL	KUKA Robot Language
KUKA.CNC-HMI	User interface of the KUKA.CNC technology package on the KUKA smartHMI (CNC.Human-Machine Interface)
KUKA smartHMI	User interface of the KUKA System Software (KUKA smart Human-Machine Interface)
MDI	Manual data input Operating mode for set-up of the CNC machine. Short NC blocks can be specified in an MDI block.
NC	Numerical control The NC is an electronic device for the computer-aided control of machine tools. The NC is able to read a data set of control commands from a storage medium, convert them to work and motion sequences, and process them one after the other.
NC program	NC programs are an integral part of the NC control data, like the tool data and the zero point offset data. NC programs describe the sequence of machining processes.
PLC	Programmable Logic Controller The PLC is a module for higher-level control tasks in a plant bus system.

2 Product description

2.1 Overview of KUKA.CNC

Functions

KUKA.CNC is an add-on technology package with the following functions:

- Execution of NC programs of a CAD/CAM system and MDI blocks
- Program execution control by displaying runtime data
- Editing of NC programs and MDI blocks
- Teaching of robot positions in NC programs (Teach mode)

Areas of application

- Machining tasks in which low process forces are generated:
  - Water-jet cutting
  - Laser cutting
  - Milling of shaped parts from soft materials, e.g. wood, plastic, foam material, etc.
- Machining tasks in which high process forces are generated, but with low accuracy requirements:
  - Pre-machining of metal workpieces, e.g. roughing of aluminum

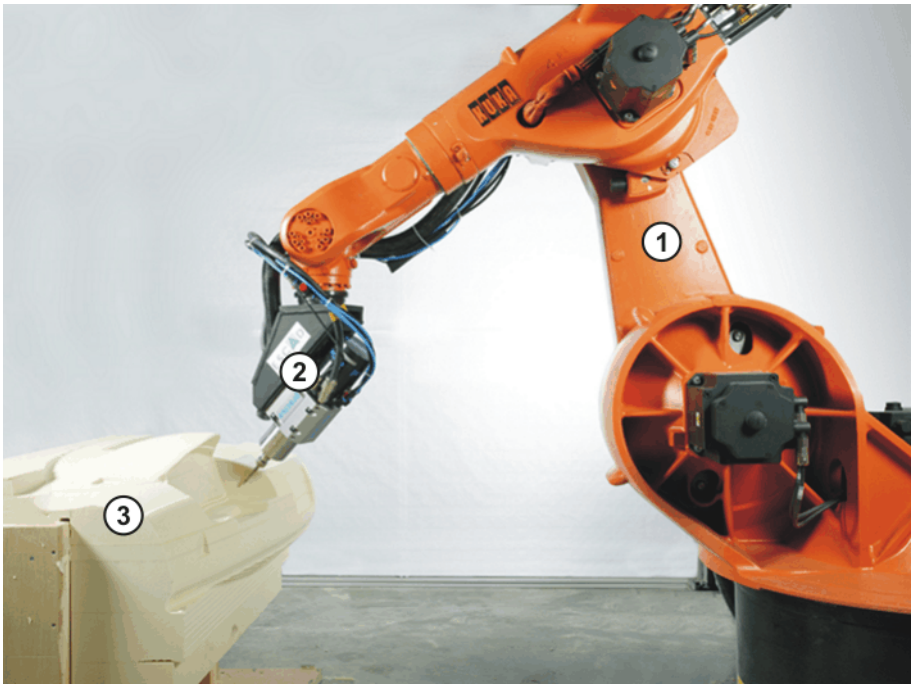


Fig. 2-1: Milling application example

1	Robot	3	Workpiece
2	Tool		

Software components

The following components are included in the scope of supply of KUKA.CNC:

- KUKA.CNC
- CNC development environment for Multiprog
- CNC WorkVisual catalog element

The CNC development environment must be installed on a start-up computer together with WorkVisual and Multiprog. It contains the Multiprog libraries required for the CNC and a CNC template that can be used in Multiprog.

The programming of CNC using G-code is not covered by this documentation. The CNC documentation, e.g. the CNC programming and diagnostic instructions, descriptions of functions and parameters, etc., are supplied with the software on the KUKA.USBData stick (directory DOC\pdf).

Functional principle

Using the NC controller kernel on the robot controller means that NC programs can be processed directly, i.e. without prior conversion to KRL programs, and executed by the robot.

Communication

The robot controller communicates with the technology controller via a field bus. There are different bus systems for the robot controller that are configured with WorkVisual.

Further information about the bus systems can be found in the corresponding KUKA documentation. Information about bus configuration is contained in the WorkVisual documentation.

Teach mode

Teach mode is provided for the following applications:

- Programming a suitable start position (approach motion of robot to workpiece)
- Programming axis space motions, e.g. on status change
- Programming orientation changes, e.g. in the case of axis space errors or singularity positions

3 Safety

This documentation contains safety instructions which refer specifically to the software described here.

The fundamental safety information for the industrial robot can be found in the “Safety” chapter of the Operating and Programming Instructions for System Integrators or the Operating and Programming Instructions for End Users.

The “Safety” chapter in the operating and programming instructions must be observed. Death to persons, severe injuries or considerable damage to property may otherwise result.

When using the CNC Multiprog template and programming with Multiprog, the relevant specifications from the “Safety” chapters in the documentation for KUKA.PLC ProConOs and KUKA.PLC Multiprog must always be observed.

4 Installation

4.1 System requirements

Hardware

- KR C4 or KR C4 compact

Software

Robot controller:

- KUKA System Software 8.3
- KUKA.PLC ProConOS 4-1 4.1

Standard laptop/PC:

- WorkVisual 3.0 or higher
- KUKA.PLC Multiprog 5-35 4.1

Compatibility

KUKA.CNC must not be installed on a robot controller together with the following technology packages:

- KUKA.ConveyorTech

KUKA.CNC can be used with KUKA.RoboTeam, but only for program synchronization (Program Cooperation) and not for motion synchronization (Motion Cooperation).

The KRC function generator may only be used together with KRL programs. Use in conjunction with NC programs is not possible.

4.2 Installing or updating KUKA.CNC

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

Precondition

- Software on KUKA.USBData stick
- No program is selected.
- T1 or T2 operating mode
- “Expert” user group

NOTICE Only the KUKA.USB data stick may be used. Data may be lost or modified if any other USB stick is used.

Procedure

1. Plug in USB stick.
2. Select **Start-up** > **Install additional software** in the main menu.
3. Press **New software**. If a software package that is on the USB stick is not displayed, press **Refresh**.
4. Select the entry **KUKA.CNC** and press **Install**. Reply to the request for confirmation with **Yes**. The files are copied onto the hard drive.
5. Remove USB stick.
6. Reboot the robot controller. Installation is completed once the system has rebooted.

LOG file

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

4.3 Uninstalling KUKA.CNC

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

Precondition

- "Expert" user group

Procedure

1. Select **Start-up** > **Install additional software** in the main menu. All additional programs installed are displayed.
2. Select the entry **KUKA.CNC** 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.

4.4 Installing the CNC development environment for Multiprog

Description

The CNC development environment must be installed on the start-up computer together with WorkVisual and Multiprog. It contains the Multiprog libraries required for the CNC and a CNC template that can be used in Multiprog.

Precondition

- WorkVisual is installed.
- KUKA.PLC Multiprog is installed.
- Administrator access rights

Procedure

- Start the program **development.exe** under MULTIPROG\development.

5 Planning

5.1 Positioning the milling table and workpiece

Description

NC programs created in CAD are independent of the type of machine with which they are executed. They describe motions in Cartesian space without the additional status and turn information used by the controller of a jointed-arm robot to ensure an unambiguous transformation to axis positions.

A conventional machine tool has 3 main linear axes. For this reason, when NC programs are executed, the transformation to axis positions is unambiguous. There is a linear relationship between the Cartesian path or orientation velocities and the resulting axis velocities, i.e. within the workspace limits of a machine tool, it is simple to use the same G-code to machine several identical surfaces of a workpiece or even multiple workpieces clamped adjacent to one another.

KRL programs, on the other hand, are taught for a specific robot type and with reference to a base, i.e. a specific workpiece position. Only then is it assured that execution of the KRL programs with a jointed-arm robot will not exceed the dynamic capabilities of the robot axes.

In order not to lose the advantage of G-code portability, we recommend positioning the milling table in such a way that, for the expected applications, the motions stay well clear of the singularity positions of the robot. If this is not taken into consideration during system planning, the machining time is increased, as the NC automatically reduces the path velocity as required. Furthermore, non-constant path velocities have a detrimental effect on the process quality.

The following remedies are possible, however, in the case of singularities or motions that exceed the dynamic capabilities (additional effort during start-up):

- Switch to axis space motion in the NC program (G-code).
- Program a rotation about the spindle axis in the NC program (G-code).
- Teach intermediate positions or a change of orientation.

  (>>> 9.3 "Re-teaching points in the NC program – changing the orientation" Page 60)

6 Start-up and configuration

6.1 Technology functions of the CNC

Technology functions, such as switching operations in the PLC, can be triggered in the NC program by means of M, S and T functions. The predefined and user-specific technology functions available in KUKA.CNC are described below.

The technology functions of the CNC are mapped to global PLC variables and can be linked to the field bus I/Os via WorkVisual.

6.1.1 Predefined technology functions

Function	PLC signal name	Type	Description
M2	CNC_M02_Out	BOOL	M2 sets the output at the end of the NC program.
	CNC_M02_In	BOOL	Acknowledgement input for M2.
M3	CNC_Spindle_CW_Out	BOOL	M3 sets the output and the spindle is started clockwise.
	CNC_Spindle_CW_In	BOOL	Acknowledgement input for M3 when the specified spindle speed has been reached.
M4	CNC_Spindle_CCW_Out	BOOL	M4 sets the output and the spindle is started counterclockwise.
	CNC_Spindle_CCW_In	BOOL	Acknowledgement input for M4 when the specified spindle speed has been reached.
M5	CNC_Spindle_Stop_Out	BOOL	M5 sets the output and the spindle is stopped.
	CNC_Spindle_Stop_In	BOOL	Acknowledgement input for M5 when the spindle speed has come to a standstill.
M6	CNC_ToolChange_Out	BOOL	M6 sets the output and the tool is changed.
	CNC_ToolChange_In	BOOL	Acknowledgement input for M6 when the tool has been changed.
M8/M9	CNC_Cooling_OnOff_Out	BOOL	M8 sets the output and the cooling is switched on. M9 resets the output and the cooling is switched off.
	CNC_Cooling_On_In	BOOL	Acknowledgement input for M8 when the cooling is switched on.
	CNC_Cooling_Off_In	BOOL	Acknowledgement input for M9 when the cooling is switched off.
M10/M11	CNC_Vacuum_OnOff_Out	BOOL	M10 sets the output and the vacuum is switched on. M11 resets the output and the vacuum is switched off.
	CNC_Vacuum_On_In	BOOL	Acknowledgement input for M10 when the vacuum is switched on.
	CNC_Vacuum_Off_In	BOOL	Acknowledgement input for M11 when the vacuum is switched off.

Function	PLC signal name	Type	Description
M30	CNC_M30_Out	BOOL	M30 sets the output at the end of the NC program and the spindle and cooling are switched off.
	CNC_M30_In	BOOL	Acknowledgement input for M30 when the spindle is stopped and the cooling is switched off.
T	CNC_Tool_Number	INT	Tool number display
S	CNC_Spindle_Speed	INT	Spindle speed display (unit: rpm)

With use of the KUKA.CNC template in Multiprog, the PLC signals from the above table can be found in the declaration of the global variables under the group **System M-Function I/O**.

The following global PLC variables can be used to access the predefined technology functions via the PLC program.

PLC variable	Type	Description
CNC_Cooling_OnOff	BOOL	Switch cooling on/off
CNC_Spindle_OnOff	BOOL	Switch spindle on/off
CNC_Vacuum_OnOff	BOOL	Switch suction on/off

With use of the KUKA.CNC template in Multiprog, these PLC variables can be found in the declaration of the global variables under the group **System M-Function signals**.

6.1.2 User-defined technology functions

Description

There are 16 user-specific digital I/O data available in the KUKA.CNC. In the NC program, a digital output is always switched on by an M function (e.g. M100) and switched off again by a second M function (e.g. M101). M functions M100 to M131 are thus available for the user-defined technology functions.

If additional M functions are required, these can be integrated into the KUKA.CNC after consultation with KUKA Roboter GmbH.
(>>> 11 "KUKA Service" Page 65)

Example of a user-defined output:

Function	PLC signal name	Type	Description
M100/M101	CNC_M100_M101_Out	BOOL	M100 sets the user-defined output. M101 resets the user-defined output.
	CNC_M100_In	BOOL	Acknowledgement input for M100.
	CNC_M101_In	BOOL	Acknowledgement input for M101.

With use of the KUKA.CNC template in Multiprog, the PLC signals from the above table can be found in the declaration of the global variables under the group **User M-Function I/O**.

The following global PLC variables can be used to access the user-defined technology functions via the PLC program.

PLC variable	Type	Description
CNC_M100_M101_OnOff	BOOL	Switch technology **M100** on/off
CNC_M102_M103_OnOff	BOOL	Switch technology **M102** on/off
CNC_M104_M105_OnOff	BOOL	Switch technology **M104** on/off

PLC variable	Type	Description
CNC_M106_M107_OnOff	BOOL	Switch technology **M106** on/off
CNC_M108_M109_OnOff	BOOL	Switch technology **M108** on/off
CNC_M110_M111_OnOff	BOOL	Switch technology **M110** on/off
CNC_M112_M113_OnOff	BOOL	Switch technology **M112** on/off
CNC_M114_M115_OnOff	BOOL	Switch technology **M114** on/off
CNC_M116_M117_OnOff	BOOL	Switch technology **M116** on/off
CNC_M118_M119_OnOff	BOOL	Switch technology **M118** on/off
CNC_M120_M121_OnOff	BOOL	Switch technology **M120** on/off
CNC_M122_M123_OnOff	BOOL	Switch technology **M122** on/off
CNC_M124_M125_OnOff	BOOL	Switch technology **M124** on/off
CNC_M126_M127_OnOff	BOOL	Switch technology **M126** on/off
CNC_M128_M129_OnOff	BOOL	Switch technology **M128** on/off
CNC_M130_M131_OnOff	BOOL	Switch technology **M130** on/off

With use of the KUKA.CNC template in Multiprog, the PLC variables can be found in the declaration of the global variables under the group **User M-Function signals**.

Synchronization

If execution of the NC program is to be synchronized with an M function, the synchronization type must be set accordingly in the channel parameter configuration.

Precondition

- “Expert” user group

Procedure

1. Open the channel parameter configuration via the menu sequence **CNC > Configuration > Channel parameters**.
2. Click twice on **Next** to switch to the configuration page of the synchronization parameters.
3. Configure the desired synchronization type and if necessary the additive parameter for the corresponding user-defined M command.

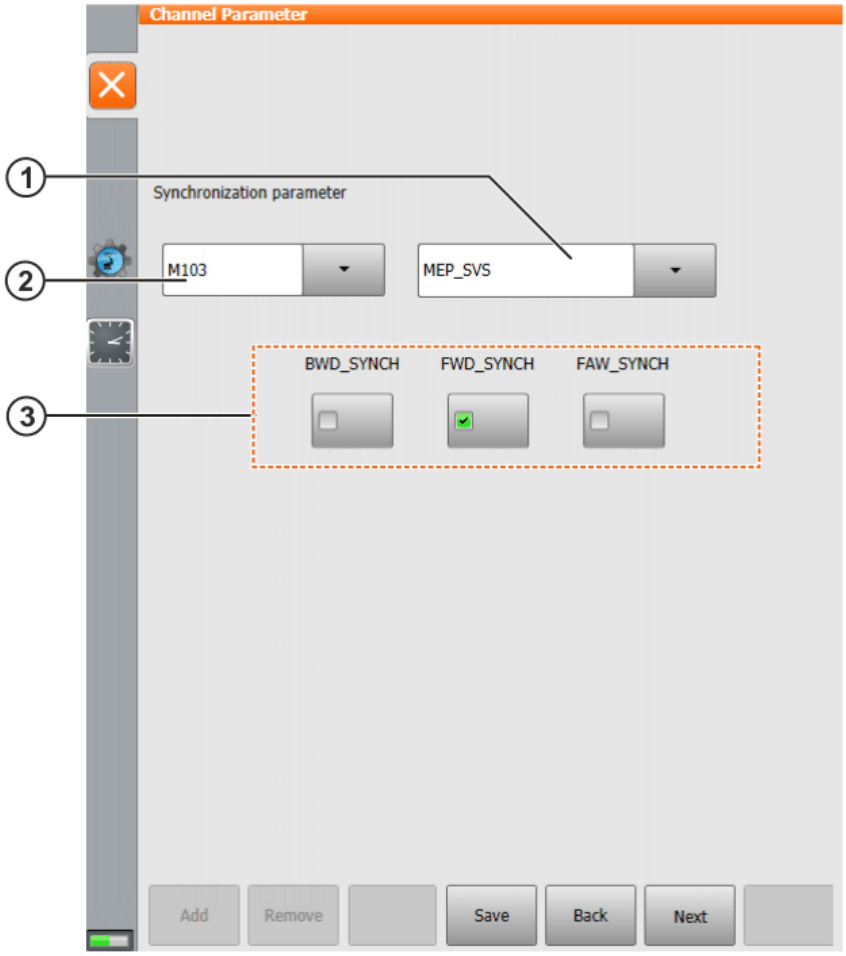


Fig. 6-1: Synchronization parameters

Item	Description
1	Selection of the synchronization type for the chosen user-defined M command.
2	Selection of the user-defined M command to be configured.
3	Additive parameters which can be configured for the user-defined M command in addition to the synchronization type. Green check mark = additive parameters activated for the M command selected in point 1

4. Click on **Save** to save the changes.
5. Perform a reconfiguration of the controller in order to apply the changes.

6.1.3 Mapping technology functions to the periphery

Description

There are two methods for mapping technology functions to the periphery:

- Mapping via the KUKA.CNC Multiprog template
- Mapping via the KUKA.CNC WorkVisual catalog element

The I/O mapping itself is performed in the same way in both cases. The two methods differ in terms of the operator actions carried out before mapping.

NOTICE The mapping method via the KUKA.CNC WorkVisual catalog element should only be used if Multiprog is not available.

Procedure

NOTICE PLC variables and thus also the technology functions are mapped in WorkVisual in the same way as the I/O signals. The exact procedure for bus mapping and transferring the project to the robot controller is described in the **WorkVisual** documentation.

Example In this example, an Interbus is configured. 2 outputs of the Interbus have been linked to a PLC variable.

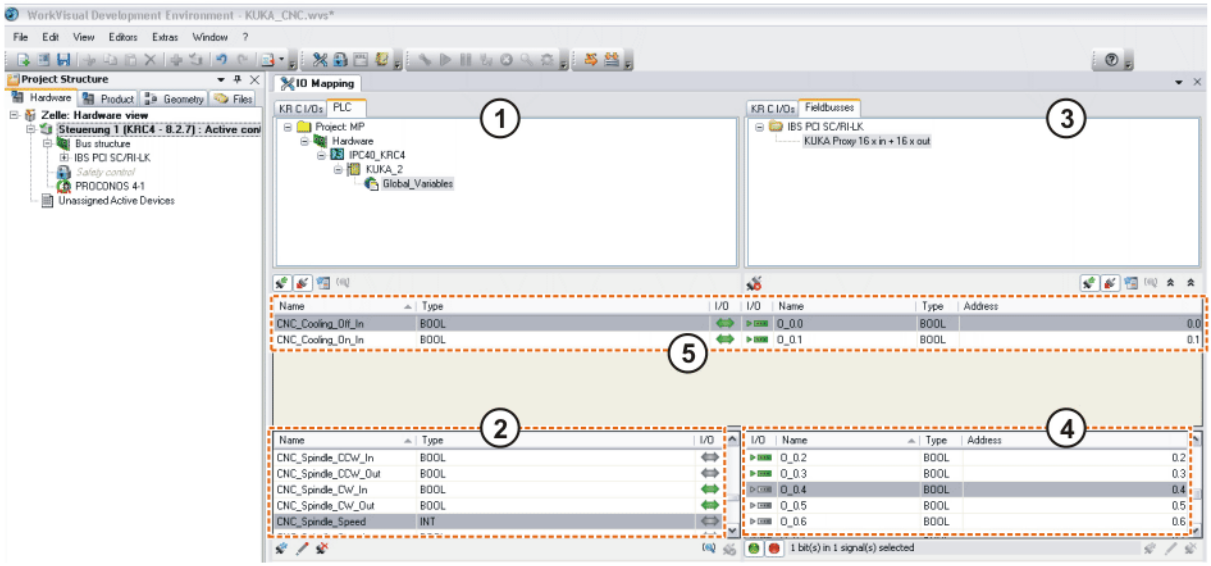


Fig. 6-2: Mapping technology functions to field bus I/Os

1 **PLC** tab – select **Global_Variables**.
2 List of available PLC variables
3 **Field buses** tab – select the field bus
4 List of configured field bus I/Os
5 List of mapped field bus I/Os

6.1.3.1 Mapping by means of the Multiprog CNC template

Precondition

- WorkVisual 3.0 is installed.
- KUKA.PLC Multiprog 5-35, V4.1 is installed.
- The KUKA.CNC development environment for Multiprog is installed.
- Field bus and field bus I/Os are configured.

Procedure

1. Start WorkVisual and open the desired project.
2. Add the catalog element **PROCONOS 4-1** to the robot controller.
   On the **Hardware** tab, select **Add** in the context menu of the robot controller.
   Add the catalog element **PROCONOS 4-1**. **PROCONOS 4-1** is displayed in the robot controller under **Options**.
3. Set the robot controller as the active controller via the context menu. Select the correct version of the system software.
   The Multiprog project is created and the **Select template** window is opened. If the window does not open automatically, the window can be opened by double-clicking on the option **Open PROCONOS 4-1** geöffnet werden.
4. In the **Select template** window, select the template **KRC4 CNC** and accept it with **OK**. The mapping editor in WorkVisual and the Multiprog appli-

cation are opened automatically. On the **PLC** tab of the mapping editor, the technology functions of KUKA.CNC are available as global variables in the groups **User M-Functions I/O** and **User M-Functions signals**.

5. Connect the required PLC variables to the field bus I/Os by means of Drag&Drop.

   Once all the required I/Os have been mapped, code generation can be started and the project can then be transferred to the robot controller and activated. Once the project has been activated, the signal goes via the field bus to the periphery when a mapped technology function is called in the NC program.

6.1.3.2 Mapping by means of the CNC WorkVisual catalog element

Description

The KUKA.CNC catalog element can be used to map technology functions to the periphery.

The KUKA.CNC catalog element is located on the KUKA.CNC option in the **WoV** directory.

Precondition

- WorkVisual 3.0 is installed.
- Field bus and field bus I/Os are configured.

Procedure

1. Start WorkVisual.
   The Project Explorer is displayed.
2. Load the current controller project.
3. Open the Catalog Management via the menu sequence **File** > **Catalog Management...**.
4. Click on **Open** in the Catalog Management.
5. Navigate to the catalog element and open it.

   The KUKA.CNC catalog element is automatically added to the list of project catalogs for the current project.
6. Close the Catalog Management.

   The KUKA.CNC catalog element is displayed in the view of catalogs that are available in the project.
7. Add the KUKA.CNC catalog element to the robot controller:

   On the **Hardware** tab, select **Add** in the context menu of the robot controller.

   The catalog element **KUKA.CNC** is located on the **KUKA.CNC** tab. Add the **KUKA.CNC** catalog element. **KUKA.CNC** is now displayed in the robot controller under **Options**.
8. Set the robot controller as the active controller via the context menu. Select the correct version of the system software. The mapping editor opens automatically.

   The technology functions **User M-Functions** are now available on the **PLC** tab.
9. Connect the required PLC variables to the field bus I/Os by means of Drag&Drop.

   Once all the required PLC variables have been mapped, code generation can be started and the project can then be transferred to the robot controller and activated.

   Once the project has been activated, the signal goes via the field bus to the periphery when a mapped technology function is called in the NC program.

6.2 Base for KUKA.CNC

The zero point for KUKA.CNC on the KRC is determined by $BASE, i.e. the last base active before activation of CNC mode is used. An additional zero point offset can be programmed in the CNC code.

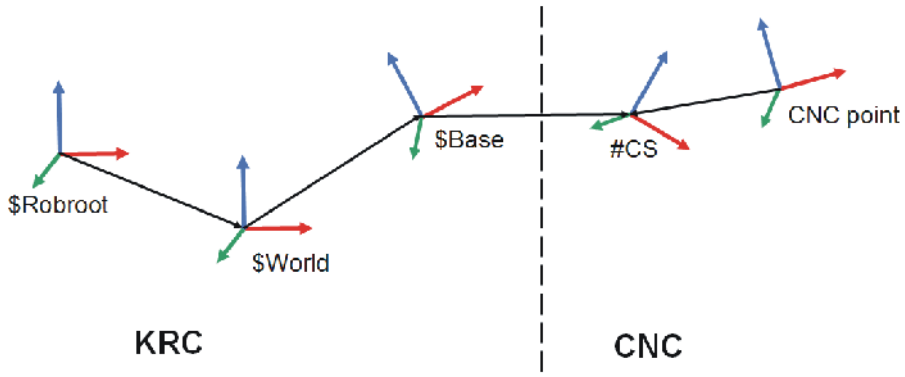


Fig. 6-3: Base for KUKA.CNC

6.3 Tool management and tool change

Description

In many cases, it is necessary to work with several different tools. For example, different milling heads may be used in a milling application. For this purpose, it is possible to perform a tool change.

The TCP data for the CNC are determined by **$Tool** in the KRC. Unlike in the case of the base, the last valid TCP is not used for CNC mode; instead, the tool data or number can be specified via the CNC. To update the TCP, CNC mode is interrupted, **$Tool** is updated and CNC mode is restarted.

Determination of the TCP data varies according to the variable **cncReferenceTool** (local integer variable in the program **CNCMotion.dat**).

Variant 1

If the variable **cncReferenceTool** = 0, only the tool number is transferred by the CNC code (X) and the corresponding tool data are loaded from **$config.dat**.

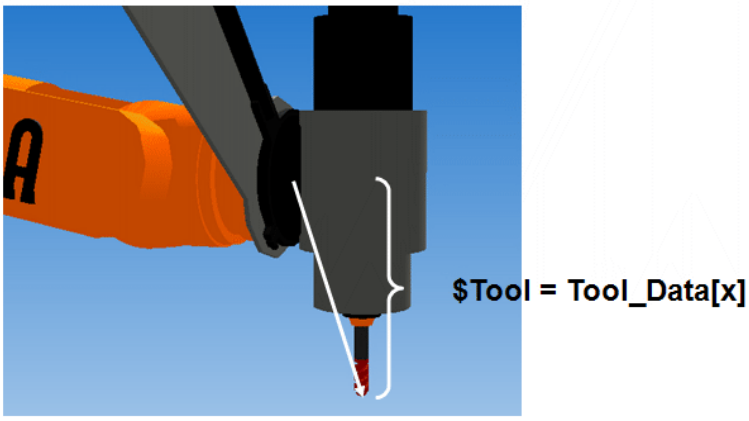


Fig. 6-4: Tool change variant 1

Variant 2

If the variable **cncReferenceTool** > 0, a reference TCP is loaded from **$config.dat** and used to define the spindle mount. Based on this TCP, when a tool is selected in the CNC code (X), the values from the CNC tool configuration

for the selected tool X are linked to the data of the reference tool and **$Tool** is updated with the result.

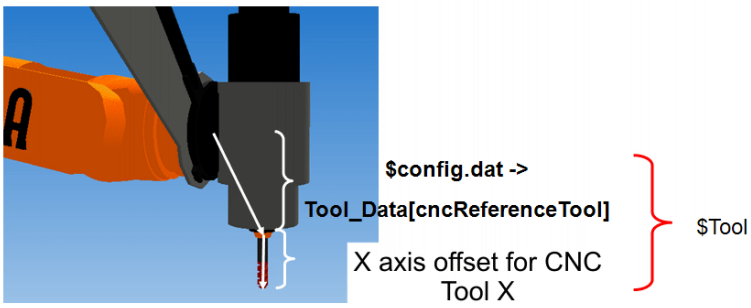


Fig. 6-5: Tool change variant 2

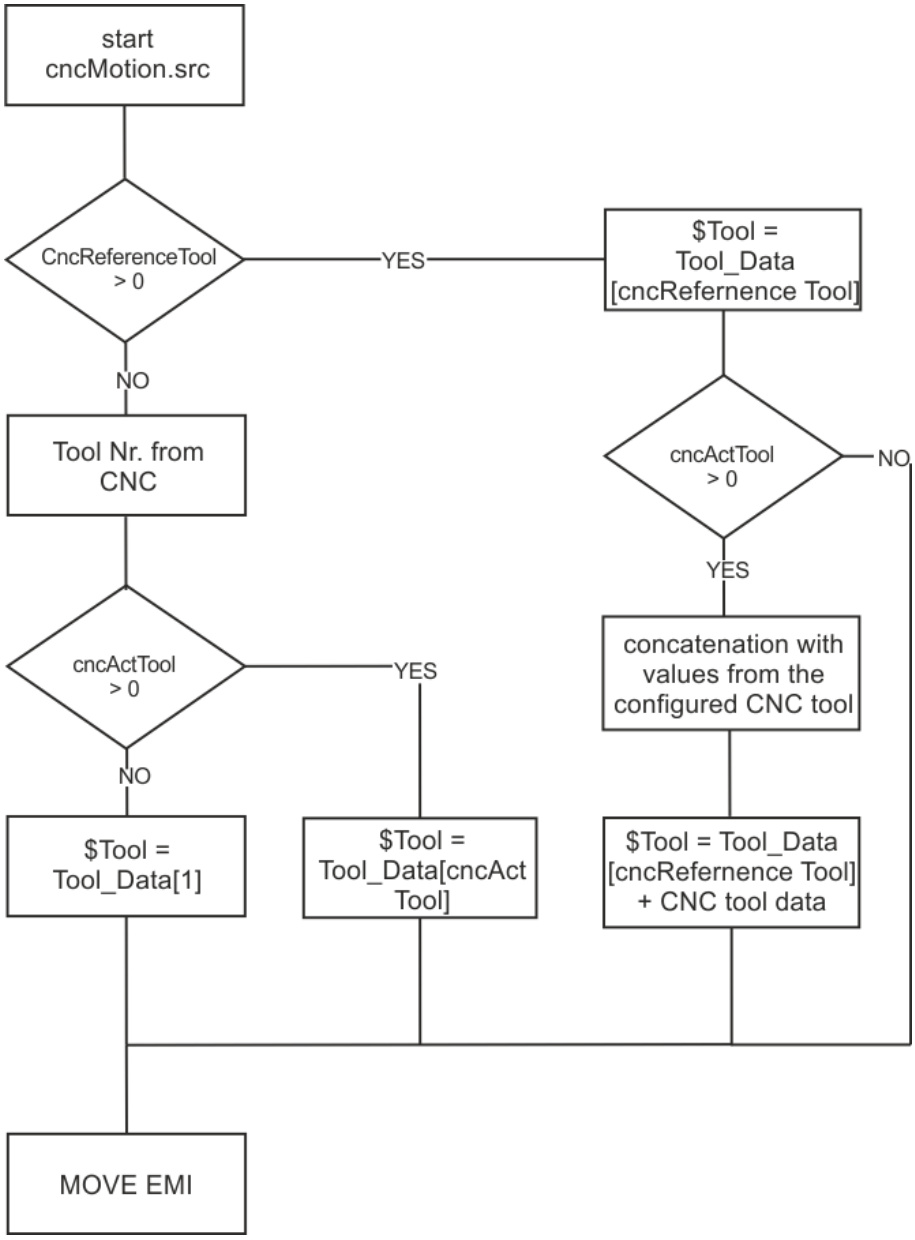


Fig. 6-6: Tool change flowchart

6.3.1 Tool management via KRC

Description

The default tool change method of the KRC can also be used with KUKA.CNC. For this purpose, all the tools to be used must be calibrated using the customary calibration methods of the KRC and correspondingly entered in the tool management ($config.dat) of the KRC. The tool change is performed as usual via a KRL program. For this method, the value of cncReferenceTool must be 0 (variant 1) .

Further information is contained in the operating and programming instructions for the KUKA System Software (KSS).

6.3.2 Tool management via CNC

Description

For the NC controller, the tool is e.g. the milling head mounted on the spindle mount. The tool offset from the spindle mount to the TCP (= tip of spindle) must be measured for every tool. A reference tool must be calibrated in the KRC and its index stored in **cncReferenceTool** (variant 2). The offsets entered in the CNC tool configuration are accordingly linked to this reference tool in the case of a tool change.

6.3.2.1 Tool calibration

Description

The CNC tool data refer to a reference tool on the KRC. For this reference tool, the offset from the robot flange to the tool mount, e.g. of the milling spindle, is measured. The standard KUKA tool calibration methods can be used for this, e.g. the XYZ 4-point and ABC 2-point methods.

The calibration data must be saved under the tool number used for CNC operation. For subsequent CNC operation, the index of the reference tool must be entered as the value of the variable **cncReferenceTool** in the data list **KRC:\R1\TP\CNC\cncMotion.dat**, e.g.:

```
cncReferenceTool = 5
```

The tool offset from the spindle mount to the TCP (= tip of spindle) must be measured mechanically for every tool by means of a coordinate measuring machine and entered in the CNC tool configuration.

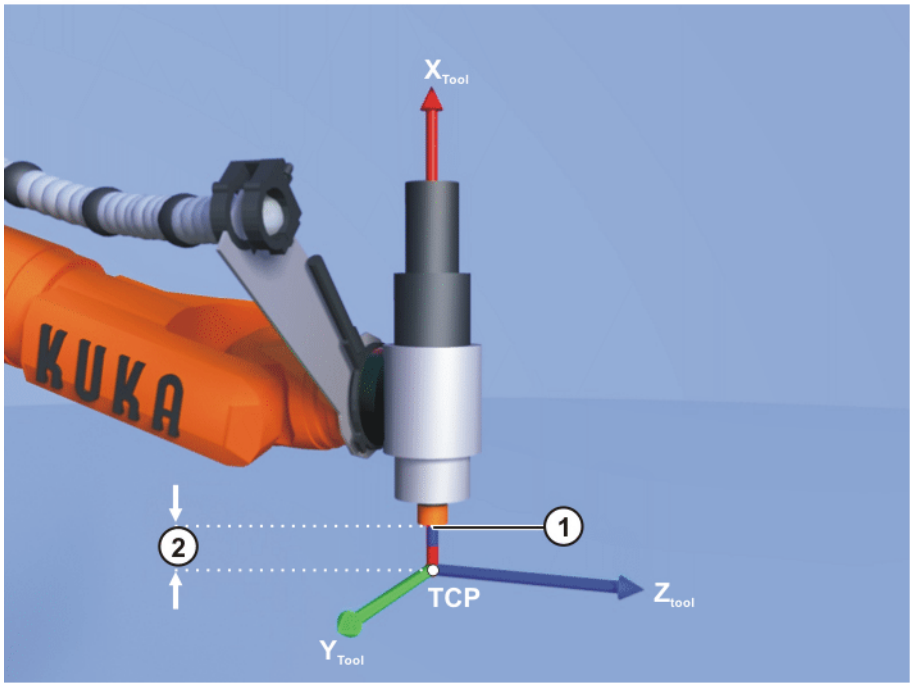


Fig. 6-7: Calibrating the reference tool

1 Spindle mount
2 Tool offset (= offset from spindle mount to TCP)

6.3.2.2 Configuring the CNC tool data

Description

The tool data configuration can be found in the menu of the configuration interface under **CNC** > **Configuration** > **Tool data**. On this configuration page, tools of the CNC can be selected and the corresponding tool data entered or changed.

Tool data can also be modified online by means of variable access in the NC program. Information about this can be found in the CNC programming instructions.

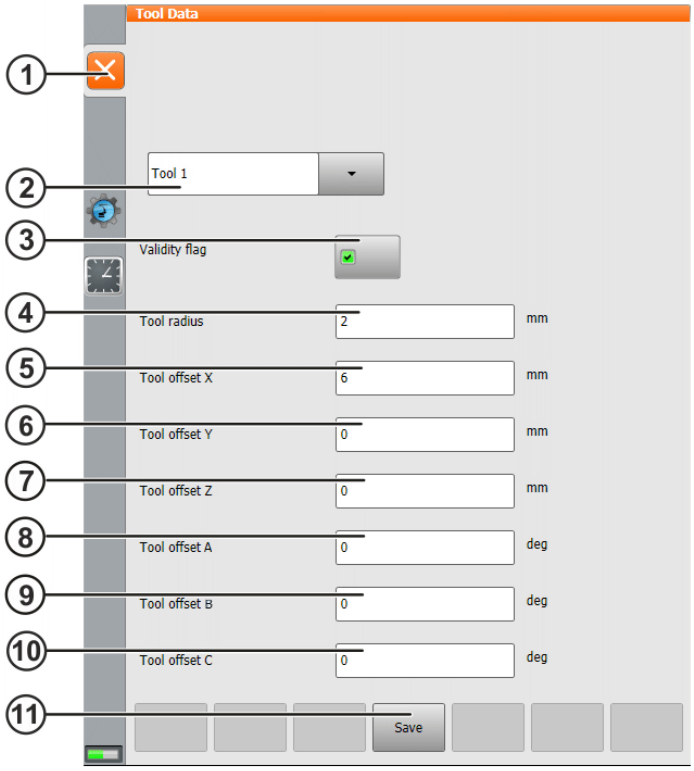


Fig. 6-8: Tool data

Item	Description
1	Close the tool configuration. If data have been changed, a request for confirmation is generated when the window is closed, asking whether the changed data are to be saved. The changes will be discarded if they are not saved. The changes are only applied after a reconfiguration or a cold start of the controller.
2	Selection of the tool to be configured. The number of the tool displayed here is used when programming the tool change in the NC program.
3	Indicates whether the currently selected tool is active, so that it is possible to change to this tool from the NC program. Green check mark = tool available for tool change. No check mark = tool not available for tool change. Pressing the button toggles between active and inactive.
4	Radius of the currently selected tool in millimeters, e.g. radius of a milling head, which is to be used for a tool radius correction.
5	Dimension of the tool in the X direction in millimeters, e.g. length of a milling head
6	Dimension of the tool in the Y direction in millimeters
7	Dimension of the tool in the Z direction in millimeters
8	Orientation of the tool about the Z axis in degrees
9	Orientation of the tool about the Y axis in degrees
10	Orientation of the tool about the X axis in degrees
11	Accept and save the entered tool data for the current tool

NOTICE Following installation of KUKA.CNC, the CNC tool configuration already contains a number of activated tools that must be adapted by the start-up technician according to the tools actually used. Tools that are not required must be deactivated and any further tools required must be activated.

If the CNC function “tool radius correction” is to be used, the tool radius must be correctly configured. This applies for both variant 1 and variant 2 of the tool change.

⚠ CAUTION Incorrectly configured tool data may result in damage to the workpiece, the machine or other objects in the vicinity of the robot. In such cases, this may also constitute a danger to persons. After a change to the tool data, these should therefore be checked for correctness in the set-up mode T1.

6.3.2.3 Programming a tool change in the NC program

The technology function **M6** is available for programming a tool change in the NC program. It is called using the number of the new tool.

```
%Move_Vertical

N010 G01 G91 Z100 F1000
N020 T4 M6
N030 G01 G91 Z100 F1000
N040 T5 M6
N050 G01 G91 Z100 F1000
N060 T0 M6
N070 G01 G91 Z-300 F1000

N080 M30
```

The command **T4 M6** in the above example means that the tool with the number 4 (T4 = Tool 4), that was configured via the tool data during start-up, is to be selected.

6.4 Managing NC programs

Description

The CNC HMI offers the following options for NC programs:

- Switching the current NC program directory
  (>>> 6.4.1 "Toggling the NC program directory" Page 27)
- Creating new NC programs
  (>>> 6.4.2 "Creating new NC programs" Page 27)
- Editing NC programs
  (>>> 6.4.3 "Editing NC programs" Page 29)
- Deleting NC programs
  (>>> 6.4.4 "Deleting NC programs" Page 30)
- Saving NC programs under another name
  (>>> 6.4.5 "Saving NC programs under a different name" Page 32)
- Editing internal NC programs
  (>>> 6.4.6 "Editing internal NC programs" Page 33)
- Importing NC programs from other sources, e.g. from a network drive
  (>>> 6.4.7 "Importing NC programs" Page 35)

6.4.1 Toggling the NC program directory

Description

Depending on the user that is currently logged on, it is possible to toggle between two or three directories for the current NC program directory.

- The directory **prg_intern** contains internal utility programs (>>> 6.4.6 "Editing internal NC programs" Page 33) and can only be selected if the current user has Expert privileges or higher.
- The directory **prg** contains NC programs which are not archived.
- The directory **prg_sync** contains NC programs which are archived.

NOTICE The distinction between **prg** and **prg_sync** is necessary because very large NC programs of several hundred MB cannot be archived for system reasons and should therefore be saved under **prg**. These NC programs must be archived manually. All NC programs saved under **prg_sync** are archived automatically when an archive is created. The procedure for creating an archive is described in the system software documentation.

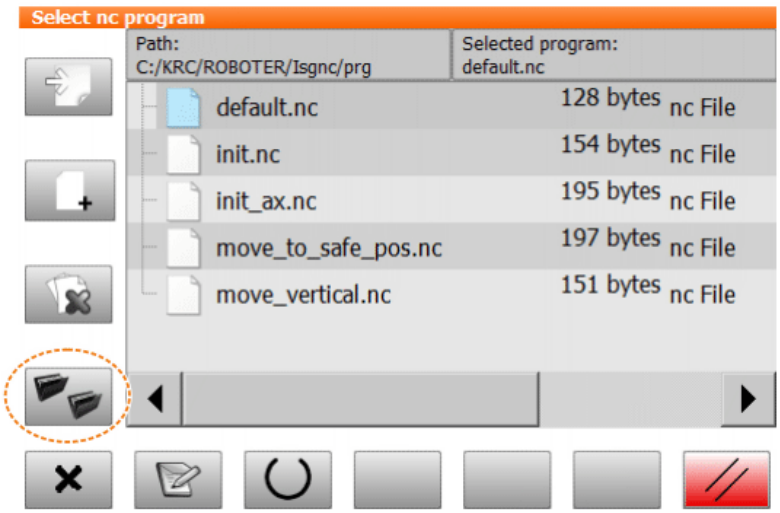


Fig. 6-9: Toggling the NC program directory

6.4.2 Creating new NC programs

Description

New NC programs can be created via the CNC HMI. The newly created NC programs are saved to the hard drive in the currently selected NC working directory.

Procedure

1. Switch to the view of available NC programs.

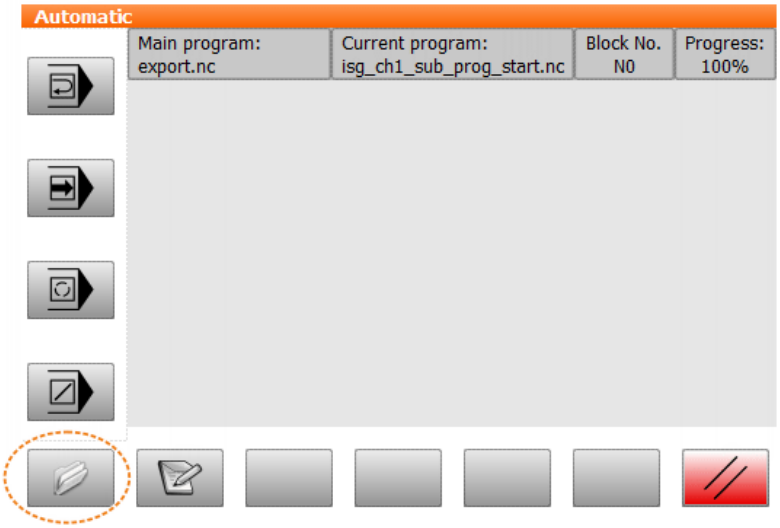


Fig. 6-10: Switching to the view of NC programs

2. If necessary, toggle to the directory in which the new program is to be created.
3. Create a new NC program.

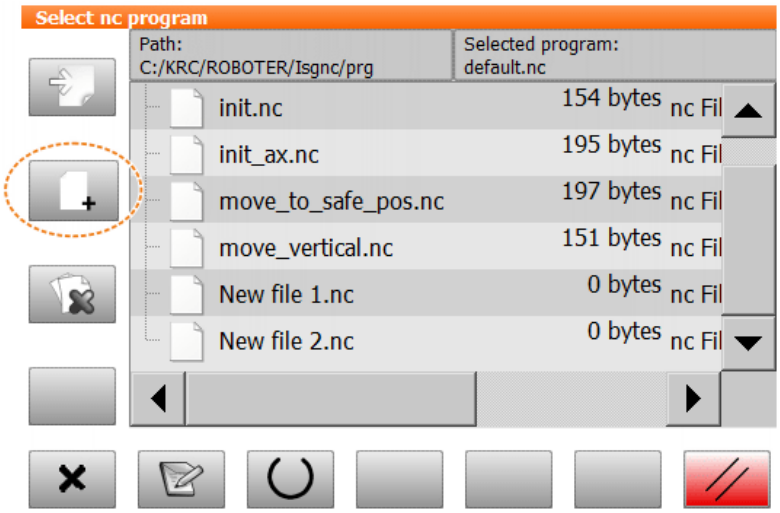


Fig. 6-11: Creating a new NC program

4. Enter a name for the NC program, and confirm.
5. The new NC program is displayed in the list of available programs.

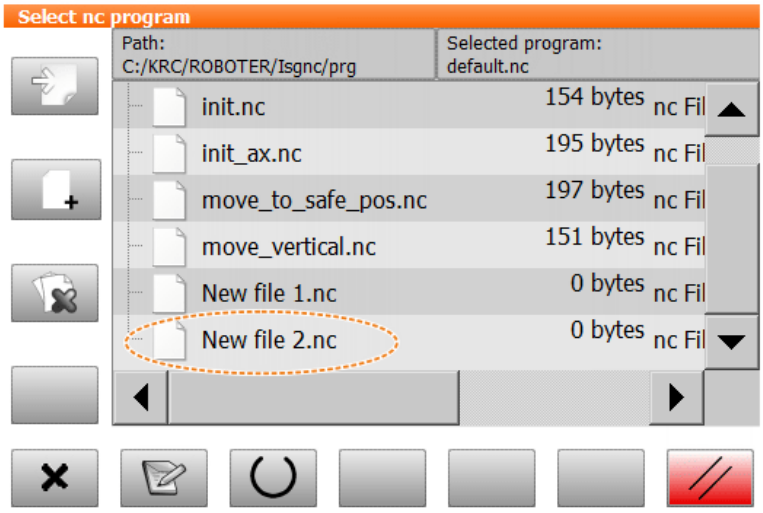


Fig. 6-12: Program list

6.4.3 Editing NC programs

Description NC programs can be edited via the CNC HMI.

Procedure

1. Switch to the view of available NC programs.

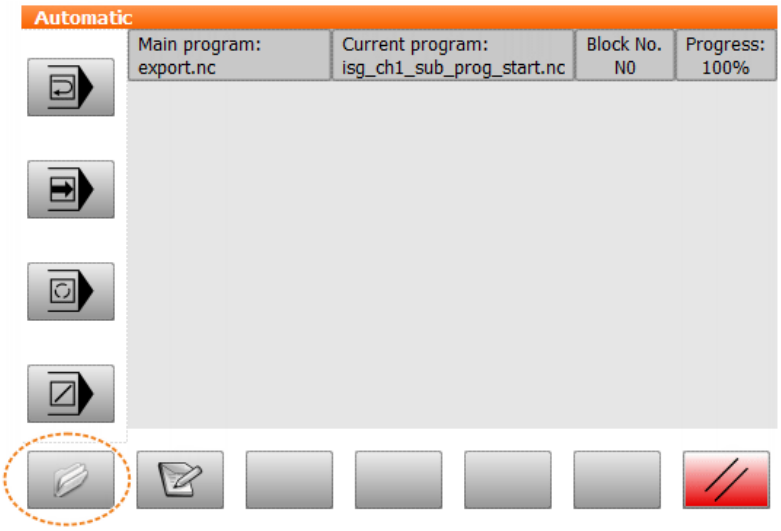


Fig. 6-13: Switching to the view of NC programs

2. Select the NC program to be edited, and press Edit.

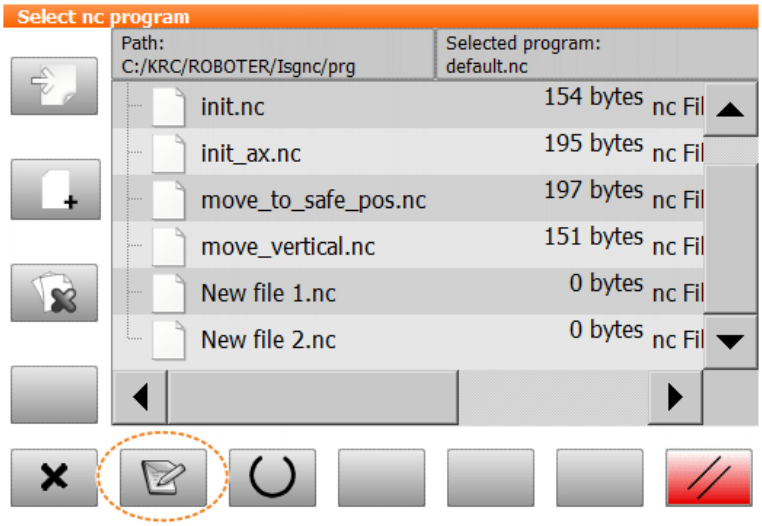


Fig. 6-14: Selecting the NC program

3. The NC program is opened in the editor and can be edited.

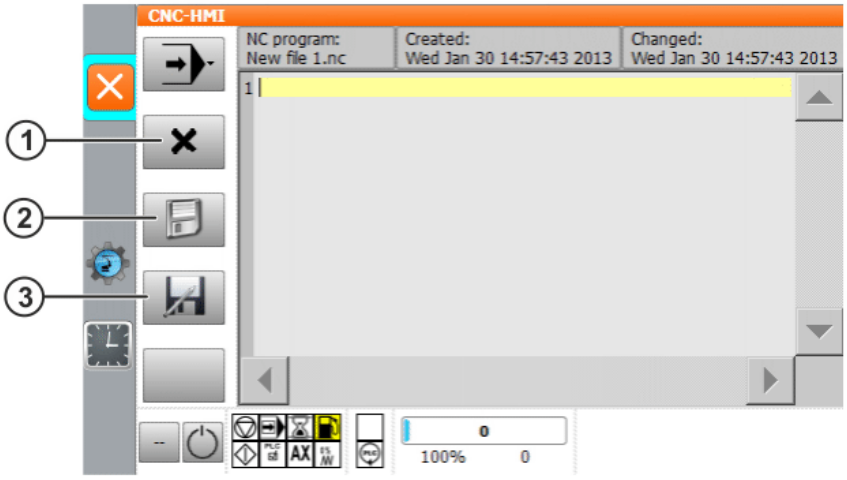


Fig. 6-15: Editor

Item	Description
1	Quit program editing. If an NC program is closed without saving, the changes are discarded.
2	Save the changes that have been made.
3	Save the NC program under a different name (>>> 6.4.5 "Saving NC programs under a different name" Page 32).

6.4.4 Deleting NC programs

Description NC programs which are no longer required can be deleted via the CNC HMI.

NOTICE If an NC program is deleted, it is removed from the hard drive and can no longer be restored. It is advisable to back up the NC programs at regular intervals using the KRC archiving mechanism.

Precondition

- "Expert" user group

Procedure

1. Switch to the view of available NC programs.

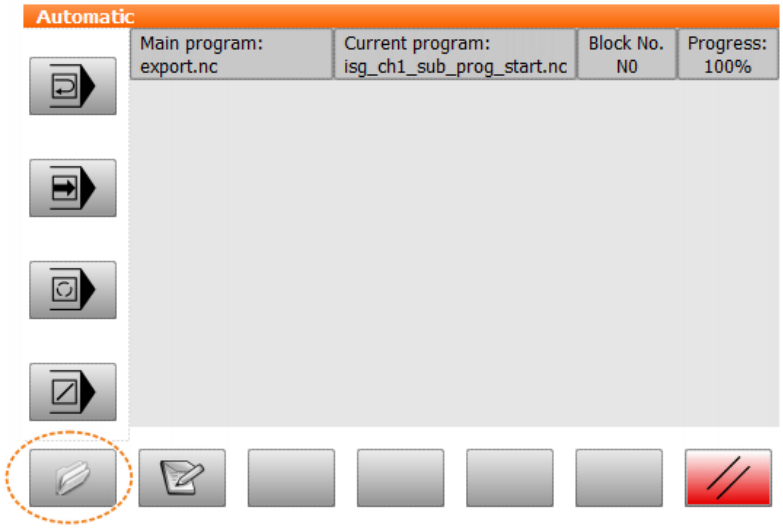


Fig. 6-16: Switching to the view of NC programs

2. Select an NC program and delete it using the corresponding button.

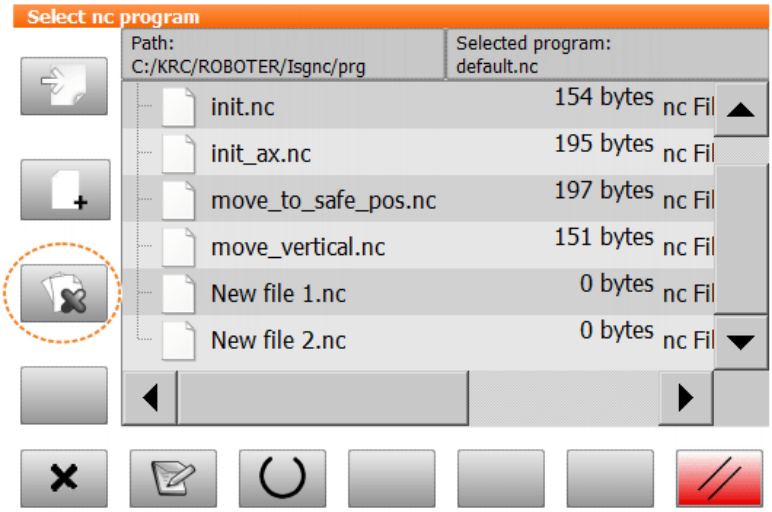


Fig. 6-17: Deleting an NC program

3. Confirm the request for confirmation.

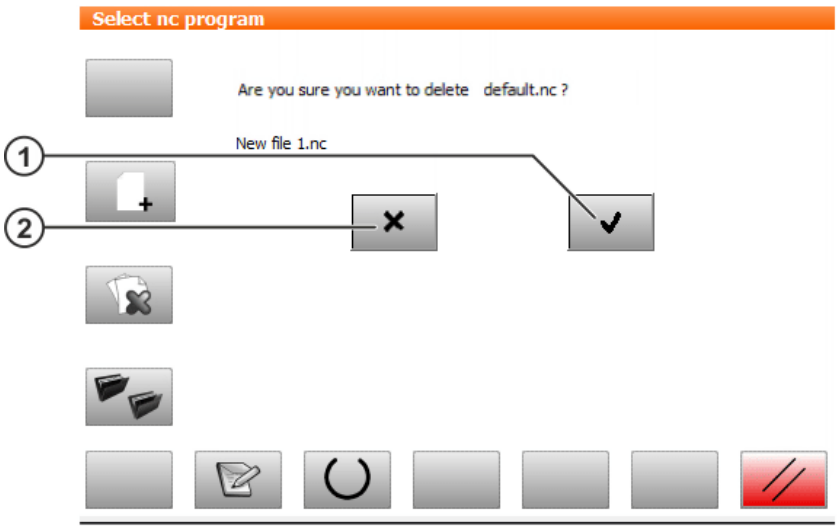


Fig. 6-18: Request for confirmation before deleting a file

Item	Description
1	Delete. The file is removed from the hard drive.
2	Cancel the action. The file is not deleted.

6.4.5 Saving NC programs under a different name

Description

After editing, an NC program can be saved under a new name, with all the changes made. Saving an NC program under a new name without making any changes duplicates the content of the file in a second file with a different name.

Procedure

1. Open the file in Edit mode.
2. Make any changes required and press the **Save as** button.

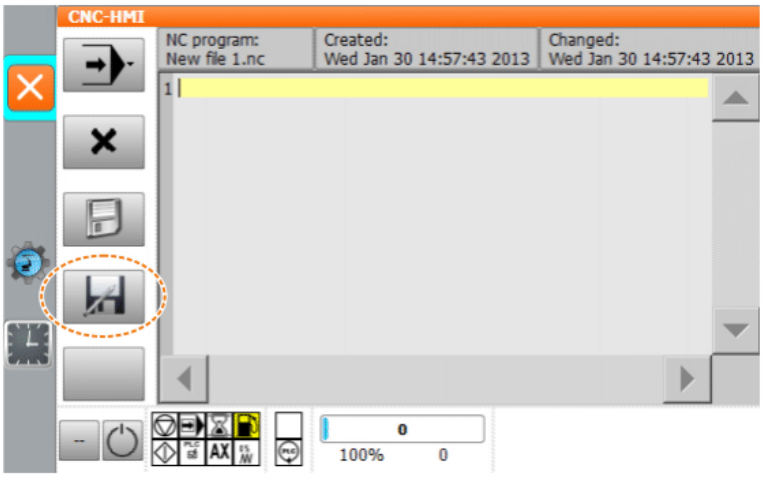


Fig. 6-19: Saving an NC program under another name

3. Enter a file name for the new file and save it.

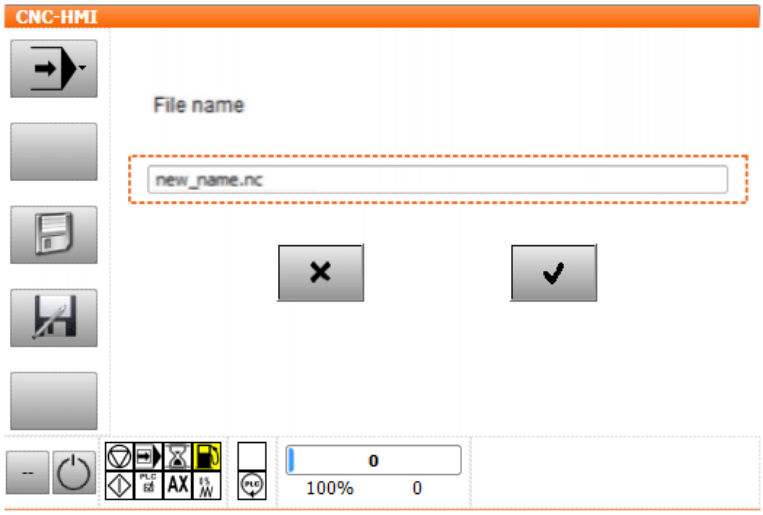


Fig. 6-20: Entering a file name

4. Save the file under the specified name.

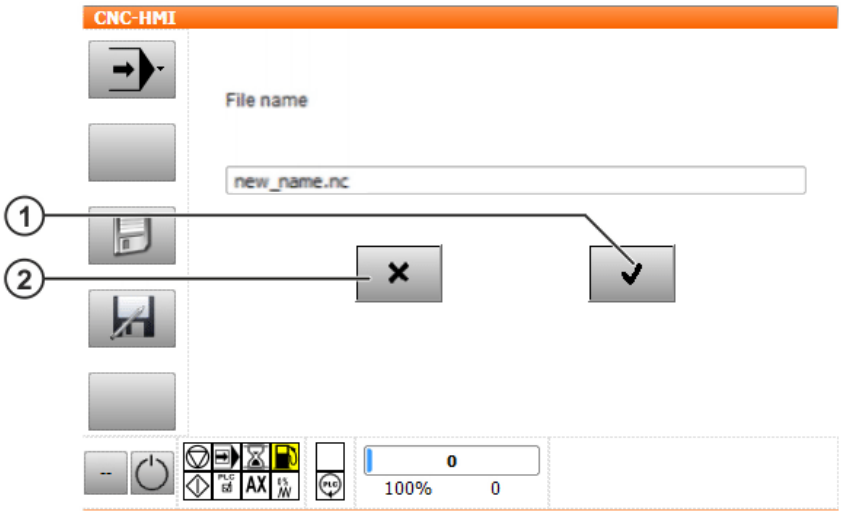


Fig. 6-21: Saving the file name

Item	Description
1	Save. The file is saved under the specified name.
2	Cancel the action. The file is not saved.

NOTICE If a file is already saved under the same name, a message is displayed to the effect that this file already exists. The file is therefore not saved. In this case, steps 3 and 4 must be repeated and a different name must be entered.

6.4.6 Editing internal NC programs

Description The directory **prg_intern** contains system-internal utility programs which need to be modified under certain conditions, e.g. cycle for pocket milling. Should this be necessary, the CNC HMI provides a way of modifying these NC programs.

Precondition
- "Expert" user group

Procedure
1. Switch to the view of available NC programs.

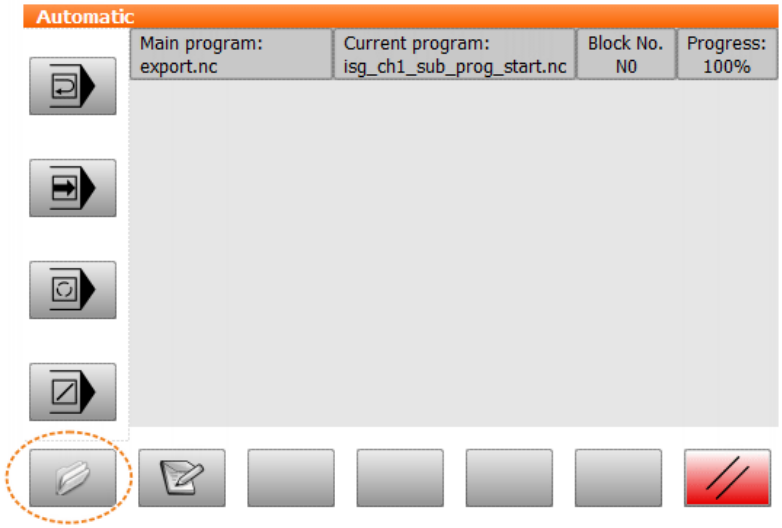


Fig. 6-22: Switching to the view of NC programs

2. All the user and example programs in the directory **prg** are displayed.

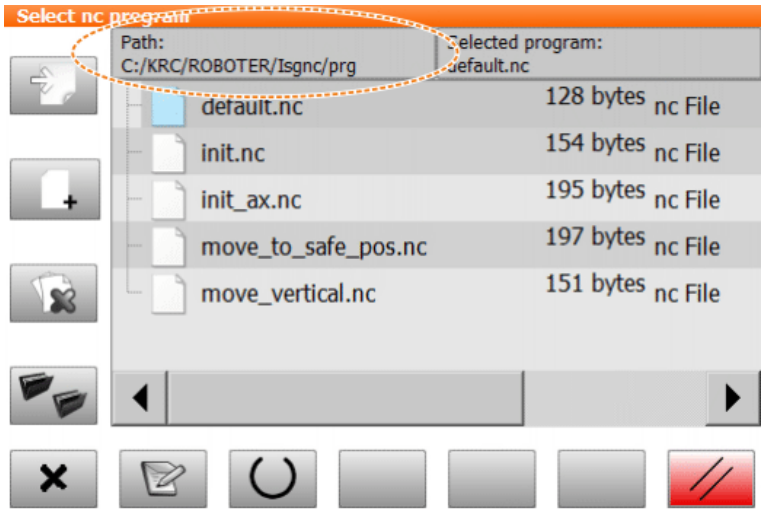


Fig. 6-23: “prg” directory

3. Switch to the directory **prg_intern**.

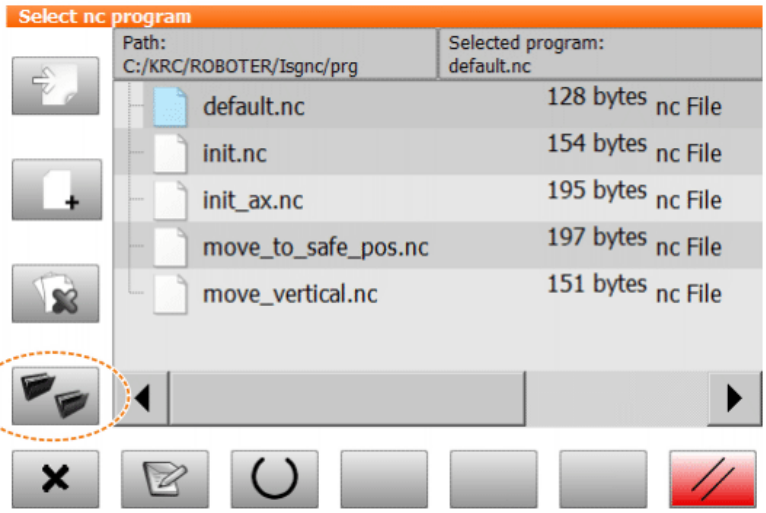


Fig. 6-24: Switching to the “prg_intern” directory

This button is only displayed if the user is logged on in the “Expert” user group. The log-on procedure is described in the **KSS** documentation.

4. The NC programs available in the directory **prg_intern** are displayed.

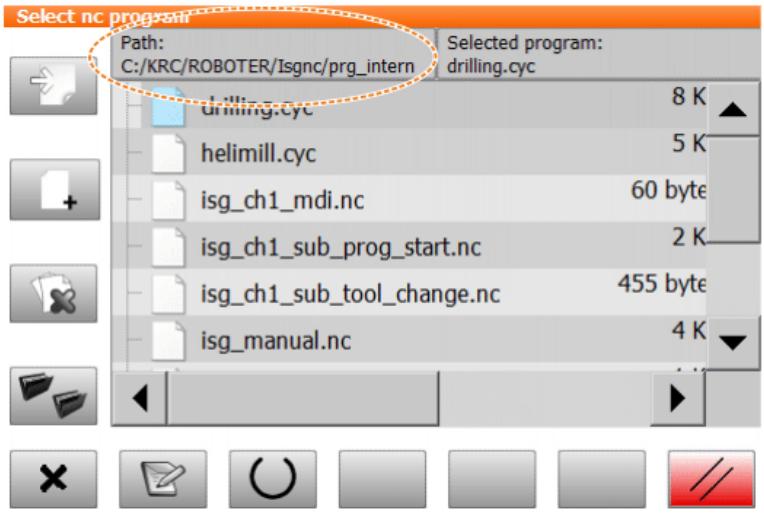


Fig. 6-25: “prg_intern” directory

5. Select the NC program to be edited, and switch to Edit mode.

6.4.7 Importing NC programs

Description

NC programs can be imported via the CNC HMI. For example, these may be NC programs on network drives enabled on the controller, on USB sticks plugged into the controller or on one of the partitions of the controller. The files are copied using the import mechanism into the **prg** directory, where they can then be edited and run.

Procedure

1. Switch to the view of available NC programs.

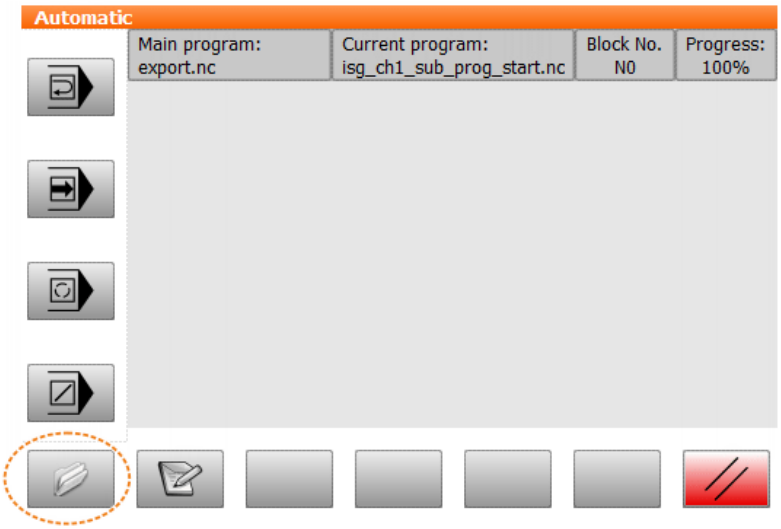


Fig. 6-26: Switching to the view of NC programs

2. Click on the **Import file** button.

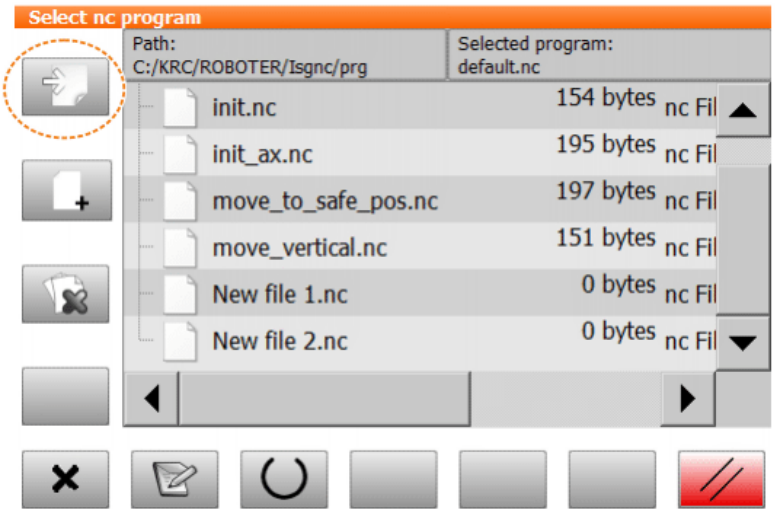


Fig. 6-27: Importing an NC program

3. Navigate to the location of the NC program that is to be imported, and select the NC program.

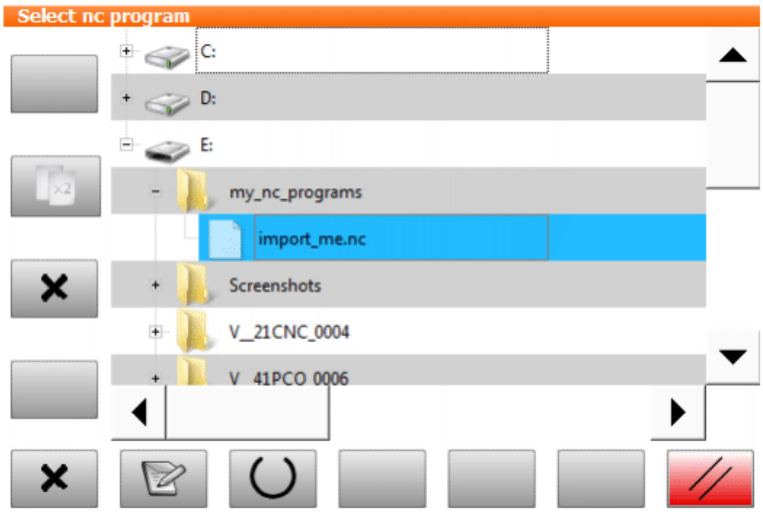


Fig. 6-28: Selecting a program

4. Click on the **Start import** button.

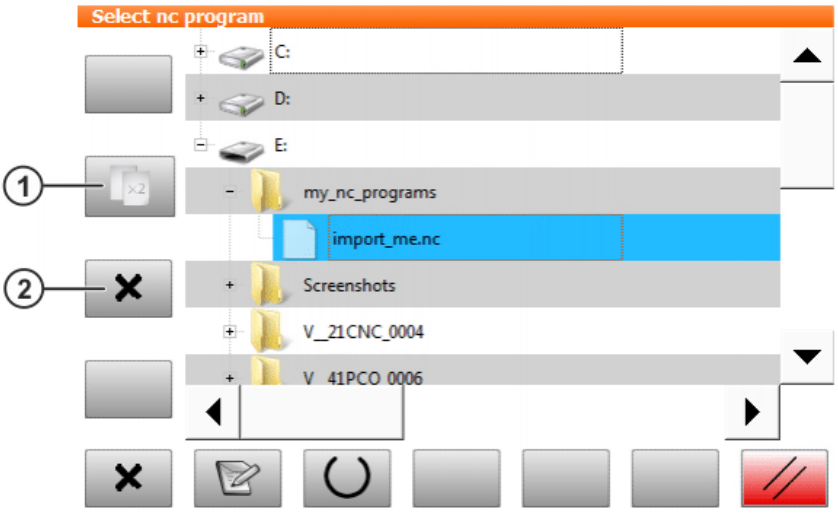


Fig. 6-29: Starting the NC program import

Item	Description
1	Start import. The file is copied to the **prg** directory.
2	Cancel import. The file is not copied.

5. The file is located in the **prg** directory and can now be used.

6.5 Configuring zero offset data

Description

Various zero point offset groups can be specified and selected in the NC program using the G commands **G54** to **G59**. In each of these groups, an offset can be specified in the X, Y and Z directions.

The groups **G54** to **G59** can be used to activate zero point offsets within an NC program. The command **G53** resets the currently selected zero point offset.

The zero offset data are configured via the corresponding configuration page on the KRC user interface. The configuration page is accessed via the menu sequence **CNC > Configuration > Zero offsets**.

NOTICE Further information about the zero offset data and their use can be found in the **NC** documentation and in the **CNC online help**. The CNC online help is located in the **KUKA.CNC option** in the **DOC** directory.

Overview

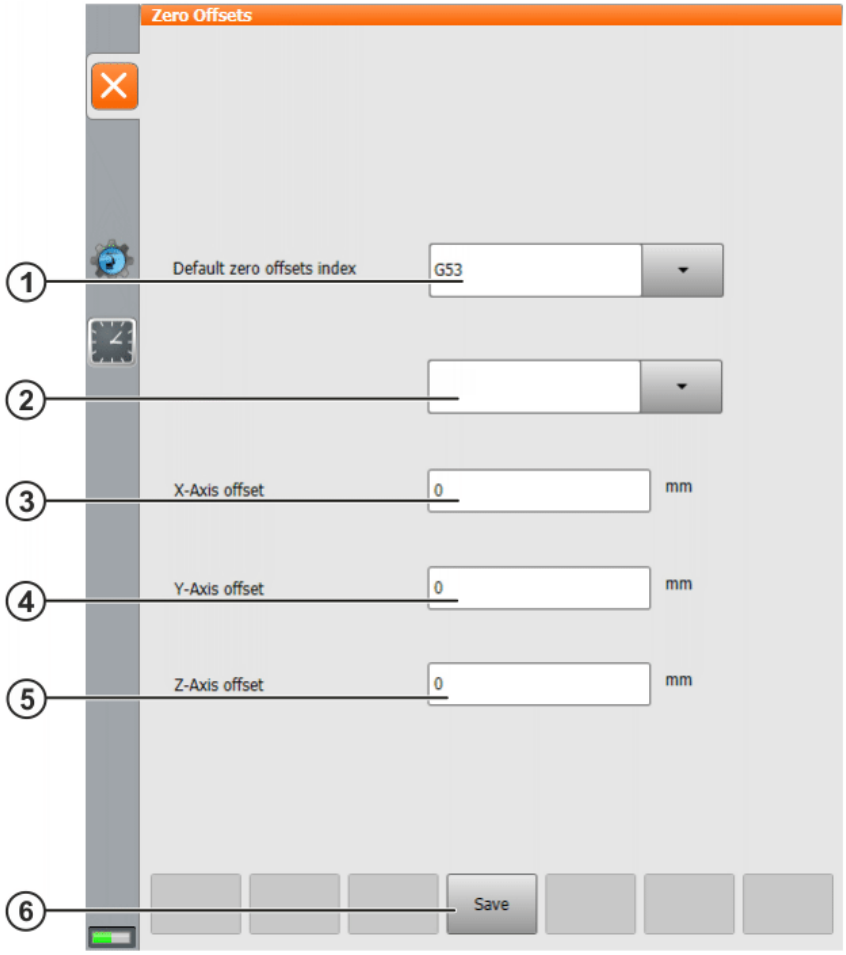


Fig. 6-30: Zero offset data

Item	Description
1	Selection of the zero point offset group which is to be used by the NC controller by default if no other offset is specified.
2	Selection of the zero point offset group to be configured.
3	Zero point offset of the group selected under item 2, in the direction of the X axis in millimeter.
4	Zero point offset of the group selected under item 2, in the direction of the Y axis in millimeter.
5	Zero point offset of the group selected under item 2, in the direction of the Z axis in millimeter.
6	Accept and save the entered zero offset data. If the configuration page is closed without saving, all changes made since last saving are discarded.

6.6 Configuring clamp offset data

Description

The configuration page for clamp offset data allows different clamp offset groups to be selected and the corresponding clamp offset data to be specified. The configuration page is accessed via the menu sequence **CNC > Configuration > Clamp offsets**.

Selecting the clamp offset index before NC program start allows the corresponding clamp offset group to be loaded. Each clamp offset group contains the clamp offset data for the X, Y and Z directions.

When the NC program is started, the selected clamp offset data are taken into account in the coordinates. The start axis configuration of the NC channel is defined in the channel parameters.

Further information about the clamp offset data and their use can be found in the NC documentation and the CNC online help. These are located in the **KUKA.CNC option** in the **DOC** directory.

Overview

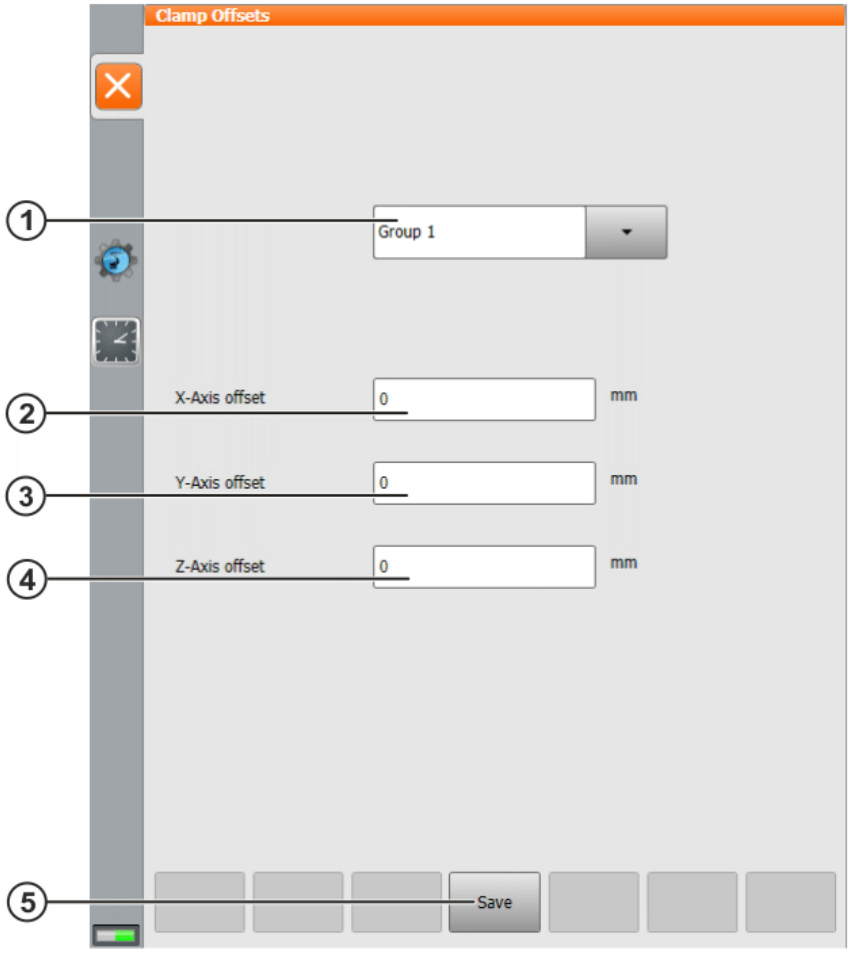


Fig. 6-31: Clamp offset data

Item	Description
1	Selection of the clamp offset group to be configured.
2	Clamp offset of the group selected under item 1, in the direction of the X axis in millimeter.
3	Clamp offset of the group selected under item 1, in the direction of the Y axis in millimeter.
4	Clamp offset of the group selected under item 1, in the direction of the Z axis in millimeter.
5	Accept and save the entered clamp offset data for the currently selected group. If configuration page is closed without saving, any changes made are discarded.

6.7 Channel parameters

Description

The configuration interface for the general channel parameters is opened via the menu sequence **CNC > Configuration > Channel parameters**. The configuration interface consists of several pages, which can be toggled using the buttons **Next** and **Back**. Before switching pages or closing the configuration interface, any changes made should be saved using the **Save** button. Unsaved changes will be rejected.

Precondition

- "Expert" user group

6.7.1 Configuring axis groups

Description

This configuration page is used to add axes to the current axis group or to remove them. In addition, a number and a name can be assigned to each axis.

> Further information about the axis groups and their use can be found in the NC documentation and the CNC online help. These are located in the **KUKA.CNC option** in the **DOC** directory.

Overview

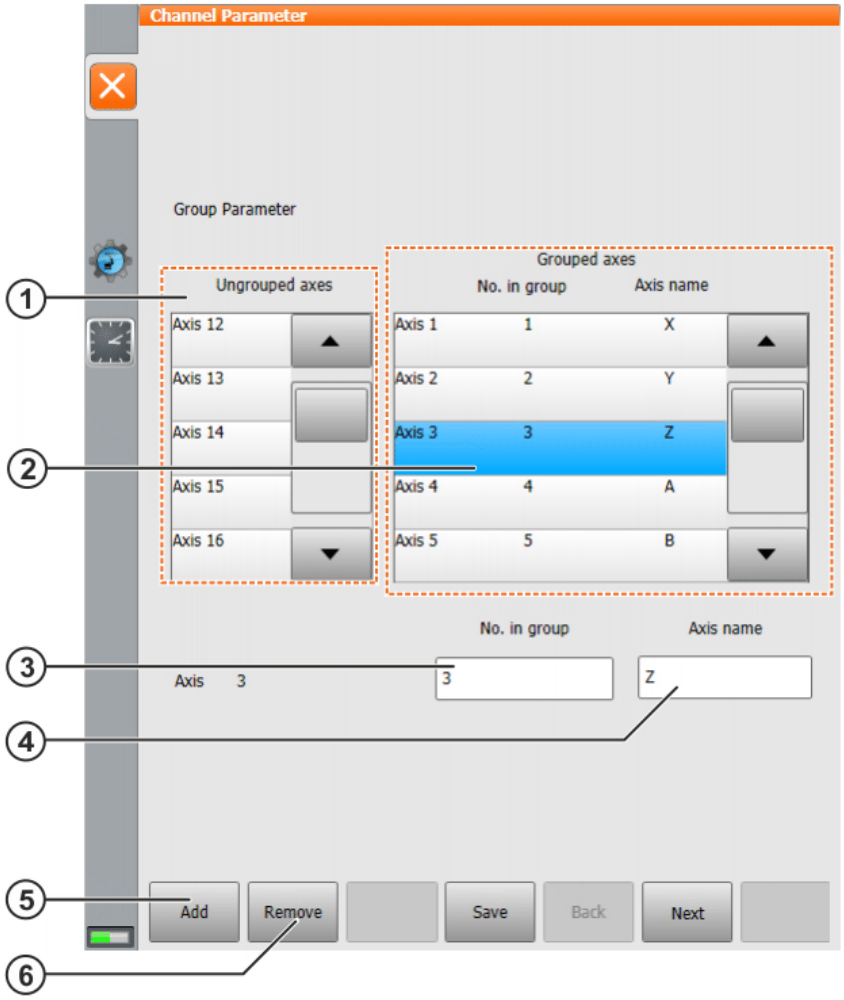


Fig. 6-32: Configuring axes

Item	Description
1	List of axes that have not yet been assigned to an axis group.
2	List of axes that are assigned to the axis group. The axis itself, and the number and name of this axis within the axis group are displayed.
3	Number of the axis selected in list 2 within the group. This box can be used to change the number of the axis.
4	Name of the axis selected in list 2 within the group. This box can be used to change the name of the axis.
5	This button can be used to assign the ungrouped axis selected in list 1 to the axis group.
6	This button is used to remove the axis selected in list 2 from the axis group, thereby making it an ungrouped axis again.

6.7.2 Configuring spindles

Description

This configuration page allows the configuration of spindles. It must be ensured that only the spindles configured here are addressed in the NC program. This applies to both position-controlled and PLC-controlled spindles.

Overview

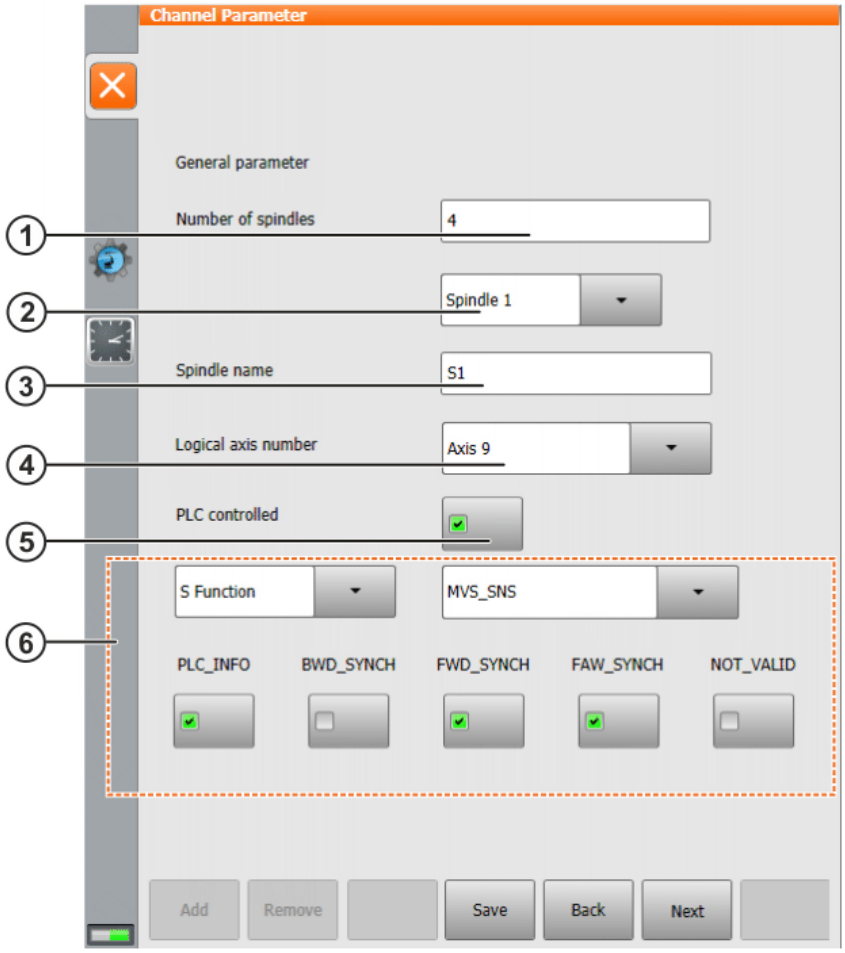


Fig. 6-33: Configuring a spindle

Item	Description
1	Number of available spindles.
2	Selection of the spindle to be configured.
3	Name of the spindle to be configured.
4	Logical axis number of the spindle to be configured.
5	This button is used to define whether the selected spindle is to be controlled via a PLC program or directly by the NC controller. If the button is activated, the selected spindle is controlled by a PLC program.
6	Synchronization type of the spindle to be configured.

Further information about the spindles and their use can be found in the NC documentation and the CNC online help. These are located in the **KUKA.CNC option** in the **DOC** directory.

6.7.3 Synchronization of user-defined technology functions

Description

The configuration options provided on this configuration page are described in Section (>>> 6.1.2 "User-defined technology functions" Page 16).

7 Operation

7.1 Menus

The following menus and commands are specific to this technology package:

Display

- CNC
  - CNC-HMI

7.2 KUKA.CNC-HMI user interface

Call

- Select **Display** > **CNC** > **CNC-HMI** in the main menu.

The user interface is opened in Standby mode.

Overview

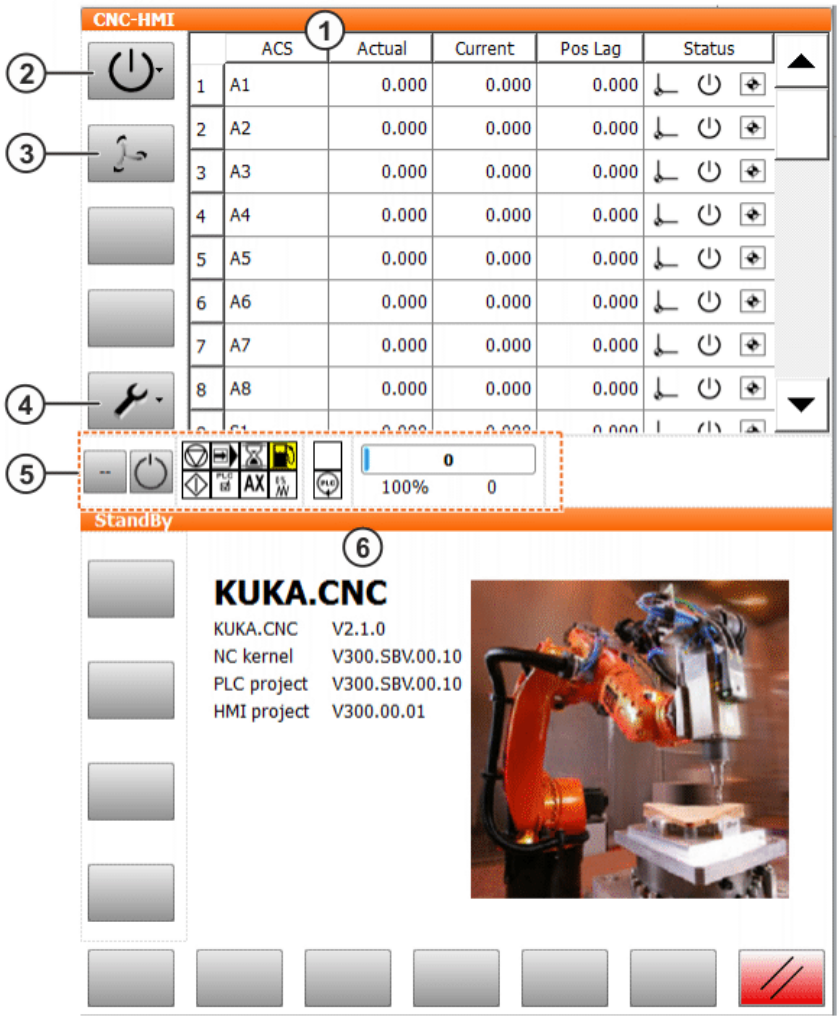


Fig. 7-1: KUKA.CNC-HMI user interface (Standby mode)

Item	Description
1	**CNC-HMI** window The window contains information about the axis positions and the status of the CNC. It is possible to switch between the display of the axis-specific position (ACS) and the Cartesian position (PCS).
2	**Operation mode** button (>>> "Operation mode" Page 44)
3	**ACS/PCS view** button (>>> "ACS/PCS view" Page 44)
4	**Diagnosis & Settings** button
5	Status bar
6	Main window The window contains the display and operator control elements of the selected operating mode.

Operation mode

This button can be used to select the operating mode:

Button	Description
	Operating mode **Standby mode** The version information is displayed in Standby mode.
	Operating mode **Automatic mode**
	Operating mode **MDI mode**

ACS/PCS view

Button	Description
	In the **CNC-HMI** window, the axis-specific position (ACS) is displayed. Pressing the button switches to the display of the Cartesian position (PCS). (>>> 7.2.3 "Display of the Cartesian position (PCS)" Page 47)
	In the **CNC-HMI** window, the Cartesian position (PCS) is displayed. Pressing the button switches to the display of the axis-specific position (ACS). (>>> 7.2.2 "Display of the axis-specific position (ACS)" Page 46)
	This button is only available if the diagnosis or the spindle configuration has been opened and edit mode is active. Switches back to the display of the axis-specific position (ACS).

Diagnosis & Settings

This button can be used to select the following functions:

Button	Description
	In the **CNC-HMI** window, it switches to the axis positions.
	In the **CNC-HMI** window, it switches to the diagnostic functions.
	In the **CNC-HMI** window, it switches to the technology settings.
	Switches the selected NC program in the main window to Teach mode. Robot positions can be taught.
	The information window is minimized.

7.2.1 Status bar

The status bar indicates the status of the CNC interface and the CNC, the current error status, and information about override and velocity. The status bar is always visible as long as the information window is not hidden.

Overview

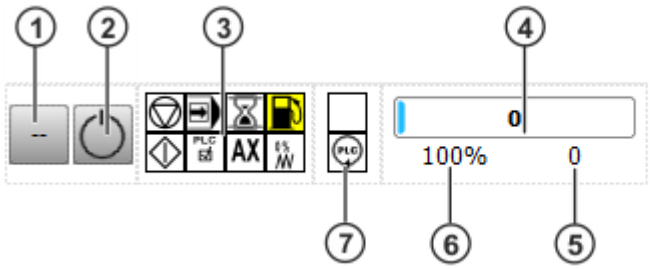


Fig. 7-2: Status bar

Item	Description
1	Status of the CNC interface (>>> "Status of CNC interface" Page 45)
2	Status of the CNC (>>> "Status of CNC" Page 46)
3	Causes of the CNC stop
4	Current velocity
5	Command velocity
6	Current program override (POV) The program override is set via the smartHMI.
7	Status of the Soft PLC

Status of CNC interface

Icon	Description
	CNC interface is not active.
	CNC interface is active.

Status of CNC

Icon	Description
	CNC is not active.
	CNC is active. NC program or MDI block is being executed.
	CNC has been stopped. NC program or MDI block has been stopped.
	CNC signals an error.

Causes of the CNC stop

The cause of the CNC stop is indicated by the LED on the icon lighting up yellow.

Icon	Description
	The motion has been stopped, e.g. due to a programmed stop or because the **Stop CNC** button has been pressed.
	Program run mode **Single Step** is active.
	Waiting for wait time to elapse (G04 in the NC program)
	The interpolator has no motion blocks available.
	Program run mode **Single Step**: Stop after every program line
	Waiting for acknowledgement of PLC
	Waiting for axis, e.g. axis exchanged (NC command #CALL AX)
	Current program override (POV) is 0%.
	Status of the Soft PLC White = Soft PLC running Yellow = Soft PLC not running

7.2.2 Display of the axis-specific position (ACS)

The positions of axes A1 to Ax and spindles S1 and Sx are displayed. If external axes are being used, the position of the external axes is also displayed (here A7).

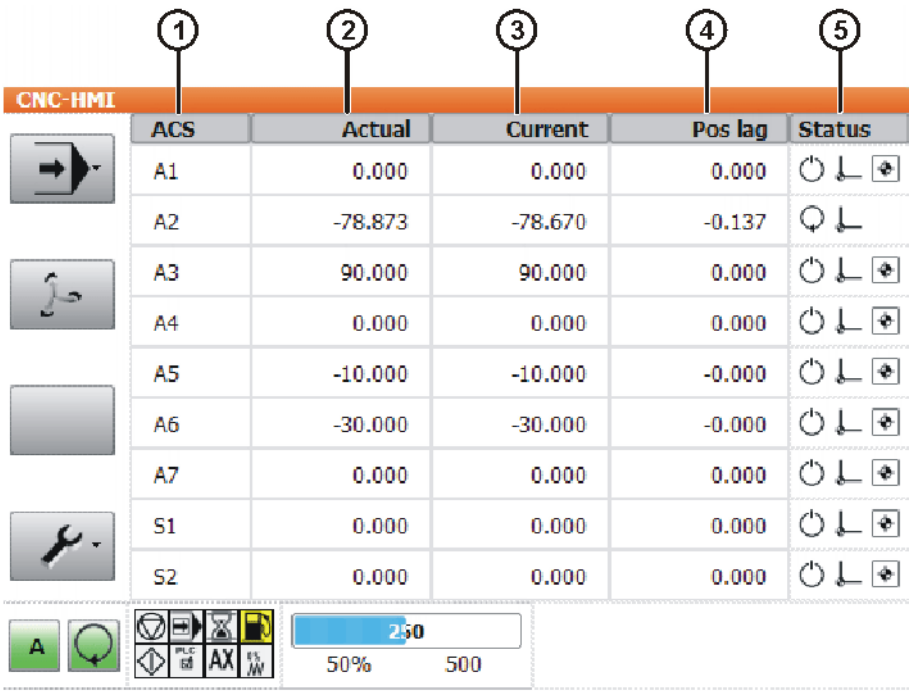


Fig. 7-3: Display of axis-specific position (ACS)

Item	Description
1	Name of axis or spindle
2	Axis-specific actual position
3	Axis-specific setpoint position
4	Axis-specific difference from setpoint position
5	Status of axis or spindle

The following icons indicate the status of the axis or spindle:

Icon	Description
	Axis or spindle at standstill
	Axis or spindle in motion
	The axis is mastered.
	The axis is not mastered.
	The axis or spindle has reached the target position. If the target position has not yet been reached, no icon is displayed.

7.2.3 Display of the Cartesian position (PCS)

The position (X, Y, Z) and orientation (A, B, C) of the TCP and the position of spindles S1 to Sx are displayed. If external axes are being used, the position of the external axes is also displayed (here Y1).

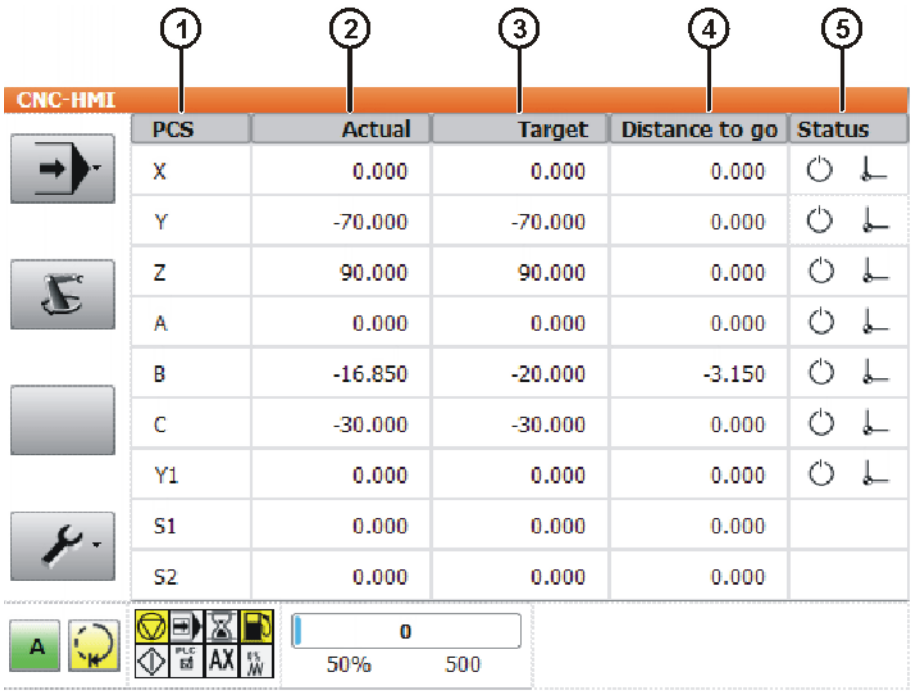


Fig. 7-4: Display of Cartesian position (PCS)

Item	Description
1	Components of the Cartesian position or name of the external axis or spindle
2	Cartesian actual position
3	Cartesian setpoint position
4	Cartesian difference from setpoint position
5	Status of axis or spindle

In some cases, the display of the Cartesian position on the KUKA.CNC-HMI does not match the display of the Cartesian position on the KUKA smartHMI. The reason for this is that the robot controller, unlike the NC controller kernel, uses status and turn values.

The following icons indicate the status of the axis or spindle:

Icon	Description
	Axis or spindle at standstill
	Axis or spindle in motion
	The axis is mastered.
	The axis is not mastered.

7.2.4 Technology settings

Here it is possible to switch the external spindle, the vacuum and the spindle cooling on and off, and to set the spindle speed and override.

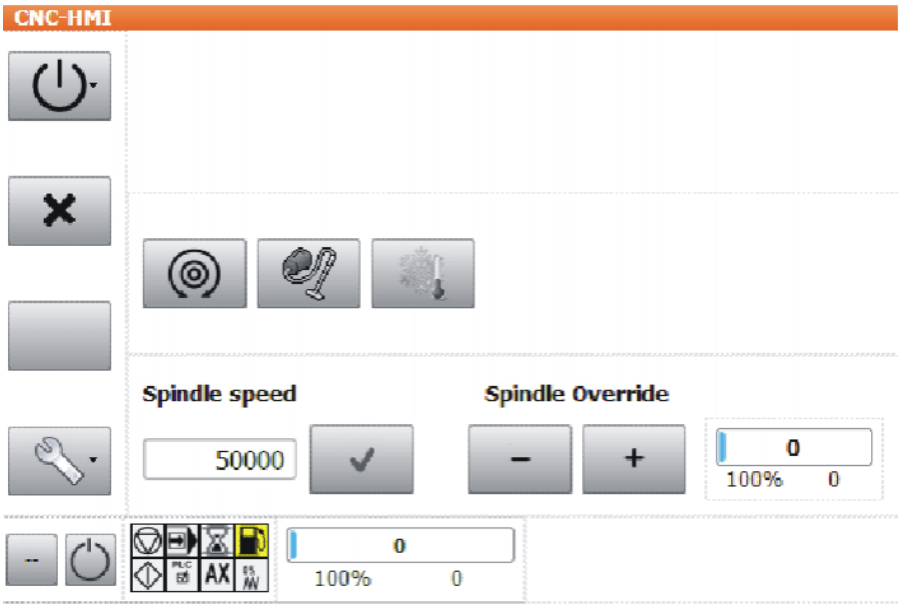


Fig. 7-5: Technology settings

The following buttons are available:

Button	Description
	**Spindle ON** button The spindle is switched off. Pressing the button switches the spindle on.
	**Spindle OFF** button The spindle is switched on. Pressing the button switches the spindle off.
	**Vacuum ON** button The vacuum is switched off. Pressing the button switches the vacuum on.
	**Vacuum OFF** button The vacuum is switched on. Pressing the button switches the vacuum off.
	**Cooling ON** button The cooling is switched off. Pressing the button switches the cooling on.
	**Cooling OFF** button The cooling is switched on. Pressing the button switches the cooling off.
	Accepts the spindle speed entered in the box to the left of the button Unit: RPM
	Decreases the spindle override (increment 5%)
	Increases the spindle override (increment 5%)

7.2.5 Operating mode “Automatic mode”

In **Automatic mode**, an NC program can be selected, executed and edited.

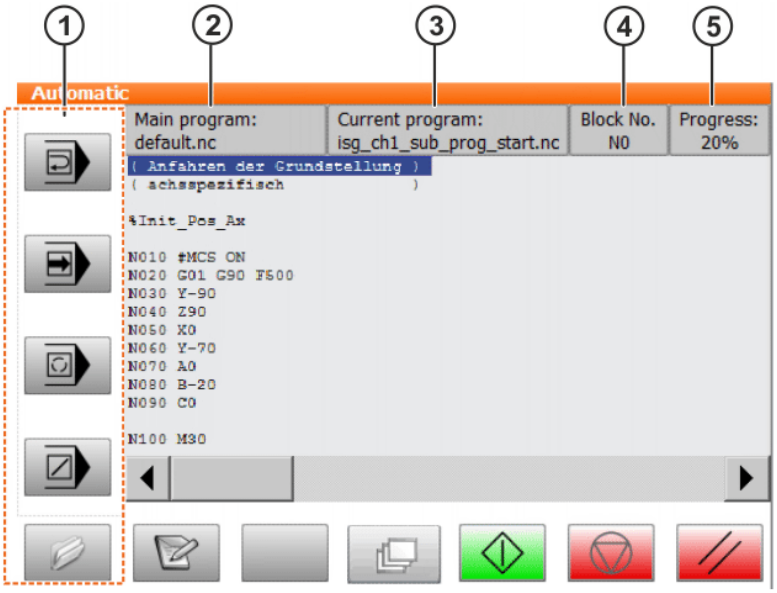


Fig. 7-6: Automatic mode

Item	Description
1	Program run modes (>>> 7.4.1 "Program run modes" Page 54)
2	Name of the main program
3	Name of the currently executed program (main program or subprogram)
4	Line number in the program
5	Program progress

The following buttons are available:

Button	Description
	**Select NC program** button The file view is opened and the NC program can be selected.
	**Edit** button Opens the selected NC program in the **CNC-HMI** window. The program can be edited.
	**Start CNC** button Starts the selected NC program.
	**Stop CNC** button Stops the NC program.

Button	Description
	**Reset CNC** button Resets the NC program.
	**Maximize** button If the information window is hidden, the button for displaying the information window is displayed at the bottom of the screen.

7.2.6 Operating mode “MDI mode”

In **MDI mode**, an MDI block can be executed and edited.

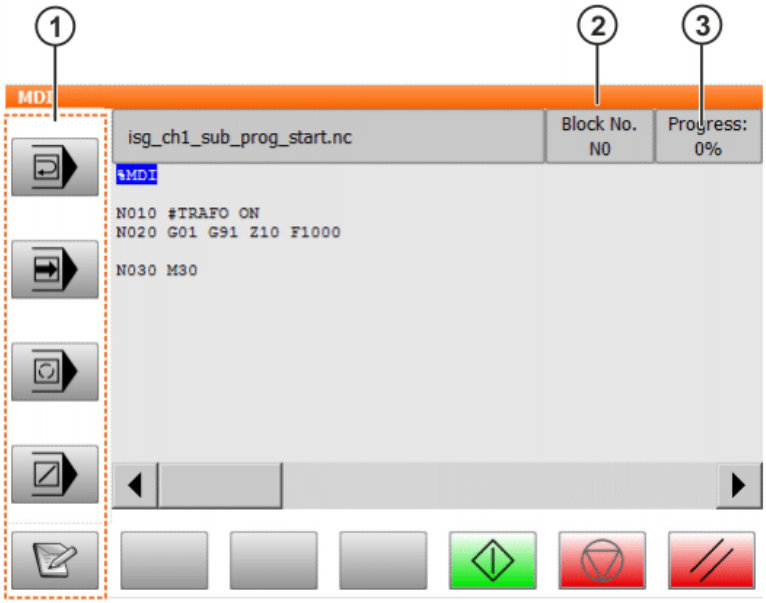


Fig. 7-7: MDI mode

Item	Description
1	Program run modes (>>> 7.4.1 "Program run modes" Page 54)
2	Line number in the program
3	Program progress

The following buttons are available:

Button	Description
	**Edit** button Opens the MDI block in the **CNC-HMI** window. The MDI block can be edited.
	**Start CNC** button Starts the MDI block.
	**Stop CNC** button Stops the MDI block.
	**Reset CNC** button Resets the MDI block.

7.2.7 Teach mode

Robot positions can be taught in Teach mode, e.g. to program the approach motion of the robot. During teaching, an NC subprogram call is inserted into the NC program. The taught motion blocks are saved in this subprogram.

The subprogram name has the following structure:

`L` *NC program name*`_T`*Time stamp*`_`*Subprogram number*`.sub`

Example: L default_T20110621_155955.sub

- NC program name: default
- Time stamp: 20110621
- Subprogram number: 155955

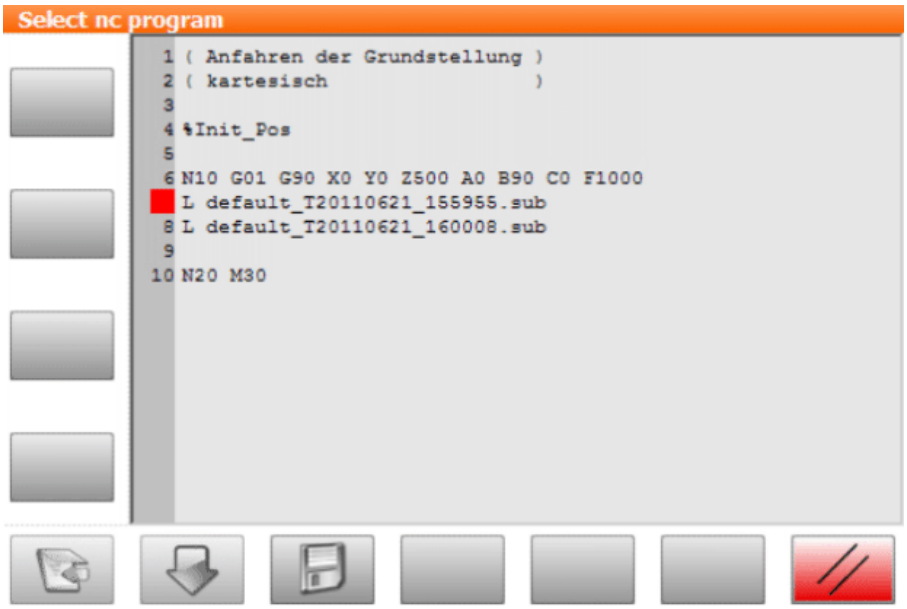


Fig. 7-8: Teach mode

The following buttons are available:

Button	Description
	**Start teach mode** button Activates Teach mode and inserts a subprogram call into the line indicated in red in the editor.
	**Teach** button Writes the current robot position into the subprogram. This button is only available if Teach mode is activated.
	**Save** button Saves the subprogram in the program directory **C:\KRC\ROBOTER\Isgnc\prg** and terminates Teach mode. Switches to Standby mode.

7.2.8 Edit mode

The NC blocks of an NC program and MDI blocks can be edited in Edit mode.

Detailed information about the scope of the NC language can be found in the CNC programming instructions.

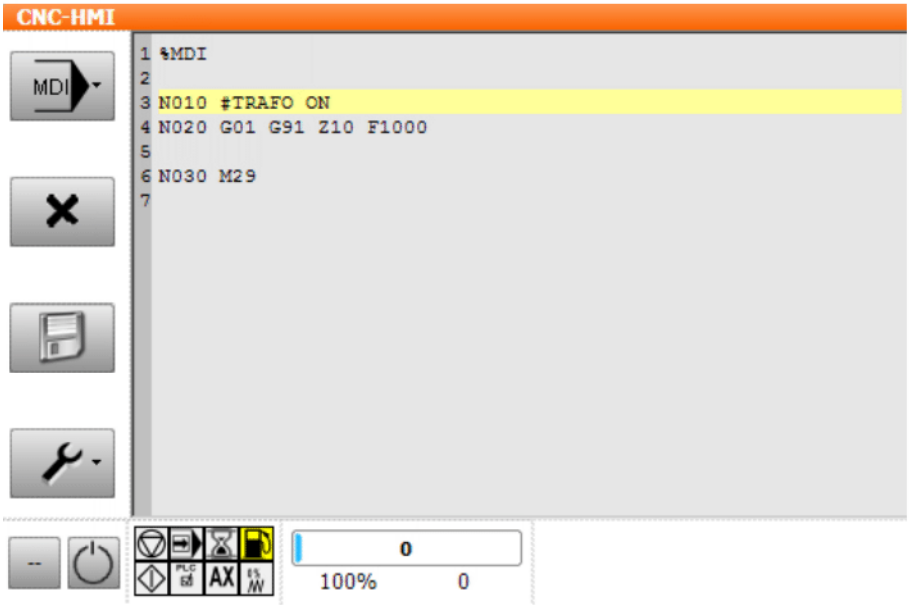


Fig. 7-9: Edit mode (MDI)

The following buttons are available:

Button	Description
	Terminates Edit mode and switches back to the display of the axis-specific position (ACS).
	**Save** button Saves the changes in the NC program or MDI block.

7.3 Activating CNC operation

In order to execute NC programs on the robot controller, CNC operation must be activated via a robot program. This can either be done in batch mode by calling the KRL function gCodeExecute() (see 6.4) or in interactive mode by calling the KRL function cncMotion().

In interactive mode, the CNC interface is permanently activated and not deactivated again until the robot program is stopped. Interactive mode can be used, for example, for setting up programs or in continuous operation if there are no KRL commands to be executed between execution of NC programs. The KRL function cncMotion() is called without parameters and does not send back a return value.

Precondition

- "Expert" user group
- Custom-made KRL program with the command cncMotion()

Procedure

- Select the created KRL program, start it and execute it as far as the CNC selection block (MOVE EMI).

Description

As soon as the KRL interpreter reaches the CNC selection block (MOVE_EMI), it stops at this block:

```
MOVE_EMI deviceName[] "MCS" FLT 0
```

CNC operation is now active and the message "CNC_ADAPTER: CNC motion active (Axial)" is displayed in the message window. NC programs can now be executed.

NOTICE In interactive mode, the robot remains under servo-control, even if no NC program is currently being executed.

7.4 Selecting an NC program

Precondition

- Operating mode **Automatic mode**
- CNC operation is activated.

Procedure

1. Press the **Select NC program** button.
   The file view **Select nc program** is opened.
2. Select the desired NC program and press the **Select** button.
   The NC program is displayed in the main window and can be started.

If the NC program is executed in T1 or T2 mode, the enabling switch and Start key on the smartPAD must be pressed and held down.

Description

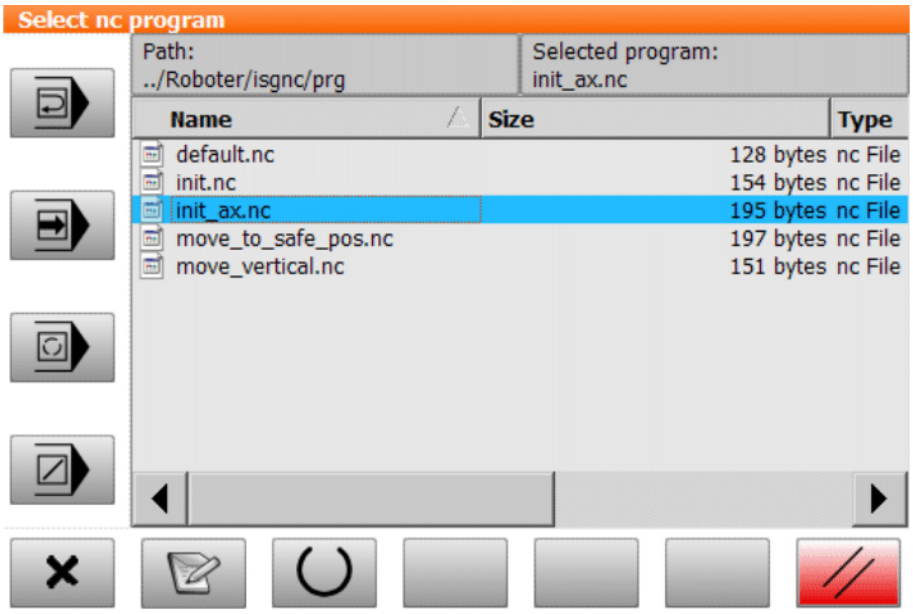


Fig. 7-10: File view Select nc program

The following buttons are available:

Button	Description
	Switches back to the main window.
	**Edit** button Opens the selected NC program in the **CNC-HMI** window. The program can be edited.
	**Select** button Opens the selected NC program in the main window.

7.4.1 Program run modes

By default, the NC programs or NC blocks are executed through to the end without stopping. The following program run modes can also be activated via buttons:

Program run mode	Button	Description
Backwards		Run mode is inactive.
		Run mode is active. The NC program is executed backwards.
Single step		Run mode is inactive.
		Run mode is active. The NC program is executed with a stop after each program line. The **Start CNC** button must be pressed again for each line.
Optional stop		Run mode is inactive.
		Run mode is active. The NC program is stopped at an NC block with the machine function M01. To continue the program, the **Start CNC** button must be pressed.
Block skip		Run mode is inactive.
		Run mode is active. When the NC program is executed, NC blocks preceded by the character “/” are skipped.

Further information about the functions “Optional stop” and “Block skip” can be found in the CNC programming instructions.

7.5 Deselecting an NC program

In the CNC, it is not necessary to deselect NC programs. An NC program remains selected until another NC program is selected.

7.6 Stopping and restarting an NC program (Automatic mode)

If an NC program is executed in the robot operating mode Automatic, program execution can be stopped by pressing the STOP key or the EMERGENCY STOP button on the smartPad. Following such a stop, the NC program can be resumed by pressing the Start key on the smartPad.

Procedure

Restarting the NC program after it has been stopped with the STOP key:

- Press the Start key.

Restarting the NC program after it has been stopped with the EMERGENCY STOP button:

1. Release the EMERGENCY STOP pushbutton.
2. Acknowledge acknowledgement messages in the message window of the smartHMI.
3. Switch on the drives.
4. Press the Start key.

NOTICE If an NC program is stopped with the **Stop CNC** button of the CNC-HMI, the robot remains under servo-control. To avoid damage to the gear unit or motor, it is advisable not to leave the robot under servo-control for prolonged periods of time, e.g. overnight.

7.7 Jogging the robot

In CNC operation the robot cannot be jogged. For this reason, the CNC operation must be interrupted by means of the STOP key of the smartPAD. The CNC interface is deactivated.

Following jogging, the CNC interface can be reactivated by means of the Start key of the smartPAD.

8 Diagnosis

8.1 Diagnostic functions

Overview

Irrespective of the operating mode, the following diagnostic functions are available on the KUKA.CNC-HMI:

- Display of CNC error messages
  - Channel errors
  - General errors
- CNC and PLC diagnosis
  - Diagnosis of the CNC kernel: the diagnostic file `diag_data_yyyy-mm-dd-hh-mm-ss.txt` is written.

    The file contains status information about the status of the CNC.
  - Diagnosis of the PLC: the diagnostic file `PLCaxes_Diagnostic_yyyymmdd_hhmmss.log` is written.

    The file contains status messages of the CNC kernel and PLC, and commands that have been executed by the PLC.
- TRACE function

  The following CNC data can be recorded:
  - Command and actual values of the position controller, e.g. velocity and acceleration

    The position controller data are written to the TRACE file `AxesTrace_yyyy_mm_dd_hhmmss00.log`.
  - Command and actual values of the CP motion, e.g. velocity and acceleration

    The path data are written to the TRACE file `PathTrace_yyyy_mm_dd_hhmmss00.log`.

The error logs are written to the directory C:\KRC\ROBOTER\ISGNC\DIAGNOSE.

The diagnostic files and the TRACE files are written to the directory C:\KRC\ROBOTER\LOG.

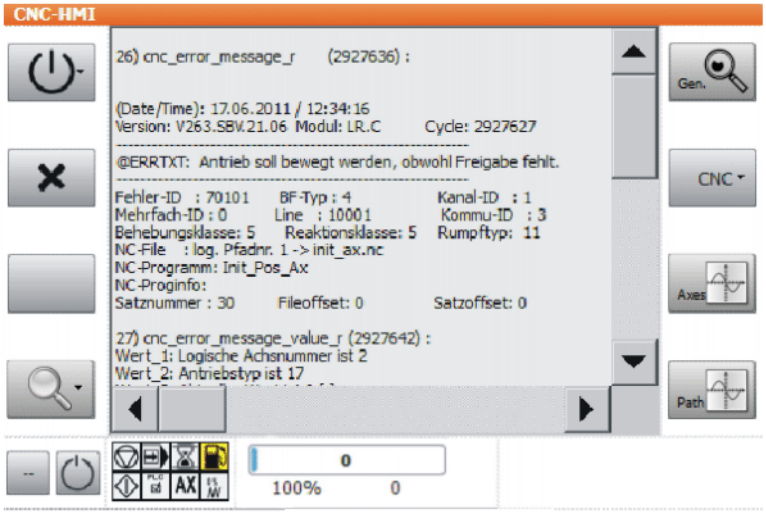
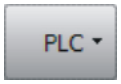
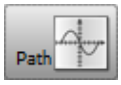


Fig. 8-1: Overview of diagnostic functions

The following buttons are available:

Button	Description
	The channel error messages are displayed in the **CNC-HMI** window. Pressing the button switches to the display of the general errors (Gen.).
	The general error messages are displayed in the **CNC-HMI** window. Pressing the button switches to the display of the channel errors (Chn.).
	The CNC diagnosis is carried out.
	The PLC diagnosis is carried out.
	**Axes trace** button (function inactive) Pressing the button switches on the recording of the position controller data.
	**Axes trace** button (function active) Pressing the button switches off the recording of the position controller data.
	**Path trace** button (function inactive) Pressing the button switches on the recording of the path data.
	**Path trace** button (function active) Pressing the button switches off the recording of the path data.

8.1.1 Displaying TRACE data with ISG monitor

Description

The ISG monitor **Display R2** is available under C:\KRC\ROBOTER\ISGNC\TOOLS\DISPLAY R2. This monitor can be used to display the recorded TRACE data as curves. Precise information about operation of the monitor can be found in the help file Display.HLP.

Alternatively, the recorded TRACE data can be opened in a spreadsheet, e.g. to create diagrams.

Procedure

1. Start the program **Display.exe**.
   The ISG monitor **Display R2** is opened.
2. Select the TRACE file and display the desired measurement values as curves.

9 Programming

9.1 Structure of an NC subprogram

Description

Robot positions can be taught in the NC subprogram as axis-specific positions (ACS) or Cartesian positions (PCS). When an ACS position is taught, a switch is made by default to the machine coordinate system (NC command #MCS ON). In this way, singularities can be avoided, e.g. when approaching a workpiece.

Example

NC subprogram with 2 taught ACS positions and 1 taught PCS position:

```
#MCS ON
G01 G90 F1000 X=-10.0353 Y=-59.8777 Z=69.6935 A=-0.2071 B=-9.8159
C=0.2041 Y1=0
#MCS OFF
#MCS ON
G01 G90 F1000 X=-50.0735 Y=-69.9876 Z=69.6935 A=-0.2071 B=-9.8159
C=0.2041 Y1=0
#MCS OFF
G01 G90 F5000 X=1801.3228 Y=318.6284 Z=1353.2956 A=-30.5522 B=90 C=-
40.5522
M29
```

If required, the subprogram can be edited, e.g. to remove unnecessary MCS selection and deselection commands:

```
#MCS ON
G01 G90 F1000 X=-10.0353 Y=-59.8777 Z=69.6935 A=-0.2071 B=-9.8159
C=0.2041 Y1=0
G01 G90 F1000 X=-50.0735 Y=-69.9876 Z=69.6935 A=-0.2071 B=-9.8159
C=0.2041 Y1=0
#MCS OFF
G01 G90 F5000 X=1801.3228 Y=318.6284 Z=1353.2956 A=-30.5522 B=90 C=-
40.5522
M29
```

9.2 Teaching points in the NC program

Precondition

- NC program is selected.
- Operating mode T1

Procedure

1. Select the **Diagnosis & Settings** button and switch the NC program to Teach mode.
2. Position the cursor in the line into which a subprogram call is to be inserted. The line is marked in red.
3. Press the **Start teach mode** button. Teach mode is activated and a subprogram call is inserted.
4. Move the robot to the desired position by jogging with the jog keys.
5. In the **CNC-HMI** window, display either the axis-specific position (ACS) or the Cartesian position (PCS). During teaching, either the axis-specific position or the Cartesian position is written to the subprogram accordingly.
6. Press the **Teach** button. The position is written to the subprogram.
7. If additional points are to be taught in the subprogram, repeat steps 4 to 6.
8. Press the **Save** button. The subprogram is saved and Teach mode is terminated.

9.3 Re-teaching points in the NC program – changing the orientation

Description

If, for example when approaching a workpiece, axis space errors or errors arising from singularities occur, the orientation of the robot must be changed and re-taught.

Precondition

- NC program is selected.
- Operating mode T1

Procedure

1. Open the NC program with **Edit** and delete the NC line that contains the subprogram call and the position to be re-taught.
2. Save the NC program with **Save**.
3. Select the **Diagnosis & Settings** button and switch the NC program to Teach mode.
4. Position the cursor in the line into which a new subprogram call is to be inserted. The line is marked in red.
5. Press the **Start teach mode** button. Teach mode is activated and a subprogram call is inserted.
6. Move the robot to the new position with the desired orientation by jogging with the jog keys.
7. In the **CNC-HMI** window, display either the axis-specific position (ACS) or the Cartesian position (PCS). During teaching, either the axis-specific position or the Cartesian position is written to the subprogram accordingly.
8. Press the **Teach** button. The position is written to the subprogram.
9. If additional points are to be re-taught in the subprogram, repeat steps 6 to 8.
10. Press the **Save** button. The subprogram is saved and Teach mode is terminated.

9.4 Programming a tool change

Description

A tool change is programmed in the NC program with the T number for the tool selection and machine function M06 for the tool change. By default, M06 calls a subprogram so that the robot automatically moves to the tool magazine, for example, and changes the tool there.

In the case of a manual tool change, the motion to the tool magazine is dispensed with. The new tool must also be selected in the same way with the T number and M06, however.

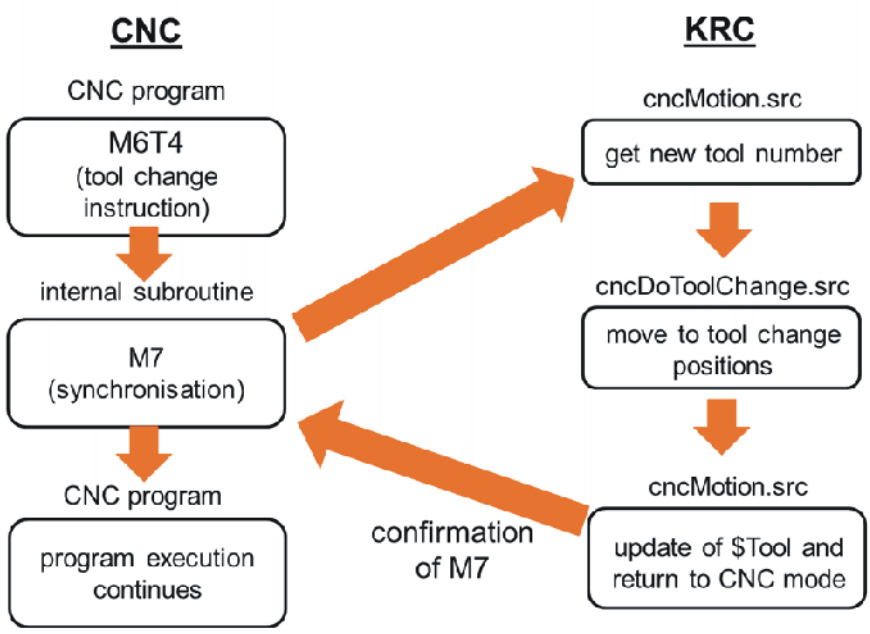


Fig. 9-1: Programming a tool change

Example

The tools with the numbers 1 (T1) and 2 (T2) are selected and automatically changed.

```
...
N010 G01 G90 X100 F5000
N020 T1 M6  (Selection Tool Nr.1)
N030 G01 G41 X110
N040         X200
N050 T2 M6  (Selection Tool Nr.2)
N060         X300
...
```

9.5 Batch mode

Description

It is possible to execute an NC program once from a KRL program and then resume work in the KRL program. The KRL function DEF gCodeExecute (GCodeFileName:IN) available in KUKA.CNC can be used for this. The name of the NC program to be executed is transferred as the transfer parameter.

This function can be used to implement a batch mode. Using a KRL program, NC programs can be executed, for example, between the handling tasks programmed in KRL.

Excerpt from a KRL program:

```
LOOP
gCodeExecute("move_vertical.nc")
$BASE.X = $BASE.X+100
WAIT SEC 3.0
gCodeExecute("move_to_safe_pos.nc")
WAIT SEC 3.0
ENDLOOP
```

10 Troubleshooting

10.1 Errors in NC operation

In the case of errors in NC operation, an error message is generated by the CNC and displayed in the message window. At the same time, program execution is canceled and, if possible, the motion is stopped on the contour.

NC errors must be acknowledged via the KUKA.CNC-HMI by means of the **Reset CNC** button. The program is reset. When restarted, program execution starts again at the beginning of the program.

The CNC error messages, the causes of the errors and the remedies are described in the documentation **CNC diagnostic instructions**.

11 KUKA Service

11.1 Requesting support

Introduction

The KUKA Roboter GmbH documentation offers information on operation 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 robot
- Model and serial number of the controller
- Model and serial number of the linear unit (if applicable)
- Model and serial number of the energy supply system (if applicable)
- Version of the KUKA System Software
- Optional software or modifications
- Archive of the software

  For KUKA System Software V8: instead of a conventional archive, generate the special data package for fault analysis (via **KrcDiag**).
- Application used
- Any external axes used
- Description of the problem, duration and frequency of the fault

11.2 KUKA Customer Support

Availability

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

Argentina

Ruben Costantini S.A. (Agency)
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