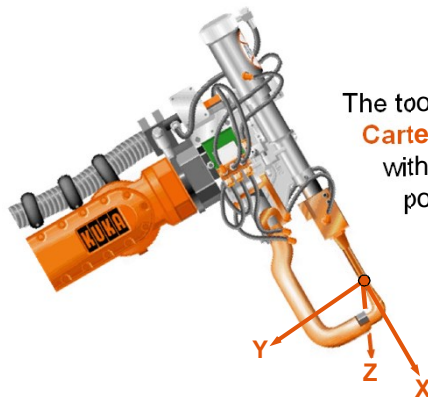




### What happens during tool calibration?



The tool receives a user-defined **Cartesian coordinate system** with its origin at a reference point specified by the user.



### What are the advantages of tool calibration?



Orientation



CP velocity



Tool direction

General procedure for tool calibration

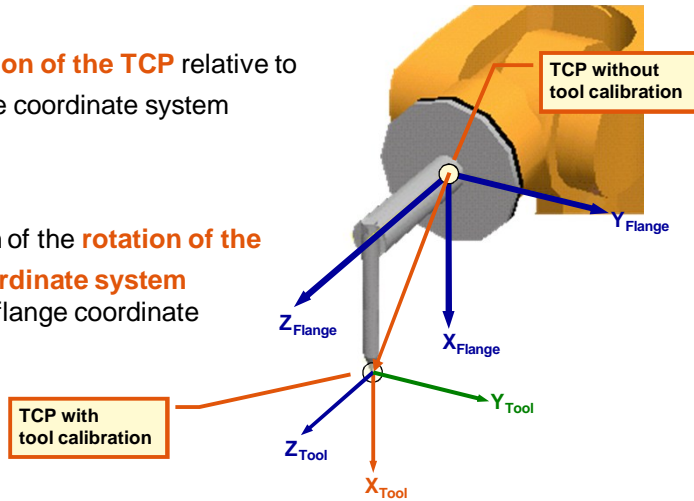


1st step:

Calculation of the TCP relative to the flange coordinate system

2nd step:

Definition of the rotation of the Tool coordinate system from the flange coordinate system



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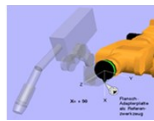
Tool calibration methods



1. TCP calibration



or



XYZ - 4-Point

XYZ - Reference

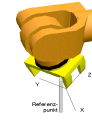
2. Orientation calibration



or



or



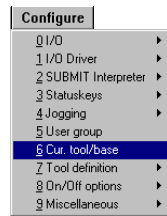
ABC - World 5D

ABC - World 6D

ABC - 2-Point

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## Activating the tool



Current tool/base

Tool no.

Tool name: PEN

Base No.

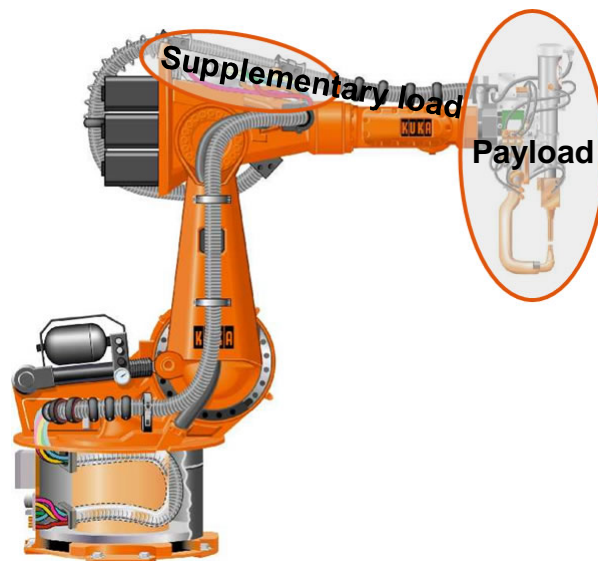
Base system name: (\$NULLFRAME)

Select the tool and base to be activated.

Enter the tool number  
**1 - 16**

Tool name  
is displayed

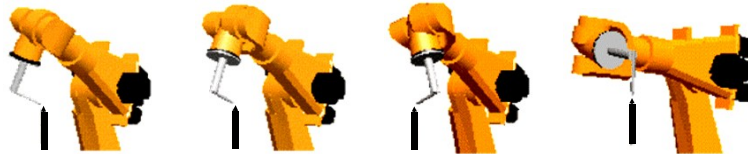
## Load data



### The X Y Z - 4 Point method



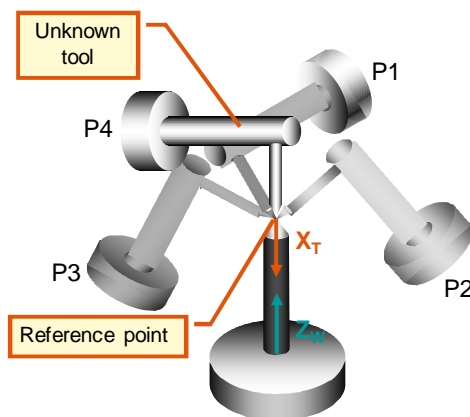
In the XYZ - 4-point method, the TCP of the tool is moved to a reference point from four different directions.



The TCP of the tool is then calculated from the different flange positions and orientations.

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### Diagram of the X Y Z - 4 Point method



- Move the tool to the reference point with 4 different orientations (P1 to P4).
- **Tip:** Set the final orientation (P4) so that  $+X_T$  runs in the direction of  $-Z_W$ .
- **Important:** The orientations of the tool positions (flange positions) must differ sufficiently from one another.



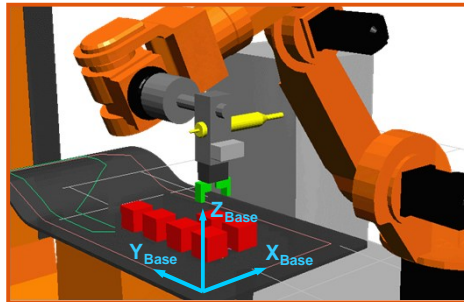
Reduce the velocity in the vicinity of the reference point in order to avoid a collision.

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### Base calibration



The work surface (pallet, clamping table, workpiece...) receives a user-defined Cartesian coordinate system with its origin at a reference point specified by the user.



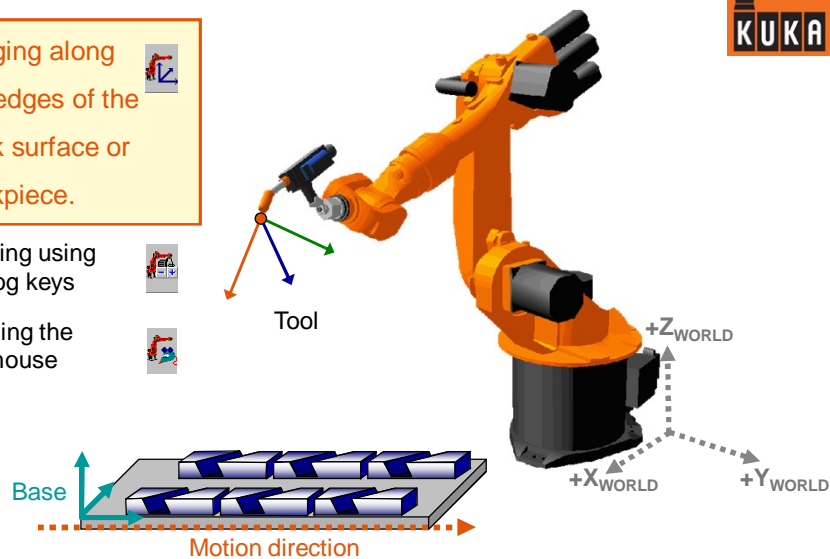
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### Purpose of base calibration



Jogging along the edges of the work surface or workpiece.

Jogging using the jog keys  
or using the 6D mouse

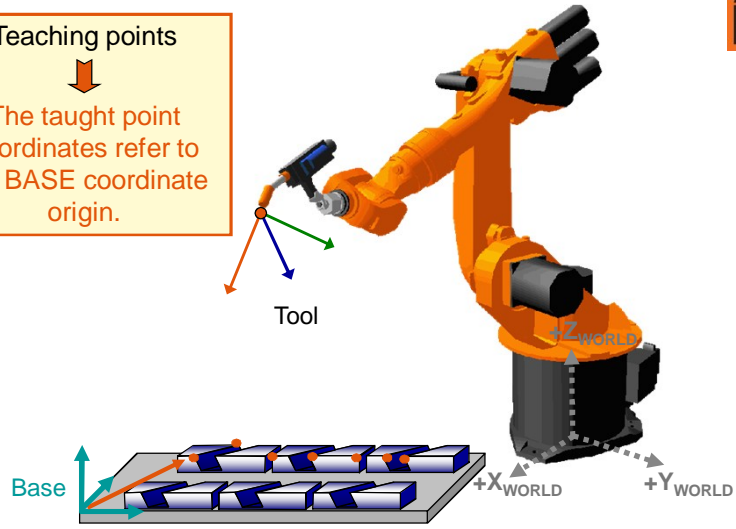


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*Purpose of base calibration*



Teaching points  
↓  
The taught point coordinates refer to the BASE coordinate origin.

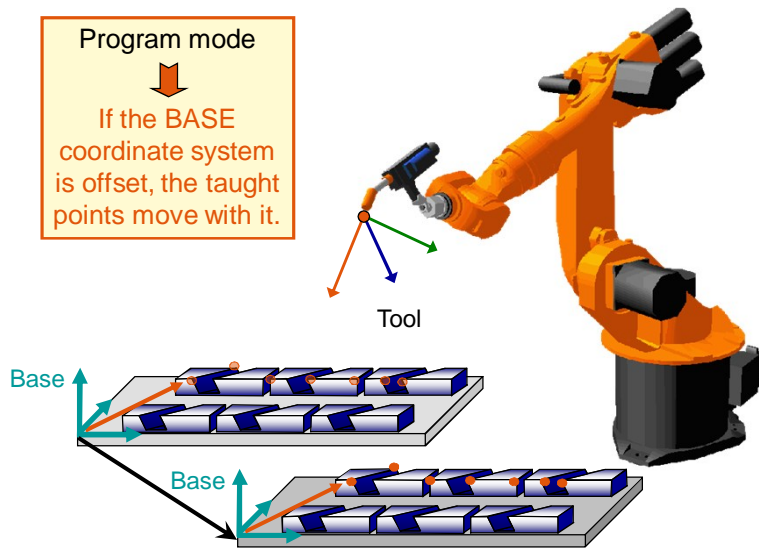


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*Purpose of base calibration*



Program mode  
↓  
If the BASE coordinate system is offset, the taught points move with it.



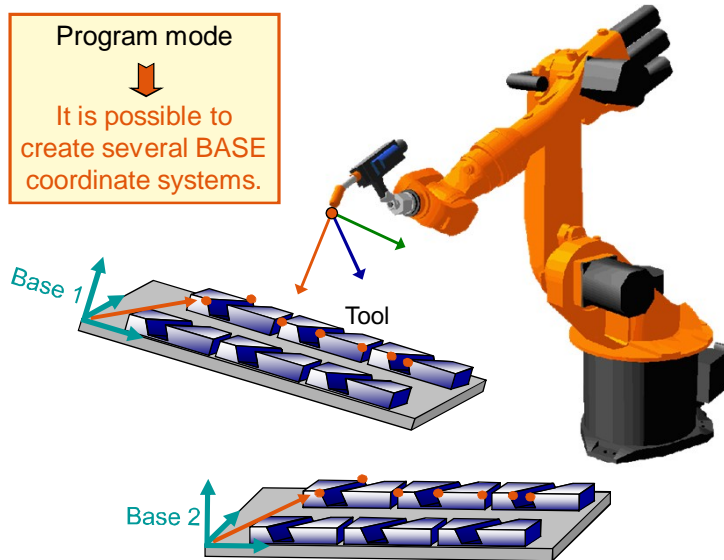
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*Purpose of base calibration*



Program mode

It is possible to create several BASE coordinate systems.



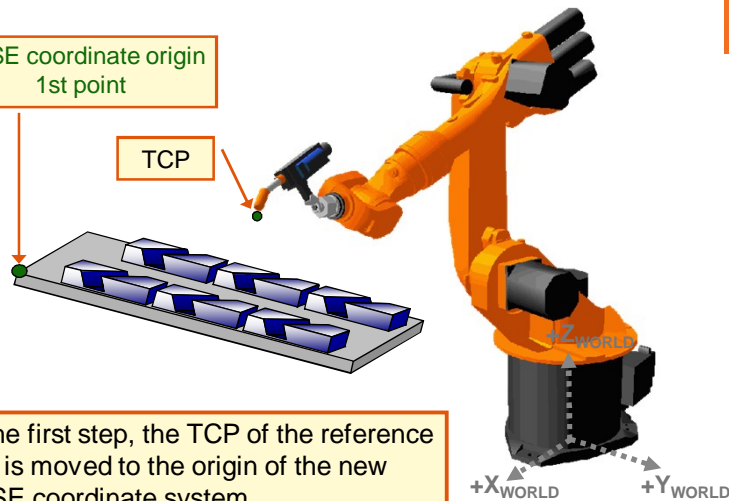
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*The "3-Point" method 1st step*



BASE coordinate origin  
1st point

TCP



In the first step, the TCP of the reference tool is moved to the origin of the new BASE coordinate system.

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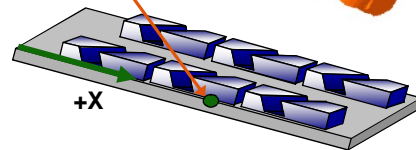
The "3-Point" method

2nd step



Positive X axis  
2nd point

TCP



In the second step, the TCP of the reference tool is moved to a point on the positive X axis of the new BASE coordinate system.

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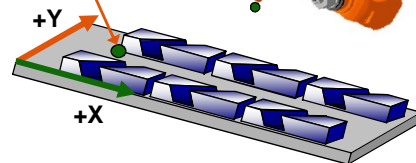
The "3-Point" method

3rd step



Positive Y value on XY plane  
3rd point

TCP

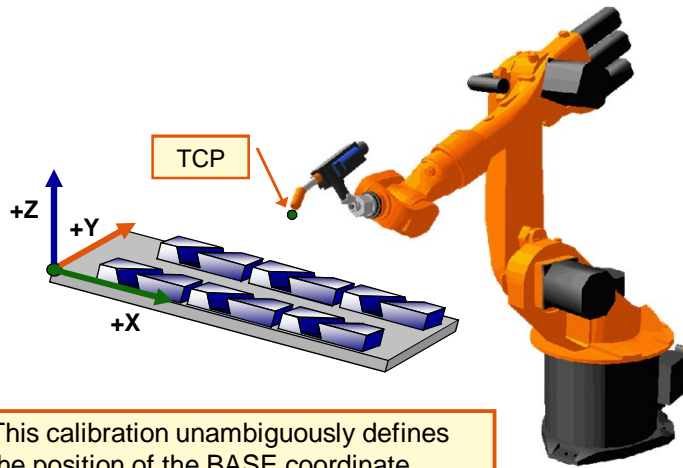


In the third step, the TCP of the reference tool is moved to a point with a positive Y value on the XY plane of the new BASE coordinate system.

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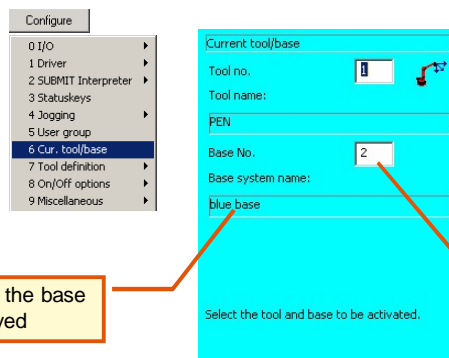


### Calibrated base



This calibration unambiguously defines the position of the BASE coordinate system.

### Activating a base



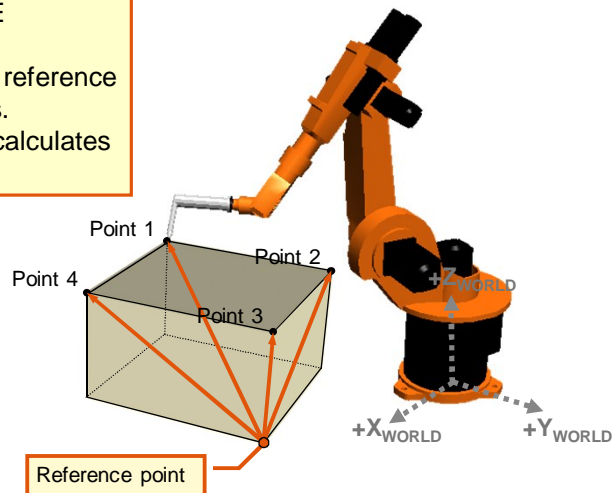
Name of the base is displayed

Enter the number of the base  
BASE\_DATA[1-32]

### Calculating the BASE coordinate system indirectly

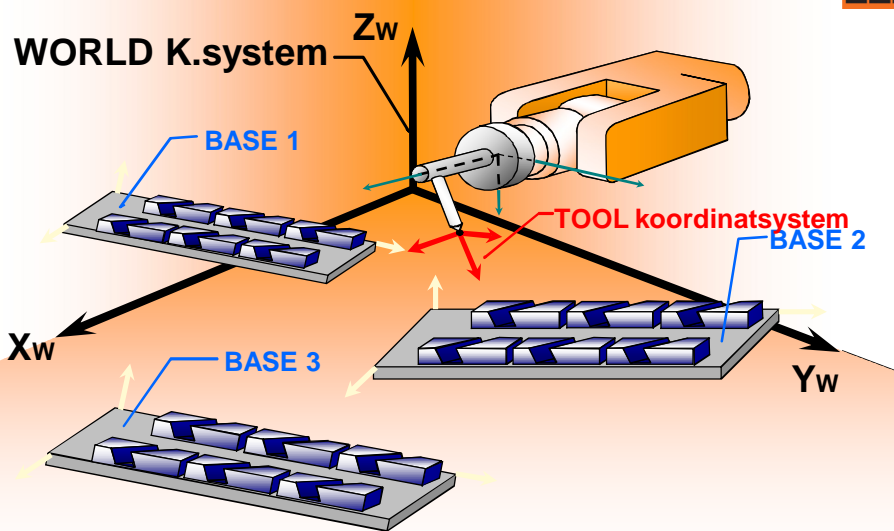


- In the controller, enter the coordinates of 4 points referring to the BASE (e.g. from CAD).
- Move the TCP of the reference tool to the four points.
- The robot controller calculates the BASE.



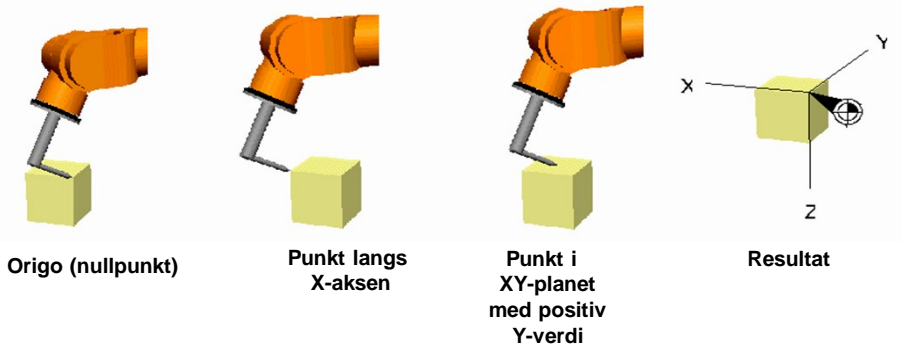
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### Base opmåling



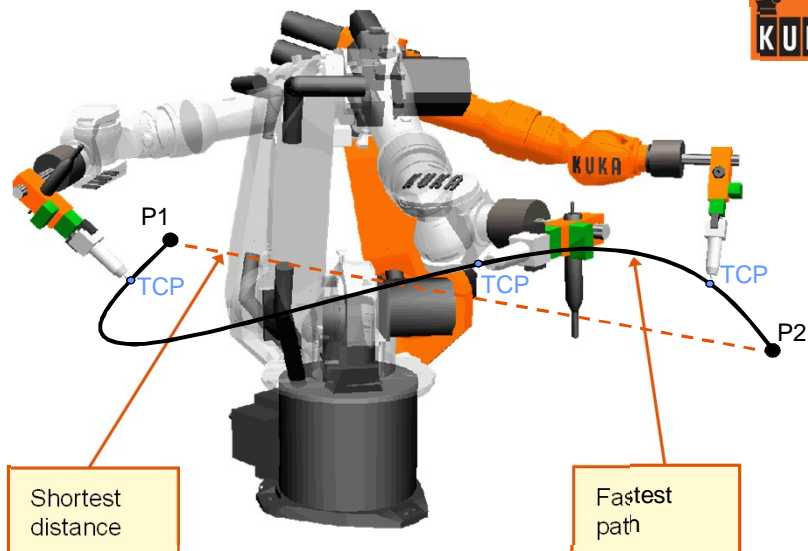
: 120

### 3-punkts metoden



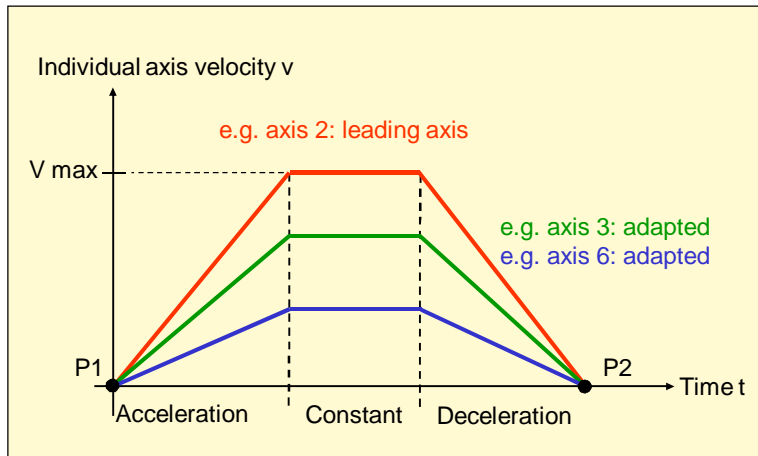
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### PTP - motion



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SYNCHRO - PTP

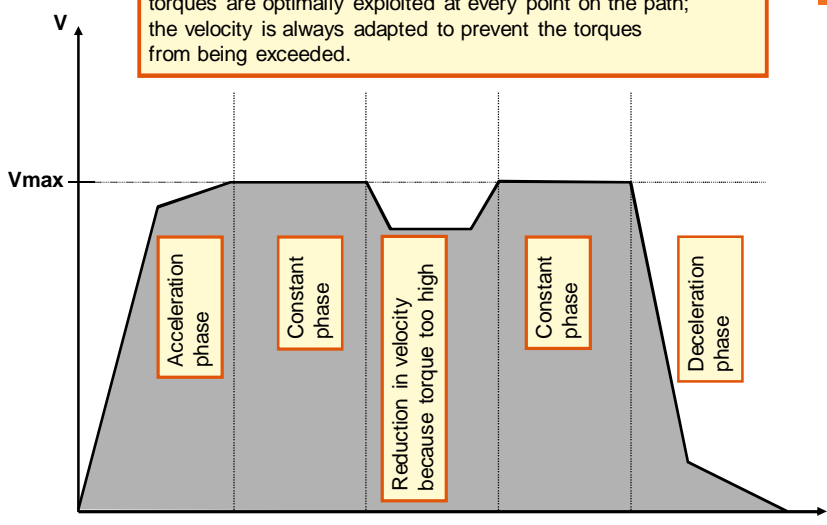


Leading axis is the name given to the axis that takes longest to reach the end point; the velocity specified in the inline form is disregarded.

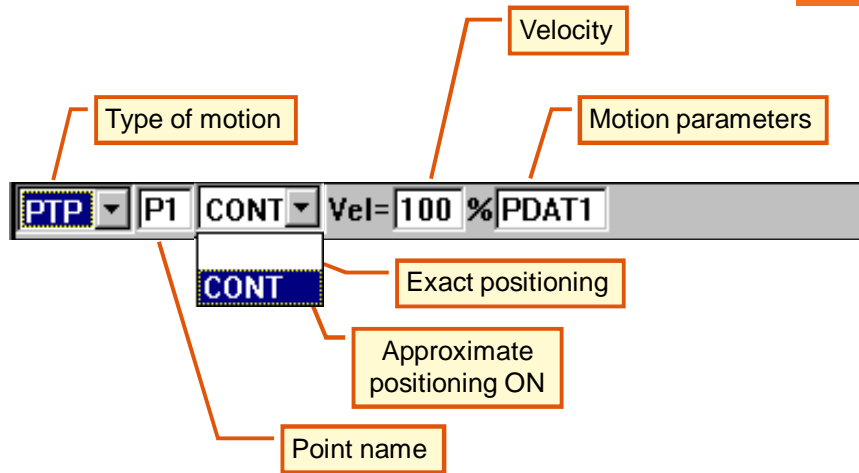
PTP motion – higher motion profile



The higher motion profile is used by default, i.e. the permissible torques are optimally exploited at every point on the path; the velocity is always adapted to prevent the torques from being exceeded.

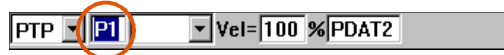


Programming a PTP motion



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Programming a PTP motion



Frames 1/1

Tool  
 TOOL\_DATA[4]

Base  
 NULLFRAME

External TCP  
 False

**Tool**  
 Tool selection  
 Tool\_Data[1]..[16], Nullframe

**Base**  
 Workpiece coordinate system selection  
 Base\_Data[1]..[32], Nullframe

**External TCP**  
 Robot guiding tool: False  
 Robot guiding workpiece: True

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## Programming a PTP motion



PTP ▾ P1 CONT ▾ Vel=100 % **PDAT2**

**CONT**

Motion parameter 1/1

Acceleration

1 100 % 100

Approximation distance

0 100 % 100

**Acceleration**  
Acceleration used for the motion.  
Range of values: 1..100%

**Approximation distance<sup>\*)</sup>**  
Size of approximate positioning range for the motion.  
Range of values: 0..100%

\*) The parameter "Approximation distance" is displayed if approximate positioning has been selected (CONT).

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## Status and Turn



The entries "S" and "T" serve to select a specific, unambiguously defined robot position where several different axis positions are possible for the same point in space.



The specification of Status and Turn is only evaluated for PTP motions. For this reason, the first motion in a program must be a PTP motion.

```
DEFDAT MAIN_PROGRAM ( )
DECL POS XPOINT1={X 900, Y 0, Z 800, A 0, B 0, C 0, S 6, T 27}
DECL FDAT FPOINT1...
...
ENDDAT
```

STATUS

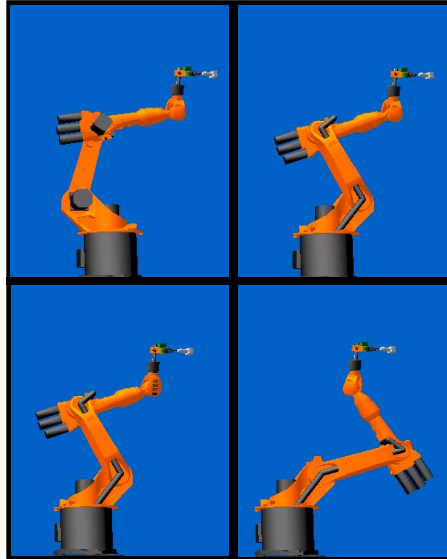
TURN

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## Status and Turn



Status = 1  
Turn = 46



Status = 2  
Turn = 43

Status = 6  
Turn = 59

Status = 4  
Turn = 63

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## Status and Turn



The screenshot displays the KUKA robot control software interface. The main window shows a program editor with the following code:

```

3 PTP HOME Vel= 100 % DEFAULT
4
5
6
7 ;anfahen einer position in raum
8 PIP status Vel= 100 % PDR1 Tool[1]:Entnahme Base[0]
9 halt
10 loop
11
12 wait sec 4
13 ptp (pos[x 80,y 600,z 1600,a -40,b 15,c -15,s 1,t 46])
14
15 turn-xstatus ; zuweisung auf eine variable
16 ; turn=001 status 101110
17 ; a1_p,a2_n,a3_n,a4_n,a5_p,a6_n
18 wait sec 1
19 turn.s=2
20 turn.t=43
21 ptp turn ; turn=010 status 101011
    
```

The interface also includes a 3D simulation of the robot arm, a status window showing the current program name (STATUS\_TURN) and speed (POV=100%), and a message window with the following text:

Klicken oder ziehen zum Auswählen der Komponenten; Halten Sie Shift+Ctrl, um die Auswahl unanzuschalten.  
Click to select KRC connections.

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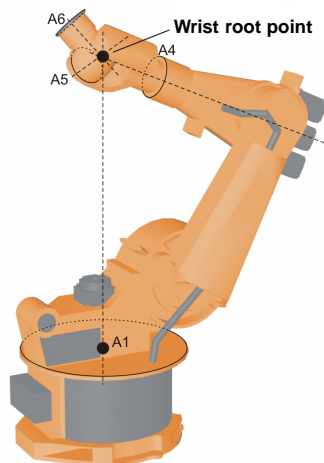
## Singularities



In a standard 6-axis kinematic system, a distinction is made between 3 different singularity positions. These are the overhead singularity, the extended position and the wrist axis singularity. One characteristic of a singularity is that unambiguous reverse transformation (conversion of Cartesian coordinates to axis-specific values) is not possible, even though Status and Turn are specified. Small Cartesian changes in the immediate vicinity of a singularity give rise to major changes in the axis angles.

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## Overhead singularity ( $\alpha_1$ position)

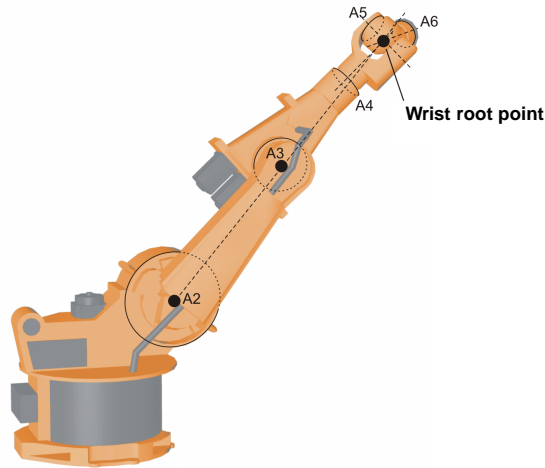


Here, the wrist root point, located at the intersection of axes A4, A5 and A6, is positioned directly on axis 1.

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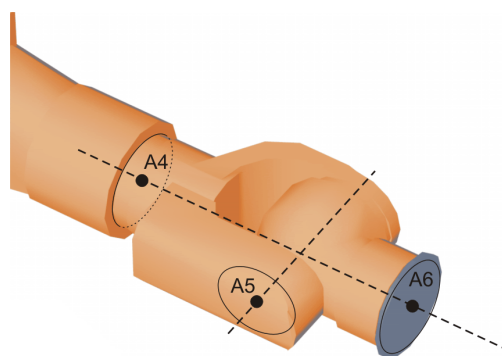
*Extended position ( $\alpha_2$  position)*



The extension of A2-A3 intersects the wrist root point.

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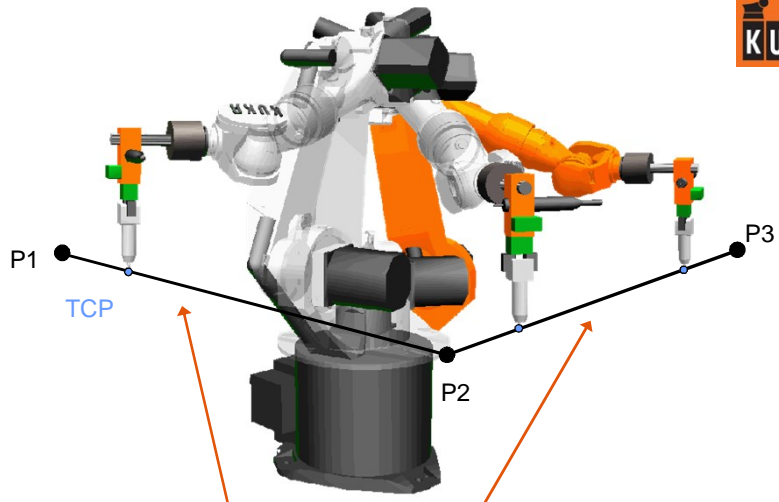
*Wrist axis singularity ( $\alpha_5$  position)*



In this case, axes 4 and 6 are parallel. It is not possible to determine the positions of these two axes unambiguously by means of reverse transformation as there is an infinite number of axis positions for A4 and A6.

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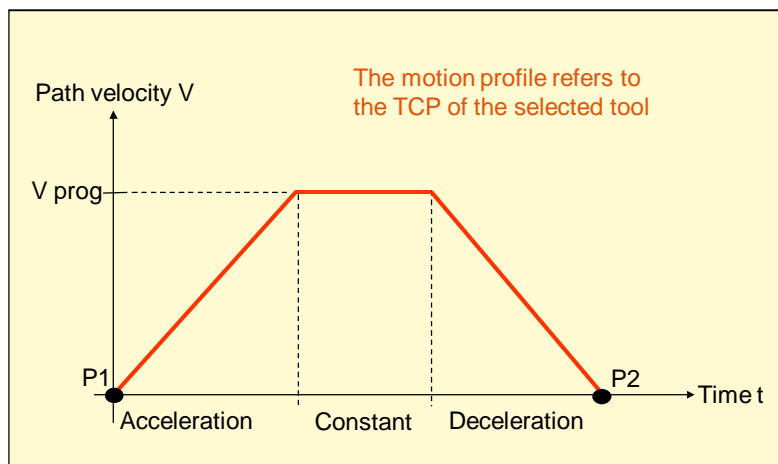
### LIN - motion



The TCP is moved along a straight line to the end point

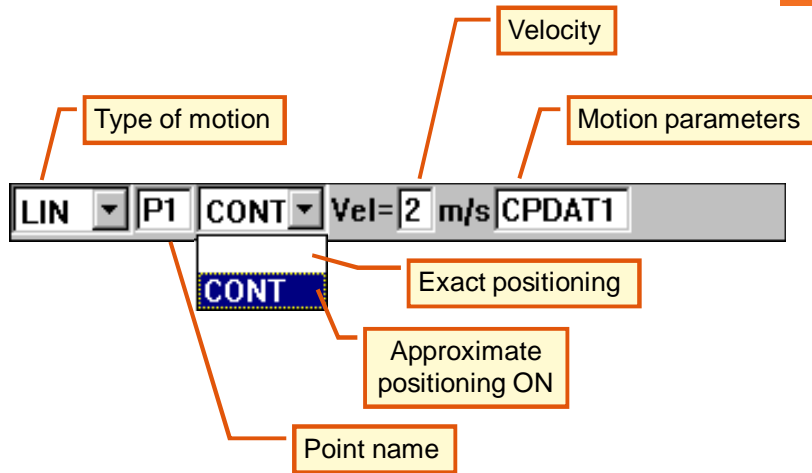
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### Velocity profile



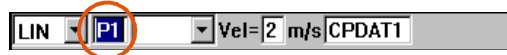
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Programming a LIN motion



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Programming a LIN motion



Frames 1/1

Tool  
 TOOL\_DATA[4]

Base  
 NULLFRAME

External TCP  
 False

**Tool**  
 Tool selection  
 Tool\_Data[1]..[16], Nullframe

**Base**  
 Workpiece coordinate system selection  
 Base\_Data[1]..[32], Nullframe

**External TCP**  
 Robot guiding tool: False  
 Robot guiding workpiece: True

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## Programming a LIN motion



LIN | P1 | CONT | Vel=2 m/s | CPDAT1

Motion parameter 1/1

CONT

Acceleration  
1 100 % 100

Approximation distance  
0 100 mm 300

Orientation control  
Standard  
Wrist PTP  
Constant Orientation

### Acceleration

Acceleration used for the motion.  
Range of values: 1...100%

### Approximation distance<sup>\*)</sup>

Size of approximate positioning range for the motion.  
Range of values: 0...300 mm

<sup>\*)</sup> The parameter "Approximation distance" is displayed if approximate positioning has been selected (CONT).

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## Programming a LIN motion



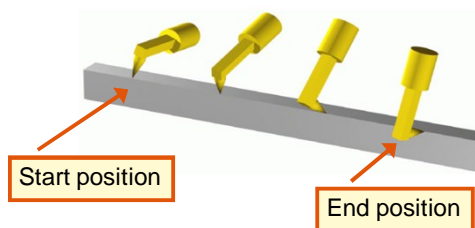
Motion parameter 1/1

Acceleration  
1 100 % 100

Approximation distance  
0 100 mm 300

Orientation control  
Standard  
Wrist PTP  
Constant Orientation

### Orientation control - Standard



During the path motion, the orientation of the tool changes continuously from the start position to the end position. This is achieved by rotating and pivoting the tool direction.

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## Programming a LIN motion



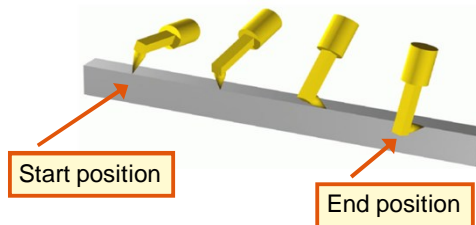
Motion parameter 1/1

Acceleration  
1 100 % 100

Approximation distance  
0 100 mm 300

Orientation control  
Standard  
Wrist PTP  
Constant Orientation

### Orientation control - Wrist PTP



During the path motion, the orientation of the tool changes continuously from the start position to the end position. This is done by linear transformation (axis-specific motion) of the wrist axis angles. The problem of the wrist singularity can be avoided using this option as there is no orientation control by rotating and pivoting the tool direction.

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## Programming a LIN motion



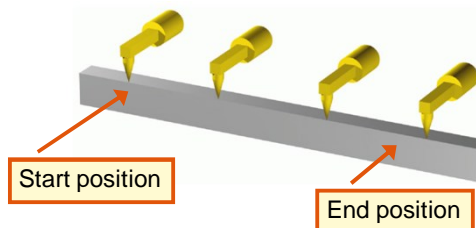
Motion parameter 1/1

Acceleration  
1 100 % 100

Approximation distance  
0 100 mm 300

Orientation control  
Standard  
Wrist PTP  
Constant Orientation

### Orientation control - Constant



The orientation remains constant during the CP motion. The programmed orientation is disregarded for the end point and that of the start point is used.

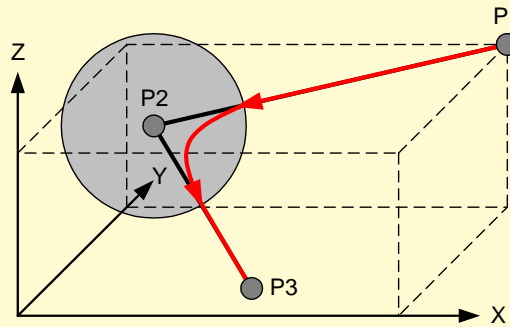
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## Approximation of motions



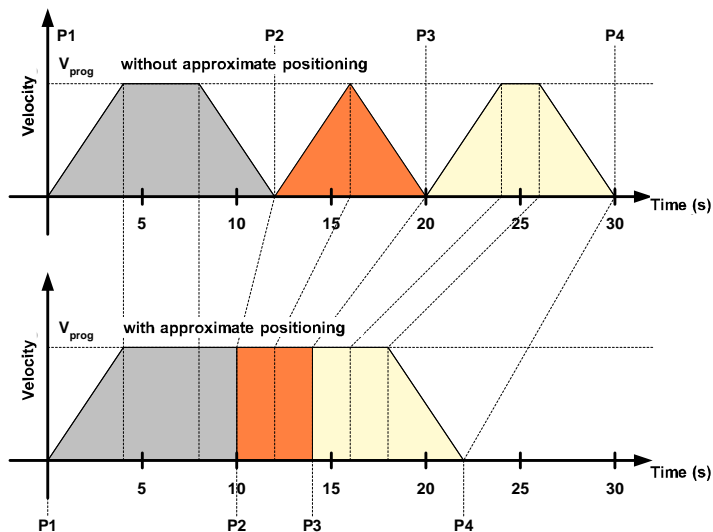
During approximate positioning, the robot does not move exactly to each programmed position, nor is it braked completely.

- Advantage:
- reduced wear
  - improved cycle times



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## Cycle time improvement by means of approximated motions

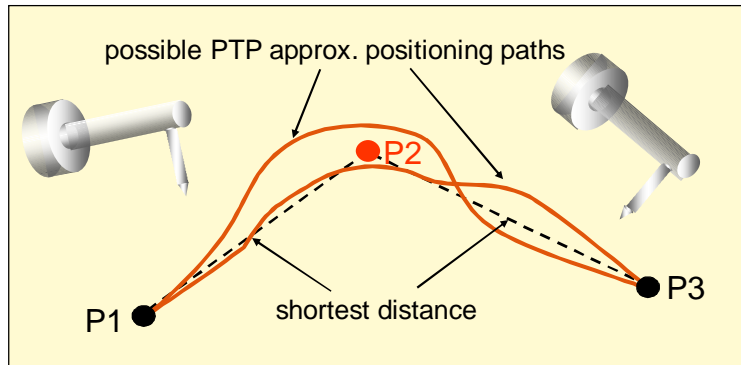


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PTP motion with approximate positioning

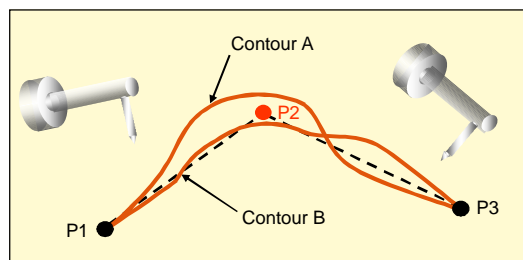
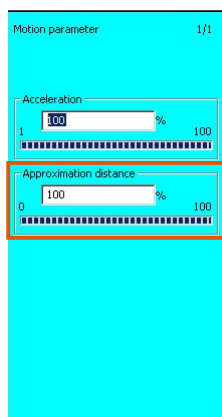


PTP motion with approx. positioning → P2 is an approx. positioning point



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PTP motion with approximate positioning



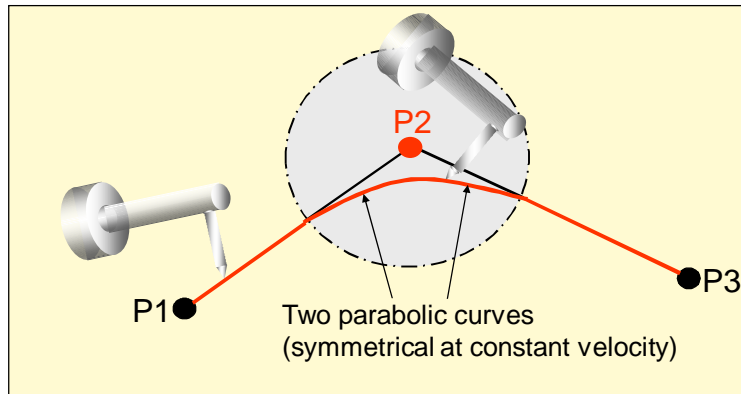
The value of "Approximation distance" specifies the size of the approximate positioning range. The path **cannot** be set, nor is it predictable.

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LIN motion with approximate positioning

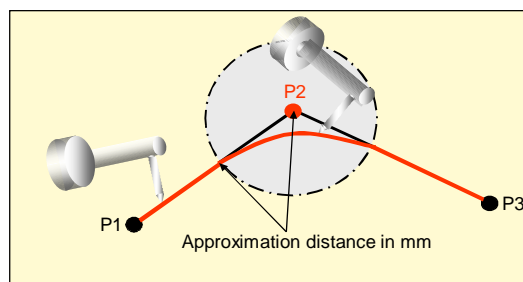
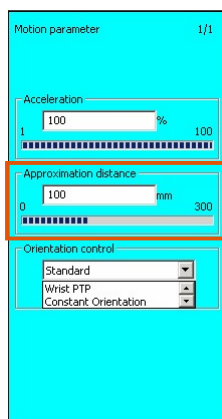


LIN motion with approx. positioning → P2 is an approx. positioning point



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LIN motion with approximate positioning



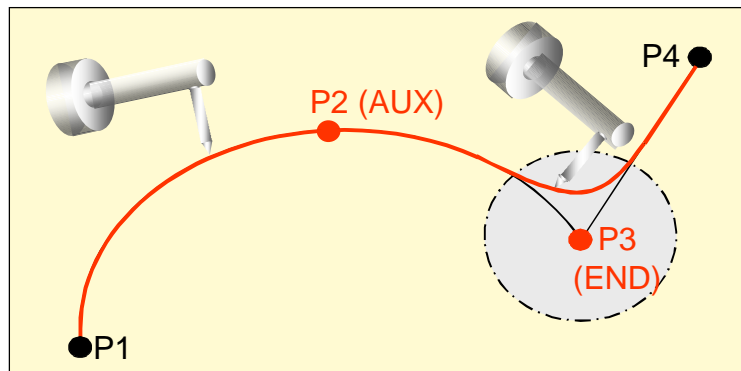
The value entered for "Approximation distance" specifies the distance from the end point and the point at which the approximation motion commences. The resulting path is **not** an arc. The same applies to the following CIRC command.

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CIRC motion with approx. positioning → P3 is an approx. positioning point



### What is the computer advance run?

The **main run pointer** (white bar), which can be seen on the graphical user interface when the program is running, always indicates the block that is currently being processed. The **advance run pointer**, on the other hand, is not visible and **precedes** the **main run pointer** by three motion blocks (default setting).

### What is the function of the advance run pointer?

In order to be able to calculate the path, e.g. of an approximation motion, it is necessary to read the path planning data using the advance run pointer. It is not only motion data that are processed, however, but also arithmetical data and commands for controlling the periphery.

### How is the advance run pointer influenced?

Instructions and data that influence the periphery (e.g. input/output instructions) trigger an advance run stop. If the advance run pointer is stopped, approximate positioning cannot be carried out.

## Computer advance run



The screenshot shows a KUKA robot control interface with a menu bar (File, Program, Configure, Monitor, Setup, Commands, Technology, Help) and a program editor. The program code is as follows:

```
1 DEF air( )
2 INI
3
4 PTP HOME Vel= 100 % DEFAULT
5
6 PTP P1 CONT Vel= 100 % PDAT1 Tool[2]:Gripper Base[1]:Table A
7 PTP P2 CONT Vel= 100 % PDAT2 Tool[2]:Gripper Base[1]:Table A
8 PTP P3 CONT Vel= 100 % PDAT3 Tool[2]:Gripper Base[1]:Table A
9 PTP P4 CONT Vel= 100 % PDAT4 Tool[2]:Gripper Base[1]:Table A
10 LIN P5 CONT Vel= 2 m/s CPDAT1 Tool[2]:Gripper Base[1]:Table A
11 SET Gripper1 State= open GDAT1
12 LIN P4 CONT Vel= 2 m/s CPDAT3 Tool[2]:Gripper Base[1]:Table A
13 PTP P2 CONT Vel= 100 % PDAT6 Tool[2]:Gripper Base[1]:Table A
14 PTP P1 CONT Vel= 100 % PDAT7 Tool[2]:Gripper Base[1]:Table A
15 PTP HOME Vel= 100 % DEFAULT
16
17 END
```

Annotations in the image:

- A red arrow points to line 6, labeled "Main run pointer (visible)".
- A red arrow points to line 10, labeled "Advance run pointer (not visible)".

At the bottom of the interface, the status bar shows: KRC:R1\PROGRAM\AIR.SRC, Ln 6, Col 0, IP= 6, T1, PDV 100%, RName 1:03 PM. The status bar also includes buttons for Change, Cap, S, I, AIR, Motion, Logic, Last Cmd, Line Sel, Touch Up, and NAVIGATOR.

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## Computer advance run



The screenshot shows the same KUKA robot control interface as above, but with the program execution stopped at line 10. The status bar now shows: KRC:R1\PROGRAM\AIR.SRC, Ln 10, Col 0, IP= 10, T1, PDV 100%, RName 1:04 PM. A notification message is displayed in the status bar area:

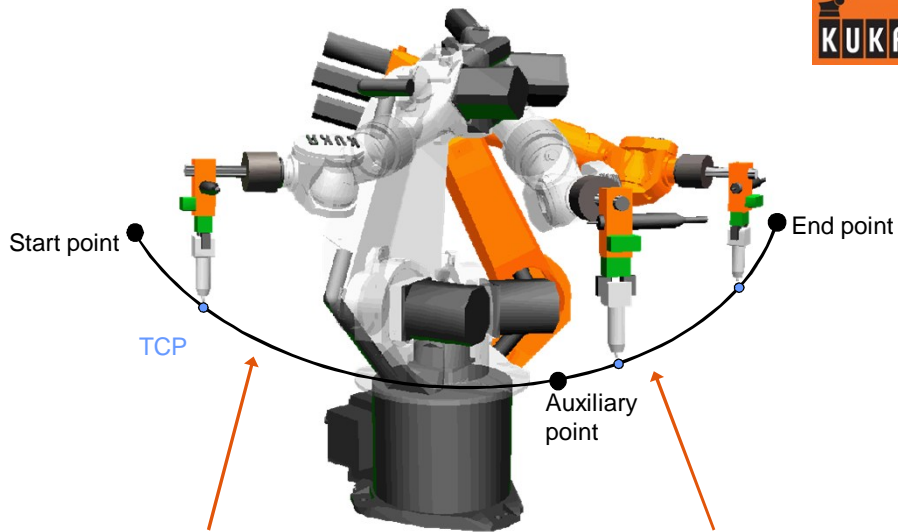
C.	Time	no.	Source	Message
!	1:03:53 PM	1123		Approximation not possible

Annotations in the image:

- A red arrow points to line 10, labeled "The advance run is stopped here".
- A red arrow points to the notification message, labeled "Notification message generated in the event of an advance run stop".

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### CIRC - motion



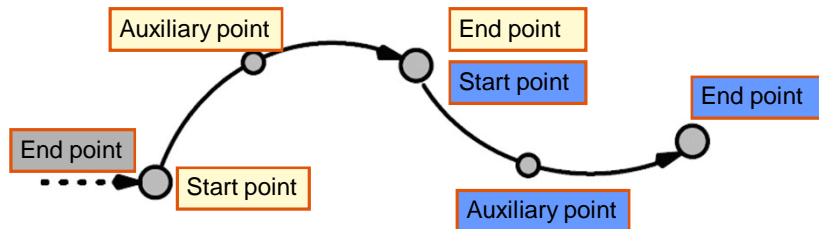
The TCP is moved along an arc to the end point

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### CIRC motion



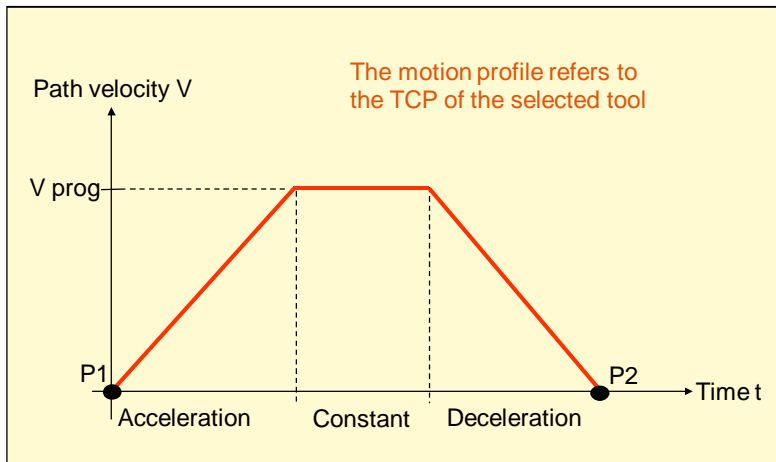
Here, the TCP or workpiece reference point moves to the end point along an arc. The path is defined using start, auxiliary and end points. The end point of a motion instruction serves as the start point for the subsequent motion.



The orientation of the TCP is not taken into consideration at the auxiliary point and is not relevant for the teaching of coordinates.

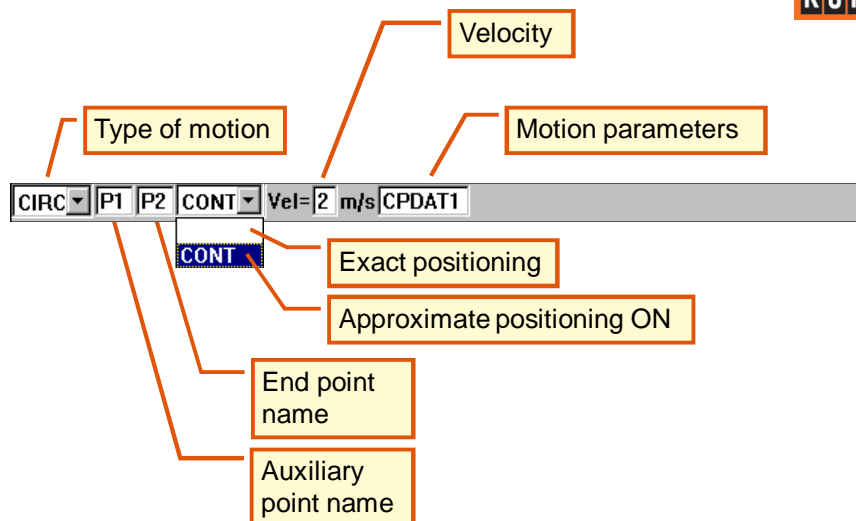
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## Velocity profile



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## Programming a CIRC motion



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Programming a CIRC motion



CIRC P1 **P2** Vel=2 m/s CPDAT1

Frames 1/1

Tool  
TOOL\_DATA[4]

Base  
NULLFRAME

External TCP  
False

**Tool**  
Tool selection  
Tool\_Data[1]..[16], Nullframe

**Base**  
Workpiece coordinate system selection  
Base\_Data[1]..[32], Nullframe

**External TCP**  
Robot guiding tool: False  
Robot guiding workpiece: True

Programming a CIRC motion



CIRC P1 P2 **CONT** Vel=2 m/s CPDAT1

CONT

Motion parameter 1/1

Acceleration  
1 100 % 100

Approximation distance  
0 100 mm 300

Orientation control  
Standard  
Wrist PTP  
Constant Orientation

**Acceleration**  
Acceleration used for the motion.  
Range of values: 1...100%

**Approximation distance<sup>\*)</sup>**  
Size of approximate positioning range for the motion.  
Range of values: 0...300 mm

<sup>\*)</sup> The parameter "Approximation distance" is only displayed if approximate positioning has been selected (CONT).

## Programming a CIRC motion



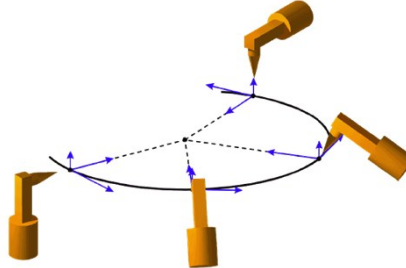
Motion parameter 1/1

Acceleration  
1 100 % 100

Approximation distance  
0 100 mm 300

Orientation control  
Standard  
Wrist PTP  
Constant Orientation

### Orientation control - Standard



During the path motion, the orientation of the tool changes continuously from the start position to the end position. This is achieved by rotating and pivoting the tool direction.

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## Programming a CIRC motion



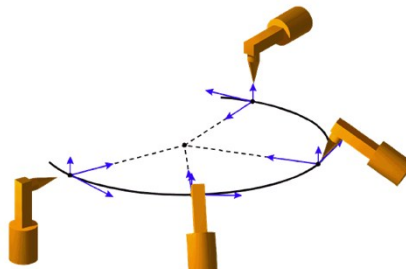
Motion parameter 1/1

Acceleration  
1 100 % 100

Approximation distance  
0 100 mm 300

Orientation control  
Standard  
Wrist PTP  
Constant Orientation

### Orientation control - Wrist PTP



During the path motion, the orientation of the tool changes continuously from the start position to the end position. This is done by linear transformation (axis-specific motion) of the wrist axis angles. The problem of the wrist singularity can be avoided using this option as there is no orientation control by rotating and pivoting the tool direction.

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## Programming a CIRC motion



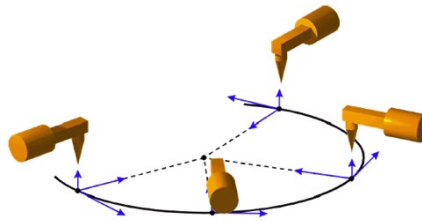
Motion parameter 1/1

Acceleration  
1 100 % 100

Approximation distance  
0 100 mm 300

Orientation control  
Standard  
Wrist-PTP  
Constant Orientation

### Orientation control - Constant

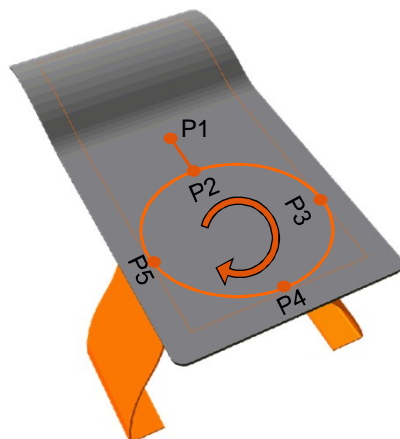


The orientation remains constant during the CP motion. The programmed orientation is disregarded for the end point and that of the start point is used.

## The 360° full circle

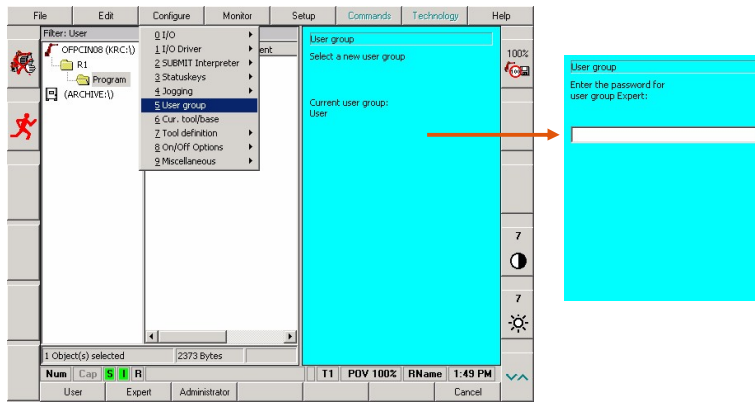


The full circle should be made up of at least two segments.



```
INI
PTP HOME
...
LIN P1
LIN P2
CIRC P3 P4 ;-> P3 is AUX; P4 is END
CIRC P5 P2 ;-> P5 is AUX; P2 is END
LIN P1
...
PTP HOME
END
```

## Changing user group



When the softkey "Expert" is pressed, the user is prompted to enter a password. The preset password is "kuka".

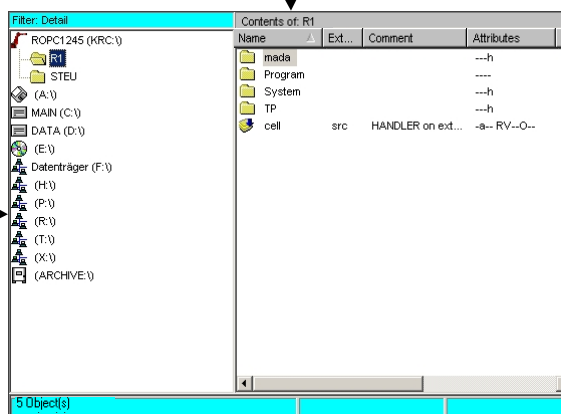
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## Navigator (expert)

System files and directories are displayed.

Drives are displayed



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### Additional symbols in the Navigator (expert)



#### Drives

Symbol	Type	Default path
	Hard drive	e.g. Kukadisk (C:\) or Kukadata (D:\)
	CD-ROM	E:\
	Mapped network drive	e.g. F:\, G:\, etc.

#### Directories and files

Symbol	Type	Meaning
	SRC file	Program file
	SRC file	Subprogram
	SRC file contains errors	Program with errors that cannot be interpreted by the compiler.
	DAT file	Data list
	DAT file contains errors	Data list with errors that cannot be interpreted by the compiler.
	ASCII file	Text file
	Other files	Binary files

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### Creating a new module (expert)



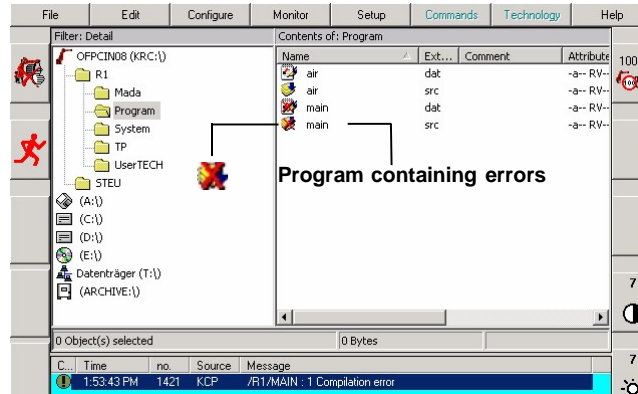
A KRL program can be made up of SRC and DAT files.

- SRC - contains program code
- DAT - contains specific program data

<b>Cell</b>	Skeleton program for control via a PLC
<b>Expert</b>	SRC and DAT file without a skeleton program
<b>Expert Submit</b>	SUB file without a skeleton program
<b>Function</b>	SRC file without a skeleton program
<b>Module</b>	SRC and DAT file with a skeleton program
<b>Submit</b>	SUB file with a skeleton program

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## Error display



If the focus is moved to a file marked as containing errors, the appearance of the softkey bar changes as follows:



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## Error list



**Short description**

**Error number**

**Line and column**

**Cursor is positioned on the line containing errors**



So that the line numbers in the error list correspond to those in the editor, the options "All FOLDS op" and "Detail view" must be activated.

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## Filhåndtering på Ekspertnivå



Name	Ext.	Attribut	Size	User	Comment
\$CONFIG	DAT	A-\$-1...	100 KB		
\$MACHINE	DAT	A-\$-RV	56 KB		
\$OPERATE	SRC	-\$-RV	28 KB		
\$ROBCDR	DAT	-\$-RV	20 KB		
A10	SRC	---0-R-	112 KB		ARC-TECH
A10	DAT	---0-R-	64 KB		ARC-TECH
A10_INI	SRC	---R-	32 KB		ARC_TECH
A10_INI	DAT	---R-	28 KB		ARC_TECH
A20	SRC	---01R-	64 KB		Arc20 for Pro
A20	DAT	A---01R-	40 KB		Arc20 for Pro
A50	SRC	---R-	28 KB		TAST Sensc
A50	DAT	---R-	24 KB		TAST Sensc
ARCSPS	SUB	---0-RV	28 KB		PLC program
AS	SRC	---1R-	32 KB		BASIS pack
BOSCH	SRC	---R-	8 KB		
CELL	SRC	---0-RV	12 KB		HANDLER c
CELL	DAT	---0-RV	16 KB		HANDLER c
COR_T1	SRC	---0-RV	20 KB		Tool Correct
FLT_SERV	SRC	---1RV	12 KB		User definec
FLT_SERV	DAT	---1RV	16 KB		User definec
H50	SRC	---1R-	44 KB		HANDLING
H70	SRC	---R-	80 KB		TOUCH SEN

## Filtypen i KRC1



- .SRC** • Program eksikvering  
På brukernivå ser man bare  
filtypen SRC
- .DAT** • Datalagring for program med samme navn (data, deklarasjoner og initsieringer)
- .SUB** • Bakgrunnsprogram (Kontroller, PLS-fil)
- .ERR** • Fil for å vise innkorrekt syntaks  
 (Skapes automatisk ved stengning av fil med felaktig syntaks)

## To muligheter å editere programmer



Tillegg og forandring av ekspertkommandoer  
uten bruk av Inlineformulærer  
Programeksikvering ikke mulig



Samme funksjoner som i anvendarnivå Tillegg og  
forandring med Inlineformulærer Programeksikvering  
mulig

## Programstruktur



Initieringsdel

```
DEF PROG1()  
;----- Declaration section -----  
INT J  
;----- Instruction section -----  
$VEL_AXIS[1]=100 ;Definition of axis velocities  
$VEL_AXIS[2]=100  
$VEL_AXIS[3]=100  
$VEL_AXIS[4]=100  
$VEL_AXIS[5]=100  
$VEL_AXIS[6]=100  
  
$SACC_AXIS[1]=100 ;Definition of axis accelerations  
$SACC_AXIS[2]=100  
$SACC_AXIS[3]=100  
$SACC_AXIS[4]=100  
$SACC_AXIS[5]=100  
$SACC_AXIS[6]=100  
  
PTP {A1 0,A2 -90,A3 90,A4 0,A5 0,A6 0}  
  
FOR J=1 TO 5  
  PTP {A1 45}  
  PTP {A2 -70,A3 50}  
  PTP {A1 0,A2 -90,A3 90}  
ENDFOR  
  
PTP {A1 0,A2 -90,A3 90,A4 0,A5 0,A6 0}  
END
```

## Meldinger ved kompilingsfeil



1 SRC 62 \*\*\*J==J+1 &2309 (6)

Posisjon på raden

Feilnummer, se dokumentation

Tekst i raden som inneholder feilen

Radnummer (med FOLDS åpne men uten "begrenset visning", &ACCESS eller &COMMENT-raden)




Filtype for feilen: DAT, SRC eller SUB

Numering av feilmelding

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## Programkjøringsmodi



Mode	Beskrivelse
 ISTEP	Incrementel Step (individuell instruksjon) Programmet kjører med en rad om gangen, m.a.o. med STOPP etter hver (til og med tom) rad.
 MSTEP	Motion Step (bevegelsesinstruksjon) Programmet kjører en bevegelsesinstruksjon om gangen, m.a.o. med STOPP før hver bevegelsesinstruksjon.
 GO	Hele programmet kjøres i ett strekk uten STOPP mellom instruksjonene.

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## Eksempel på en betingelses innhold

### Override & Driftsmodi:

```
IF (($OV_PRO==100) AND ($MODE_OP<>#T1) AND ($PRO_MODE1==#GO)) THEN  
WELD_ON=TRUE  
ENDIF
```

Tenningen av sveisen skurs kun på om følgende betingelser er oppfylt:

Programkjøringshastigheten er 100%

Operatørsmodusen får ikke være i T1 (redusert hastighet)

programmet får ikke kjøres stegvis

## Folder (FOLDS)



### Brukssområde:

- Gruppere programseksjoner
- Navngi og gjemme funksjoner

Eksempel:

**Gripper initialization** stengt fold

åpen fold

```
;FOLD Gripper initialization  
$OUT[7]=TRUE  
$OUT[8]=FALSE  
$OUT[9]=FALSE  
$OUT[19]=TRUE  
;ENDFOLD
```

## Fargenøkkel



Editor farger:



Stengt fold



Åpen fold



underfold



Programkode



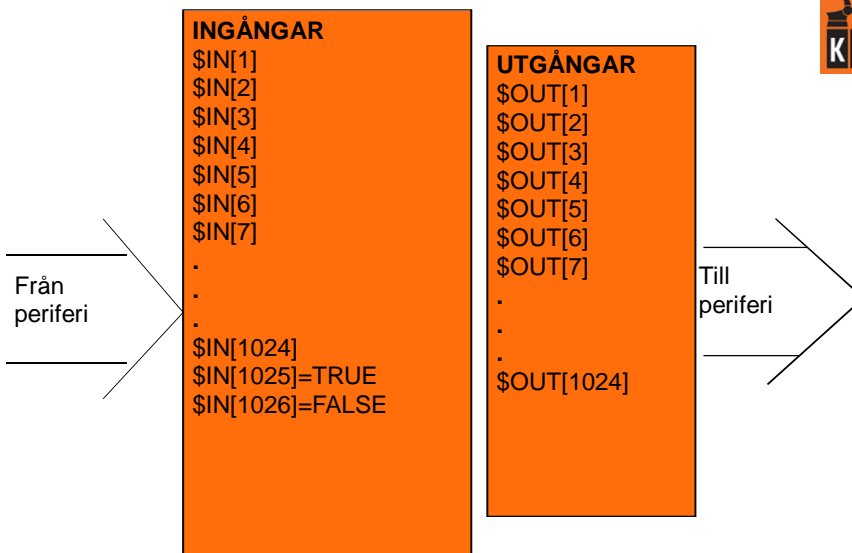
Programkode i folder

Eksempel:

```
;FOLD Gripper initialization  
;FOLD Preset outputs  
$OUT[7]=TRUE  
$OUT[8]=FALSE  
;ENDFOLD  
$OUT[9]=FALSE  
$OUT[19]=TRUE  
;FOLD Switch vacuum on  
$OUT[3]=FALSE  
;ENDFOLD  
;ENDFOLD
```

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## Styrskåp Ingångar / Utgångar



**+24V=TRUE, 0V=FALSE**

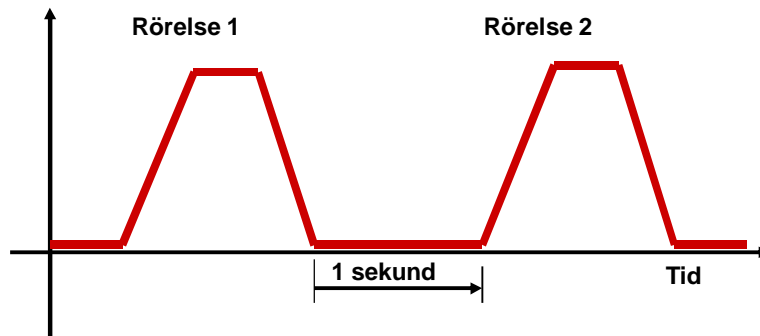
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### Wait instruktionen



```
LIN P1 PDAT1  
WAIT SEC 1.0  
LIN P2 PDAT2
```

Hastighet



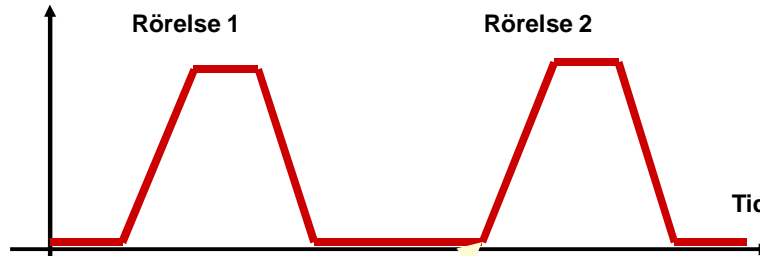
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### Vänta på en ingång (WAIT FOR IN)



```
LIN P1 PDAT1  
WAIT FOR IN 1 :symNameState= TRUE  
LIN P2 PDAT2
```

Hastighet



Ingång 1

TRUE  
FALSE



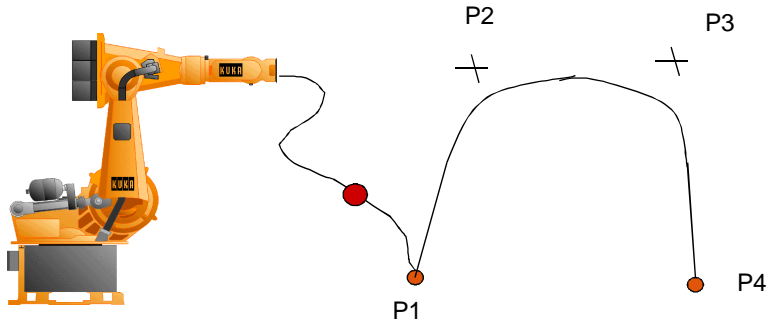
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**Sätta en utgång med aktiv advance (med CONT)**

PTP P1 VEL=100% PDAT1  
LIN P2 CONT VEL=1.0m/s CPDAT1  
LIN P3 CONT VEL=1.0m/s CPDAT1  
**OUT 1 STATE=TRUE CONT**  
LIN P4 VEL=1.0m/s CPDAT1

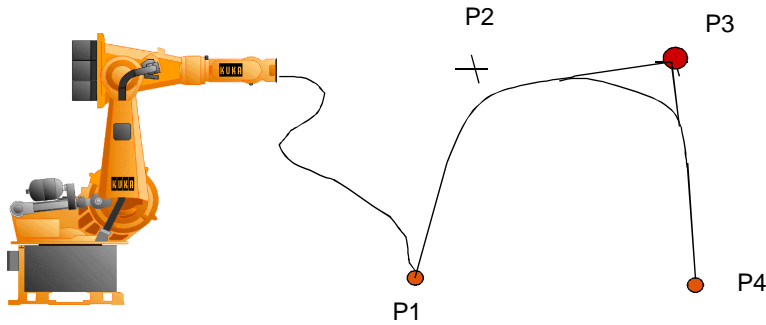


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**Sätta en utgång med stoppad advance (utan CONT)**

PTP P1 VEL=100% PDAT1  
LIN P2 CONT VEL=1.0m/s CPDAT1  
LIN P3 CONT VEL=1.0m/s CPDAT1  
**OUT 1 STATE=TRUE**  
LIN P4 VEL=1.0m/s CPDAT1

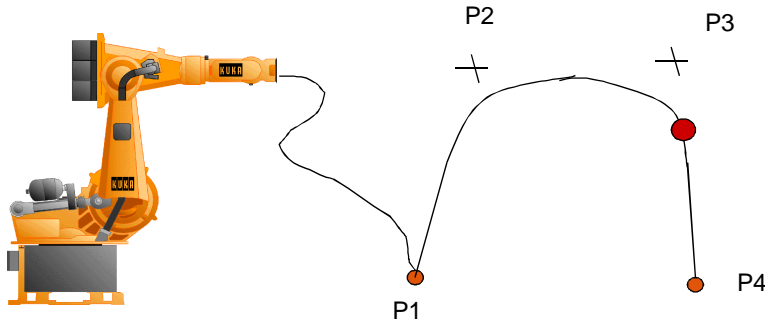


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**Sätta en utgång i en approximerad pos. (SYNOUT)**

PTP P1 VEL=100% PDAT1  
 LIN P2 CONT VEL=1.0m/s CPDAT1  
 LIN P3 CONT VEL=1.0m/s CPDAT1  
**SYNOUT 1 STATE=TRUE at START DELAY= 0ms**  
 LIN P4 VEL=1.0m/s CPDAT1



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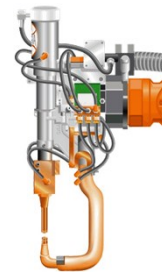
The polling of the inputs and setting of the outputs are used for communication between the robot controller and the periphery (e.g. tools, sensors, etc.)



Robot controller

**Outputs:**  
 \$OUT[1] ... \$OUT[4096]

**Inputs:**  
 \$IN[1] ... \$IN[4096]  
 \$IN[1025]=TRUE  
 \$IN[1026]=FALSE



Periphery

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## Logic commands available



The following logic commands can be selected:

File	Program	Configure	Monitor	Setup	Commands	Technology	Help
------	---------	-----------	---------	-------	----------	------------	------

0 WAIT  
1 WAITFOR  
2 OUT  
3 IBUS-Seg. on/off

0 Last command  
1 Motion  
2 Moveparams  
3 Logic  
4 Analog output  
5 Comment  
6 KRL assistant

Time-dependent wait function

Signal-dependent wait function

Switching functions

Coupling/decoupling an Interbus segment



Time- and signal-dependent wait functions, and simple switching and pulse functions can trigger an advance run stop.

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## Time-dependent wait function (WAIT)



If "WAIT" has been selected, the wait time can be specified. This command always triggers an advance run stop, even with a wait time of 0 seconds.

WAIT Time=1 sec

Wait time in seconds

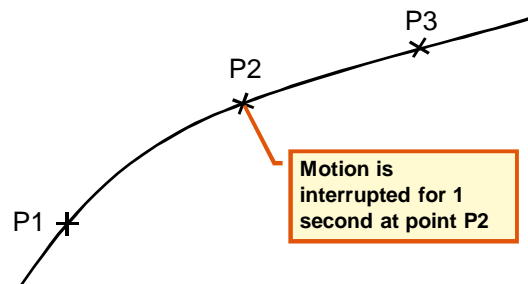
Example:

PTP P1 VEL=100% PDAT1

PTP P2 VEL=100% PDAT2

**WAIT Time=1 sec**

PTP P3 VEL=100% PDAT3

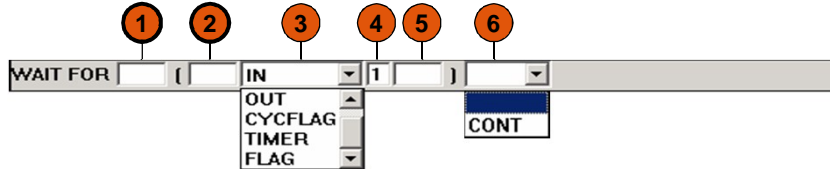


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### Signal-dependent wait function (WAIT FOR)



If "WAIT FOR" has been selected, the following parameters can be specified:



Box	Values	Remarks
1	" "	<ul style="list-style-type: none"> <li>Insertion of an external logic operation (e.g. <b>WAIT FOR (IN1) AND (IN2)</b>)</li> <li>Negation of the Boolean expression</li> </ul>
2	" "	<ul style="list-style-type: none"> <li>Insertion of an internal logic operation (e.g. <b>WAIT FOR (IN1) AND (IN2)</b>)</li> <li>Negation of the Boolean expression</li> </ul>

### Signal-dependent wait function (WAIT FOR)



The wait condition can be programmed, for example, in the following general form:

WAIT FOR (IN1 OR IN2 OR IN3) AND (NOT OUT1 OR OUT2) OR NOT (IN4)

Internal logic operation: the operator is situated inside a bracketed expression.

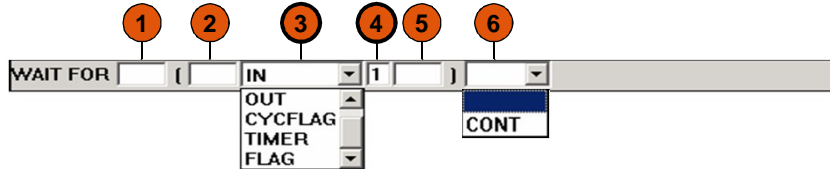
External logic operation: the operator is situated between the bracketed expressions.

Mixed forms are possible: a maximum of 12 operands can be linked in a form.

### Signal-dependent wait function (WAIT FOR)



If "WAIT FOR" has been selected, the following parameters can be specified:



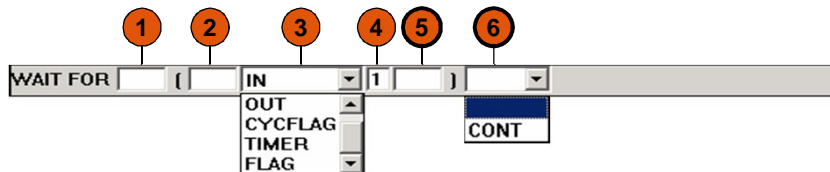
Box	Values	Remarks
3	IN, OUT, TIMER, FLAG, CYCFLAG, user variable	Inputs/outputs, various flags, timers or user-defined names are possible
4	1- 4096	Value of the input/output, flag or timer

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### Signal-dependent wait function (WAIT FOR)



If "WAIT FOR" has been selected, the following parameters can be specified:



Box	Values	Remarks
5	" " Existing long text name	The long text name can be programmed in Expert mode with the system list activated
6	" " "CONT"	<ul style="list-style-type: none"> <li>•Execution <b>with</b> advance run stop</li> <li>•Execution <b>in</b> the advance run</li> </ul>

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Signal-dependent wait function (WAIT FOR)

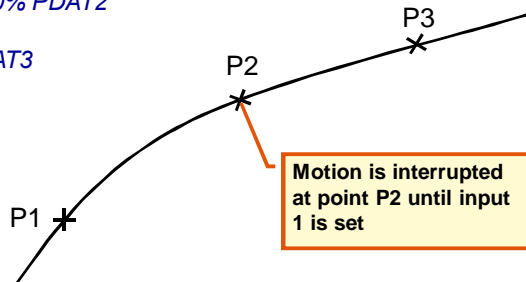


If "WAIT FOR" is selected with advance run stop activated, exact positioning is always carried out, even if the event condition is met.

WAIT FOR [ ] ( [ ] IN [ ] 1 [ ] ) [ ]

Advance run stop on

Example:  
 PTP P1 VEL=100% PDAT1  
 PTP P2 CONT VEL=100% PDAT2  
 WAIT FOR IN 1  
 PTP P3 VEL=100% PDAT3



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Signal-dependent wait function (WAIT FOR)



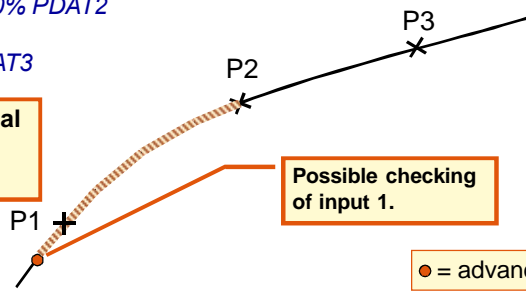
If "WAIT FOR" is selected with "CONT", the event is checked in the advance run. If the event condition is met, then approximate positioning is carried out.

WAIT FOR [ ] ( [ ] IN [ ] 1 [ ] ) CONT [ ]

Execution in the advance run

Example:  
 PTP P1 VEL=100% PDAT1  
 PTP P2 CONT VEL=100% PDAT2  
 WAIT FOR IN 1 CONT  
 PTP P3 VEL=100% PDAT3

Subsequent signal changes are not detected.



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## Switching functions



The following switching functions can be selected:

File Program Configure Monitor Setup **Commands** Technology Help

- 0 Last command
- 1 Motion
- 2 Moveparams
- 3 **Logic**
- 4 Analog output
- 5 Comment
- 6 KRL assistant

- 0 WAIT
- 1 WAITFOR
- 2 **OUT**
- 3 IBUS-Seg. on/off

- 0 OUT
- 1 PULSE
- 2 SYN OUT
- 3 SYN PULSE

Simple switching function

Simple pulse function

Path-dependent switching function

Path-dependent pulse function

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## Simple switching function (OUT)



If "OUT" has been selected, the following parameters can be specified:

Box	Values	Remarks
1	1- 4096	Output number
2	Existing long text name	The long text name can be programmed in Expert mode with the system list activated
3	TRUE FALSE	State to which the output is switched
4	"CONT"	<ul style="list-style-type: none"> <li>•Execution <b>with</b> advance run stop</li> <li>•Execution <b>in</b> the advance run</li> </ul>

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Simple switching function (OUT)

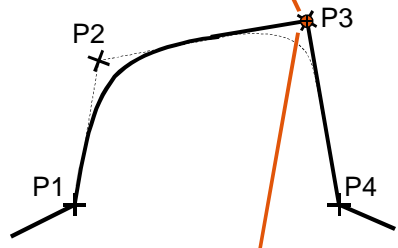


OUT 1  State= TRUE

Example:

LIN P1 VEL=0.2 m/s PDAT1  
 LIN P2 CONT VEL=0.2 m/s PDAT2  
 LIN P3 CONT VEL=0.2 m/s PDAT3  
**OUT 1 ' ' State= TRUE**  
 LIN P4 VEL=0.2 m/s PDAT4

Point 3 is **not** approximated (because of advance run stop).



Output 1 is set at point 3.

Simple switching function (OUT)

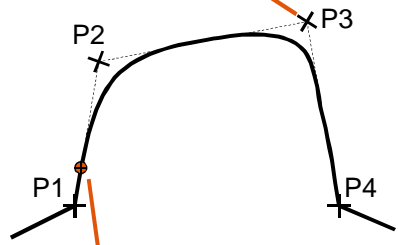


OUT 1  State= TRUE  CONT

Example:

LIN P1 VEL=0.2 m/s PDAT1  
 LIN P2 CONT VEL=0.2 m/s PDAT2  
 LIN P3 CONT VEL=0.2 m/s PDAT3  
**OUT 1 ' ' State= TRUE CONT**  
 LIN P4 VEL=0.2 m/s PDAT4

Point 3 is approximated



Possible position at which output 1 is set by the advance run.



### Simple pulse function (PULSE)



If "PULSE" has been selected, the following parameters can be specified:

PULSE 1
State=
TRUE
Time=
0.1 sec

Box	Values	Remarks
1	1- 4096	Output number
2	" " Existing long text name	The long text name can be programmed in Expert mode with the system list activated
3	TRUE FALSE	State to which the output is switched
4	" " "CONT"	•Execution <b>with</b> advance run stop •Execution <b>in</b> the advance run
5	0.1 ... 3	Length of the pulse in seconds

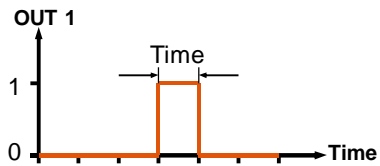
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### Simple pulse function (PULSE)



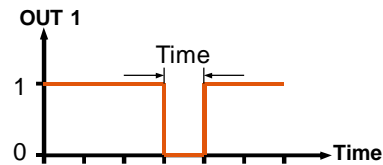
"HIGH" level switching: **STATE=TRUE**

PULSE 1
State=
TRUE
Time=
0.1 sec



"LOW" level switching: **STATE=FALSE**

PULSE 1
State=
FALSE
Time=
0.1 sec



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### Time-distance function "SYN OUT"



SYN OUT | 1 | State= TRUE | at START | Delay= 0 ms

START  
END  
PATH

Path-dependent switching (with PTP, LIN, CIRC) can be triggered relative to a start or end point.

Such applications include, e.g.:

- Closing or opening the weld gun during spot welding
- Switching the welding current on/off during arc welding
- Starting or stopping the flow of adhesive in bonding or sealing applications.

### Switching action at the start or end point of the path



If "SYN OUT" has been selected, the following parameters can be specified: here end point with **START** or **END**

1 2 3 4 5

SYN OUT | 1 | State= TRUE | at START | Delay= 0 ms

Box	Values	Remarks
1	1- 4096	Output number
2	" " Existing long text name	The long text name can be programmed in Expert mode with the system list activated
3	TRUE FALSE	State to which the output is switched
4	"START" "END"	End point at which the switching function is executed
5	-1000 ... +1000	Delay of the switching action (in ms)

Switching action at the start or end point of the path

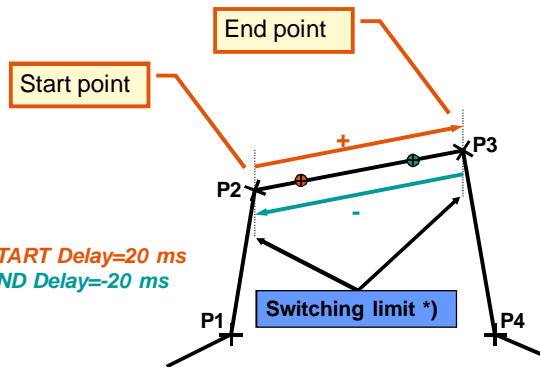


Start point and end point are exact positioning points:

SYN OUT 1 | State= TRUE | at START | Delay= 0 ms

Example:

LIN P1 VEL=0.3 m/s CPDAT1  
 LIN P2 VEL=0.3 m/s CPDAT2  
 SYN OUT 1 ' ' State= TRUE at START Delay=20 ms  
 SYN OUT 2 ' ' State= TRUE at END Delay=-20 ms  
 LIN P3 VEL=0.3 m/s CPDAT3  
 LIN P4 VEL=0.3 m/s CPDAT4



\*) Switching limit: If the specified values are outside the switching limits, the controller automatically switches at the switching limit.

Switching action at the start or end point of the path

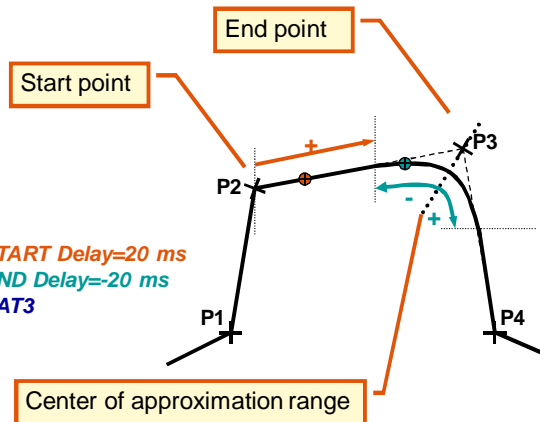


Start point is exact positioning point, end point is approximated:

SYN OUT 1 | State= TRUE | at START | Delay= 0 ms

Example:

LIN P1 VEL=0.3 m/s CPDAT1  
 LIN P2 VEL=0.3 m/s CPDAT2  
 SYN OUT 1 ' ' State= TRUE at START Delay=20 ms  
 SYN OUT 2 ' ' State= TRUE at END Delay=-20 ms  
 LIN P3 CONT VEL=0.3 m/s CPDAT3  
 LIN P4 VEL=0.3 m/s CPDAT4



### Switching action at the start or end point of the path

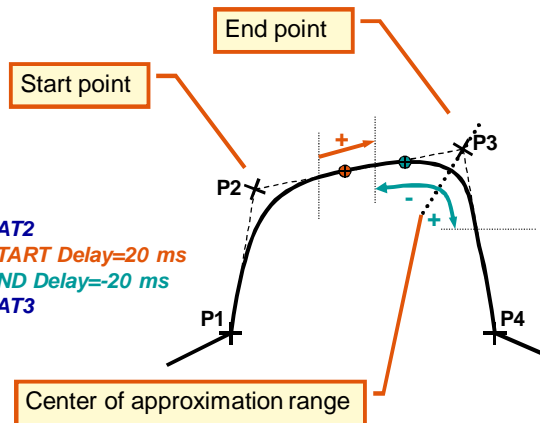


Start point and end point are approximated:

```
SYN OUT 1 State= TRUE at START Delay= 0 ms
```

#### Example:

```
LIN P1 VEL=0.3 m/s CPDAT1  
LIN P2 CONT VEL=0.3 m/s CPDAT2  
SYN OUT 1 ' ' State= TRUE at START Delay=20 ms  
SYN OUT 2 ' ' State= TRUE at END Delay=-20 ms  
LIN P3 CONT VEL=0.3 m/s CPDAT3  
LIN P4 VEL=0.3 m/s CPDAT4
```



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### Switching action at any point on the path



- If you are using the path-related SYNOUT-PATH statement, you can trigger the switching action at any position along the path by specifying a distance.
- As with switching actions at the start or end points, this again can additionally be delayed or brought forward.
- The path-related switching action is only allowed with continuous-path motions (LIN or CIRC).
- The SYNOUT-PATH statement refers here to the next programmed motion block.



If a SYNOUT-PATH statement with path specification is programmed for a PTP motion, this will be refused by the interpreter when the motion is executed.

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### Switching action at the start or end point of the path



If "SYN OUT" has been selected, the following parameters can be specified: here end point with **PATH**

1 2 3 4 5 6  
 SYN OUT | 1 | State= TRUE ▾ | PATH ▾ | = 0 mm Delay= 0 ms

Box	Values	Remarks
1	1- 4096	Output number
2	" " Existing long text name	The long text name can be programmed in Expert mode with the system list activated
3	TRUE FALSE	State to which the output is switched
4	"PATH"	End point at which the switching function is executed
5	-2000 ... +2000	Distance of the switching action from the end point (in mm)
6	-1000 ... +1000	Delay of the switching action (in ms)

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### Switching action at any point on the path



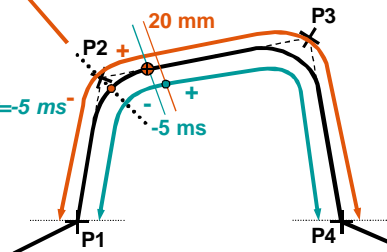
Start point is exact positioning point, end point is approximated:

SYN OUT | 1 | State= TRUE ▾ | PATH ▾ | = 20 mm Delay= -5 ms

End point

#### Example:

LIN P1 VEL=0.3 m/s CPDAT1  
 SYN OUT 1 ' ' State= TRUE PATH=20 mm Delay=-5 ms  
 LIN P2 CONT VEL=0.3 m/s CPDAT2  
 LIN P3 CONT VEL=0.3 m/s CPDAT3  
 LIN P4 VEL=0.3 m/s CPDAT4



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Switching action at any point on the path



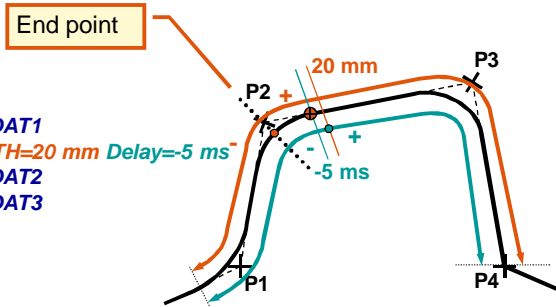
Start point and end point are approximated:

SYN OUT1 State= TRUE PATH = 20 mm Delay= -5 ms

Example:

```

LIN P1 CONT VEL=0.3 m/s CPDAT1
SYN OUT 1 ' State= TRUE PATH=20 mm Delay=-5 ms'
LIN P2 CONT VEL=0.3 m/s CPDAT2
LIN P3 CONT VEL=0.3 m/s CPDAT3
LIN P4 VEL=0.3 m/s CPDAT4
    
```

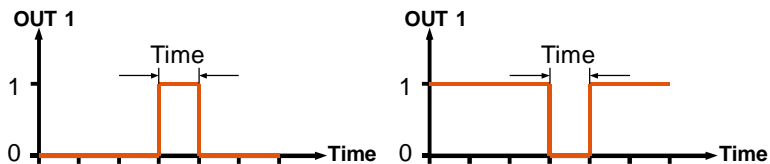


Switching action at any point on the path



If "SYN PULSE" has been selected, the following parameters can be specified:

SYN PULSE1 End State= TRUE Time= 0.1 sec PATH = 0 mm Delay= 0 ms



## Subprograms

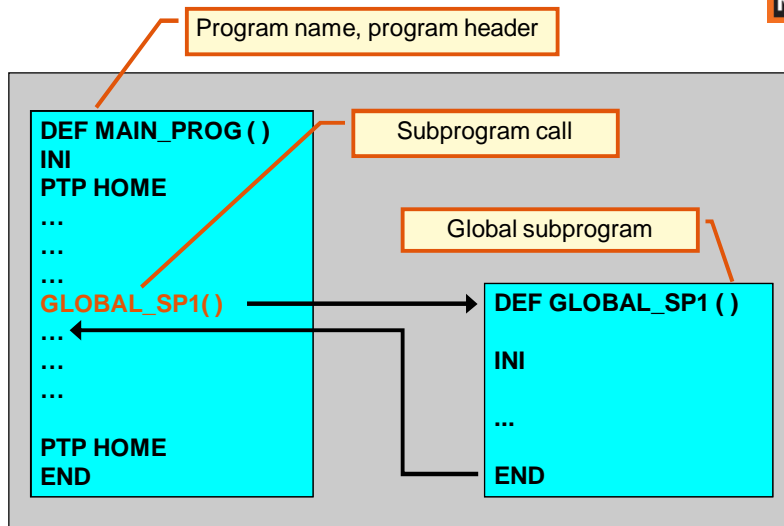


Subprograms are used for identical program sections that are repeated frequently.

- Subprograms **reduce the amount of typing** during programming.
- Subprograms **reduce the program length** thus making the program more transparent.
- Subprograms **can be reused** in other programs.
- Subprograms can be used for **structuring a program**.

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## Global subprograms



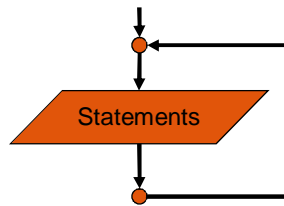
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## Endless loop (LOOP)



### Description

Cyclic executions can be programmed using LOOP. The statement block in the LOOP is continually repeated. If you want to end the repeated execution of the statement block, you must call the EXIT statement.



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## Endless loop



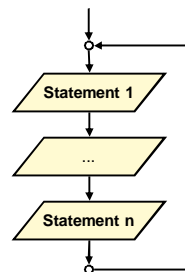
**Syntax:**

```
LOOP
  Statement 1
  ...
  Statement n
ENDLOOP
```

```
...
PTP HOME

LOOP
  LIN P1
  LIN P2
  LIN P4
ENDLOOP

PTP HOME
...
```



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## Conditional branch (IF..THEN..ELSE)



### Description

Depending on a condition, either the first statement block (THEN block) or the second statement block (ELSE block) is executed.

- There is no limit on the number of statements contained in the statement blocks.
- Several IF statements can be nested in each other.
- The keyword ELSE and the second statement block may be omitted.
- There must be an ENDIF for each IF.

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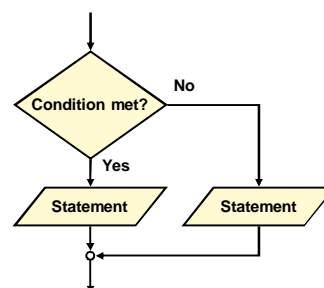
## Conditional branch



### Syntax:

```
IF Execution_Condition THEN  
    Statement  
ELSE  
    Statement  
ENDIF
```

```
...  
IF $IN[22]==TRUE THEN  
    PTP HOME  
ELSE  
    $OUT[17]=TRUE  
    $OUT[18]=FALSE  
    PTP HOME  
ENDIF  
...
```



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## Unconditional exit from loops (EXIT)



### Description

The EXIT statement appears in the statement block of a loop. It may be used in any loop.

The EXIT statement can be used to exit the current loop. The program is then continued after the ENDLOOP statement.



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## Unconditional exit from loops



### Syntax: EXIT

```
DEF EXIT_PRO ( )
  PTP HOME
  LOOP          ;Start of endless loop
  LIN P1
  IF $IN[1] == TRUE THEN
    EXIT        ;Terminate when input 1 set
  ENDIF
  LIN P2
  ENDLOOP      ;End of endless loop
  PTP HOME
END
```

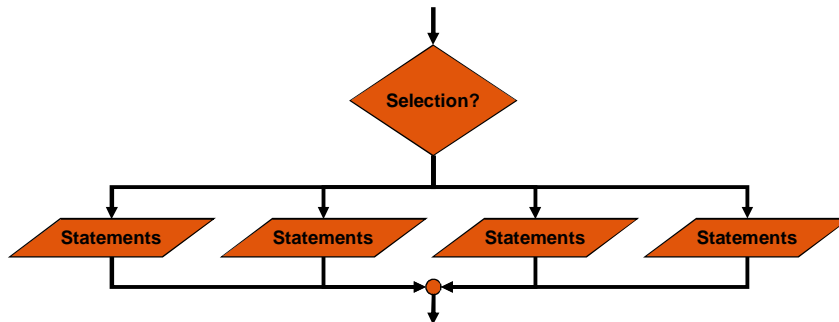
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## Switch



### Description

The SWITCH statement is a selection instruction for various program branches. Only one program branch is executed and the program then jumps immediately to the ENDSWITCH statement.



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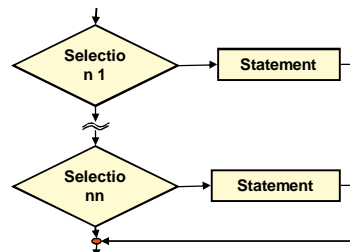
## Switch



### Syntax:

```
SWITCH Variable  
CASE 1  
    Statement  
CASE 2  
    Statement  
DEFAULT  
ENDSWITCH
```

```
SWITCH PROG_NR  
CASE 1  
    Part1 ( ) ; if Prog_No = 1  
CASE 2  
    Part2 ( ) ; if Prog_No = 2  
DEFAULT  
    ERROR_SP ( ) ; all other values  
ENDSWITCH
```



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## Data manipulation



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## Arithmetic operators



Basic arithmetic operations for the data types INTEGER and REAL:

Operator	Description
+	Addition or positive sign
-	Subtraction or negative sign
*	Multiplication
/	Division

Result of an arithmetic operation:

Operands	INT	REAL
INT	INT	REAL
REAL	REAL	REAL

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## Program example



```

DEF ARITH()
;----- Declaration section -----
INT A,B,C
REAL K,L,M
;----- Initialization section ----- ;All variables are invalid prior to initialization!
A = 2 ;A=2
B = 9.8 ;B=10
C = 7/4 ;C=1
K = 3.5 ;K=3.5
L = 0.1 E01 ;L=1.0
M = 3 ;M=3.0
;----- Main section-----
A = A * C ;A=2
B = B - 'HB' ;B=-1
C = C + K ;C=5
K = K * 10 ;K=35.0
L = 10 / 4 ;L=2.0
L = 10 / 4.0 ;L=2.5
L = 10 / 4. ;L=2.5
L = 10./ 4 ;L=2.5
C = 10./ 4. ;C=3
M = (10/3) * M ;M=9.0
END
    
```

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## Relational operators



Using relational operators, it is possible to form logic expressions. The result of a comparison is always of data type BOOL.

Operator	Description	Permissible data types
==	equal to	INT, REAL, CHAR, ENUM, BOOL
<>	not equal to	INT, REAL, CHAR, ENUM, BOOL
>	greater than	INT, REAL, CHAR, ENUM
<	less than	INT, REAL, CHAR, ENUM
>=	greater than/equal to	INT, REAL, CHAR, ENUM
<=	less than/equal to	INT, REAL, CHAR, ENUM

Example: BOOLA,B

```

...
B = 10 < 3 ;B=FALSE
A = 10/3 == 3 ;A=TRUE
B = ((B == A) <> (10.00001 >= 10)) == TRUE ;B=TRUE
    
```

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## Logic operators



Logic operators are used for logic operations with Boolean variables, constants and simple logic expressions.

Operator	Operand number	Description
NOT	1	Inversion
AND	2	Logic AND
OR	2	Logic OR
EXOR	2	Exclusive OR

Example: ...

BOOLA,B,C

...

A = TRUE

;A=TRUE

B = NOT A

;B=FALSE

C = (A AND B) OR NOT (B EXOR NOT A);C=TRUE

A = NOT NOT C

;A=TRUE


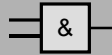
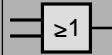
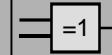
...

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## Truth table



Truth table for logic operations:

Operation		NOT A 	A AND B 	A OR B 	A EXOR B 
A=TRUE	B=TRUE	FALSE	TRUE	TRUE	FALSE
A=TRUE	B=FALSE	FALSE	FALSE	TRUE	TRUE
A=FALSE	B=TRUE	TRUE	FALSE	TRUE	TRUE
A=FALSE	B=FALSE	TRUE	FALSE	FALSE	FALSE

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## Bit operators



Bit operators are used to perform logic operations on the individual bits of whole numbers.

Operator	Operand number	Description
B_NOT	1	Bit-by-bit inversion
B_AND	2	Bit-by-bit AND operation
B_OR	2	Bit-by-bit OR operation
B_EXOR	2	Bit-by-bit exclusive OR operation



As ASCII characters can also be addressed via the integer ASCII code, the data type of the operands may also be CHAR besides INT. The result is always of type INT.

## Bit operators



Values	$2^3$	$2^2$	$2^1$	$2^0$	
	8	4	2	1	

Example:

1st number	0	1	0	1	=5
2nd number	1	1	0	0	=12

B_AND	0	1	0	0	=4
-------	---	---	---	---	----

B_OR	1	1	0	1	=13
------	---	---	---	---	-----

B_EXOR	1	0	0	1	=9
--------	---	---	---	---	----



Bit-by-bit inversion does not simply involve all the bits being inverted. Instead, 1 is added to the operand and the sign is changed, e.g.:  
**B\_NOT 10 = -11** or **B\_NOT -10 = 9**

## Priority of operators



Operators will be executed in order of priority.

Priority	Operator
1	NOT B_NOT
2	* /
3	+ -
4	AND B_AND
5	EXOR B_EXOR
6	OR B_OR
7	== <> < > >= <=

Example:

INT A,B  
 BOOL E,F  
 A = 4  
 B = 7  
 E = TRUE  
 F = FALSE  
 E = NOT E OR F AND NOT (-3 + A \* 2 > B) ;E=FALSE

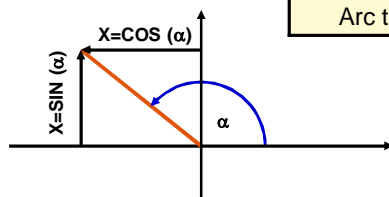
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## Standard functions



Standard functions for calculating mathematical problems:

Description	Function
Absolute value	ABS (X)
Square root	SQRT (X)
Sine	SIN (X)
Cosine	COS (X)
Tangent	TAN (X)
Arc cosine	ACOS (X)
Arc tangent	ATAN2 (Y, X)



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