SOFTWARE

KR C

KUKA.CAMRob

Release 1.0

Issued: 28 Apr 2004 **Version: 01**

PD Interleaf

Contents

1 Characteristics

1.1 General, range of application

The **KUKA.CAMRob** package makes it possible to machine shaped parts by means of tools adapted for use on the robot, and on the basis of data created using common CAD programs. "KUKA.CAMRob" uses specific RAW files to generate simple motion blocks, which are then executed by the KR C robot controller.

Files of type "CL DATA" (DIN 66215) and "NC DATA" (DIN 66025) are supported as source files.

Descriptions of the format of the points in space, the orientations of the points, and a list of the commands supported can be found in **Section 6.1** of this documentation.

Examples of practical applications include:

- milling of shaped parts from soft materials such as wood, plastic, aluminum, etc., but not hard materials such as steel;
- polishing of shaped parts;
- coating of complex contours.

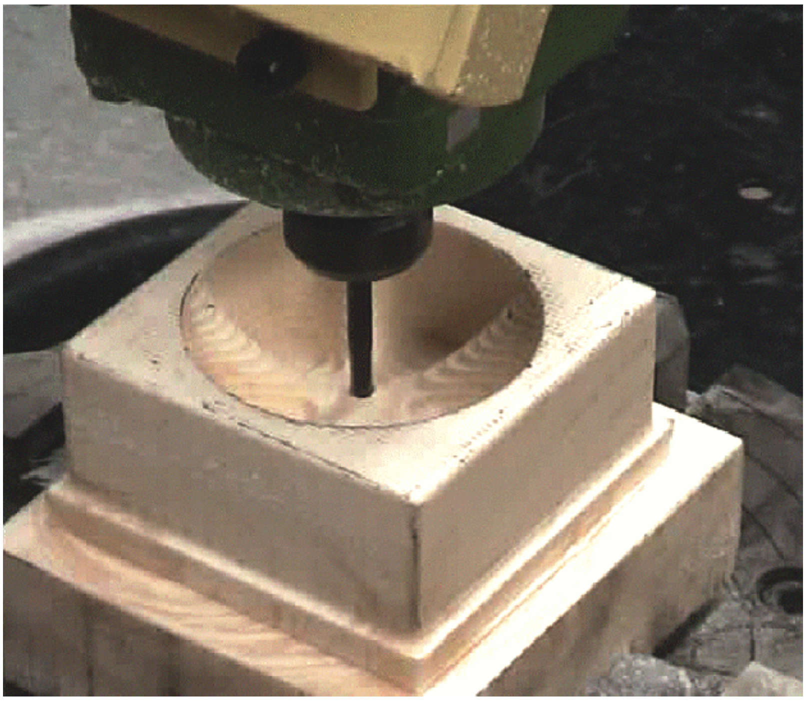


Fig. 1 Application example: Milling of a shaped part

KUKA.CAMRob consists of two components:

- **KRC module** for installation on a robot controller (KR C)

and

- **PC module** for conversion of RAW files and data transmission to the robot controller for installation on a PC or notebook with the operating system Windows 2000™ or Windows XP™

1.2 Safety instructions, designated use

The instructions in this documentation with respect to the designated use of this software must be observed at all times.

Using the software for any other or additional purpose is considered contrary to its designated use, and shall nullify the warranty and any claims for damages against KUKA Roboter GmbH.

The safety regulations must always be observed when carrying out work with the robot.

Please refer to the chapter [Safety] included in the documentation of the robot.

When working with KUKA.CAMRob, the robot motions are determined by the data specified in the RAW source file.

In order to ensure that the motion sequence is correct and that there is no risk of collisions, each CAMRob application must first be tested and accepted manually.

1.3 System requirements

1.3.1 KUKA.CAMRob PC module

The KUKA.CAMRob PC module can be run on all standard commercial personal computers and notebooks meeting the following requirements:

Hardware

Pentium II; 128 MB RAM

Operating system

Windows 2000™, Windows XP™

1.3.2 KUKA.CAMRob KRC module

Robot software

KR C1 or KR C2 controller, version 4.1

Please note that once the CAMRob KRC module has been installed on the robot controller, only CAMRob applications can be executed.

Connection from PC to robot controller

A standard commercial null-modem cable for RS232 interfaces (two female SUB-D connectors) of the appropriate length is required for data transmission from the PC or notebook on which the KUKA.CAMRob program is executed to the robot controller.

Windows 2000™ and Windows XP™ are registered trademarks of Microsoft Corporation.

2 Installing the software – Setup

The “KUKA.CAMRob” technology package consists of two components:

- **KRC module** for installation on a **robot controller** (KR C).
- **PC module** for installation on an external **PC** or **notebook**; used to convert RAW files and to transmit data to the robot controller.

When the “Setup” program is started, the menu illustrated in Fig. 2 is displayed.

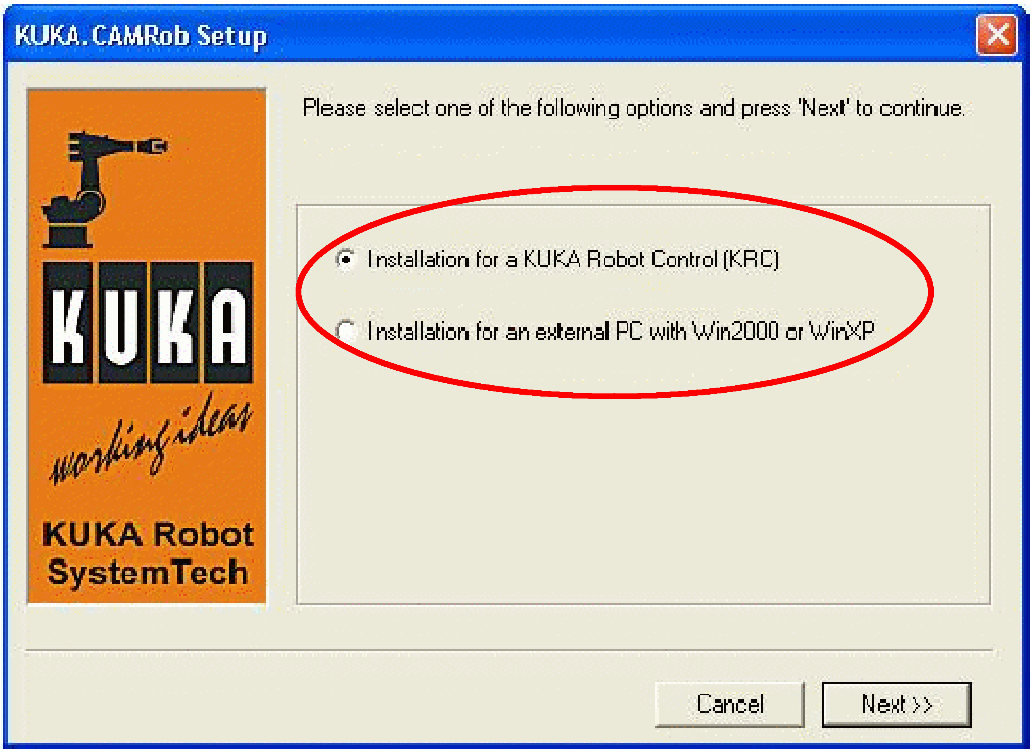


Fig. 2 KUKA.CAMRob setup menu – installation on KRC or PC

Use this menu to select one of the following:

- **Installation for a KUKA Robot Control (KRC)**
  the **KRC module** is installed on a robot controller (KR C)
  (see Section 2.1);
- **Installation for an external PC with Win2000 or WinXP**
  the **PC module** is installed on an external PC
  (see Section 2.2).

2.1 Installation of KRC module on a robot controller

System requirements
The KUKA.CAMRob KRC module can only be run on a KUKA robot controller (KR C) with software version 4.1.

KUKA technology packages for the robot controller (KR C) are offered exclusively as add-on software modules on CD-ROM.

Information about installation, uninstallation, reinstallation and update of technology packages on the robot controller (KR C) is provided in the documentation [Installation/ Uninstallation/Update of Tech Packages].

2.2 Installation of the PC module

System requirements
The PC module can be installed on a PC or notebook with the operating system Windows 2000™ or Windows XP™.

Before installation, any version of the KUKA.CAMRob PC module already on the computer must be uninstalled by means of the Windows function
"Control Panel" → "Software" → Add/Remove Programs".

If you are installing the PC module on a PC or notebook, i.e. if you have selected the option "Installation on an external PC with Win2000 or WinXP", then the dialog box shown in Fig. 3 is opened.

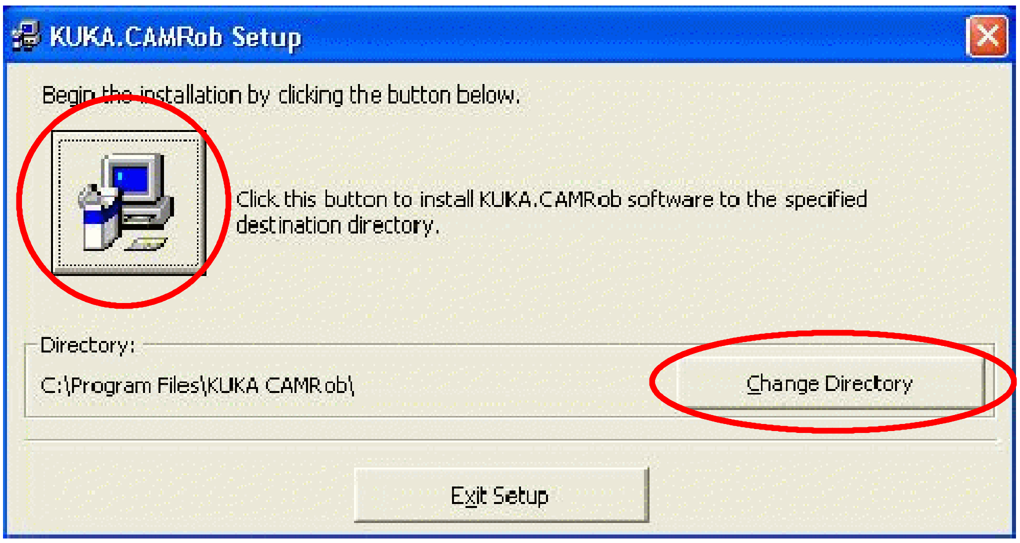


Fig. 3 KUKA.CAMRob Setup – beginning installation

If you wish to change the suggested path, click on "Change Directory"; otherwise click on the Begin Setup button.

You can cancel the installation process by clicking on "Exit Setup".

Once the installation procedure has been started, the necessary files are copied and the default configuration is carried out.

When installation of the KUKA.CAMRob software is successfully completed, the setup program is terminated and a corresponding message is displayed.

Installation on the external PC or notebook is now complete.

Uninstalling the PC module

The KUKA.CAMRob PC module can be uninstalled from the computer by means of the Windows function

"Control Panel" → "Software" → Add/Remove Programs.

3 Configuration

3.1 Configuring the PC module

The KUKA.CAMRob PC module offers a number of configuration options, which are described in this section.

3.1.1 Setting the language

The menu function "File" → "Preferences" → "Language" can be used to select the language in which texts will be displayed on the user interface.

Two languages are available: English and German.

3.1.2 Serial interface

The serial interface and the baud rate can be set by means of the menu function "Configuration" → "Ser. Interface".

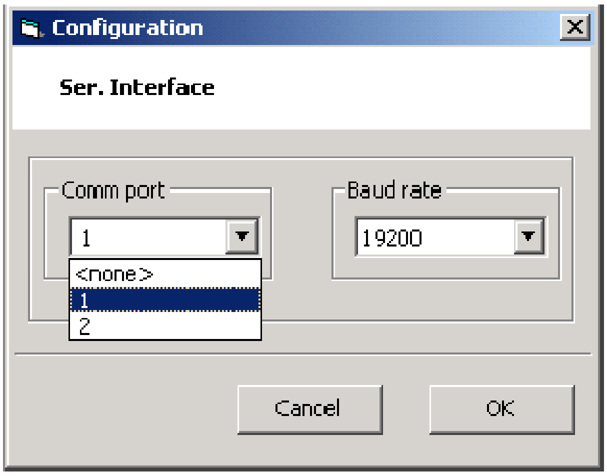


Fig. 4 Menu "Configuration" – configuring the serial interface

Administrator privileges are required to configure the serial interface in the Windows 2000 and Windows XP operating systems.

The "Comm port" selection list shows all of the COM interfaces physically and logically available on the system. Physical interfaces are present as hardware, while logical interfaces are implemented as drivers for IrDa, ISDN, etc.

Interfaces already in use by other applications are indicated by an asterisk (*). Such programs can typically be found in the Startup folder, and are used for communication between the PC and a PDA or cell phone.

The "Baud rate" selection list offers baud rates from 600 to 38400; the default setting for this value is 19200.

The baud rate entered here must correspond to the baud rate setting in the KRC.

The number of start bits, data bits, stop bits, and the parity are defined by protocol 3964R, and cannot be changed.

3.1.3 Transfer

In some applications, it may be desirable not to transfer all points of a data block, but only a specified range. The desired range can be defined with the aid of the menu function "Configuration" → "Transfer".

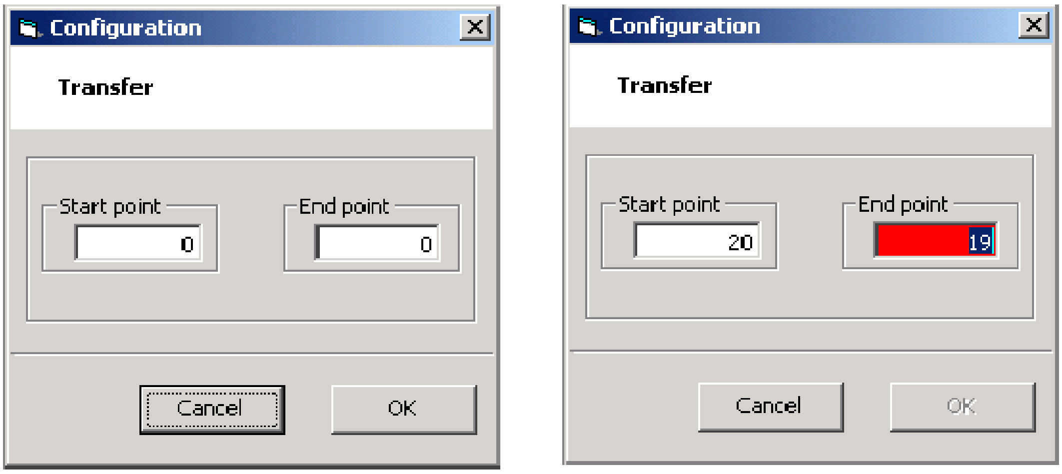


Fig. 5 Menu "Configuration" – configuring the serial interface

This is done by defining the start point (where the transfer begins) and the end point, i.e. the last point to be transferred.

Only whole numbers are permitted, and the number of the end point must be larger than that of the start point.

Incorrect entries are indicated in red (see Fig. 5, right). The "OK" key remains disabled until the values entered are valid.

3.1.4 Type of source file

The type of source file can be defined by means of the menu function "Configuration" → "Type of source file".

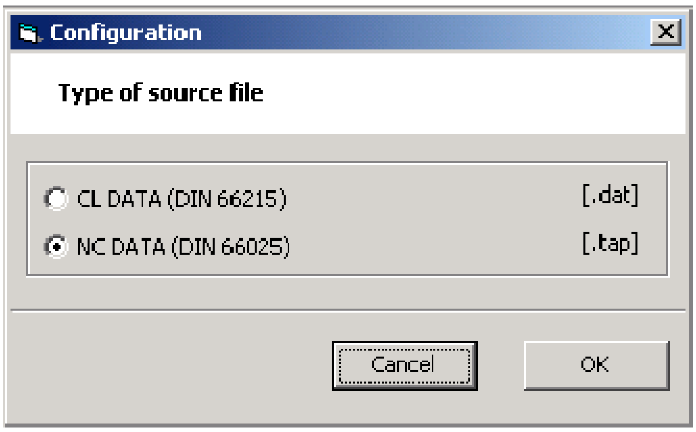


Fig. 6 Menu "Configuration" – Type of source file

Only the following file types are supported as source files:

- CL DATA (DIN 66215) file extension *.dat

and

- NC DATA (DIN 66025) file extension *.tap

A list of the commands supported can be found in Section 6.1 of this documentation.

3.1.5 Constant angle

In the case of five-axis CNC machines, only two angles are specified as unit vectors. When processing is carried out using robots, however, three angles are required. The missing angle must therefore be defined as a constant value.

Unless a different definition is required by the tool geometry or the supply lines which are present, the default setting (0 degrees) can be retained. Otherwise, a value must be entered which ensures that no problems can occur with the tool or the supply lines when processing is carried out over the entire range of motion.

Fig. 7 portrays a possible situation on the robot, with a simplified depiction of the tool and supply lines.

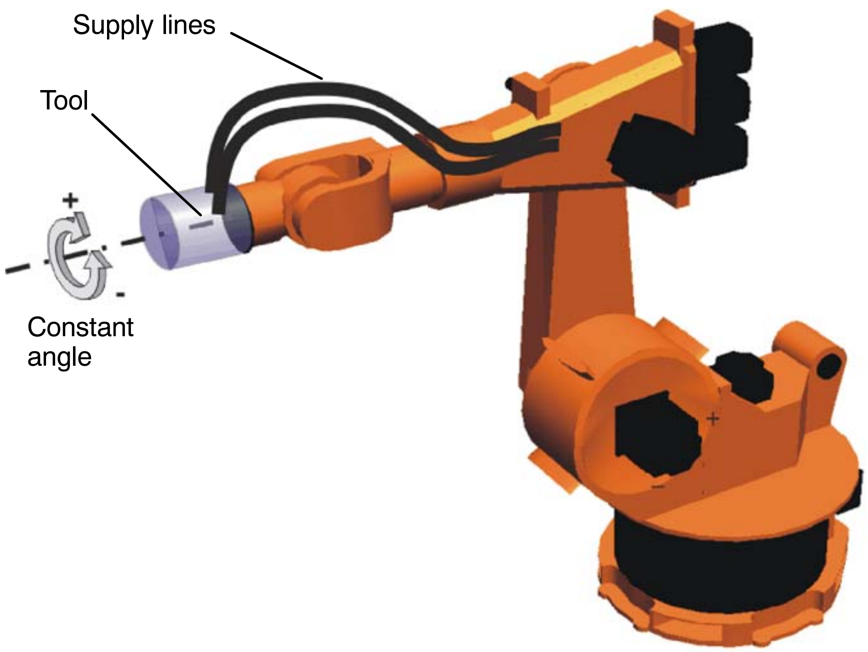


Fig. 7 "Constant angle" setting for the tool

The menu depicted in Fig. 8 is opened using the menu function "Configuration" → "Constant angle".

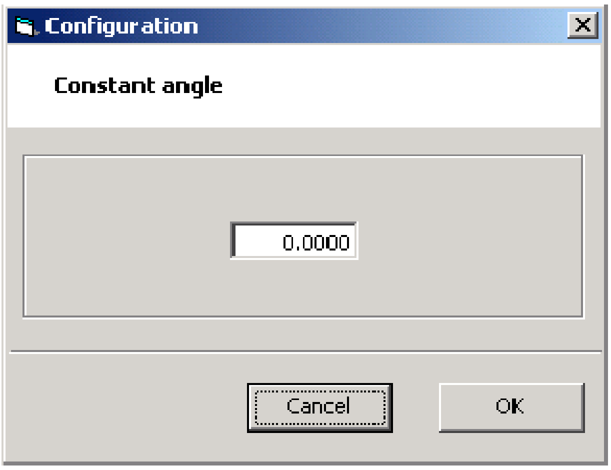


Fig. 8 Menu “Configuration” – Constant angle

The permissible range of angles is +/- 180.0000 degrees. If an impermissible value is entered, the input box is highlighted in red and the “OK” button is disabled.

3.1.6 Process parameters

The menu depicted in Fig. 9 can be selected using the menu function “Configuration” → “Process parameters”. Here process parameters can be selected and assigned with the required values.

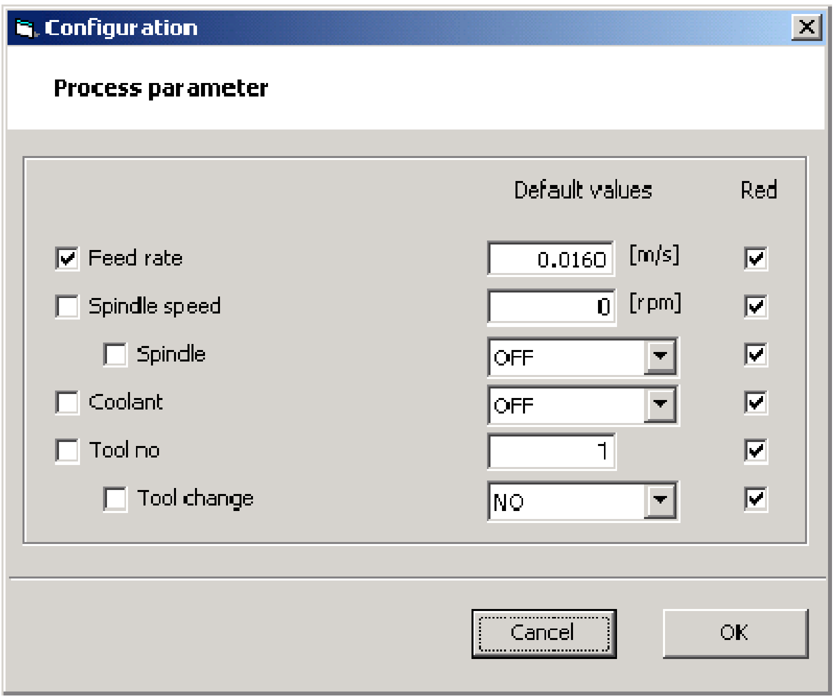


Fig. 9 Menu “Configuration” – Process parameters

A parameter is activated and assigned the corresponding value by checking the box to the left. Parameters which are not activated are ignored, even if they are present in the NC program. In Fig. 9, for example, only the feed rate has been selected, and the value 0.0160 [m/s] entered.

Checking a box in the “Red” column means that an activated parameter is taken into account in point reduction (see Section 3.1.7).

If two points are in fact geometrically identical, but differ in other parameters (e.g. the spindle speed), then the second point will be retained in each case.

Description of the parameters

Parameter	Description	Range of values
Feed rate	Feed rate in meters per second	0.0050 ... 0.0200 [m/s]
Spindle speed	Speed of the spindle [rpm]	
Spindle	Spindle off, CW (clockwise) or CCW (counterclockwise)	OFF, CW, CCW
Coolant	Switch coolant feed on or off	OFF, ON
Tool number	Number of the tool used	1 ... 16
Tool change	Execution of a tool change	NO, YES
Red	Parameter is taken into consideration in point reduction.	Activated by checking a box.

Selecting “Red” (see Fig. 9) means that point reduction is activated.
If two points are geometrically identical, but differ in other parameters (e.g. the spindle speed), then the second point will be retained in each case.

In order to transfer the selected parameters, the “CREAD” command must be adapted accordingly.
Please refer to the [CREAD CWRITE] documentation.

3.1.7 Point reduction

The menu depicted in Fig. 10 is opened using the menu function “Configuration” → “Point reduction”; this menu is used to define the point reduction process.

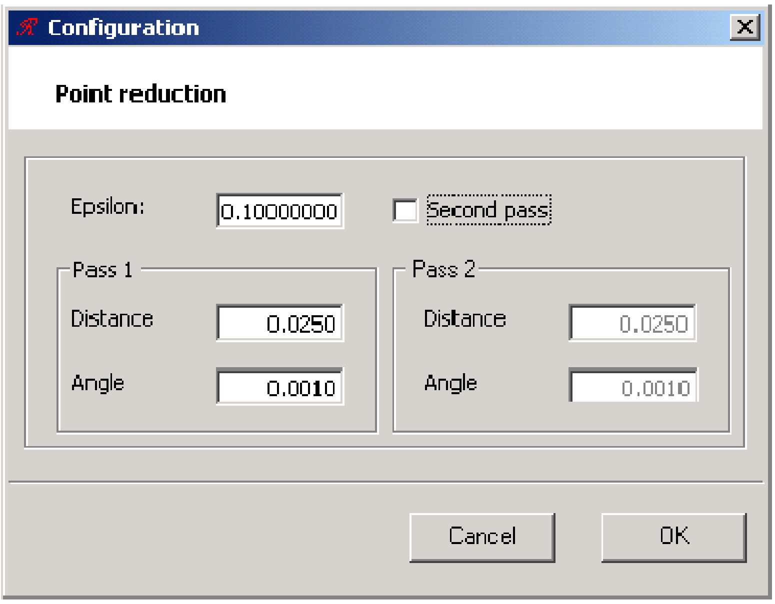


Fig. 10 Menu “Configuration” – Point reduction

The parameters used in point reduction are described below.

Epsilon

Since the parameters Feed rate and Spindle speed involve real numbers, a direct equality test for point reduction is not possible. The Epsilon value can be used to define by how much two real numbers can differ and still be considered identical.

Example: Value 1 = 2.500 Value 2 = 2.590 (difference: 0.090)

The difference between Value 1 (2.500) and Value 2 (2.590) is 0.090. After Epsilon is defined with the value 0.100 in this example, Values 1 and 2 are interpreted as being identical.

Second pass

Normally one point reduction pass is sufficient. Point reduction can be carried out a second time using the parameters “Distance” and “Angle” by checking the “Second pass” box.

Distance

This parameter determines the distance at which a point will be removed. An illustrative example:

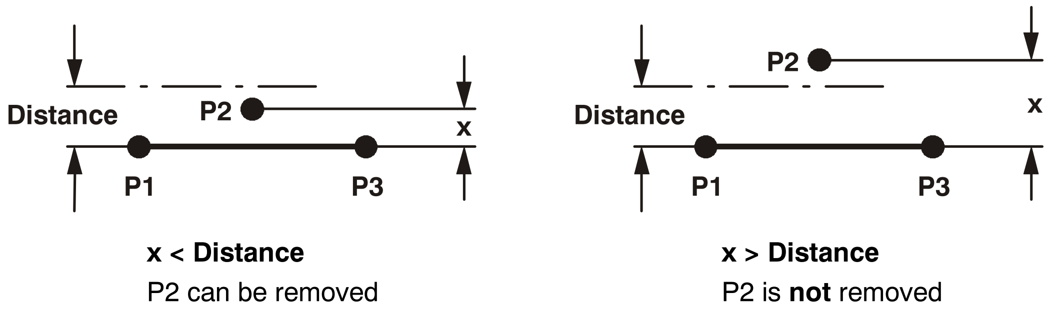


Fig. 11 Point removal at a specified distance

If a straight line is drawn between the first and third points, and the perpendicular distance to the second point (P2) is determined (in the example in Fig. 11 this is “x”), then the second point can be removed if the value for “x” is less than the value defined in the “Distance” input box.

Angle

This parameter is used to take into account the angular change in addition to the distance.

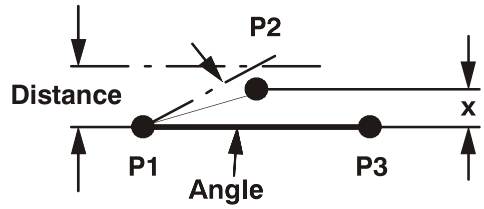


Fig. 12 Point removal at a specified distance and angle

3.1.8 Saving the configuration

The dialog menu depicted in Fig. 13 is opened using the menu function “Configuration” → “Save configuration”.

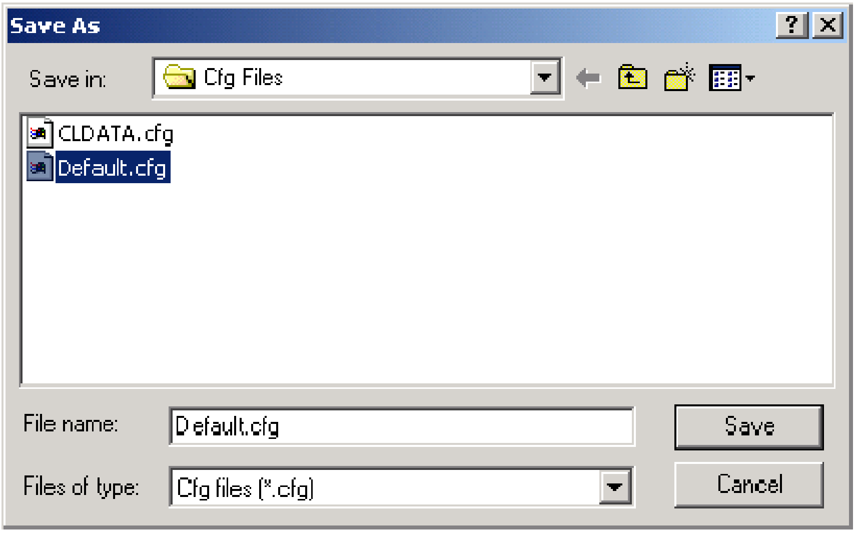


Fig. 13 Menu “Configuration” – Save configuration

This saves the current configuration.

> Settings for the serial interface are not saved in this file.

3.1.9 Retrieving a configuration

The dialog menu depicted in Fig. 14 is opened using the menu function “Configuration” → “Retrieve configuration”.

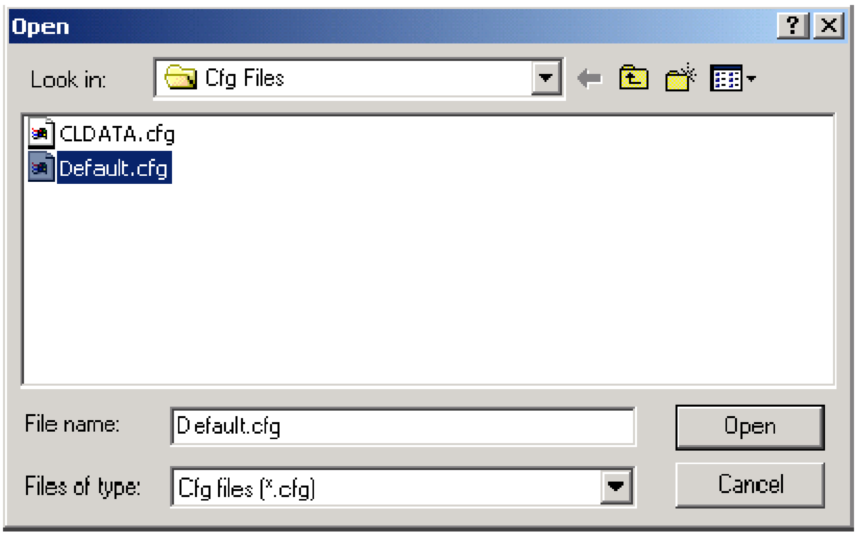


Fig. 14 Menu “Configuration” – Retrieve configuration

3.1.10 Default configuration

The dialog menu depicted in Fig. 15 is opened using the menu function “Configuration” → “Default configuration”.

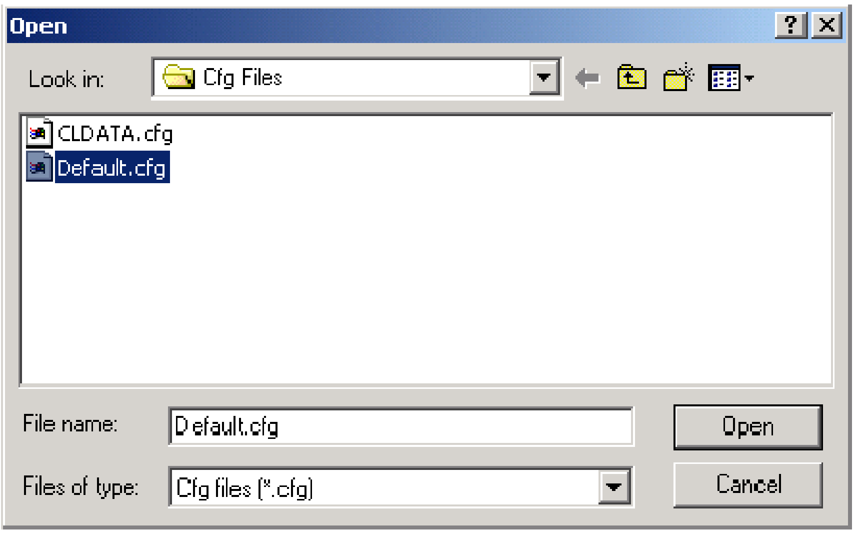


Fig. 15 Menu “Configuration” – Default configuration

This defines a saved configuration as the default configuration that is loaded every time the PC module is started.

Ending the dialog by clicking “Cancel” sets the preset default configuration as the default configuration.

This has no effect on the serial interface settings.

Administrator privileges are required to do this in the Windows 2000 and Windows XP operating systems.

3.2 Configuring the KRC module

3.2.1 Adapting "CREAD"

Adaptation is only necessary if required by parameters other than the default ones.

The KRL module **rps_load.sub** contains default settings for the KR C1 controller. In the signal name declaration for input and output channels – CREAD/CWRITE command **COPEN** – the definition **CHANNEL SER_2** is made; this corresponds to serial interface COM 2.

If a different setting for "CHANNEL" is required, this entry must be modified accordingly, e.g. **SER_3** for the KR C2 controller.

A detailed description can be found in the documentation [CREAD CWRITE].

The "CREAD" command is adapted in the file **rps_load.sub**, in the directory "C:\KRC\ROBOTER\KRC\R1\Program". Open this file using a text editor.

The necessary changes are made in the section "; ---- Testbeginn ----".

```
CREAD(HANDLE,SR_T,MR_T,TIMEOUT,OFFSET_CR,
                   "%r%.8r%1.2r",IPOSNO,POSV[],PARMS[])
```

The following assignments apply for the process parameters described in Section 3.1.6 and depicted in Fig. 9:

Feed rate	POSV[7]
Spindle speed	POSV[8]
Spindle	PARMS[1]
Coolant	PARMS[2]
Tool number	PARMS[3]
Tool change	PARMS[4]

Process parameters feed rate and spindle speed

```
CREAD(HANDLE,SR_T,MR_T,TIMEOUT,OFFSET_CR,
                   "%r%.8r%1.2r",IPOSNO,POSV[],PARMS[])
```

Entry:

Only feed rate	7	[Byte]
Only spindle speed	7	[Byte]
Feed rate and spindle speed	8	[Byte]

Process parameters spindle, coolant, tool number, tool change

```
CREAD(HANDLE,SR_T,MR_T,TIMEOUT,OFFSET_CR,
                   "%r%.8r%1.2r",IPOSNO,POSV[],PARMS[])
```

Byte — Number of parameters

Make the appropriate entries here. If none of the parameters spindle, coolant, tool number, or tool change are taken into account, the entries are discarded.

```
CREAD(HANDLE,SR_T,MR_T,TIMEOUT,OFFSET_CR,
                   "%r%.8r%1.2r",IPOSNO,POSV[],PARMS[])
```

Discarded without parameters "PARMS[ ]"
(remove entries)

3.2.2 Deactivating the default Submit interpreter

The Submit interpreter is deactivated when the CAMRob module is installed on the robot controller. When a CAMRob application is executed, the Submit interpreter installed with “KUKA.CAMRob” is accessed.

Please note that once the CAMRob KRC module has been installed on the robot controller, only CAMRob applications can be executed.

4 Operation

This chapter describes the conversion of RAW files into a format which can be read by the robot controller (KRC), as well as data transfer to the robot controller.

4.1 Conversion of RAW files

The KUKA.CAMRob PC module offers the following options for conversion:

- NC files (*.tap) to binary file
- CL files (*.dat) to binary files
- Binary file to CSV file
- Data file to
  - binary file
  - CSV file

It is also possible to carry out point reduction to an extent which is appropriate for the robot application.

RAW files generated using CAM systems or post processors must be converted into binary files which can be read by the KUKA.CAMRob Monitor.

> The following are supported:
> - NC files according to DIN66025
> - CL files according to DIN66215
>
> Information on the structure of the source files is provided in Section 6.1.

The conversion options depend on the configuration; this is described in Sections 3.1.3 to 3.1.7 of this documentation.

The flowchart in Fig. 16 provides a schematic overview of the conversion options.

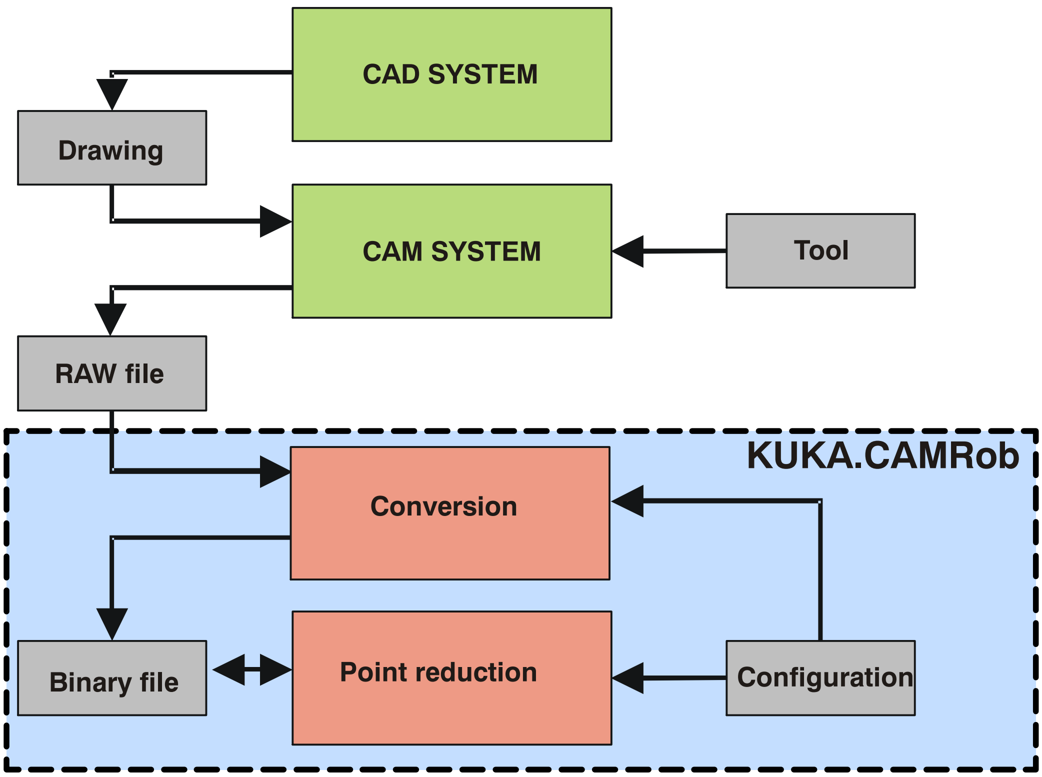


Fig. 16 Flowchart: Conversion with KUKA.CAMRob

4.1.1 Problems during conversion

Problems can occur during conversion in the following areas:

- when converting unit vectors to robot orientation;
- when using constant angles;
- if the line structure does not conform to, or only conditionally conforms to the required standard.

In such cases a precise analysis of the source file is required, and if necessary the configuration of the conversion must be adapted accordingly.

Before a converted file is used with a real robot, it must always be checked using the program “KUKA Sim” on an Office PC.

For inspection and testing purposes, CSV data files can also be checked visually with the aid of “Microsoft Excel” to ensure that the conversion was carried out properly.
For more information, please refer to Section 6.2 of this documentation.

4.1.2 Converting data files (*.dat, *.tap) into binary files

Either CL files (DIN 66215) or NC files (DIN 66025) can be converted into a binary file.

Which of these two file types is used is defined in the configuration (see also Section 3.1.4 of this documentation).

The following applies here:

- CL files (DIN 66215) have the extension *.dat
- NC files (DIN 66025) have the extension *.tap

Conversion of a data file into a binary file is called by means of the menu function “Convert” → “Data file” → “to binary file” or by clicking on the first symbol (QuickInfo: “Convert”) from the left in the toolbar.

First a dialog box for selection of the source file is opened:

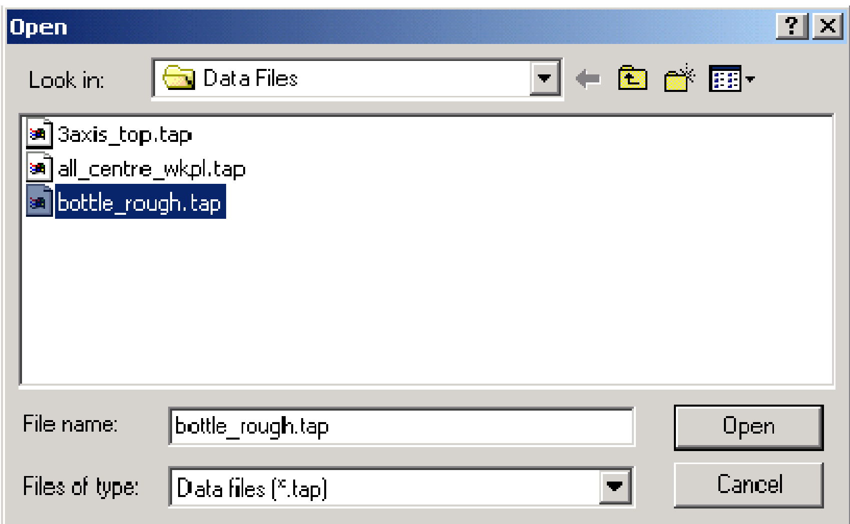


Fig. 17 Dialog box – selection of the source file to be converted

In the example in Fig. 17, files with the extension "*.tap" are available for selection. This means that this file type has been defined in the configuration. To display files with the extension "*.dat", the corresponding definition must be made in the configuration.
See also Section 3.1.4 of this documentation.

If the dialog box is exited via "Cancel", the conversion process is aborted.

When a file is selected, the current directory path is saved.
When the conversion function is called again, this directory will be displayed automatically.

Once you have selected a source file and clicked on "Open", another dialog box is opened.

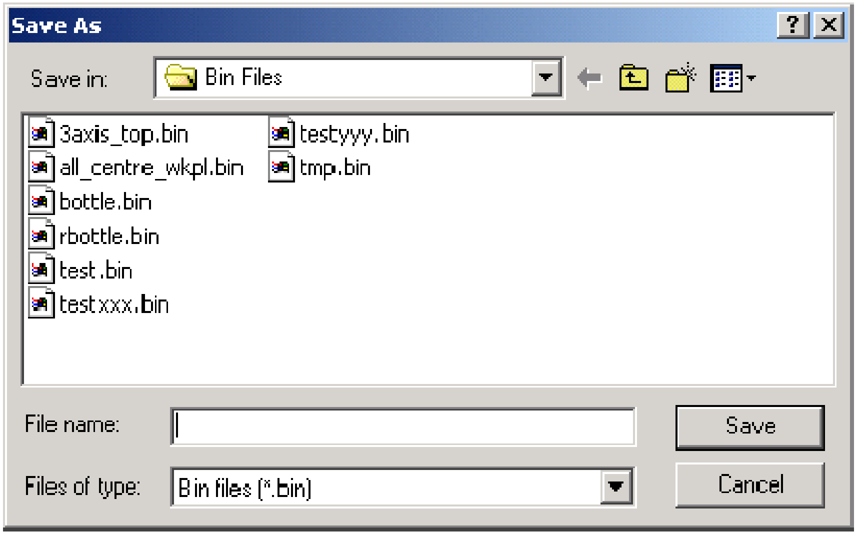


Fig. 18 Dialog box – saving the converted file

The name of the target file must be entered under "File name".

If the file name selected under "File name" already exists, the existing file will be overwritten with the new data without any additional request for confirmation.

The conversion process is started once you click on "Save"; the progress of the operation is indicated by a progress bar.

Once the conversion is concluded, a summary of the conversion (Fig. 19) is displayed.

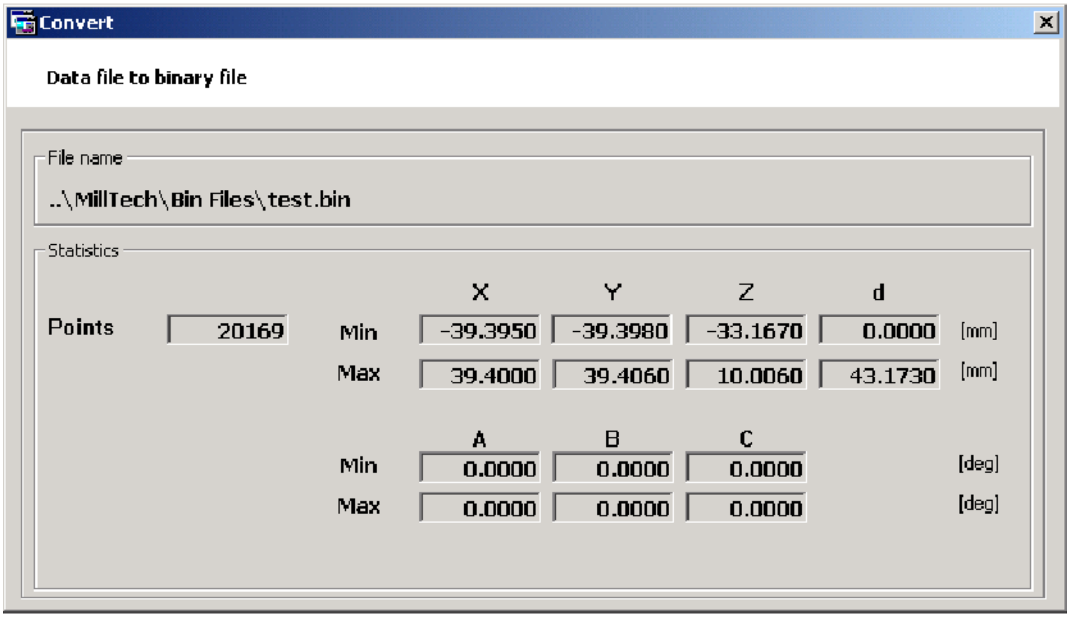


Fig. 19 Screen display after conversion has been completed

This summary shows the file name under which the converted file was saved. The “Statistics” area contains information about the minimum and maximum values for position, orientation and point distance, as well as the number of points in space (space points).

If the minimum distance of the points in space is nearly 0.0000 [mm], the “point reduction” option can be used to reduce the number of points.
See also Section 4.1.5 of this documentation.

4.1.3 Converting data files (*.dat, *.tap) into CSV files

Either CL files (DIN 66215) or NC files (DIN 66025) can be converted into a CSV file.

Which of these two file types is used is defined in the configuration (see also Section 3.1.4 of this documentation).

The following applies here:

- CL files (DIN 66215) have the extension *.dat
- NC files (DIN 66025) have the extension *.tap

Conversion of a data file into a CSV file is called by means of the menu function
“Convert” → “Data file” → “to CSV file...”.

First a dialog box for selection of the source file is opened:

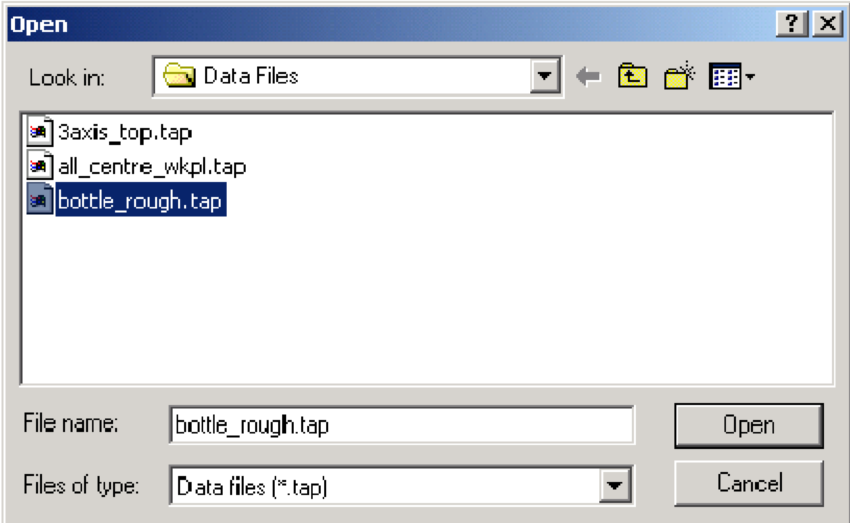


Fig. 20 Dialog box – selection of the source file to be converted

In the example in Fig. 20, files with the extension "*.tap" are available for selection. This means that this file type has been defined in the configuration. To display files with the extension "*.dat", the corresponding definition must be made in the configuration.
See also Section 3.1.4 of this documentation.

If the dialog box is exited via "Cancel", the conversion process is aborted.

When a file is selected, the current directory path is saved.
When the conversion function is called again, this directory will be displayed automatically.

Once you have selected a source file and clicked on "Open", another dialog box is opened.

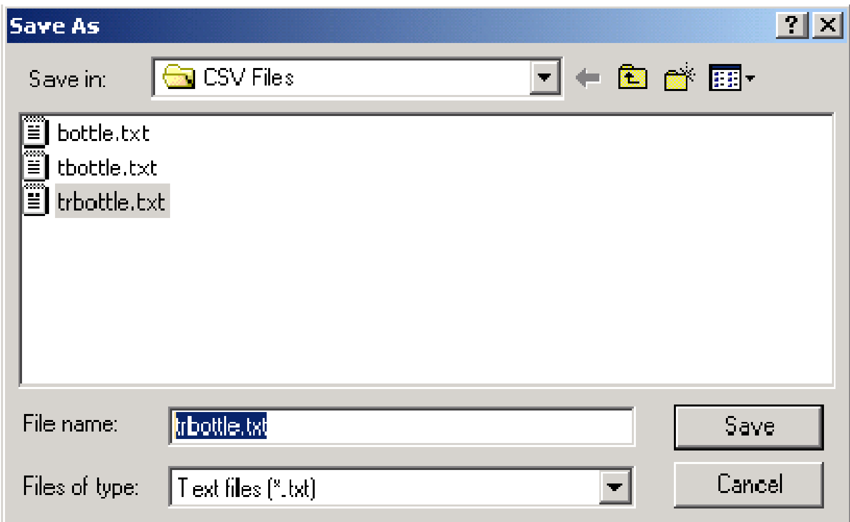


Fig. 21 Dialog box – saving the converted file

The name of the target file must be entered under "File name".

If the file name selected under "File name" already exists, the existing file will be overwritten with the new data without any additional request for confirmation.

The conversion process is started once you click on “Save”; the progress of the operation is indicated by a progress bar.

Once the conversion is concluded, a summary of the conversion is displayed.

4.1.4 Converting binary files into CSV files

This function can be used to convert a binary file which has already been converted to the KUKA.CAMRob file format into a CSV file.

Conversion of a binary file into a CSV file is called by means of the menu function
“Convert” → “Binary file to CSV file ...”.

First a dialog box (Fig. 22) for selection of the source file is opened:

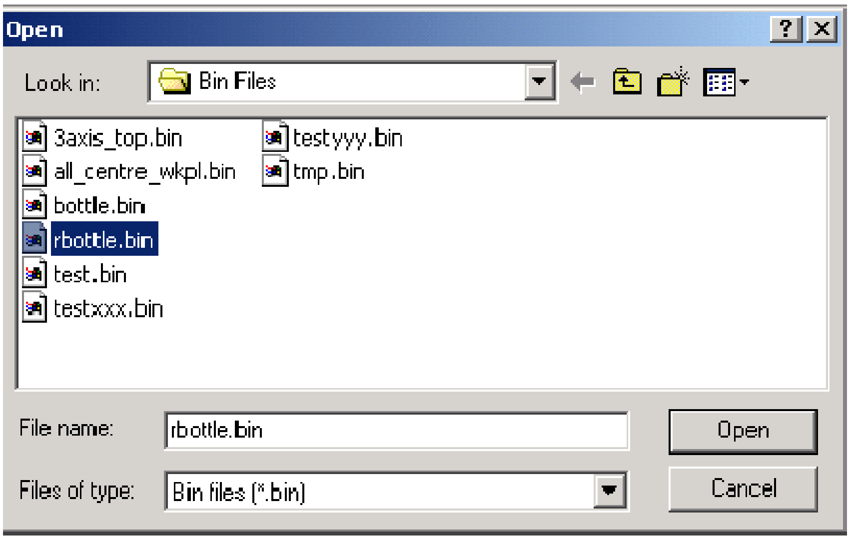


Fig. 22 Dialog box – selection of the source file to be converted

If the dialog box is exited via “Cancel”, the conversion process is aborted.

When a file is selected, the current directory path is saved.
When the conversion function is called again, this directory will be displayed automatically.

Once you have selected a source file and clicked on “Open”, another dialog box is opened.

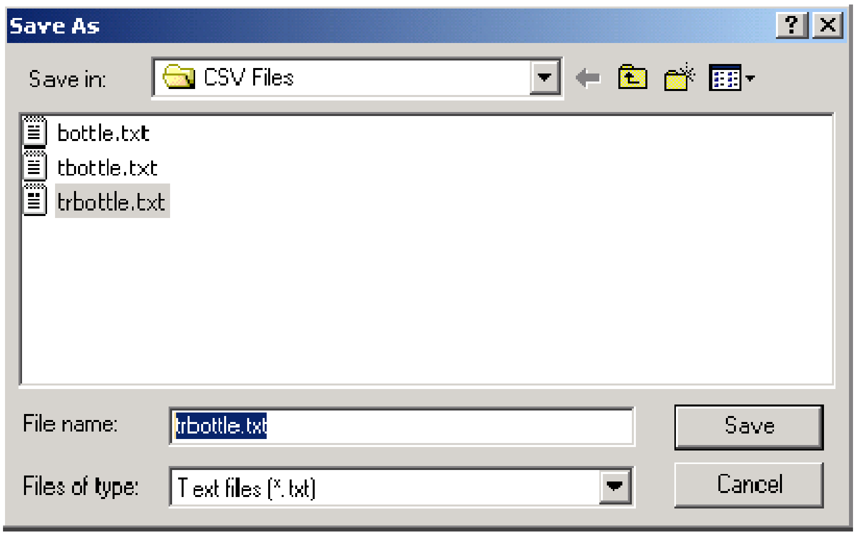


Fig. 23 Dialog box – saving the converted file

The name of the target file must be entered under “File name”.

If the file name selected under “File name” already exists, the existing file will be overwritten with the new data without any additional request for confirmation.

The conversion process is started once you click on “Save”; the progress of the operation is indicated by a progress bar.

Once the conversion is concluded, a summary of the conversion (Fig. 24) is displayed.

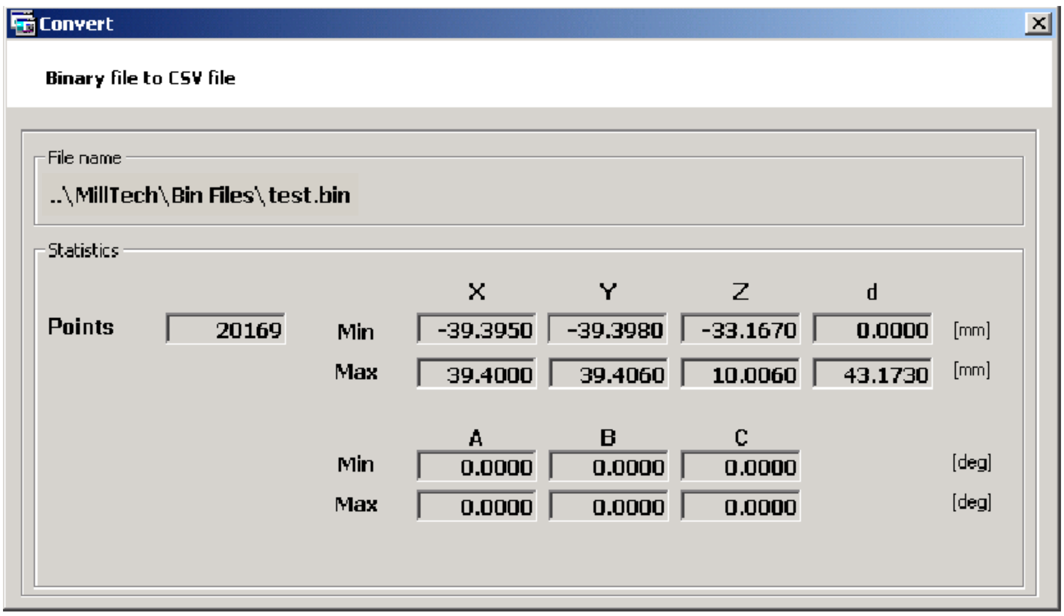


Fig. 24 Screen display after conversion has been completed

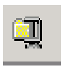
This summary shows the file name under which the converted file was saved. The “Statistics” area contains information about the minimum and maximum values for position, orientation and point distance, as well as the number of points in space (space points).

If the minimum distance of the points in space is nearly 0.0000 [mm], the "point reduction" option can be used on the basis of the corresponding binary file to reduce the number of points. See also Section 4.1.5 of this documentation.

4.1.5 Point reduction

If the minimum distance of the points in space is nearly 0.0000 [mm], the "point reduction" option can be used to reduce the number of points.
See also Section 4.1.2 of this documentation.

Point reduction is carried out in accordance with the method defined in the configuration. See Section 3.1.7 of this documentation.



Point reduction is called by means of the menu function
"Convert" → "Point reduction"
or by clicking on the second symbol (QuickInfo: "Reduce points") from the left in the toolbar.

A dialog box for selection of the source file is opened:

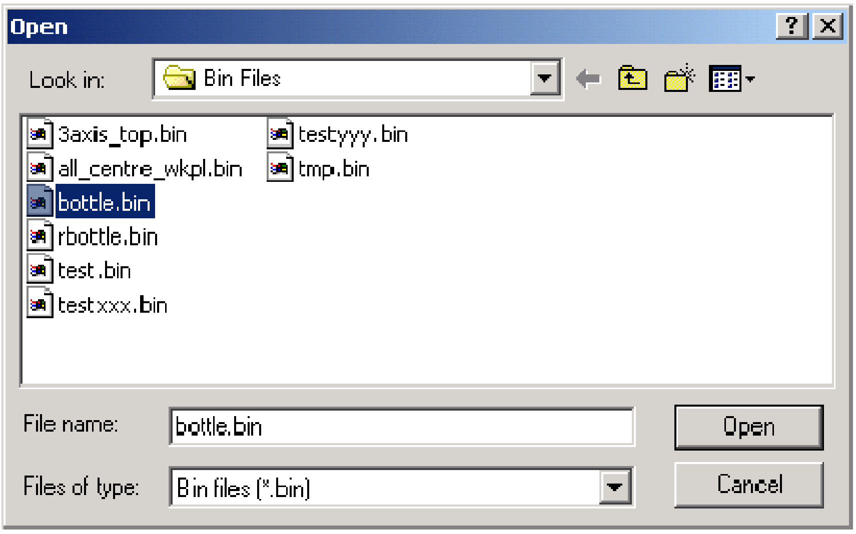


Fig. 25 Dialog box – selection of the file for point reduction

The name of the target file is automatically generated by adding an "r" at the beginning of the source file name. In the example shown in Fig. 25 with the file name "bottle.bin", the target file has the name "rbottle.bin".

Point reduction is started by clicking on "Open", after which a check is made first to see if the file is a valid KUKA.CAMRob binary file. If the structure of the file headers is correct, data reduction is started, otherwise a corresponding fault message is displayed.

The progress of this operation, which cannot be aborted, is indicated by a progress bar. Once the conversion is concluded, a summary of the conversion (Fig. 26) is displayed.

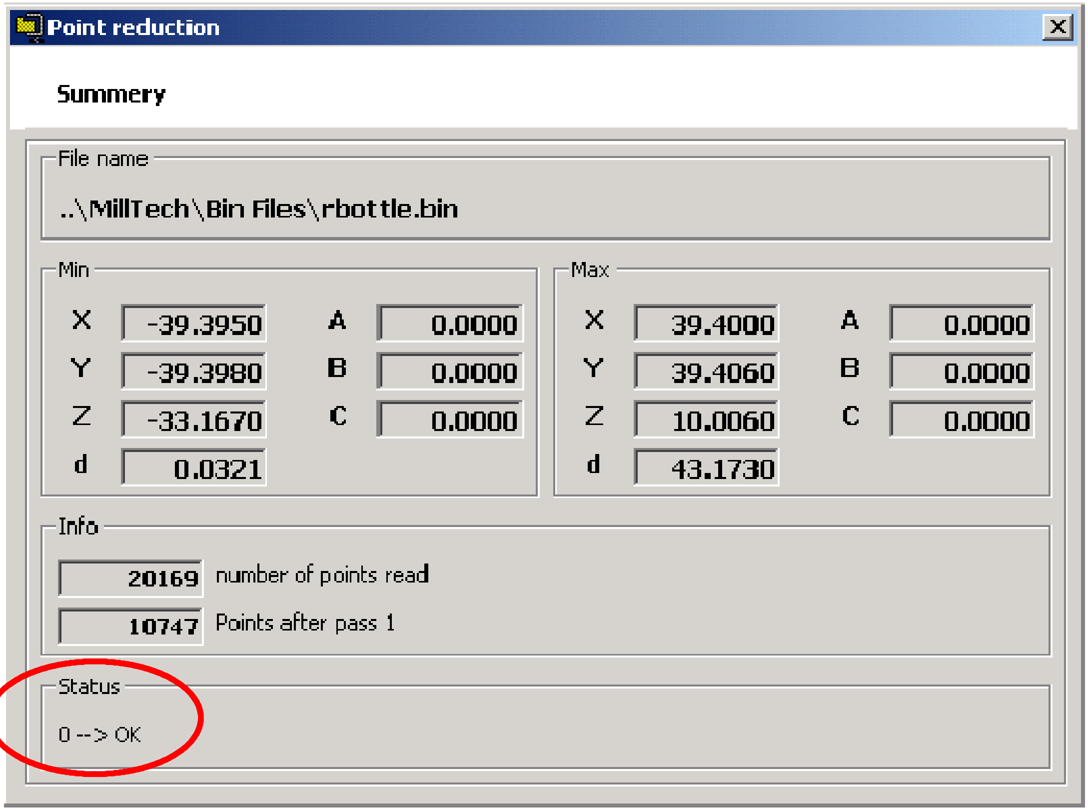


Fig. 26 Screen display after point reduction has been completed

If an error occurs, a corresponding error message will be displayed under "Status".

4.2 Monitor

The “Monitor” function is used to transfer data to the controller of a KUKA robot. Processing of the workpiece is then started by the robot controller.

A precondition for data transfer is that a connection exists between the PC or notebook and the robot controller (KR C) via the configured serial interfaces by means of a null-modem cable. See also Section 1.3.

Before the robot program is started, it must be ensured that the serial interfaces are monitored. Information about configuration of the serial interface can be found in Section 3.1.2 of this documentation.

In addition, base determination must be carried out once on the robot controller with the aid of the base offset function.
For more information, please consult the documentation for the KR C controller.

4.2.1 Calling the “Monitor – Transfer” function

The function is called on the PC or Notebook by means of the menu function

“Monitor” → “Transfer”

or by clicking on the third symbol (QuickInfo: “Monitor”) from the left in the toolbar.

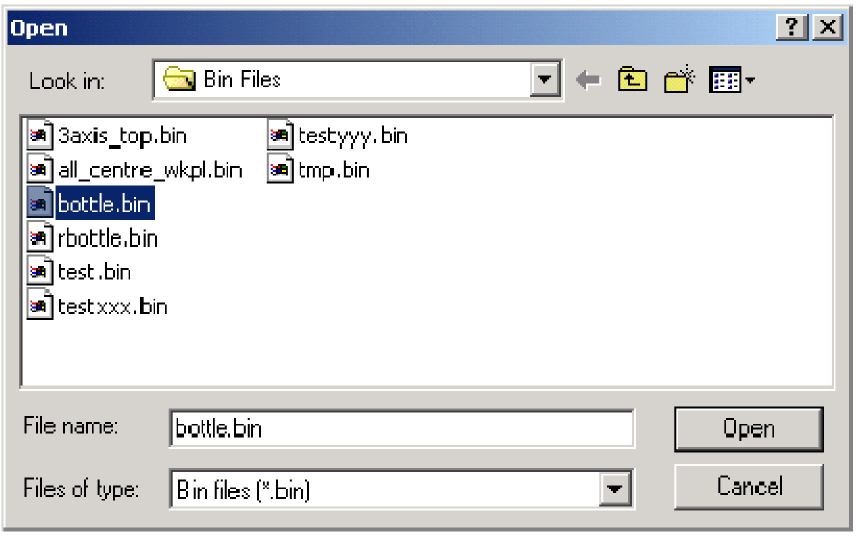


Fig. 27 Dialog box – selection of the file to be transferred

When the file is opened, a check is made first to see if it is a valid KUKA.CAMRob binary file. If this is not the case, a corresponding error message will be displayed. The reason for this could be, for example, that the file was not generated using the conversion function of KUKA.CAMRob.

In the next step the program checks whether the indices for the start and end points are correct. If they are larger than the number of points present, a corresponding error message will be displayed.

The availability of the serial interface is also checked. If it is not available because it is being used by another program or an application (for example a mouse), this fact is signaled in the status bar by a red “LED” and the text “Transfer error – check configuration”.

In such a case the program which is using the selected serial interface must be terminated, or the configuration of the serial interface must be changed accordingly. Information on this can be found in Section 3.1.2 of this documentation.

After these checks, the transfer window shown in Fig. 28 is displayed.

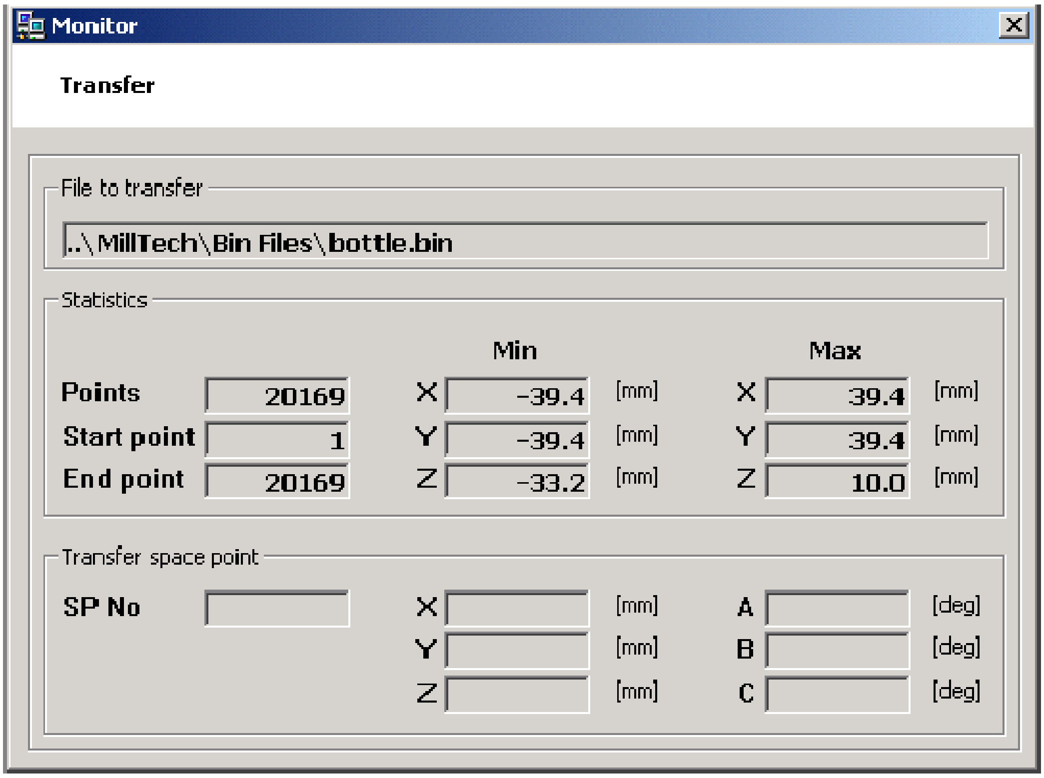


Fig. 28 Transfer window

Meanwhile, KUKA.CAMRob is waiting for requests from the robot program.

For monitoring purposes, the following is shown in the transfer window:

- Name of the selected file
- Minimum and maximum values of the positions
- Index of the start point
- Index of the end point

If the values are correct, data transfer can begin.

The orientation (A, B, C) illustrated in Fig. 28 may be displayed differently in the robot controller. The actual orientation of the robot is identical.

5 Program execution on the robot controller

The KRL modules contained in the KUKA.CAMRob "program package" (e.g. "rps_move") serve merely as templates. They must be adapted to the actual situation according to the tool and workpiece used and the base and tool data.

Before the program is executed, the CP motions of the robot from the home position to the workpiece and back must be checked to ensure that there is sufficient clearance and that the robot moves correctly to the start point.

5.1 BASE and TOOL calibration

5.1.1 Base

The reference point of a workpiece (BASE) must be calibrated. This can be done using, for example, the "3-point" method.

Detailed information on this can be found in the robot Operating Handbook [Software], in the chapter [Startup].

The positive **Z axis** of the BASE coordinate system must **always** point out of the workpiece towards the tip of the tool.

Note that the reference point of the workpiece (BASE) is identical to the reference point in the CAM program. This affects both the relative **position** of the workpiece and also the **orientation** of the coordinates (x, y, z).

5.1.2 TCP

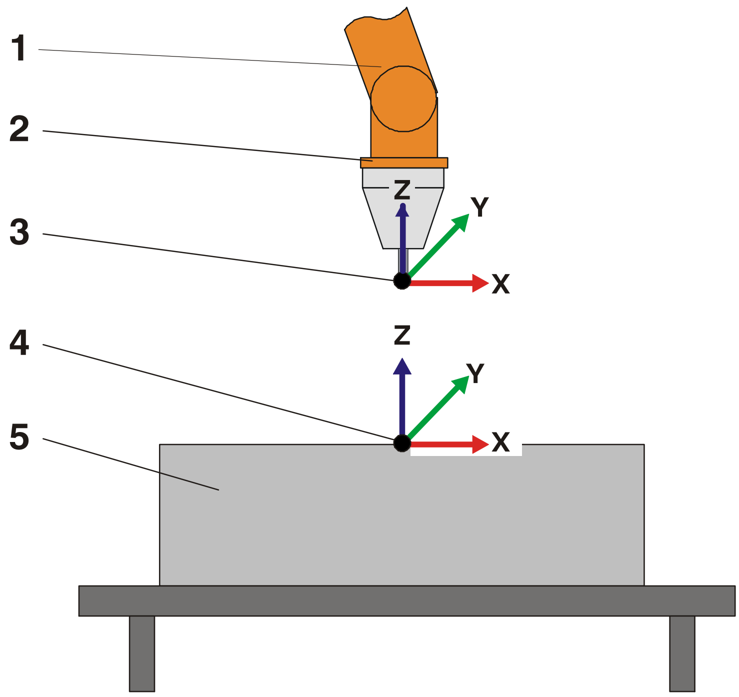
The position of the TCP (tool center point) can be determined using, for example, the "XYZ 4-point" method.

Detailed information on this can be found in the robot Operating Handbook [Software], in the chapter [Tool calibration].

The determination of the orientation of the tool coordinate system (TCP) must be carried out in such a way that the orientation of the tool coordinate system (TCP) and the orientation of the workpiece coordinate system (BASE) are identical.

The TCP orientation can be determined using, for example, the "ABC-World (6D)" method. The Z axis is to be selected as the tool direction.

The "numeric input" method can be used to set the orientation of the tool (TCP) so that the orientation of the tool coordinate system (TCP) corresponds to that of the workpiece coordinate system (BASE) (where A=0, B=0, C=0).



Legend

1	Robot
2	Robot flange
3	TOOL coordinate system
4	BASE coordinate system
5	Workpiece

Fig. 29 TOOL and BASE coordinate system

5.2 KRL module "rps_move"

The KRL module "rps_move" (consisting of "rps_move.src" and "rps_move.dat") serves as a template and must be adapted and optimized to the actual situation depending on the workpiece and the start and end points of the CAM program.

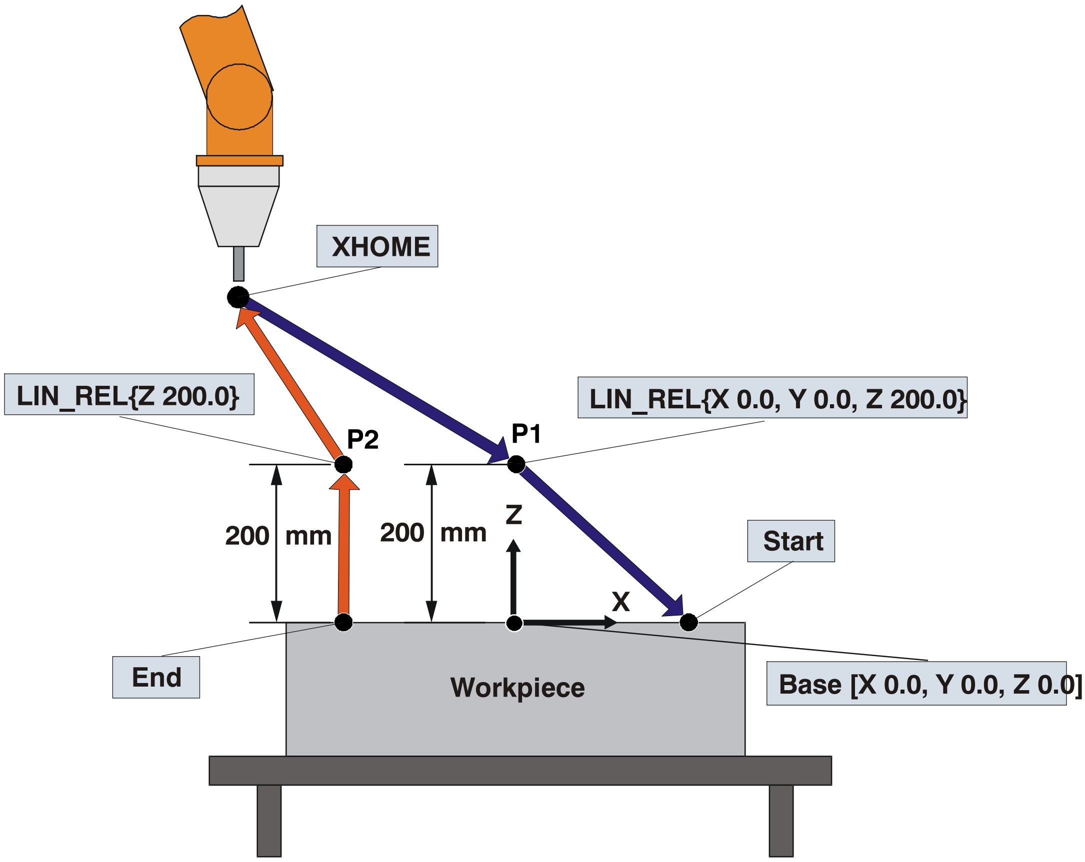


Fig. 30 Space points in the default program "rps_move"

This module contains two auxiliary points as standard; these are labeled as space points **P1** and **P2** in Fig. 30. When the program is executed, the robot will first move from the home position **XHOME** to auxiliary point P1 using the motion block "LIN {X 0.0, Y 0.0, Z 200.0}". The robot is then moved to the start point of the CAM program (labeled **Start** in Fig. 30).

Once execution of the CAM program has been completed, the robot moves from the end point of the CAM program (point **End** in Fig. 30) to the auxiliary point **P2** and then to **XHOME**.

5.3 Transferring the data to the robot controller

On the robot controller, start the program “rps_move”, which is located in the directory “...\R1\Program”.

Press the Start button (+). After the message “Programmed path reached (BCO)” appears, press the Start button once more. The message “Data Transfer Active” is displayed.

If the data transfer fails, this fact is signaled by a corresponding message.

When data transfer is underway, the number of the point in space (SP No) currently being transferred is displayed with the associated positions (X, Y, Z) and orientations (A, B, C) (see example in Fig. 31).

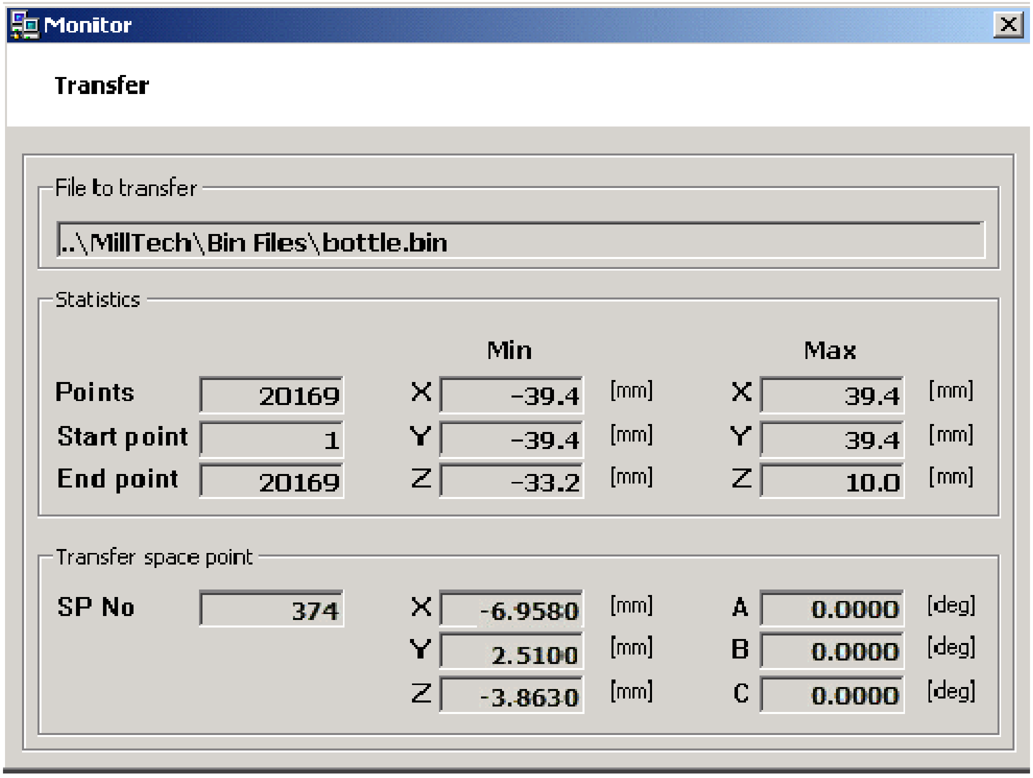


Fig. 31 Transfer window during data transfer

The length of the transferred data set depends on the number of process parameters. In the robot controller the data set is read in according to the CREAD format string.

Example

```
CREAD(HANDLE, SR_T, MR_T, TIMEOUT, OFFSET_CR, "%r%.7r",IPOSNO,POSV[])
```

If the received telegram and format string are not compatible, the Submit program is stopped. The cause of the error can be determined via the “SR_T” structure.

See also Section 3.1.6 of this documentation and the [CREAD CWRITE] documentation.

Execution of the program is started after successful data transfer.

6 Appendix

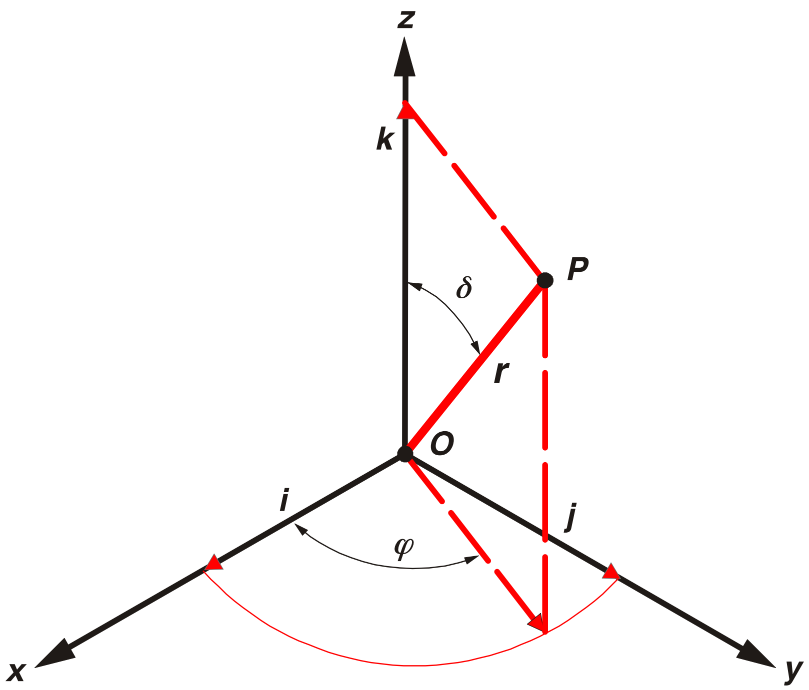
6.1 Source files

6.1.1 Format of the points in space and the orientations of the points

The determination of the points in space (x, y, z) must be specified in the source file in millimeters [mm]. These specifications describe the distance between the tip of the tool (TCP) and the origin of the workpiece coordinate system at the origin point "O" (BASE), which is usually defined on the workpiece.

Similar to the definition according to DIN 66217, a right-handed, rectangular coordinate system with axes x, y and z is expected. The Z axis is parallel to the spindle (tool) and the positive motion in the Z direction from the workpiece to the tip of the tool.

A further precondition is the specification of the orientations *(i, j, k)* by the CAM module in the RAW file. Fig. 32 schematically illustrates the definition that applies for conversion of the RAW data to the robot orientation.



Legend

O	Coordinate origin
P	Point in space ***[P(r, i, j, k)]***
r	Length of radius vector $\overline{OP}$ from the coordinate origin (r = 1 → unit vector)
i	Projection of radius vector $\overline{OP}$ in the *x* axis
j	Projection of radius vector $\overline{OP}$ in the *y* axis
k	Projection of radius vector $\overline{OP}$ in the *z* axis
δ	Angle between positive *z* axis and radius vector $\overline{OP}$
φ	Angle between positive *x* axis and the projection $\overline{OP}$ on the plane (*x*, *y*)

Fig. 32 Projection of the radius vector in the spherical coordinate system

The angles (δ, φ) are **not** relevant for KUKA.CAMRob.

In the RAW files, the orientation must be specified using exclusively the radius vectors *(i, j, k)*. Other specifications are not supported.

6.1.2 Supported source files

KUKA.CAMRob supports source files of the following types:

- **CL DATA** (DIN 66215) file extension *.dat

and

- **NC DATA** (DIN 66025) file extension *.tap

A list of the commands supported is given below.

6.1.2.1 CL DATA

The structure of source files of type "CL DATA" (*.dat) corresponds to the example shown in Fig. 33.

Axis coordinates (X, Y, Z) — **Radius vectors** (*i*, *j*, *k*)

```
RAPID
FROM  /  379.227720, -127.595787,   34.000000,  0.00000000,  0.34202014,  0.93969262
RAPID
GOTO/  379.227720, -127.595787,   34.000000,  0.00000000,  0.34202014,  0.93969262
RAPID
GOTO/  379.227720, -128.963868,   -6.180126,  0.00000000,  0.34202014,  0.93969262
GOTO/  379.227720, -130.673969,  -10.878589,  0.00000000,  0.34202014,  0.93969262
GOTO/  379.303754, -129.857312,  -11.175828,  0.00000000,  0.34202014,  0.93969262
GOTO/  379.379787, -129.040655,  -11.473066,  0.00000000,  0.34202014,  0.93969262
GOTO/  379.455821, -128.223998,  -11.770305,  0.00000000,  0.34202014,  0.93969262
GOTO/  379.455821, -127.404222,  -12.068679,  0.00000000,  0.34202014,  0.93969262
GOTO/  379.455821, -126.584445,  -12.367054,  0.00000000,  0.34202014,  0.93969262
GOTO/  379.455821, -125.764669,  -12.665428,  0.00000000,  0.34202014,  0.93969262
GOTO/  379.379787, -124.948012,  -12.962667,  0.00000000,  0.34202014,  0.93969262
GOTO/  379.303754, -124.131356,  -13.259905,  0.00000000,  0.34202014,  0.93969262
GOTO/  379.227720, -123.314699,  -13.557144,  0.00000000,  0.34202014,  0.93969262
GOTO/  379.076232, -122.507377,  -13.850985,  0.00000000,  0.34202014,  0.93969262
GOTO/  378.924743, -121.700055,  -14.144827,  0.00000000,  0.34202014,  0.93969262
GOTO/  378.773254, -120.892732,  -14.438668,  0.00000000,  0.34202014,  0.93969262
GOTO/  378.547464, -120.100889,  -14.726875,  0.00000000,  0.34202014,  0.93969262
GOTO/  378.321673, -119.309046,  -15.015082,  0.00000000,  0.34202014,  0.93969262
GOTO/  378.095883, -118.517203,  -15.303290,  0.00000000,  0.34202014,  0.93969262
```

Fig. 33 Example of a source file according to CL DATA (*.dat)

The following table contains the permissible commands.
No other commands are supported.

Not all DIN 66215 commands are supported.

The following table contains the commands from source files of type "CL DATA" that are supported by KUKA.CAMRob.

In the case of commands and command sequences that are not listed here, conversion is aborted and a corresponding error message is generated.

DIN 66215	Description	Comment
RAPID	High speed	Feed rate is taken from the setting "Process parameters" (see Section 3.1.6).
FROM /	Start position	Corresponds to "GOTO /"

DIN 66215	Description	Comment
GOTO /	End position	Corresponds to “FROM /”
FEDRAT / MMPM xxxx.xxxx	Feed rate	[mm/min]
SPINDL / xx.xx CLW	Spindle speed, clockwise	
SPINDL / xx.xx CCLW	Spindle speed, counterclockwise	
SPINDL / OFF	Spindle off	
TOOLNO /x	Tool number	
COOLNT/ ON	Cooling on	OK
COOLNT/ OFF	Cooling off	OK
PRINT /		Ignored
PAINT /		Ignored
; xyz ...		Ignored

6.1.2.2 NC DATA

The structure of source files of type “NC DATA” (*.tap) corresponds to the example shown in Fig. 33.

```
P9999
G40
G90G94
T1M6
G90
S2000M3
X248.886Y-0.641Z65.I-0.515J0.008K0.857F20000
X248.886Y-0.641Z65.I-0.515J0.008K0.857
X250.946Y-0.673Z3.044I-0.515J0.008K0.857
X253.521Y-0.713Z-1.242I-0.515J0.008K0.857
X253.696Y-0.763Z-1.242I-0.515J0.008K0.857
X253.869Y-0.782Z-1.242I-0.515J0.008K0.857
X254.043Y-0.77Z-1.242I-0.515J0.008K0.857
X254.212Y-0.728Z-1.242I-0.515J0.008K0.857
X254.371Y-0.657Z-1.242I-0.515J0.008K0.857
X254.516Y-0.559Z-1.242I-0.515J0.008K0.857
X254.641Y-0.438Z-1.242I-0.515J0.008K0.857
X254.744Y-0.298Z-1.242I-0.515J0.008K0.857
X254.82Y-0.141Z-1.242I-0.515J0.008K0.857
X254.867Y0.018Z-1.242I-0.515J0.008K0.857
X254.876Y0.054Z-1.242I-0.515J0.023K0.857
X254.941Y0.338Z-1.242I-0.493J0.149K0.857
```

Axis coordinates: `X, Y, Z`
Radius vectors: `I` ***(i)***, `J` ***(j)***, `K` ***(k)***

Fig. 34 Example of a source file according to NC DATA (*.tap)

Not all DIN 66025 commands are supported.

The following table contains the commands from source files of type “NC DATA” that are supported by KUKA.CAMRob.

In the case of commands and command sequences that are not listed here, conversion is aborted and a corresponding error message is generated.

DIN 66025	Description	Comment
G0	High speed	Feed rate is taken from the setting “Process parameters” (see Section 3.1.6).
G1	Straight	
G40	Deselection of cutting radius correction	
G90	Absolute position	
G94	Feed rate [mm/min]	
Fxxxx	Feed rate	
SxxxxM3	Spindle speed, clockwise	
SxxxxM4	Spindle speed, counterclockwise	
M5	Spindle off	
TxM6	Tool number	
M08	Cooling on	
M09	Cooling off	
M30	End of program	
; xyz ...		Line ignored (comment)
(xyz ...		Line ignored (comment)

6.2 Visual checking of CSV files using Microsoft Excel

For inspection and testing purposes, CSV text files can be checked visually with the aid of “Microsoft Excel ©”.

We recommend that you check all files using Excel to ensure that the conversion has been carried out properly.

To do this, start the program “Microsoft Excel”. Open the CSV text file (*.txt) to be displayed using the menu function “File” → “Open”; to display files with the extension “*.txt”, use the menu to select “List Files of Type” and the item “All Files *.*”.

This starts the Excel text conversion wizard.

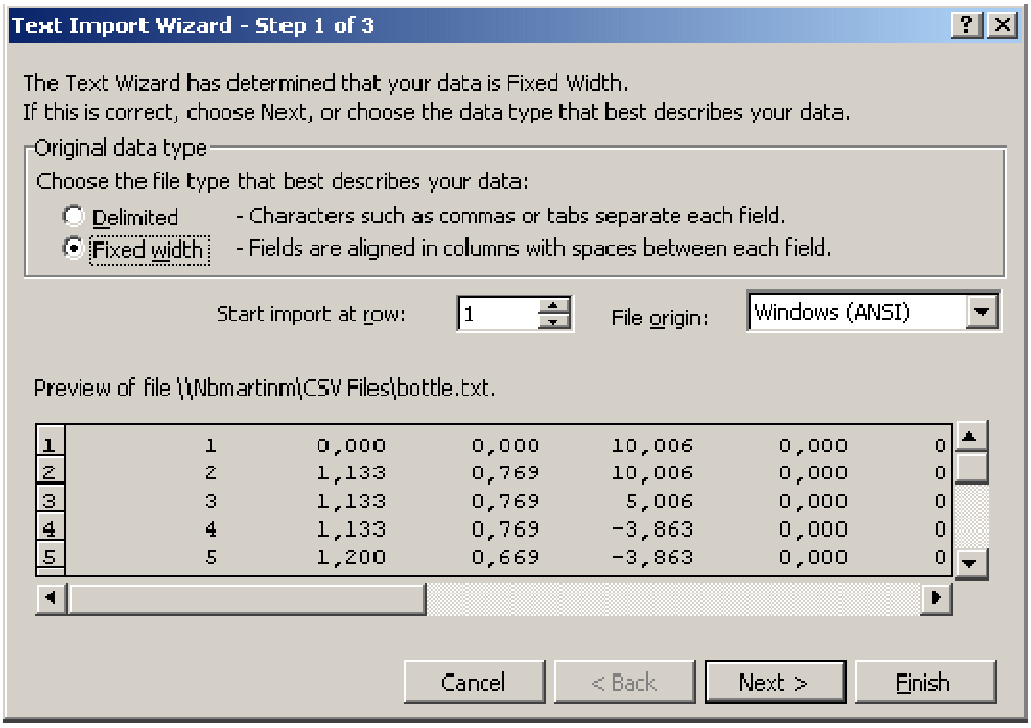


Fig. 35 Microsoft Excel text conversion wizard

As a rule, it is not necessary to make any corrections here. Click on “Finish”.

The loaded data are shown as an Excel table (Fig. 36).

	A	B	C	D	E
1	1	0	0	10,006	0
2	2	1,133	0,769	10,006	0
3	3	1,133	0,769	5,006	0
4	4	1,133	0,769	-3,863	0
5	5	1,2	0,669	-3,863	0
6	6	1,267	0,57	-3,863	0
7	7	1,299	0,492	-3,863	0
8	8	1,347	0,322	-3,863	0
9	9	1,373	0,162	-3,863	0
10	10	1,377	0,115	-3,863	0
11	11	1,383	-0,079	-3,863	0
12	12	1,373	-0,186	-3,863	0
13	13	1,354	-0,302	-3,863	0
14	14	1,314	-0,451	-3,863	0
15	15	1,233	-0,638	-3,863	0
16	16	1,201	-0,705	-3,863	0

Fig. 36 Partial view of a Microsoft Excel table: Point coordinates X (column B), Y (column C), Z (column D)

Now select the level which is to be depicted graphically; in the Excel table example shown in Fig. 36, B (for X) and C (for Y) have been selected.

Call the Chart Wizard using the menu function “Insert” → “Chart...”.

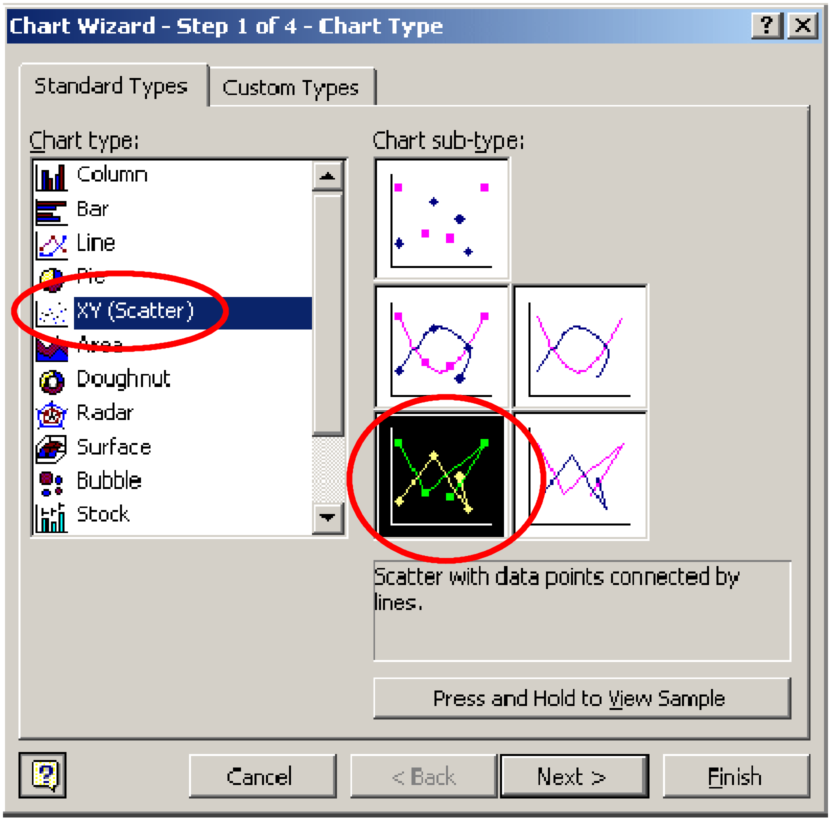
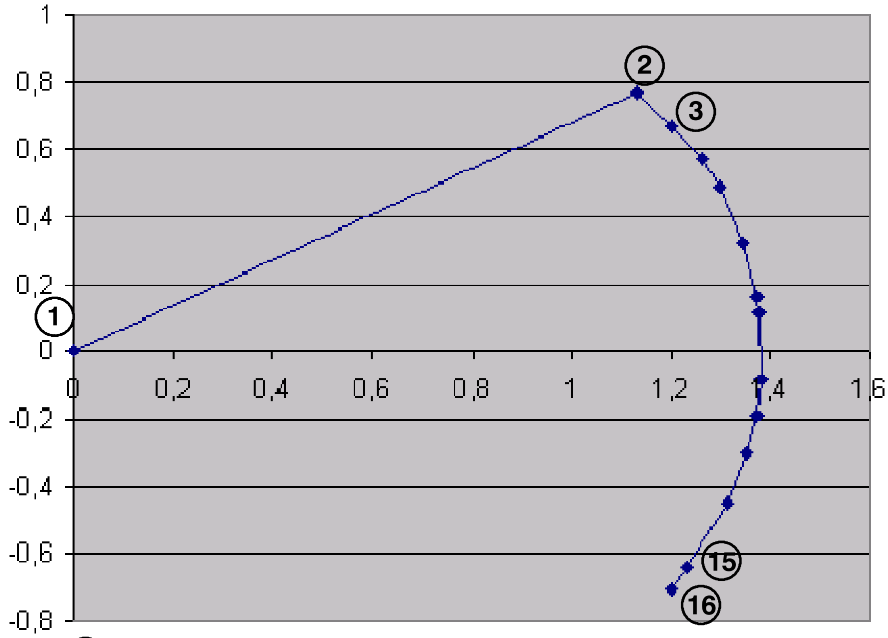


Fig. 37 Microsoft Excel ChartWizard

To generate an XY-chart, go to the selection window “Chart type”, select the option “XY (Scatter)” and select the appropriate “Chart sub-type” on the right.

Click on “Finish”. For the example shown in Fig. 36, the chart which is generated is depicted graphically as shown in Fig. 38:



(n) XY coordinate as per line number in Excel data sheet (Fig. 36).

Fig. 38 Microsoft Excel – graphical representation of XY coordinates

Fig. 39 shows the XY coordinates from a file with over 1700 points.

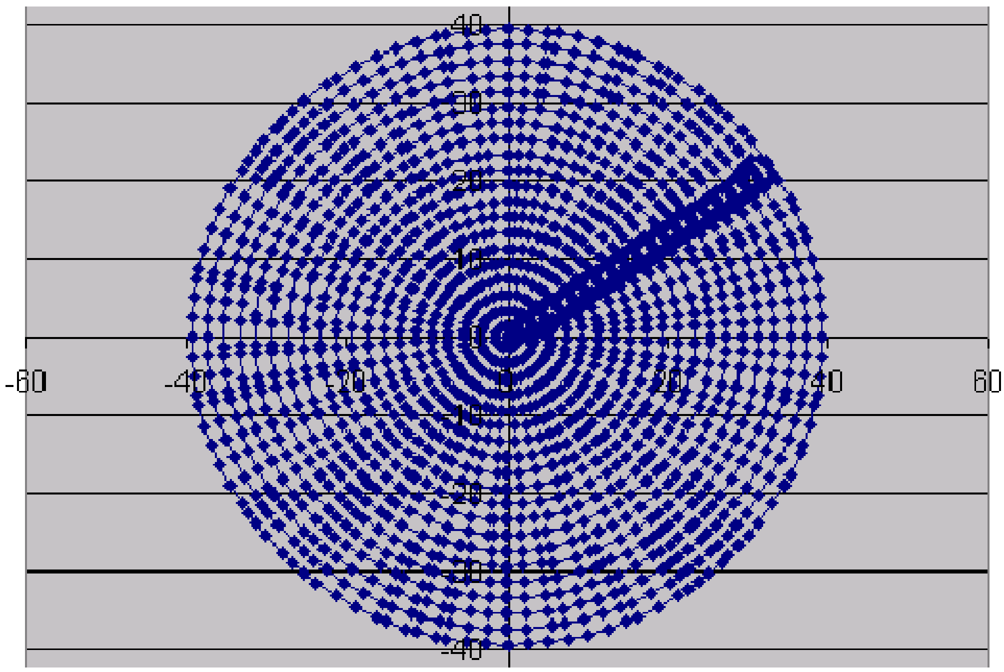


Fig. 39 Microsoft Excel – graphical representation of XY coordinates (Z constant).

Symbols

A

B

C

D

E

F

I

K

L

M

N

O

P

R

S

T

U

V