SOFTWARE

KR C2 / KR C3

Start–up

KUKA System Software (KSS)

Release 5.2

Issued: 26 Sep 2003 Version: 00

PD Interleaf

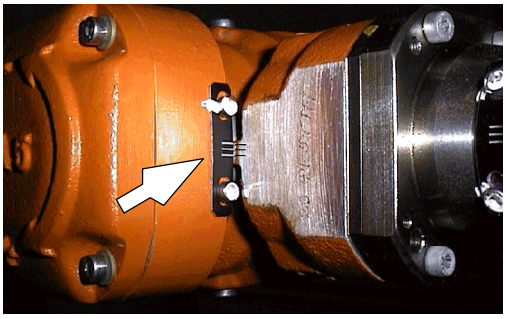
Contents

1 Robot mastering/unmastering

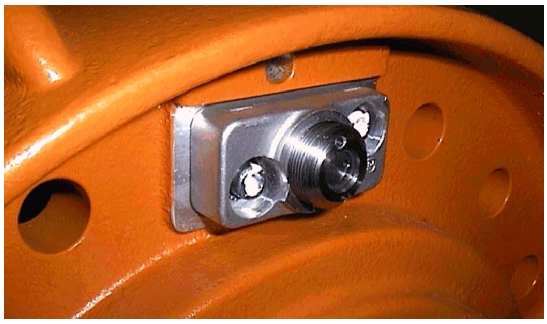
1.1 General

When mastering the robot, the axes are moved into a defined mechanical position, the so–called mechanical zero position. This mechanical zero position represents an assignment to the axis drive angle and is defined by a reference notch or mark.
Once the robot is in this mechanical zero position, the increment counter for each axis is set to the value corresponding to the axis angle (generally 0 increments for 0 degrees). In order to move the robot exactly to the mechanical zero position, a dial gauge or electronic measuring tool (EMT) is used.

The robot must always be mastered under the same temperature conditions and with the same load in order to avoid inaccuracies arising through thermal expansion. This means that mastering must be carried out with the robot always cold or always at operating temperature.

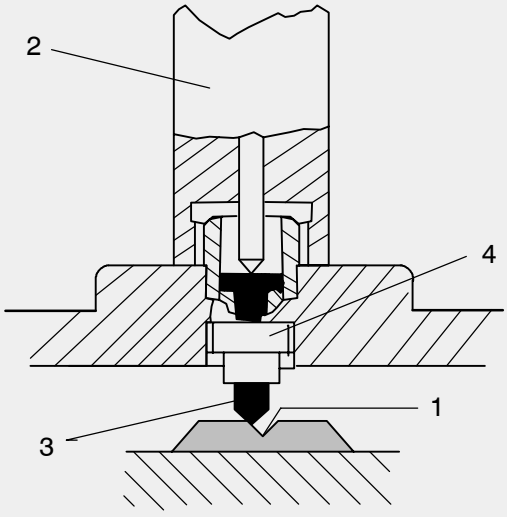


Vernier on axis 5



Gauge cartridge on axis 2

Depending on the size of the robot, the axes feature either a vernier or a gauge cartridge for receiving a dial gauge or an electronic measuring tool (EMT).



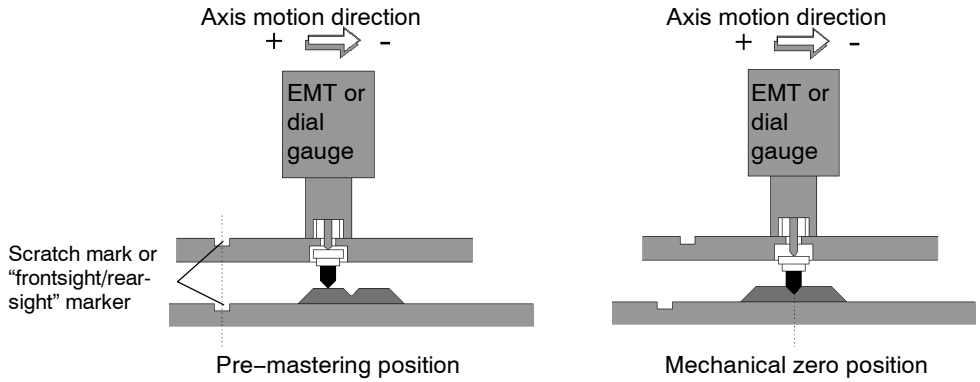
1 Reference notch
2 Electronic measuring tool or dial gauge
3 Gauge pin
4 Gauge cartridge

Cross–section of a gauge cartridge

To locate the mechanical zero position of a robot axis precisely, it must first be aligned to its pre–mastering position. The protective cap of the gauge cartridge is then removed and a dial gauge or an EMT is fitted to it. The EMT is connected via a cable to connection “X32” on the robot junction box.

When, on moving over the reference notch, the gauge pin reaches its lowest point, the mechanical zero position is reached. The electronic measuring tool sends an electronic signal to the controller. The corresponding axis is mastered.
If using a dial gauge, the zero position can be recognized by the abrupt reversal of the pointer.

The pre–mastering position makes it easier to move to the mechanical zero position. The pre–mastering position is indicated externally by a scribed line or “frontsight/rearsight” markers and is located just before the zero position. The robot must be brought into this position before the actual mastering procedure.



An axis may only be moved to its mechanical zero position from “+” to “–”. If the axis has to be moved from “–” to “+”, it must first be moved past the pre–mastering position mark in order to move it subsequently back to the mark in the right direction. This is of **vital importance**, in order to eliminate the effect of gear backlash.

The robot may have to be remastered for a number of different reasons:

The robot has to be mastered...	Mastering is canceled...
... after repairs (e.g. replacement of a drive motor or RDC)	... automatically on booting the system[1)]
... when the robot has been moved without the controller (e.g. with hand crank)	... automatically on booting the system[1)]
... after an impact with a mechanical end stop at more than jog velocity (20 cm/s)	... manually by the operator
... after a collision between the tool or robot and the workpiece	... manually by the operator
[1)] If discrepancies are detected between the resolver data saved when shutting down the controller and the current position, all mastering data are deleted for safety reasons.	

The robot can be unmastered...	Mastering is canceled...
... if the mastering values saved for the individual axes are to be specifically deleted	... manually by the operator

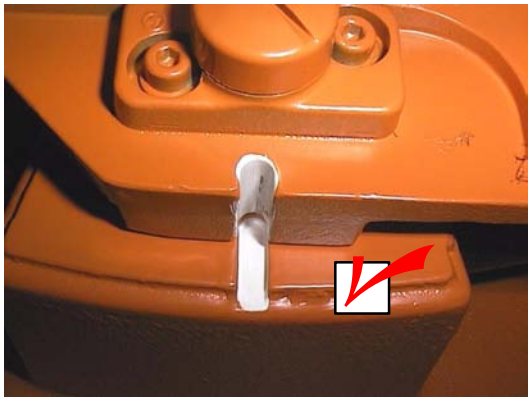
You can only master the axes if there is no EMERGENCY STOP situation and the drives are switched on. The EMERGENCY STOP circuits of the periphery must be wired up, if applicable.

When mastering the wrist axes, consideration needs to be given to the position of any external energy supply system as axes 4 and 6 are defined as infinitely rotating before the mastering process is carried out.

1.2 Mastering with the dial gauge

Bring **all** axes to the pre–mastering position.

The pre–mastering position depends on the robot type.

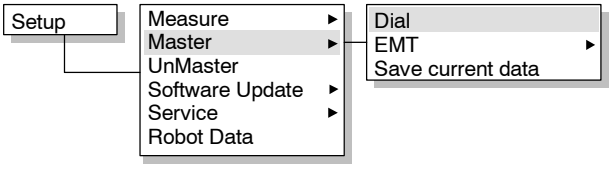



Pre–mastering position of axis 3

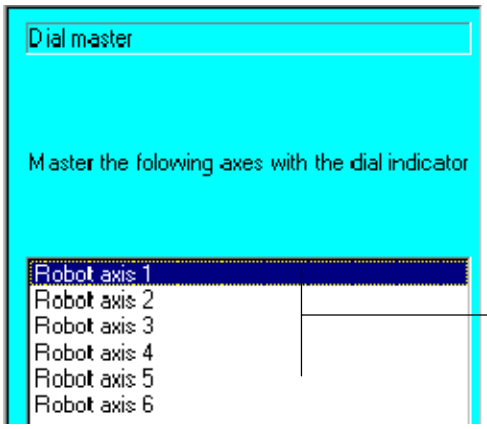
An axis may only be moved to its mechanical zero position from "+" to "–". If the axis has to be moved from "–" to "+", it must first be moved past the pre–mastering position mark in order to move it subsequently back to the mark in the right direction. This is of **vital importance**, in order to eliminate the effect of gear backlash.

Remove the protective cap of the gauge cartridge and fit the dial gauge.


This function is only available in the operating mode Test (T1/T2). If, when selecting this function, a different operating mode is set, a corresponding error message is generated.



A status window opens, in which the axes to be mastered are displayed.



The axes are displayed in the order in which they are to be mastered. The axis that is to be mastered next is indicated by a color background.

Axes that are already mastered are no longer listed and, if remastering is desired, must first be unmastered.

If axis 1 has been mastered, it may be moved for the purposes of mastering the remaining axes. Axes 2...6, on the other hand, may not be moved until all axes have been mastered.

The mastering operation will be aborted if you try to master an axis with a higher number than this one first. Mastering must always be carried out on the axis with the lowest number.

Before carrying out mastering, please use jog override to reduce the jog velocity to 1%. Move the robot axis that is to be mastered across the pre–mastering position marker, in the negative axis direction, while watching the pointer of the dial gauge. At the lowest position of the reference notch, recognizable by the abrupt change in direction of the pointer, set the dial gauge to 0.

Then move the axis back to the pre–mastering position. Move the axis that is to be mastered in the negative axis direction again. Stop when the pointer of the dial gauge is about 5–10 scale divisions before the zero position. In order to increase the accuracy of mastering, move the robot forward more carefully now, in predefined increments (incremental jogging).

In this way, move the axis in the negative axis direction until the zero position of the dial gauge is reached.

If you overshoot this point, you must go back and move to the reference notch from the pre–mastering position again.

Master

The current axis position, highlighted by the colored selection bar, is saved as the mechanical zero position for the axis by pressing the softkey “Master”. The axis that has been mastered is removed from the window.

Before mastering the next axis or ending the complete mastering procedure, switch back to the normal jog mode.

Remember to screw the protective cap back onto the gauge cartridge once an axis has been mastered. Do not allow foreign bodies to get inside as they would damage this sensitive measuring device and necessitate expensive repairs.

1.3 Mastering with the EMT

A number of different functions are available for mastering with the EMT. These are grouped together under two main points: “Standard” and “With load correction”. The difference here is that using the option “With load correction” it is possible to master the robot as if the tool had been removed, but actually leave the tool mounted on the robot. This is done by correcting the weight of the tool “arithmetically”. “Standard” mastering is used if the robot is always mastered with the same tool or always mastered with no tool.

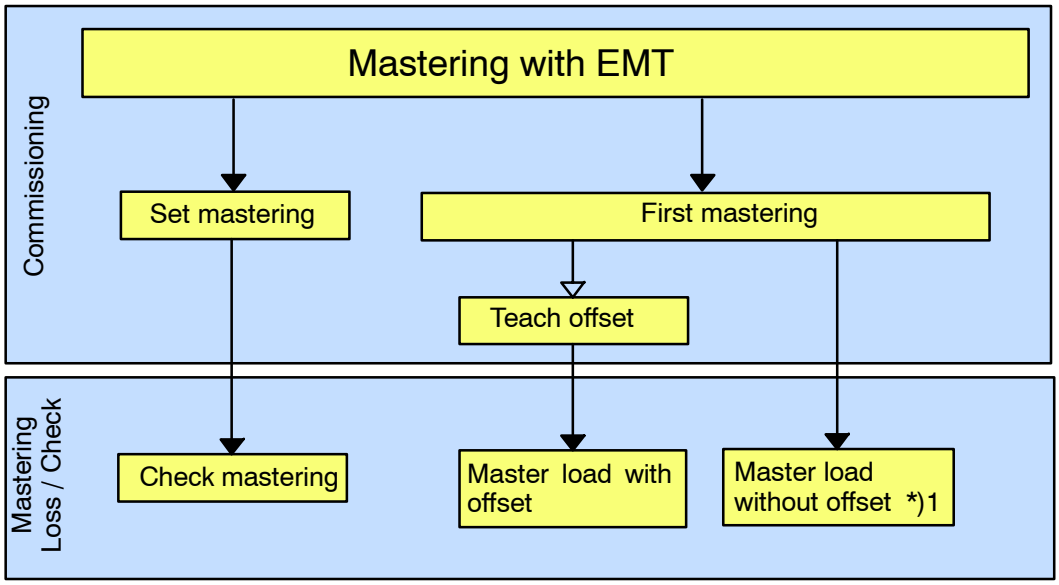
1.3.1 Brief description of the functions

Standard:

- Set mastering
  The robot is mastered in the mechanical zero position with or without a payload.
- Check mastering
  Here it is possible to check the mastering, i.e. if you are not sure whether or not the currently valid mastering is correct, the difference from the “Set mastering” values can be calculated. Bear in mind that the robot must be fitted with the same load as when “Set mastering” was carried out.

With load correction:

- First mastering
  The robot is mastered in the mechanical zero position without a payload. The absolute value of the incremental encoder is saved for each axis. First mastering serves as the basis for the other functions listed below.
- Teach offset
  Using this function, the robot is mastered with a load (tool). The encoder value for the offset from the first mastering is determined for this load and saved.
- Master load with offset
  This function is used to check the mastering of a tool mounted on the robot, for which an “offset” has been learnt. The saved “offset” is used to recalculate the mastering value “without load” and calculate and display the difference between this value and the current mastering (up to this point no values have yet been saved).
  Following this check function, the operator is asked whether the existing mastering state is to be retained or whether the newly calculated mastering values are valid and should be saved. This menu item thus allows the first mastering to be restored even after a collision or following the replacement of a motor.
- Master load without offset
  The robot can be mastered with any load (including a tool whose weight has not been learnt). i.e. no allowance is made for an offset. Instead, only the absolute encoder value determined in first mastering is used to recalculate the first mastering. A precondition for this function is that nothing has been mechanically displaced (e.g. collision, replacement of motor, parts, etc.) since the first mastering.



*)1 Only possible if the first mastery is still valid (i.e. no change to the drive train e.g. replacement of a motor or parts, or following a collision, etc.)

For reasons of accuracy, the wrist axes should remain, if possible, in their mechanical zero position during the EMT mastering function.

1.3.2 Application examples

Example 1 Mastering without consideration of the load

You have carried out “Set mastering” and then taught a program on which you have been working for some time. Now you are not sure if this mastering is correct. You can now check this using the “Check mastering” function. A precondition for this is that the robot is fitted with the same load as when “Set mastering” was carried out. Once the check has been carried out, the difference from the currently valid mastering is displayed and you have the option of overwriting the old mastering with the one just carried out or retaining the existing mastering values as valid. If you decide to opt for the new mastering, you must be aware that, in the event of a significant mastering difference, the program you have taught is no longer correct.

Example 2 Mastering with consideration of the load

Despite having a load mounted on the robot flange, you wish to master the robot, as if no load were present. In this way you can always precisely master a robot which works, for example, with different loads (gripper, tool changer, etc.), irrespective of the current load and without having to remove the load. There are two ways of doing this:

1. Taking the tool load into account by learning the weight difference:

In this case, the mastering difference caused by a load is explicitly measured and saved in advance for the load in question. Using this value, the computer can take this difference into consideration in the event of subsequent mastering with a load. When using this method, the following must be carried out:

First mastering must be carried out once without a load. The weight of each tool must then be learnt using the function “Teach offset”. Provided that this has been done, you can subsequently carry out “Master load – With offset” to restore the old first mastering.

2. Taking the tool load into account by saving the encoder value:

When mastering without a load (first mastering), the path calibration system value (absolute encoder value) is read and saved for each axis. In the event of subsequent mastery with a load, the difference is determined and corrected by comparing the current encoder value with the saved value. The precondition for this method is that the robot has not undergone any mechanical changes since the first mastering. When using this method, the following must be carried out:

First mastering must be carried out once without a load. Provided that this has been done, you can subsequently carry out “Master load – Without offset” to restore the old first mastering.

1.3.3 Preparation for EMT mastering

When mastering with the EMT, the axis that is to be mastered is moved at a preset velocity from “+” to “–” under program control. When the EMT detects the bottom of the reference notch, the controller automatically stops the robot motion and saves this point.

If during the mastering operation a specified distance is overshot, the program is aborted and an error message is displayed. The most common reason for this happening is that the axis was positioned to the pre–mastering position with inadequate accuracy.

Bring all the axes to be mastered to the pre–mastering position.

Pre–mastering position of axis 3

When mastering with the EMT, an axis is always moved to the mechanical zero position from “+” to “–”. If the axis has to be moved from “–” to “+”, it must first be moved past the pre–mastering position mark in order to be able to move it subsequently back to the mark in the right direction. This is done in order to eliminate the effect of gear backlash.

Remove the protective cap of the gauge cartridge and fit the measuring tool.

Connect the EMT to connection X32 on the robot junction box using the cable supplied with the EMT set.

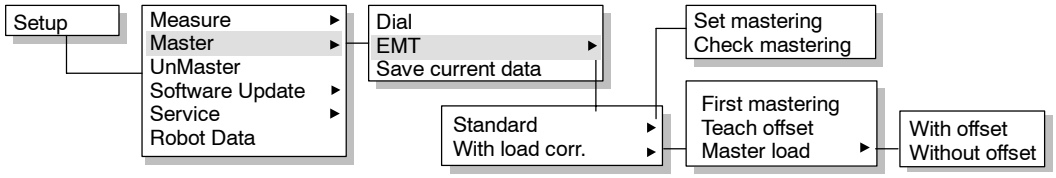
Junction box on the rotating column of the robot

Connection X32

The connecting cable for the EMT is connected here.

If you wish to remove the connecting cable from the EMT or X32, the connector on the cable must be released. Otherwise the cable could be torn out or the EMT damaged.

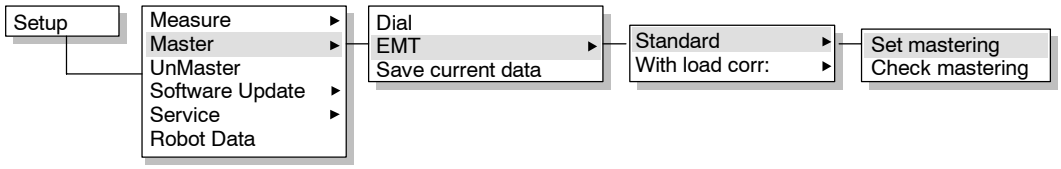
The menu structure for mastering with the EMT is organized as follows:



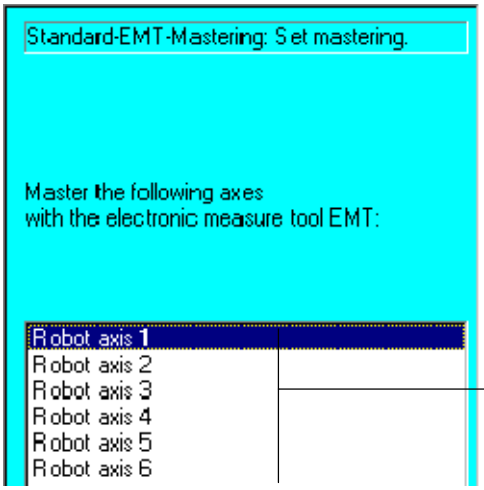
1.3.4 Standard

In the “Standard” menu, mastering **with/without a load** can be set and checked. This mastering function is recommended if the robot is always mastered with the same tool (load) or always mastered with no tool (load).

1.3.4.1 Set mastering



This function is only available in the operating mode Test (T1). If, when selecting this function, a different operating mode is set, a corresponding error message is generated.



A status window opens, in which the axes to be mastered are displayed.

The axes are displayed in the order in which they are to be mastered. The axis that is to be mastered next is indicated by a color background. If all axes have been mastered, the text “No axes to master” appears in the window.

The mastering operation will be aborted if you try to master an axis with a higher number than this one first. Mastering must always be carried out on the axis with the lowest number.

Axes that are already mastered are no longer listed and, if remastering is desired, must first be unmastered. Furthermore, it is also possible to initiate a new mastering procedure via the menu item “Check mastering”.

Master

The highlighted axis is selected for mastering by pressing the softkey “Master”. The text “Start key required” appears in the message window.

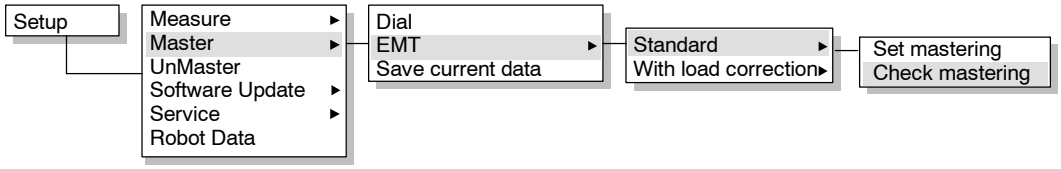
Press the enabling switch on the back of the KCP, then the “Program start forwards” key, and keep both held down. The robot axis previously selected is now moved from “+” to “–” under program control. When the EMT detects the bottom of the reference notch, the calibration program is stopped. The determined values are saved and the mastered axis removed from the window.

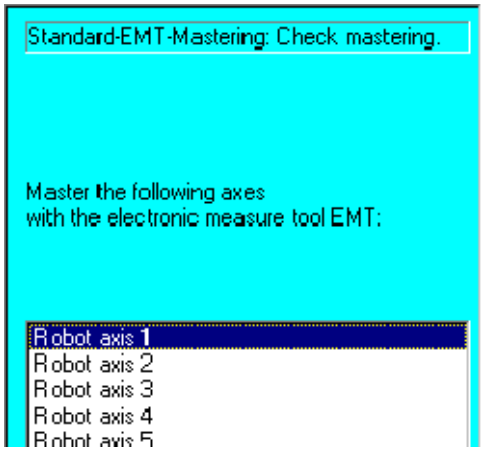
Remember to screw the protective cap back onto the gauge cartridge once an axis has been mastered. Do not allow foreign bodies to get inside as they would damage this sensitive measuring device and necessitate expensive repairs.

1.3.4.2 Check mastering

This function allows the old robot mastering values to be checked. The robot is mastered in the same way as for “Set mastering”.

This function is only available in the operating mode Test (T1). If, when selecting this function, a different operating mode is set, a corresponding error message is generated.





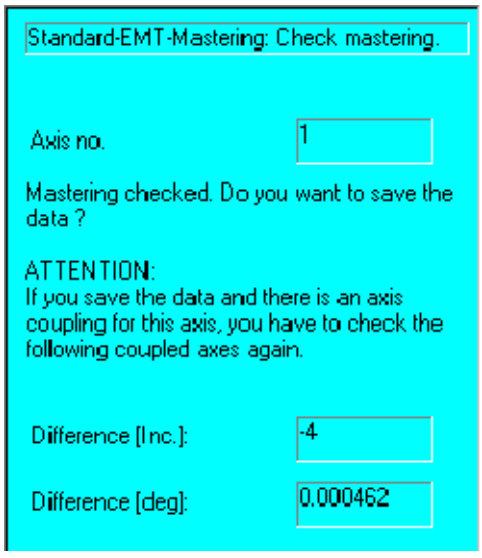
A status window is opened, in which the axes to be checked are listed.

If, for example, axis 2 has not been mastered, or has been unmastered, it is not possible to check the mastering of an axis with a higher number. Axis 2 must first be mastered using “Set mastering” or “Check mastering” in order to be able to check, for example, axis 3.

Check

The axis for which the mastering is to be checked is selected by pressing the softkey “Check”. The text “Start key required” appears in the message window.

Press one of the enabling switches and then the “Program start forwards” key. Keep both keys held down. The robot axis previously selected is now moved from “+” to “–” under program control. When the EMT detects the bottom of the reference notch, the calibration program is stopped.



The values are calculated and a status window is opened, in which the difference from the old mastering is displayed in increments and degrees.

Save

Pressing the softkey “Save” saves the mastering values and enables the selection of the next axis.

You must be aware, when accepting the new mastering, that difficulties may arise during execution of the program, depending on the difference in increments. For this reason, it is necessary to reteach all programs.
Acceptance of the new mastering also offsets the mastering of all subsequent mechanically coupled axes (the wrist axes are generally mechanically coupled). In this case, it is absolutely necessary to check the mastering of these axes and, if the deviation is too great, set the mastering as well.

Remember to screw the protective cap back onto the gauge cartridge once an axis has been mastered. Do not allow foreign bodies to get inside as they would damage this sensitive measuring device and necessitate expensive repairs.

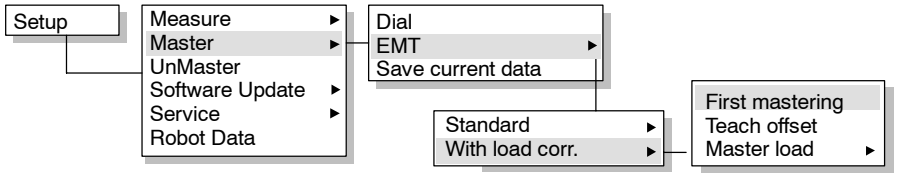
1.3.5 With load correction

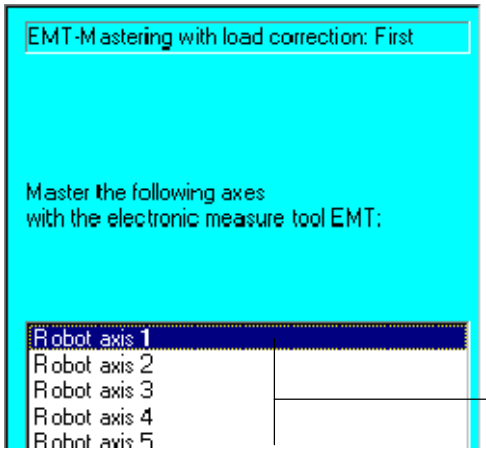
Here you can carry out first mastering and load mastering and teach offsets for various tools and loads. A precondition for “Load mastering” and “Teach offset” is first mastering.

1.3.5.1 First mastering

Please note:
The first mastering of the robot must always be carried out without a payload or a supplementary load.

This function is only available in the operating mode Test (T1). If, when selecting this function, a different operating mode is set, a corresponding error message is generated.





A status window opens, in which all the axes (both mastered and unmastered) for which an offset has been taught are available for selection. Select here the axis to be mastered.

The axes are displayed in the order in which they are to be mastered. The axis that is to be mastered next is indicated by a color background. If all axes have been mastered, the text “No axes to master” appears in the window.

Axes that are already mastered are no longer listed and, if remastering is desired, must first be unmastered. It is also possible to initiate a new mastering procedure via the menu item “Check mastering” in the “Standard” menu.

The mastering operation will be aborted if you try to master an axis with a higher number than this one first. Mastering must always be carried out on the axis with the lowest number.

Master

The axis (highlighted in color) that is to be mastered is selected by pressing the softkey “Master”. The text “Start key required” appears in the message window.

Press the enabling switch on the back of the KCP, then the “Program start forwards” key, and keep both held down. The robot axis previously selected is now moved from “+” to “–” under program control. When the EMT detects the bottom of the reference notch, the calibration program is stopped.

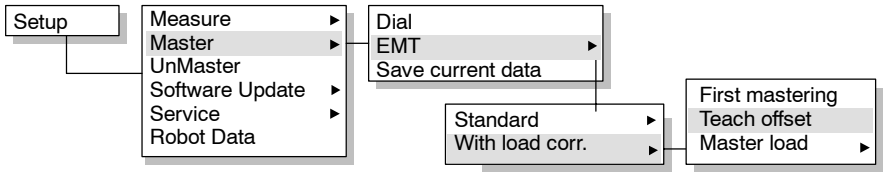
The determined values are saved and the mastered axis removed from the window.

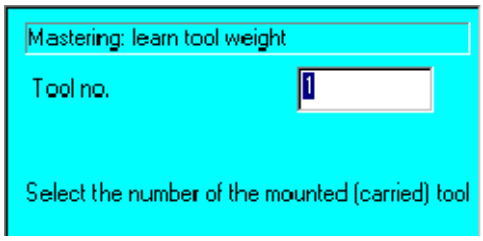
Remember to screw the protective cap back onto the gauge cartridge once an axis has been mastered. Do not allow foreign bodies to get inside as they would damage this sensitive measuring device and necessitate expensive repairs.

1.3.5.2 Teach offset

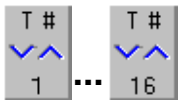
If, after first mastering, the robot is fitted with a heavy tool or workpiece, the increased load gives rise to deviations (offset) from the first mastering. Should it be necessary to repeat mastering (e.g. due to a collision or the replacement of a motor), this offset can be used to recalculate the first mastering. Where different tools or payloads are used, in order to be able to recalculate the mastering without having to change the tool, the offset must be taught for all tools and payloads.
For this purpose, the robot is fitted, after first mastering, with the corresponding tool or workpiece and, if necessary, a supplementary load. In the subsequent mastering procedure, the robot “learns” the mastering difference caused by the load (offset).

This function is only available in the operating mode Test (T1). If, when selecting this function, a different operating mode is set, a corresponding error message is generated.





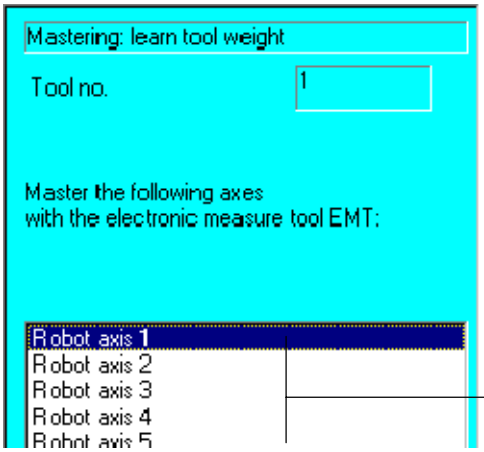
The input window for selecting a tool is opened.



Use the status key to select the tool number.

Tool OK

Press the softkey “Tool OK” in order to enter data for this tool.

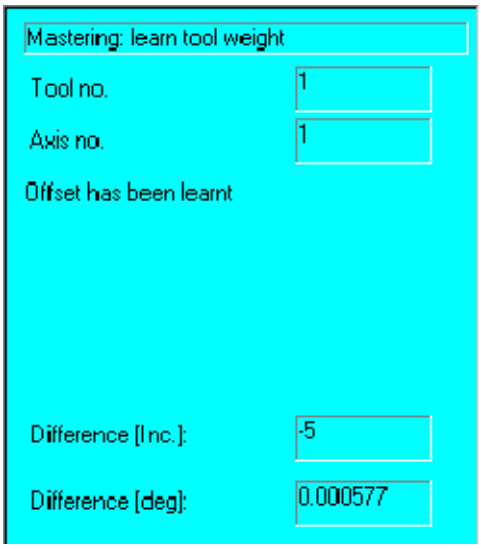


A status window opens, in which all axes are available for selection for which the load of the selected tool has not yet been taught. Select the axis to be taught.

Learn

The axis (highlighted in color) for which an offset is to be taught is selected by pressing the softkey “Teach”. The text “Start key required” appears in the message window.

Press the enabling switch on the back of the KCP, then the “Program start forwards” key, and keep both held down. The robot axis previously selected is now moved from “+” to “–” under program control. When the EMT detects the bottom of the reference notch, the calibration program is stopped.



When the data for the tool or workpiece fitted to the robot flange have been successfully determined, the status window shown here is opened, displaying in increments and degrees the offset from the mastering without load for this axis.

OK

Pressing the softkey “OK” saves the mastering values and enables the selection of the next axis. The axis whose weight has just been learnt is removed from the status window. If the offsets have been taught for all axes, the message “No offset to teach” appears in the window.

Delete

If you wish to delete an offset, press the softkey “Delete”. A window opens, in which the axes to be deleted are displayed. The tool number previously selected is confirmed.

Use the arrow keys to select the axis for which the offset is to be deleted and press the softkey “Delete”. If there are no more offsets to be deleted, the message “No offset to delete” appears in the window.

The values for learnt tools remain valid even after the replacement of a motor or a collision, as they contain only the difference from the first mastering.

If, at the beginning of the learning process, no first mastering has yet been carried out, this must be done first. For this reason the program automatically opens the necessary dialog window. Please pay particular attention to the contents of the text in the status window!

Remember to screw the protective cap back onto the gauge cartridge once an axis has been mastered. Do not allow foreign bodies to get inside as they would damage this sensitive measuring device and necessitate expensive repairs.

1.3.5.3 Master load

With the load mastering function, mastering is carried out with a load. A distinction is made here between “With offset” and “Without offset”.

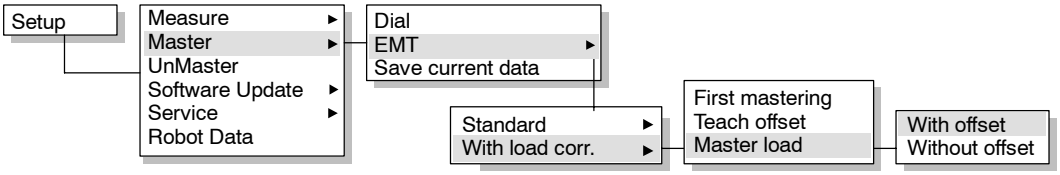
In order to carry out Load mastering, it must be ensured that robot axes A 4 and A 6 have not been rotated from the positions they occupied during first mastering.

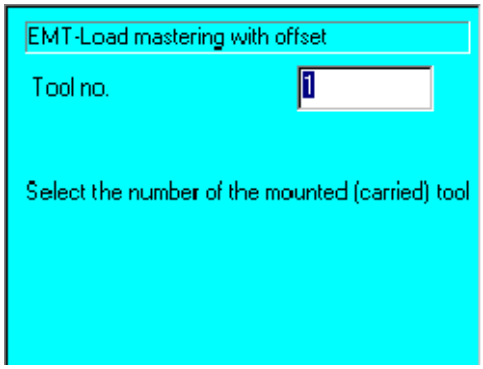
With offset

This function makes it possible to check and, if necessary, restore the robot’s old mastering values without having to remove the tool. The robot is mastered with the tool (known offset). The mastering data for the state “Without load” (first mastering) are recalculated using the offset and overwritten after confirmation by the operator. This can be necessary, for example, if a motor has been replaced or a collision has occurred.

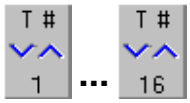
A check is also possible in the event of loss of mastering; in this case the data are marked as invalid, but these old values are nonetheless still available.

This function is only available in the operating mode Test (T1). If, when selecting this function, a different operating mode is set, a corresponding error message is generated.





The input window for selecting a tool is opened.

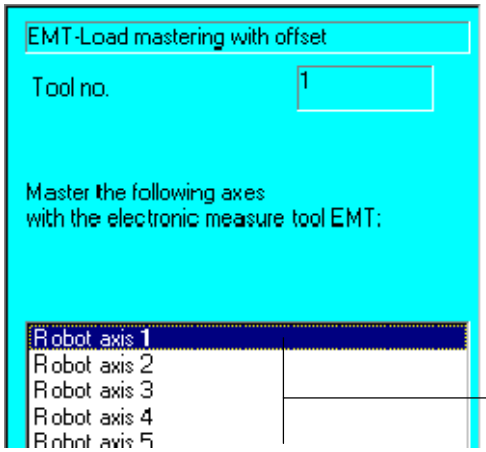


Use the status key to select the tool number.

Tool OK

Press the softkey “Tool OK” in order to enter data for this tool.

If no offset has yet been taught for the tool, an error message is now generated.



A status window opens, in which all the axes (both mastered and unmastered) for which an offset has been taught are available for selection. Select here the axis to be mastered.

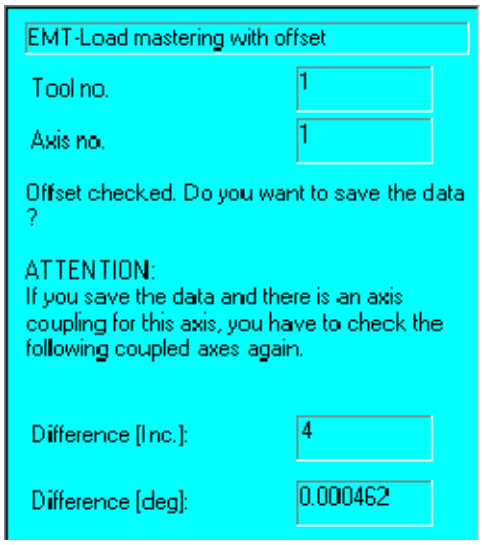
If, for example, axis 2 has not been mastered, or has been unmastered, it is not possible to check the mastering of an axis with a higher number. Axis 2 must first be mastered using “Set mastering” or “Check mastering” in order to be able to check, for example, axis 3.

Check — The axis highlighted by the colored selection bar is selected by pressing the softkey “Check”. The text “Start key required” appears in the message window.

Press the enabling switch on the back of the KCP, then the “Program start forwards” key, and keep both held down. The robot axis previously selected is now moved from “+” to “–” under program control. When the EMT detects the bottom of the reference notch, the calibration program is stopped.

When the mastering data for the tool or workpiece fitted to the robot flange have been successfully determined, a status window is opened, displaying the difference from the old mastering in increments and degrees.

No new mastering values have yet been set, however. This is done once the data have been saved.



Save — Pressing “Save” saves the new mastering values and enables the selection of the next axis. If you do not save the new data, the old mastering state is retained.

You must be aware, when accepting the new mastering, that difficulties may arise during execution of the program, depending on the difference in increments. For this reason, it is necessary to reteach all programs.
Acceptance of the new mastering also offsets the mastering of all subsequent mechanically coupled axes (the wrist axes are generally mechanically coupled). In this case, it is absolutely necessary to check the mastering of these axes and, if the deviation is too great, set the mastering as well.

Without offset

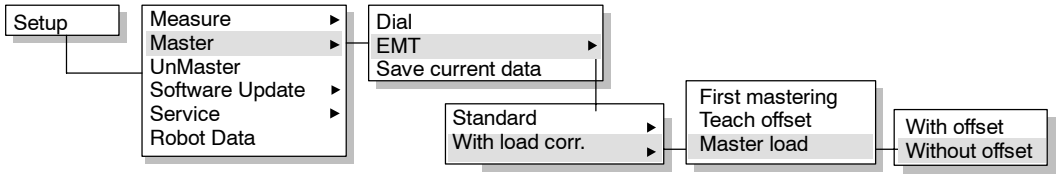
This function makes it possible to restore mastering data that have been lost. The robot can be mastered with any tool, for which the offset does not need to have been “taught” beforehand. Using the data determined in first mastering and the current values, the difference is calculated and the mastering corrected accordingly.

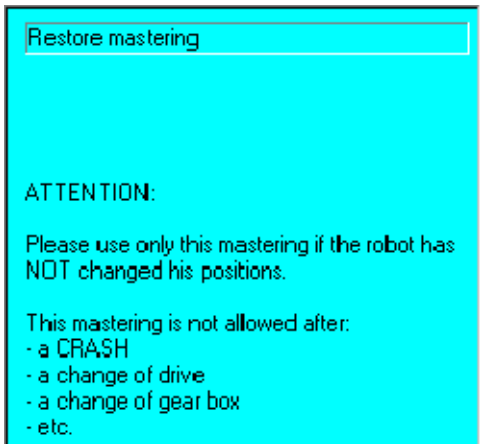
The robot must not have been changed mechanically, since first mastering, in the drive train between the drive motor with resolver and the gear system of the axis concerned (e.g. following replacement of a motor or a collision). Otherwise first mastering must be carried out again.

Unlike the menu item “Teach offset” (which only measures the difference from first mastering) “Restore mastering” uses exclusively the absolute encoder value determined during first mastering to recalculate the first mastering.

First mastering must have been carried out before mastering can be restored in this way.

This function is only available in the operating mode Test (T1). If, when selecting this function, a different operating mode is set, a corresponding error message is generated.

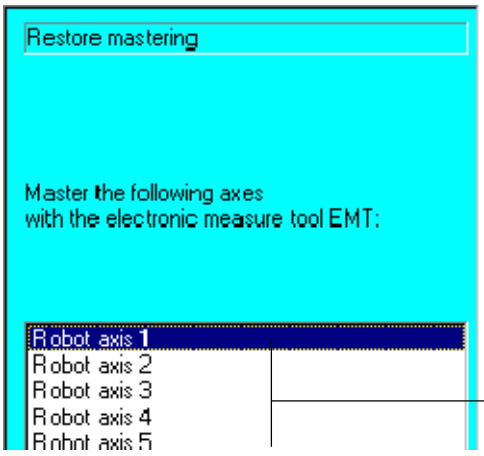




A status window opens, initially displaying just one message.

OK

Please read the message and confirm it by pressing the softkey “OK” in order to continue.



A status window opens, in which the axes to be mastered are displayed.

The axes are displayed in the order in which they are to be mastered. The axis that is to be mastered next is indicated by a color background.

Axes that are already mastered are no longer listed and, if remastering is desired, must first be unmastered.

The mastering operation will be aborted if you try to master an axis with a higher number than this one first. Mastering must always be carried out on the axis with the lowest number.

OK

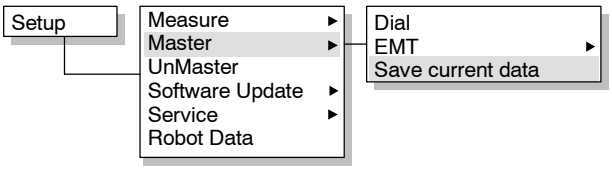
The axis to be mastered, highlighted by the colored selection bar, is selected by pressing the softkey “OK”. The text “Start key required” appears in the message window.

Press the enabling switch on the back of the KCP, then the “Program start forwards” key, and keep both held down. The robot axis previously selected is now moved from “+” to “–” under program control. When the EMT detects the bottom of the reference notch, the calibration program is stopped. The determined values are saved and the mastered axis removed from the window.

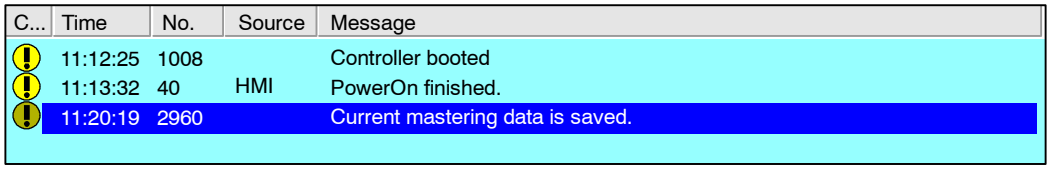
Remember to screw the protective cap back onto the gauge cartridge once an axis has been mastered. Do not allow foreign bodies to get inside as they would damage this sensitive measuring device and necessitate expensive repairs.

1.4 Save mastering data

To prevent loss of mastering, it is possible to save the mastering data. Loss of mastering can occur, for example, in the event of a defective battery preventing the system from being shut down correctly (option “Battery monitoring”).



Once the mastering data have been saved a corresponding message is generated.

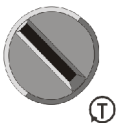


1.5 Mastering the KR 3

On the robot type “KR 3”, mastering is carried out using the verniers only; these are installed on each axis.

The mastering procedure and mastering menu are completely different from those of the KR C1 and KR C2 versions. There is a total of three different commands available:

Command	Function
Robot mastering	Normal mastering
Commutation	Motor – encoder synchronization
SetupMasterSetRobotPos	First mastering

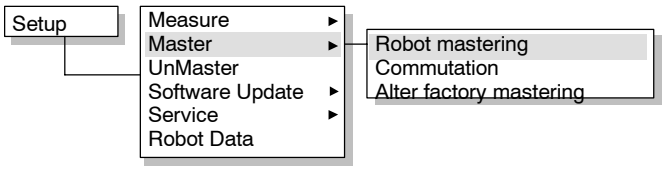


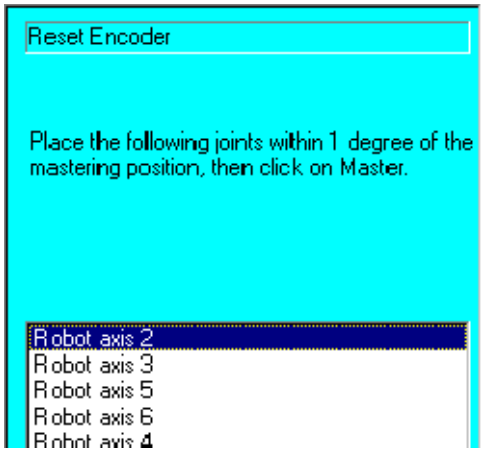
First of all, make sure that the operating mode “T1” and the option “Jog” are set.

This menu items “Commutation” and “Set robot position” are not available in the user group “User”.

1.5.1 Robot mastering

This command can be used to master the robot, provided that a first mastering (“Alter factory mastering”) has already been carried out.





This causes the corresponding status window to be opened, in which the axes still to be mastered are displayed.

Axes that are already mastered are no longer listed and, if remastering is desired, must first be unmastered.

Then move the desired axis into the mastering position by bringing the respective vernier marks into alignment.

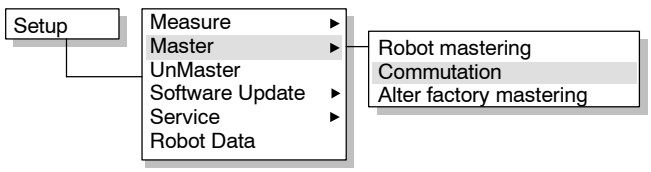
Master

Then press the softkey “Master”. The entry for the corresponding axis is then removed from the status window.

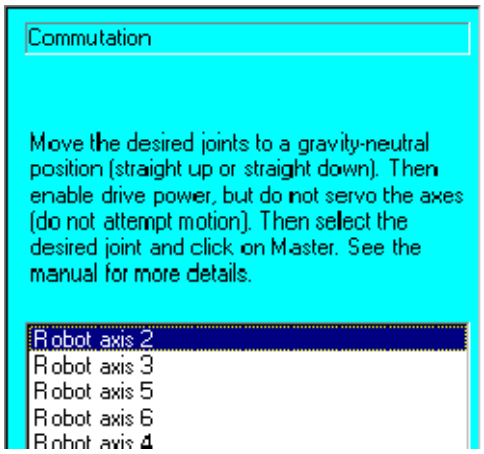
1.5.2 Commutation

Commutation is used to synchronize the motor and the encoder. This function is required in the event of an encoder or motor exchange.

This function may only be carried out by our Service department or by personnel trained at KUKA Roboter GmbH.



This causes the corresponding status window to be opened, in which the axes to be commutated are displayed.



This causes the corresponding status window to be opened, in which the axes to be commutated are displayed.

Then move the desired axes to a position which is **as gravity–neutral as possible**, and press the Start key.

A position which is as gravity–neutral as possible is necessary because the brake of the axis in question will be released briefly. An unfavorable position may lead to unintended axis motion during this procedure.

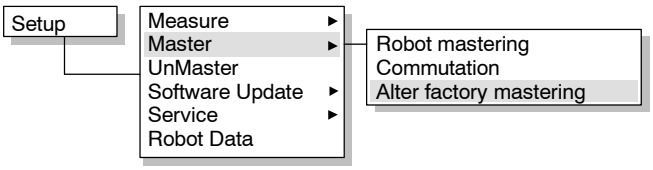
Master

Then press the softkey “Master”. The brake of the axis in question is released briefly, the synchronization is carried out and then the brake is applied again.

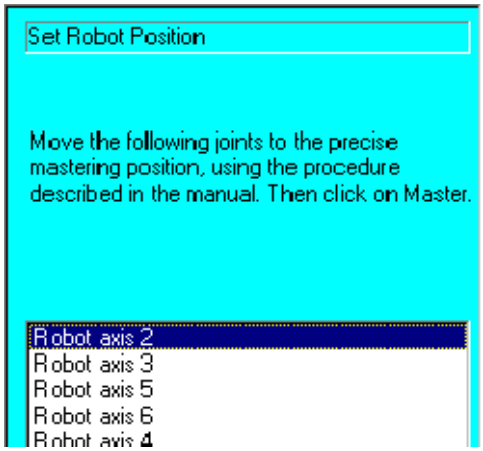
The entry for the corresponding axis is not removed from the list; the procedure can be repeated at any time.

1.5.3 Alter factory mastering

This command is used for first mastering of the KR 3. Since KUKA Roboter GmbH generally ships all robots with the first mastering already performed, this step is normally not necessary. It must be carried out, however, if an encoder or motor is exchanged.



In order to carry out first mastering, the axis in question must first be unmastered; then execute the function “Commutation”.



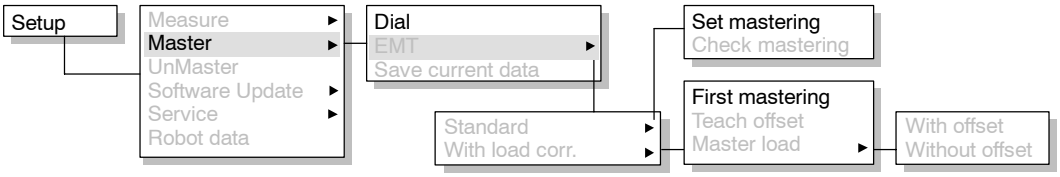
Move the axis to be mastered into the mastering position by bringing the vernier into alignment. Use a spirit level to check the exact position.

Master

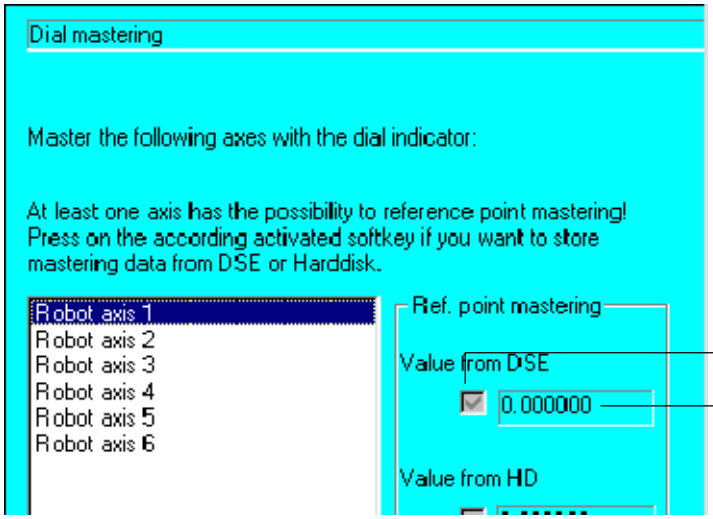
Then press the softkey “Master”. The entry for the corresponding axis is then removed from the status window.

1.6 Reference point mastering

If a robot axis has an absolute encoder, reference point mastering is possible for this axis. The following mastering types are permissible here:



If at least one axis with an absolute encoder is unmastered, an additional status window for reference point mastering is displayed.



The following options are offered in the softkey bar:

Drive +
Drive –

The two softkeys “Drive +” and “Drive –” are used to select the required master/slave drive.

DSE–Value

The data saved on the DSE are used for mastering.

HD–Value

The mastering file most recently saved to the hard drive is used.

Master

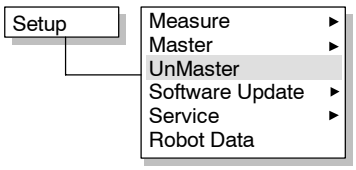
The robot is remastered using the dial gauge or EMT. The relevant procedures are described in the corresponding sections in this chapter.

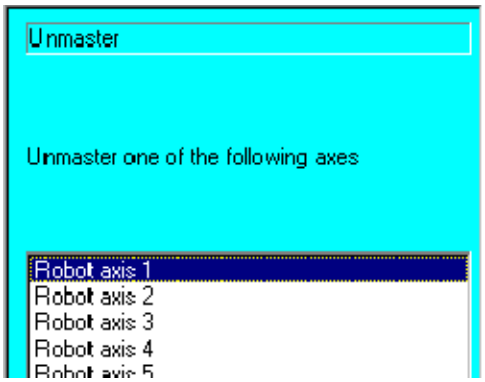
Close

Reference point mastering is terminated using the softkey “Close”.

1.7 Unmastering an axis

With the aid of this function, individual axes can be specifically unmastered.





A status window is then opened, in which the mastered axes are displayed. If all axes have already been unmastered, the text “No axes to unmaster” appears in the window.

UnMaster The mastering data for the axis highlighted in color are deleted by pressing the softkey “UnMaster”.

On account of the mechanical coupling of the robot wrist axes, the data for axes 5 and 6 will also be deleted when axis 4 is unmastered, and similarly the data for axis 6 when axis 5 is unmastered.

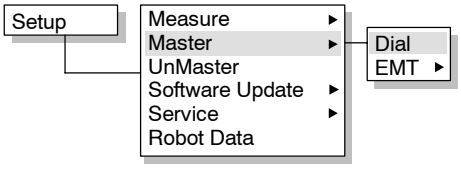
The robot axes do not move during unmastering.

1.8 Mastering of master/slave drives

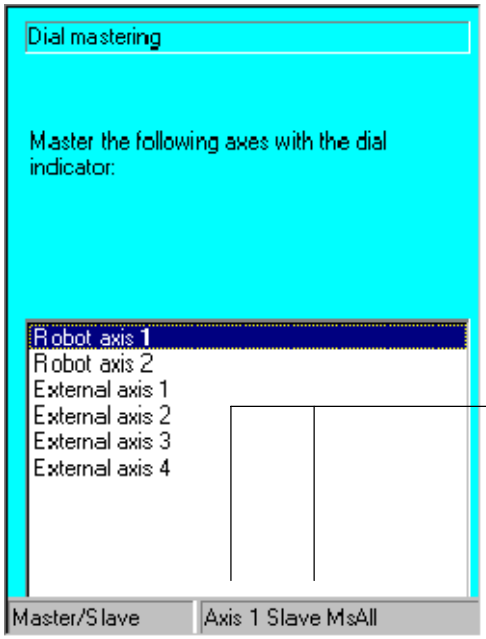
If the robot system contains additional position–controlled master/slave drives, they must be mastered prior to use.

This function is only available if the appropriate master/slave drives are present and the necessary entries have been made in the machine data.

Torque–controlled slave drives do not require mastering, and are not shown in the status window.



EMT mastering of the master/slave drives is not possible.



The status window for mastering is then opened.

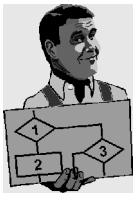
The status line of the status window shows the robot axis currently active and the drive which is selected.

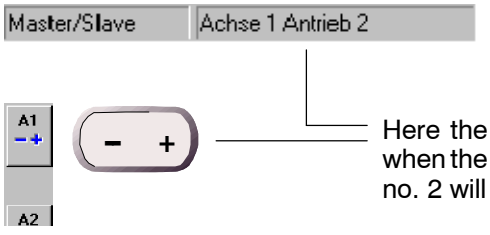
The axes are displayed in the order in which they are to be mastered. The axis that is to be mastered is indicated by a color background.

Drive +
Drive –

The status keys “Drive +” and “Drive –” can be used to select a drive, which can then be jogged using the jog key of the corresponding axis. The possibilities here are:

- All: The selected axis and the master and slave drives are jogged together
- Master: Only the master drive is jogged
- Drive 1 ... 5: Only the corresponding slave drive is jogged





Here the status line in the status window indicates that when the “+/–” jog key of axis 1 is pressed, only slave drive no. 2 will be jogged.

If all axes/drives have been mastered, the text “No axes to master” appears in the window.

The mastering operation will be aborted if you try to master an axis with a higher number than this one first. Mastering must always be carried out on the axis with the lowest number.

Axes that are already mastered are no longer listed and, if remastering is desired, must first be unmastered. Furthermore, it is also possible to initiate a new mastering procedure via the menu item “Check mastering”.

Master — The selected axis and the corresponding master and slave drives are mastered by pressing the softkey “Master”.

2 Calibration

2.1 Fundamentals

With the aid of the predefined calibration programs, you have a means of easily defining the dimensions of an

- unknown **tool** or
- unknown **workpiece**

using several different procedures.

	Tool center point (TCP)		Workpiece reference point	
Robot guides the **Tool**	Position	X Y Z – 4–Point X Y Z – Reference	Position and orientation	3–Point Indirect
	Orientation	A B C – World A B C – 2–Point		
Robot guides the **Workpiece**	Position and orientation	Tool	Position and orientation	Workpiece

The data for up to 16 tools or workpieces can be stored. These data are then called by number in the application program and enable a tool change to be easily programmed.

For reasons of safety, the calibration programs can only be executed in “T1” or “T2” mode.

2.1.1 Prerequisites

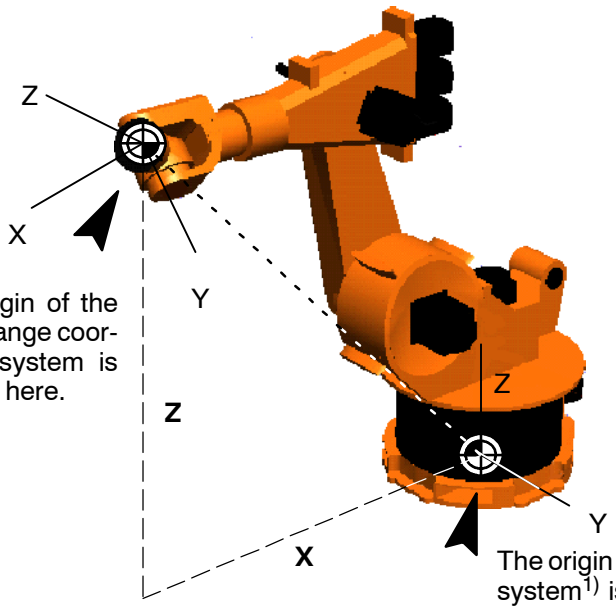
Using the calibration functions requires adequate knowledge of operating the robot system.

The following preconditions must also be met:

- the correct machine data are loaded;
- all axes must be correctly mastered;
- no program may be selected;
- mode “T1” or “T2” is selected.

2.1.2 Introduction

The **position** of the flange center point is defined by its distance from the origin of the world coordinate system[1)] (dotted line). This distance is specified in its X, Y and Z components (dashed lines).

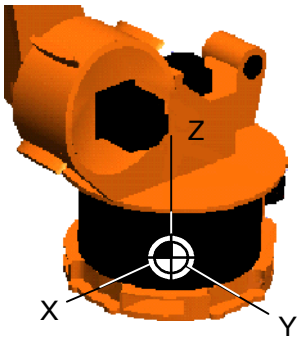


The origin of the robot flange coordinate system is located here.

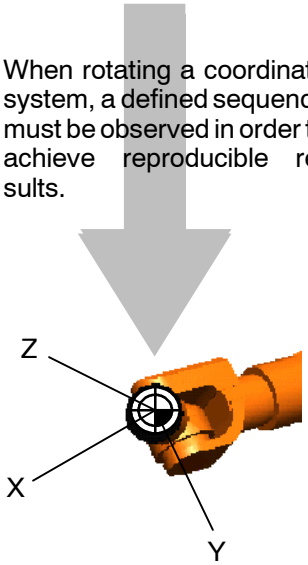
The origin of the world coordinate system[1)] is located here.

[1)] In the basic setting, the world and robot coordinate systems coincide.

The **orientation** of the robot flange coordinate system, whose origin lies at the flange centerpoint, is defined by its rotational offset (Z–Y–X Euler angles) from the world coordinate system[1)].

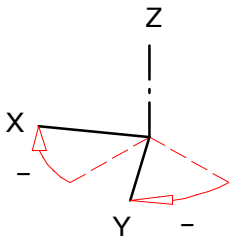


When rotating a coordinate system, a defined sequence must be observed in order to achieve reproducible results.



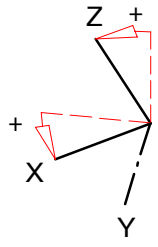
1. Rotation about the Z axis

Angle ***A***



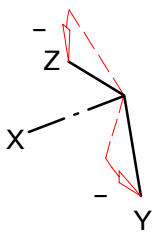
2. Rotation about the Y axis

Angle ***B***



3. Rotation about the X axis

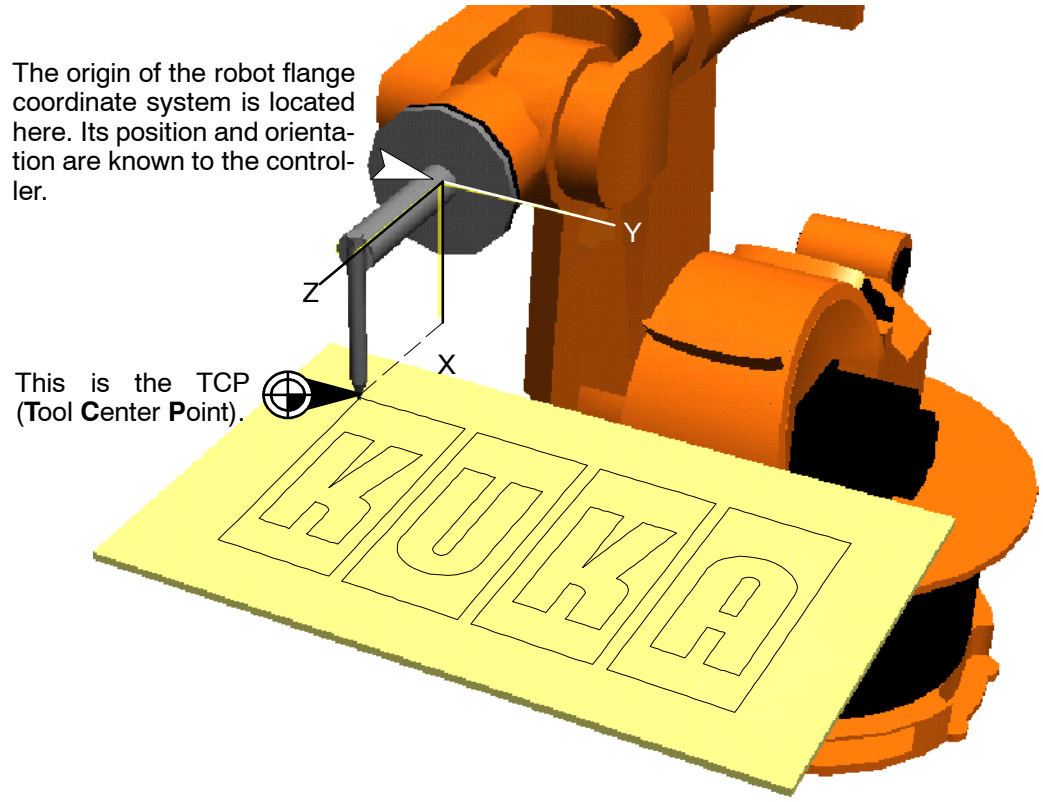
Angle ***C***



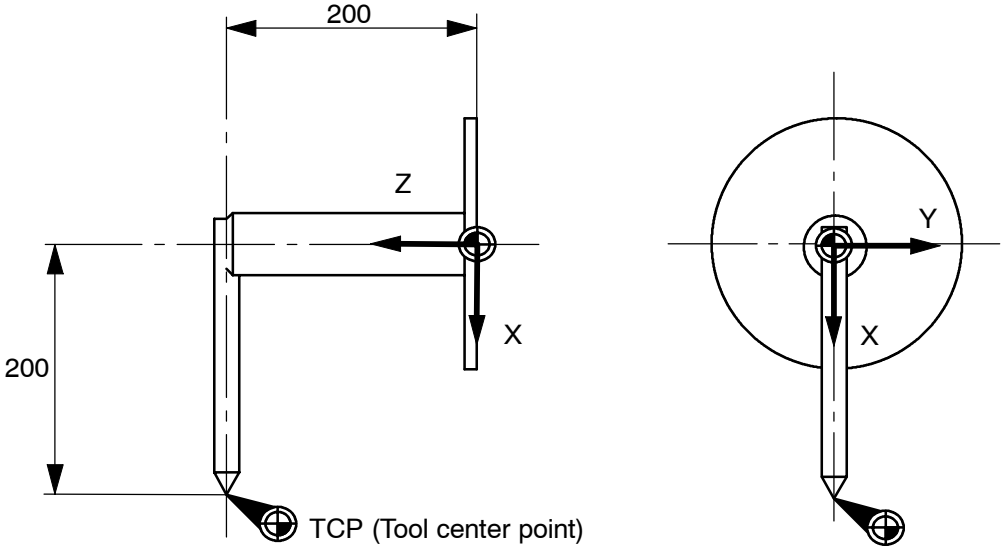
The information representing a point in space by specification of the coordinates X, Y, Z and the rotation angles A, B, C is called a ***FRAME***.

[1] In the basic setting, the world and robot coordinate systems coincide.

To enable the position of the reference point of a tool or workpiece mounted on the robot flange to be calculated, its location and orientation in relation to the robot flange coordinate system must be known to the robot controller.

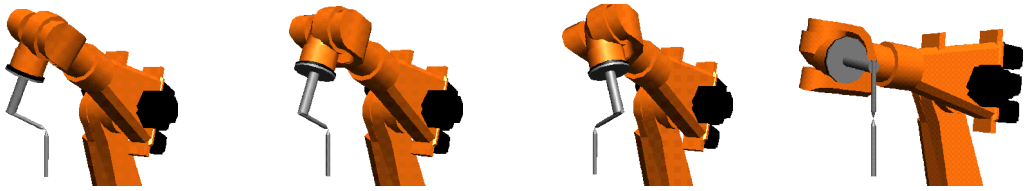


These data can be determined with the aid of an external measuring device. Having been recorded on a form, the data can be entered into the robot controller at any time. After a collision, however, these data are no longer valid and must be re–determined.



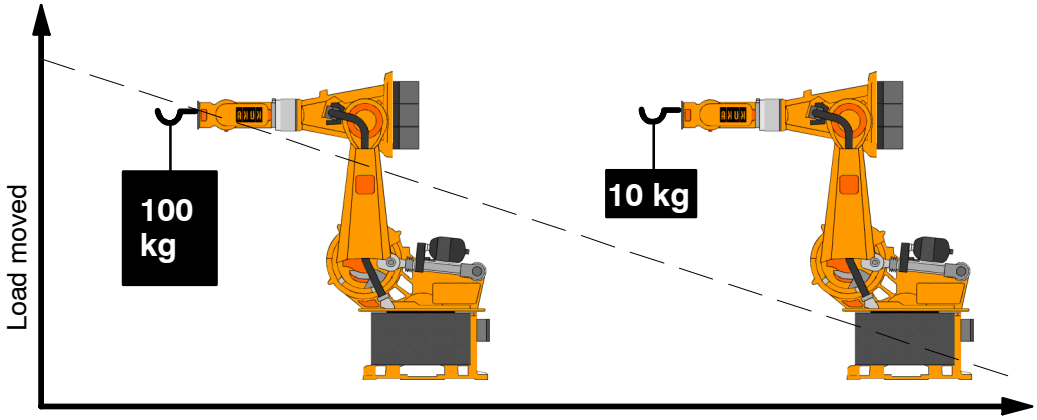
Another possible method of determining the tool data consists in measuring the tool by means of the calibration systems and calculation functions of the robot.

For this purpose, the TCP of the tool or workpiece mounted on the robot flange is moved to a reference point from various directions. This reference point can be located at any point within the work envelope of the robot.



The position of the TCP is then calculated on the basis of these various positions and orientations of the robot flange.

To enable the tool or workpiece to be moved as quickly as possible without overloading the drive systems of the robot, the load data of the tool or workpiece must be taken into account.



For this purpose, the weight, center of gravity and mass moment of inertia of the tool or workpiece must be entered into the controller.

Any supplementary loads mounted on the robot must not be forgotten.

2.2 Tool calibration

This submenu is used for calibrating a tool mounted on the robot.

The submenu “Tool” contains the following subprograms:

Program	Calibration by...
X Y Z – 4–Point	moving the robot to a fixed reference point
X Y Z – Reference	moving the robot with a known reference tool to a reference point
A B C – 2–Point	moving the robot to 2 points with orientation data
A B C – WORLD	positioning perpendicular to the world coordinate system
Numeric Input	entering the tool data
Payload data	entering the mass, center of mass, mass moment of inertia

Each of these calibration programs is assigned forms that guide you interactively through the program.

Methods for determining the position

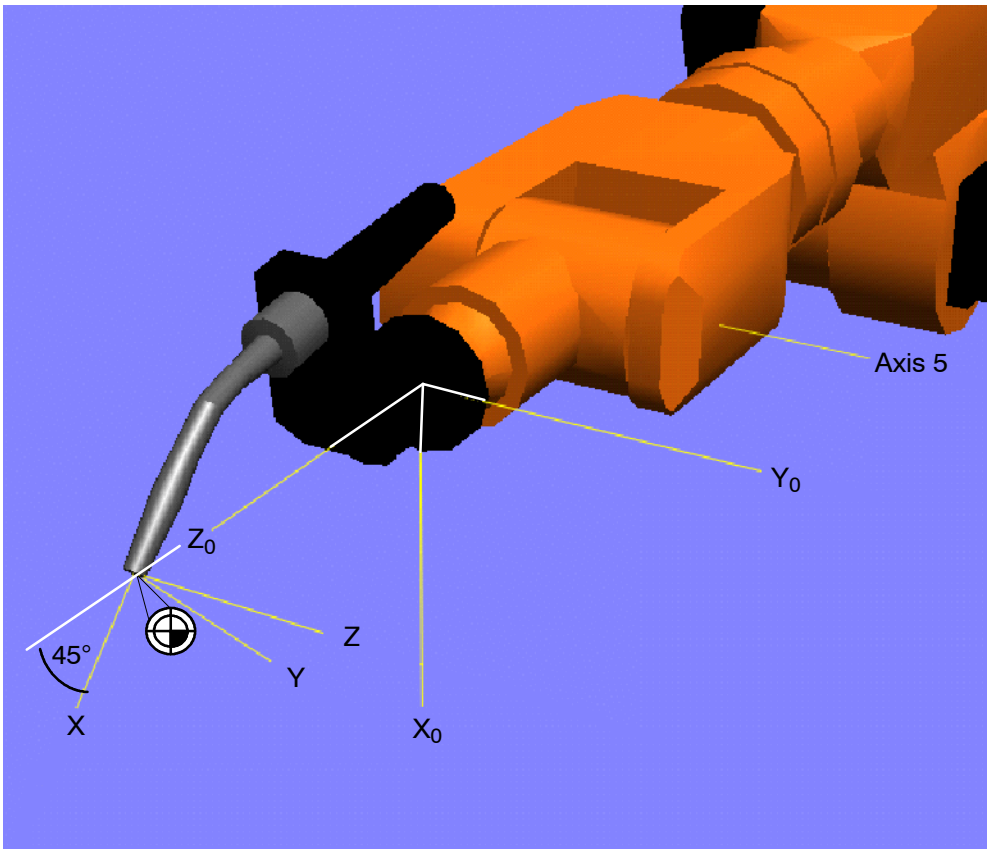
These methods are used to determine the position of the TCP in relation to the origin of the robot flange coordinate system.

These methods include the calibration programs “**XYZ – 4 Point**”, and “**XYZ – Reference**”.

Methods for determining the orientation

These methods are used to determine the rotational offset (A, B and C according to the Z–Y–X Euler angles) of the tool coordinate system from the robot flange coordinate system.

These methods include “**A B C – 2–Point**” and “**A B C – WORLD**”.



ABC – 2–Point

This method is used if an exact orientation of the three tool axes is required for positioning and manipulation. It requires marked points to be available on the positive side of the XY plane and on the negative side of the X axis of the tool.

A B C – World (5D)

This method is used if only the working direction of the tool is required for its positioning and manipulation (MIG/MAG welding, laser or waterjet cutting).

A B C – World (6D)

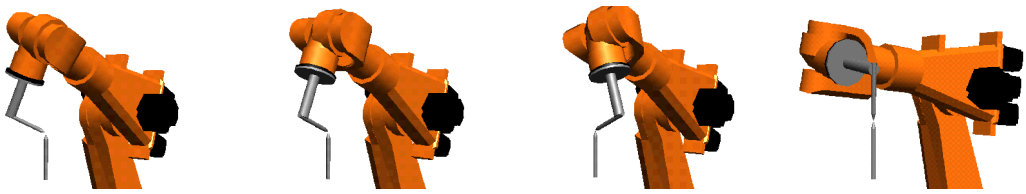
This method is used if the orientation of all three tool axes is required for positioning and manipulation (for example: welding guns, grippers, adhesive nozzles).

Method for TOOL orientation

If a tool is known, its dimensions and angular positions are entered. This is done via the menu item "**Numeric Input**" (see Section 2.2.5).

2.2.1 X Y Z – 4–Point

In the "4–Point" method, the TCP of the tool is moved to a reference point from four different directions (hence "4–Point" method).

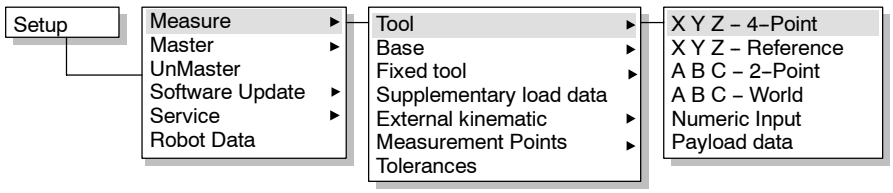


The position of the TCP is then calculated on the basis of the various positions and orientations of the robot flange.

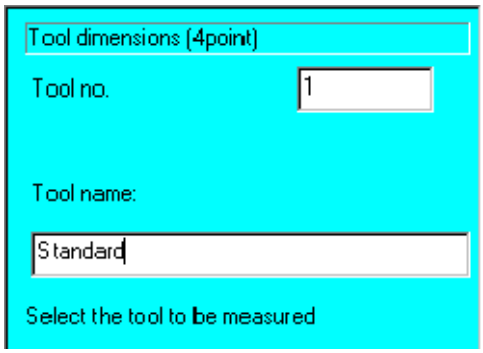
Procedure

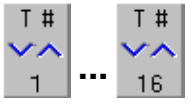
Mount the tool to be calibrated onto the robot flange and establish a suitable reference point.

This can be the tip of the reference spike installed in the work envelope or also a distinctive corner of a workpiece or a fixture.



The dialog window for 4–point calibration is opened.

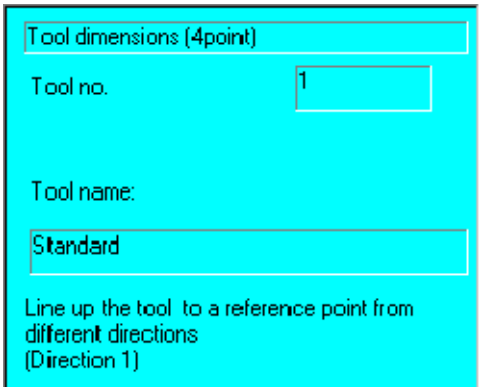




Use the status key and the +/– key to select the desired tool number. Calibration data for a total of 16 different tools can be stored. The current dimensions or angles of the tool in question are displayed in the bottom part of the status window.

You can use the arrow keys to access the tool name input box and there enter a name for the tool.

OK — Press the softkey "OK" in order to calibrate the selected tool. The next status window is then automatically opened.



You are now prompted to align the tool to a reference point from different directions. Either the axis jog keys or the Space Mouse can be used to do this. Now carry out the following steps in the order given:

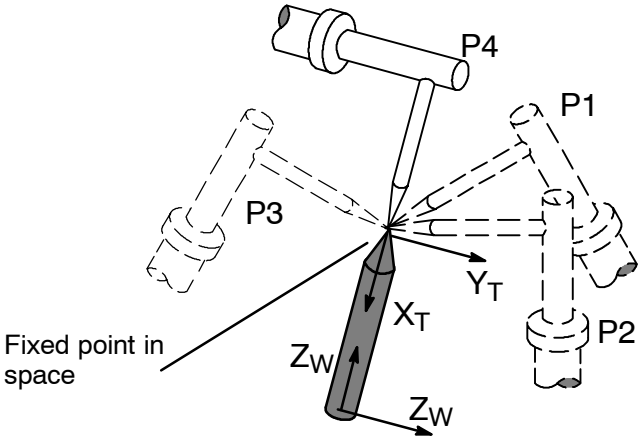
- Set the desired tool orientation.
- Move the TCP to the reference point.
- When the TCP is located exactly on the reference point, save its position by pressing the softkey “OK”.

OK

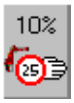
Repeat

If the selected points are too close together, an error message is generated. You can now press the softkey “Repeat” to repeat the last calibration, or the softkey “Repeat All” to repeat all calibrations.

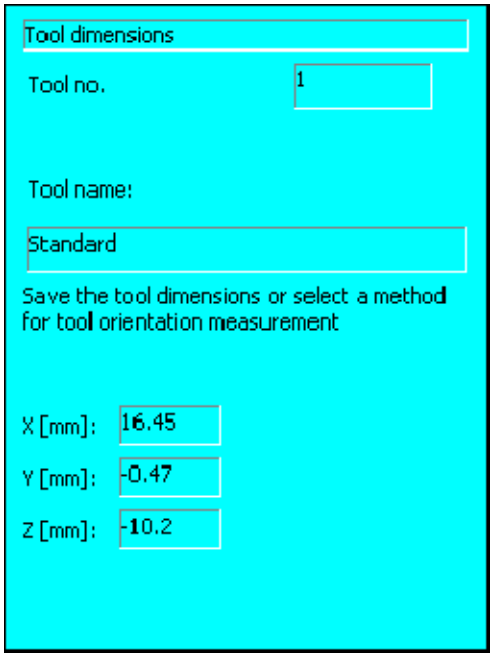
After the point has been accepted by the controller, you are prompted to align the TCP to the reference point from another direction. Repeat these steps until the reference point has been addressed from four directions and the point coordinates transferred.



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



For this purpose you can use raise or lower the jog velocity using the +/– key of the “Jog–OV” status key. Reducing the deflection of the Space Mouse also reduces the velocity.



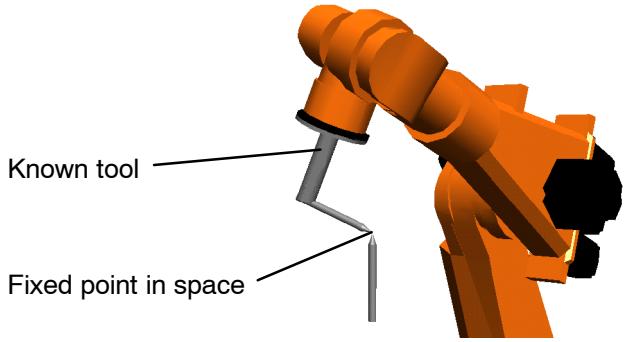
Save

At the end of the calibration procedure, you will be offered the softkey “Save”. Save the tool data by pressing this softkey. This terminates the function.

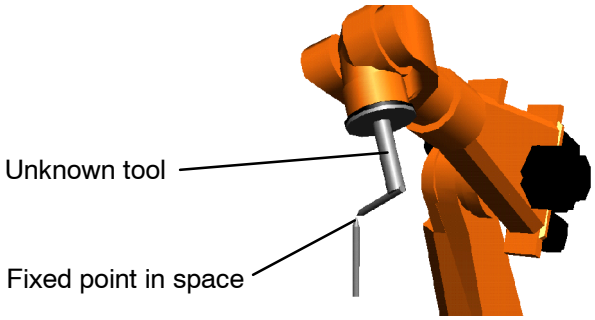
You are currently able to open the corresponding subprograms by means of the softkeys “A B C – 2–Point”, “A B C – World” or “Load data”. It is also possible to view the calibrated points by pressing the softkey “Meas. Pt.”.

2.2.2 X Y Z – Reference

In this method, the data of a tool to be calibrated are determined by means of comparison with a known tool by moving the TCP to a reference point.



This is done by moving a tool of known dimensions to a reference point from any direction.



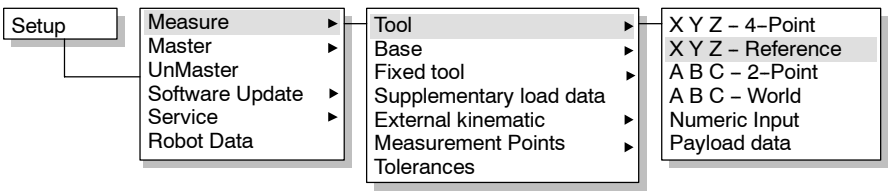
The tool to be calibrated is then mounted on the robot flange. This tool is then also moved to the reference point from any direction.

On the basis of the various positions and orientations of the robot flange and the known dimensions of the tool previously used, the robot controller can now calculate the dimensions of the tool that is to be calibrated.

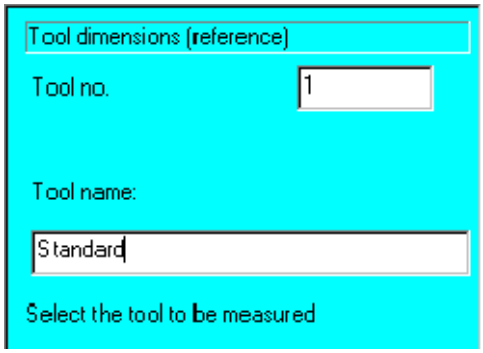
Procedure

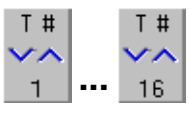
Mount a tool whose dimensions are known to the controller onto the robot flange and establish a suitable reference point.

This can be the tip of the reference spike installed in the work envelope or also a distinctive corner of a workpiece or a fixture.



The following dialog window is opened after this menu has been selected.



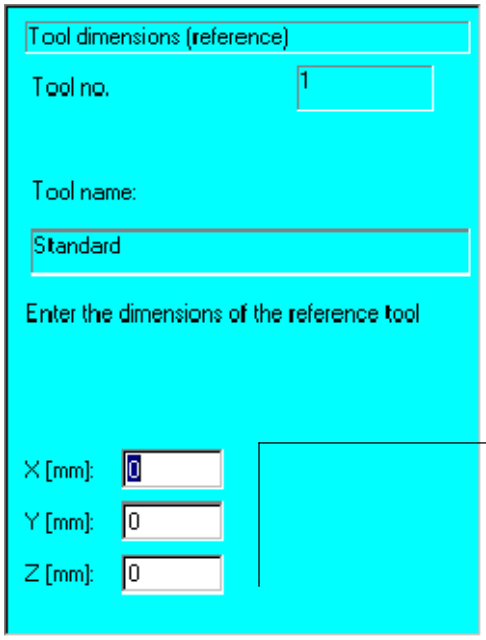


Use the status key and the +/– key to select the desired tool number. Calibration data for a total of 16 different tools can be stored. The current dimensions or angles of the tool in question are displayed in the bottom part of the status window.

You can use the arrow keys to access the input box “Tool name” and there enter a name for the tool.

OK

Press the softkey “OK” in order to edit the data for this tool. The dialog window for data entry is then opened.

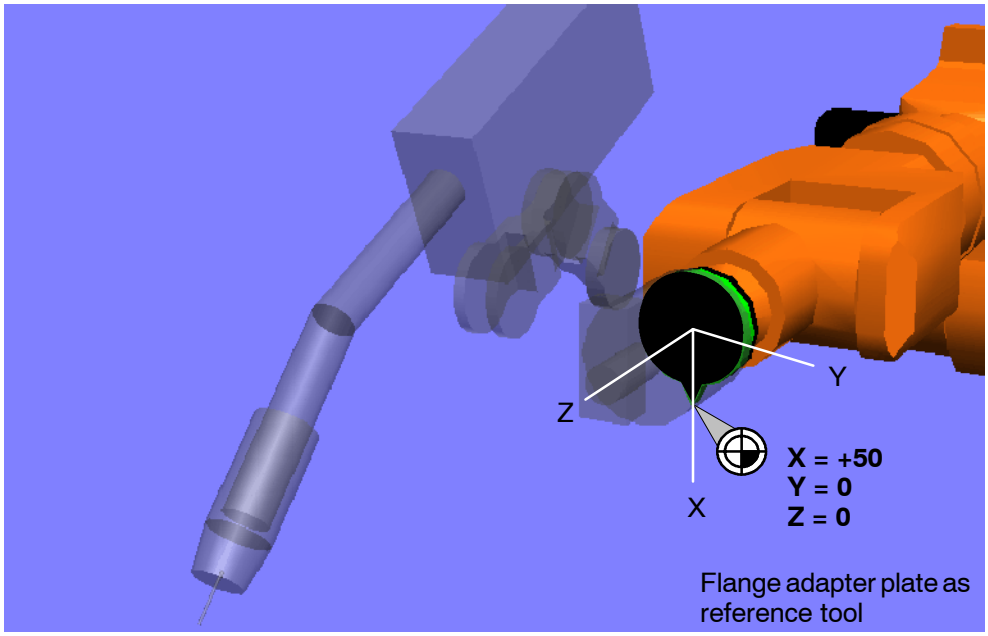


Use the numeric keypad to enter the dimensions of the reference tool, i.e. the known tool, in the input boxes X, Y and Z.

You can move between the input boxes using the “↓” and “↑” arrow keys.

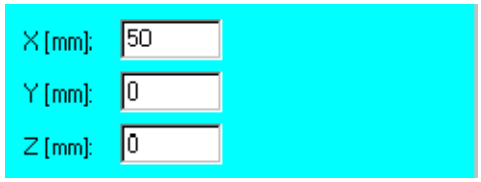
Example:

X, Y, Z Position of the TCP relative to the origin of the robot flange coordinate system (located at the center of the flange).



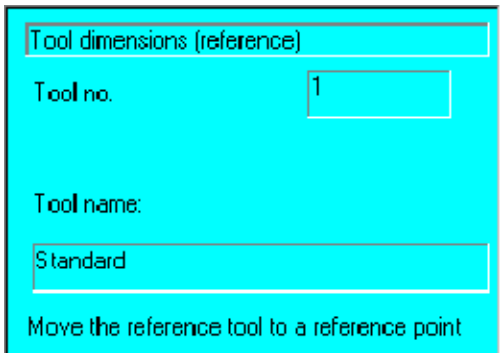
Flange adapter plate as reference tool

In the example:



OK

If the entries have been made correctly, confirm this by pressing the softkey “OK”. The window prompting you to move to the reference point is opened.



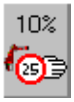
The robot can be moved using either the jog keys or the Space Mouse. Now carry out the following steps in the order given:

- Set the desired tool orientation.
- Move the TCP to the reference point.

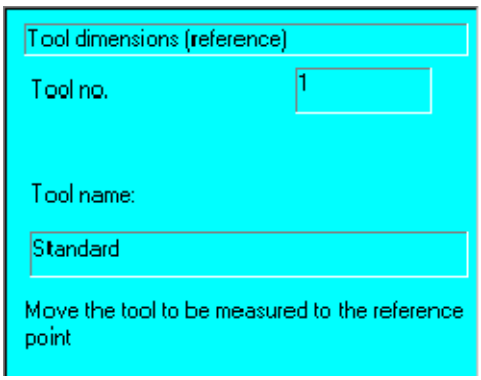
OK

When the TCP is located exactly on the reference point, save its position by pressing the softkey “OK”.

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

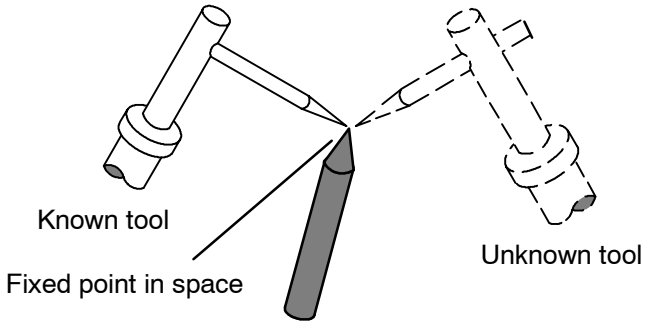


To do so, repeatedly press the status key on the right of the display.

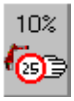


After the point has been accepted by the controller, you are prompted to align the tool that is to be calibrated to the reference point.

First move the tool away from the reference point. Then replace the known tool with the unknown tool and move to the reference point again.



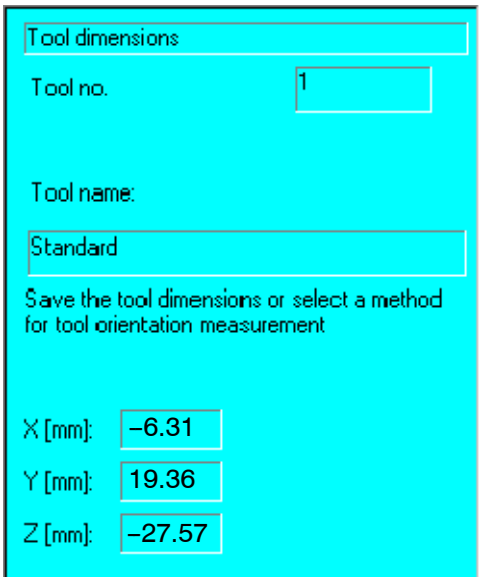
Reduce the jog velocity in the vicinity of the reference object in order to avoid a collision.



To do so, repeatedly press the status key “Jog override”, on the right of the display.

OK

Now confirm the position with the softkey “OK”. The X, Y and Z dimensions of the defined tool are displayed in the form that is then opened.



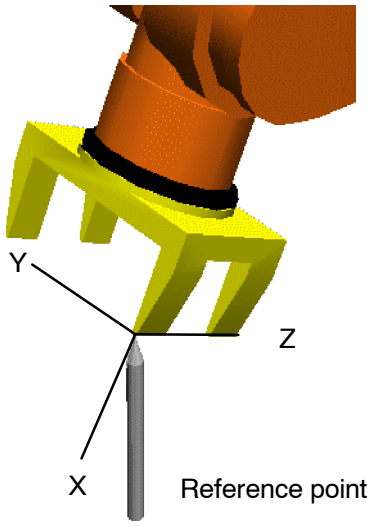
Save

The data are saved and the calibration program is ended by pressing the softkey “Save”.

You are currently able to open the corresponding subprograms by means of the softkeys “A B C – 2–Point”, “A B C – World” or “Load data”. It is also possible to view the calibrated points by pressing the softkey “Meas. Pt.”.

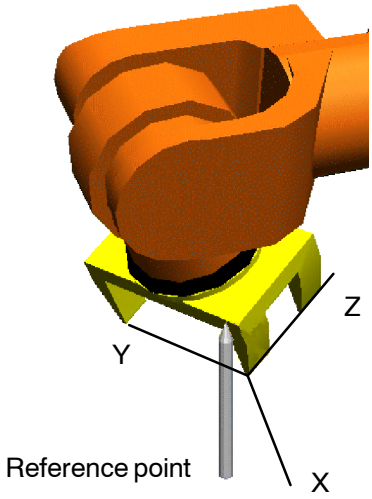
2.2.3 A B C – 2–Point

In this method, the orientation of the tool coordinate system is defined in two steps.



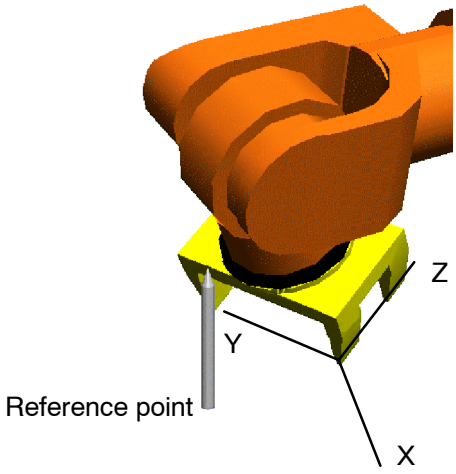
In the first step, the working direction of the tool is defined for the controller.

This is done by moving the TCP to a known reference point.



It is now necessary to move a point located opposite the TCP on the tool to the same reference point *(in the reverse working direction)*.

The working direction of the tool is now defined.



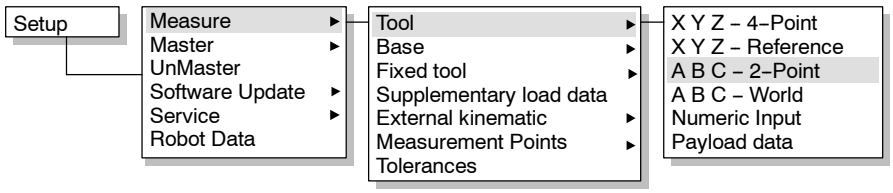
The YZ plane can still rotate freely about the X axis *(working direction)* of the tool and is defined in the second step.

This is done by moving the tool so that the reference point is located with a positive Y value on the future XY plane of the tool.

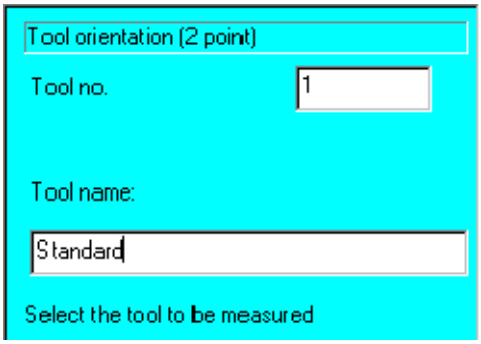
Procedure

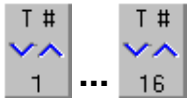
Mount the tool to be calibrated onto the robot flange and establish a suitable reference point.

This can be the tip of the reference spike installed in the work envelope or a distinctive corner of a workpiece or a fixture.



The following dialog window is opened after this menu has been selected.

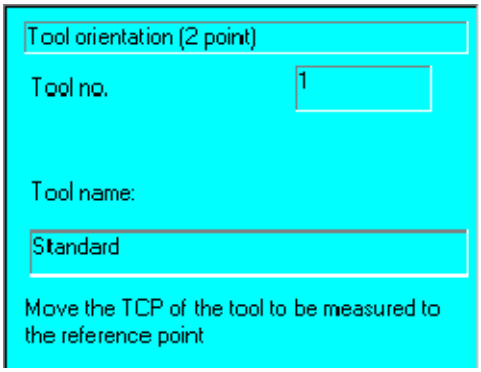




Use the status key and the +/– key to select the desired tool number. Calibration data for a total of 16 different tools can be stored. The current dimensions or angles of the tool in question are displayed in the bottom part of the status window.

You can use the arrow keys to access the input box “Tool name” and there enter a name for the tool.

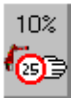
If this definition procedure is called by means of the softkey “X Y Z – Reference”, the form for entering the tool number will not be opened.



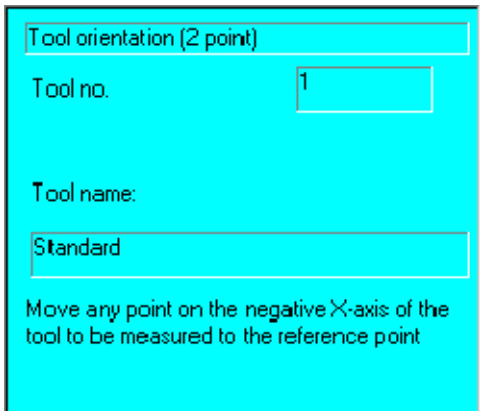
Press the softkey “OK” in order to edit the data for this tool. The dialog window for entering the TCP value is then opened.

Position the TCP (tool center point) to a reference point.

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



For this purpose you can use raise or lower the jog velocity using the +/– key of the “Jog–OV” status key. Reducing the deflection of the Space Mouse also reduces the velocity.

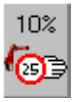


OK

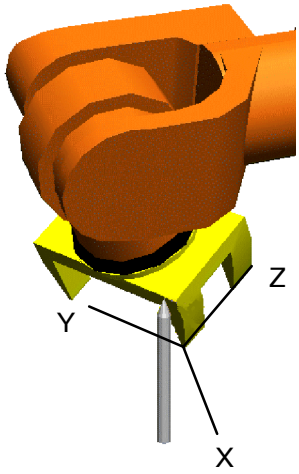
When the TCP is located exactly on the reference point, save this position by pressing the softkey “OK”. The status window then changes.

First move the tool away from the reference point.

Here also, reduce the jog velocity in the vicinity of the reference object in order to avoid a collision.

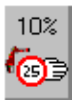


To do so, press the status key “Jog–OV” again.



Position a point located opposite the TCP in the reverse working direction to the reference point.

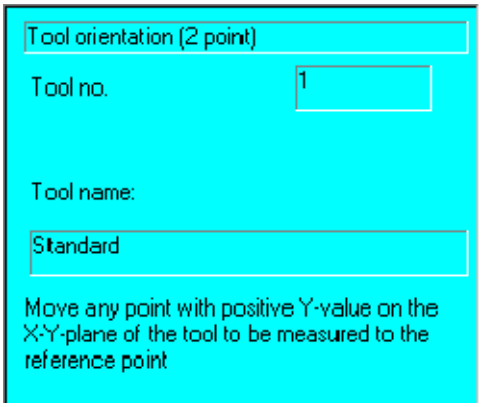
Reduce the jog velocity in the vicinity of the reference object in order to avoid a collision.



To do so, repeatedly press the status key shown here (on the right of the display).

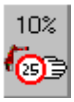
OK

When the TCP is located exactly on the reference point, save this position by pressing the softkey “OK”. The status window then changes again.



Move the tool so that the reference point is located with a positive Y value on the future XY plane of the tool.

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

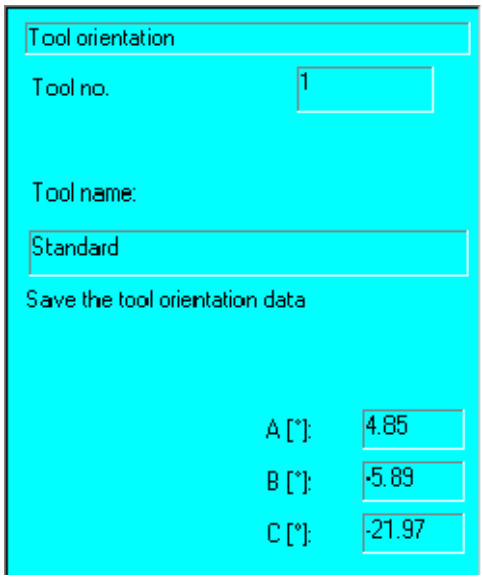


To do so, repeatedly press the jog override status key.

OK

When the TCP is located exactly on the reference point, save this position by pressing the softkey “OK”.

If the error message ***Point too near to reference point*** is displayed, the distance to the previous point is too small. The form cannot be closed by pressing “Point Ok” until the distance has been increased.

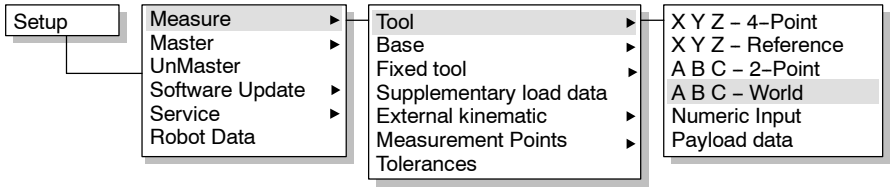


Save

Save the tool data by pressing the softkey “Save”. The function is then terminated.

At this point you can open the corresponding subprogram by means of the softkey “Load data”. More detailed information about this can be found in Section 2.2.6. It is also possible to view the three different measuring points (coordinates) by pressing the softkey “Meas. Pt.”.

2.2.4 A B C – World



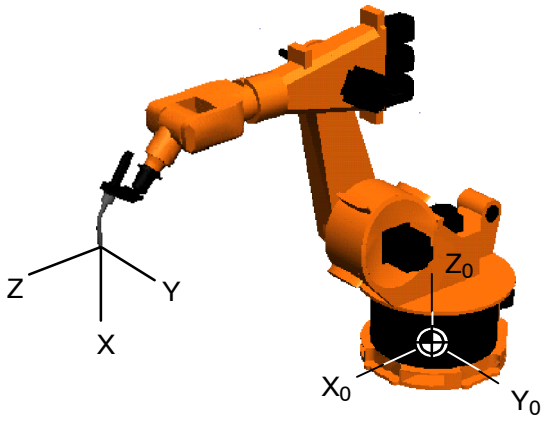
The approach is different depending on whether you are using the 5D or 6D method.

2.2.4.1 The “A B C – World (5D)” method

In this method, the tool must be oriented parallel to the Z axis of the world coordinate system in the working direction. The Y and Z axes are oriented by the robot controller. The orientation of these axes is not readily foreseeable in this instance, but it is exactly the same in each calibration procedure.

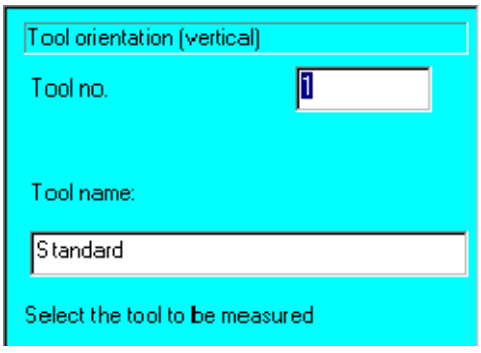
Condition:

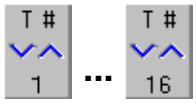
X parallel to Z_0



Procedure

Mount the tool to be calibrated onto the robot flange. Select the menu item “A B C – World”. The dialog window for selecting the tool number is then opened:

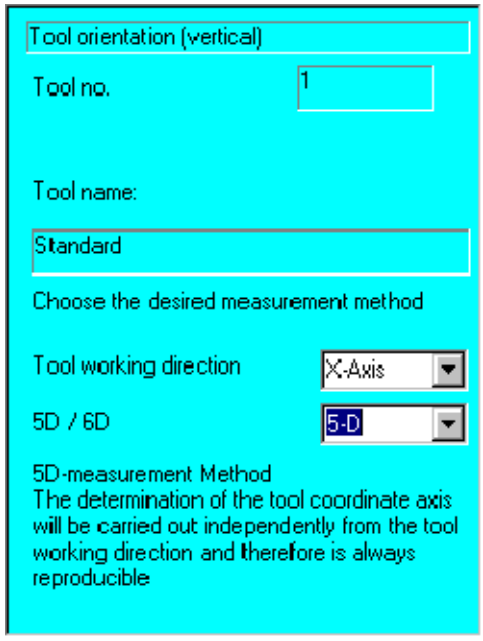


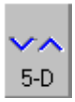


Select the tool number (1...16) which can be altered by means of the +/– keys of the corresponding status keys. The current values for the selected tool are displayed in the bottom part of the status window.

You can use the arrow keys to access the input box “Tool name” and there enter a name for the tool.

OK Press the softkey “OK” in order to enter data for this tool.

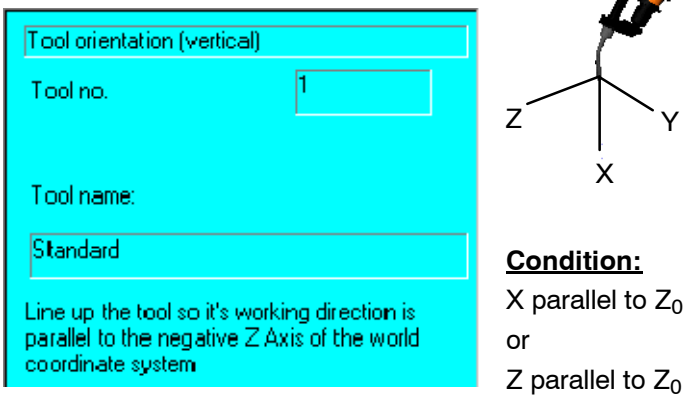


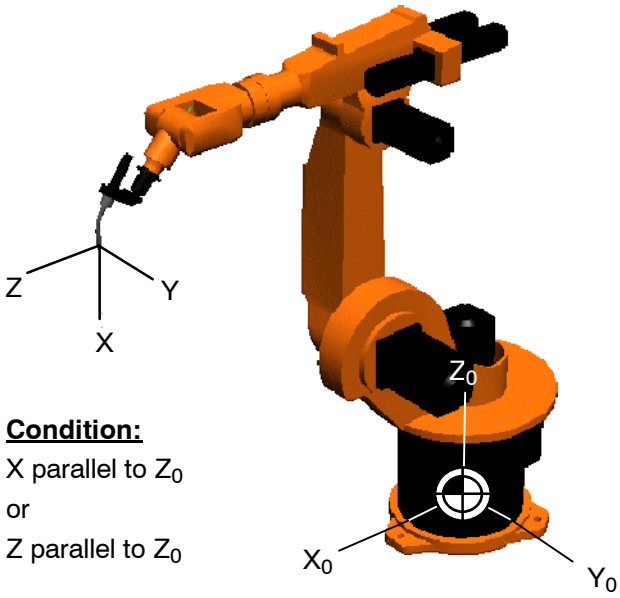


If the “6D” option is activated, you must select the “5D” method using the status key.

OK

Then press the softkey “OK” in order to be able to edit the tool data. You will now be prompted to align the tool .





Condition:

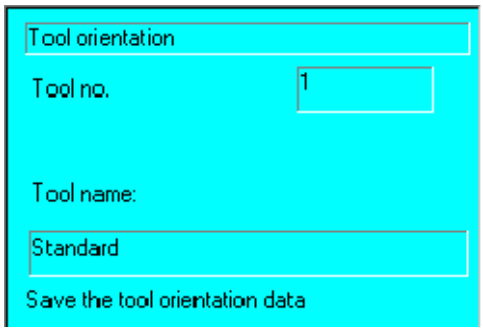
X parallel to Z_0

or

Z parallel to Z_0

OK

When all entries have been made, confirm them by pressing the softkey “OK”.



Save

Save the tool data by pressing the softkey “Save”. The function is terminated.

At this point you can open the corresponding subprograms by means of the softkeys “Load data” or “Meas. Pt.”.

In the event of 5D calibration, the angle “C” (corresponding to a rotation about the X–axis of the tool direction) is set by default to “0”.

2.2.4.2 The “A B C – World (6D)” method

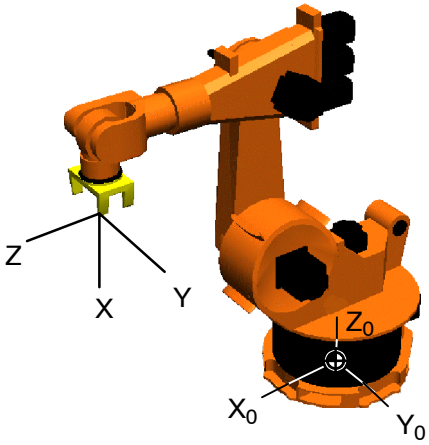
In this method, the tool must be oriented in alignment with the world coordinate system. The axes of the tool coordinate system must be parallel to the axes of the world coordinate system.

Conditions:

X parallel to Z_0

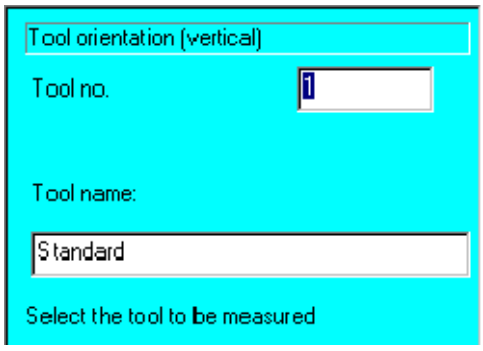
Y parallel to Y_0

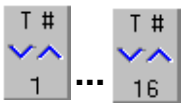
Z parallel to X_0



Procedure

Mount the tool to be calibrated onto the robot flange. Select the menu item “A B C – World”. The dialog window for selecting the tool number is then opened:

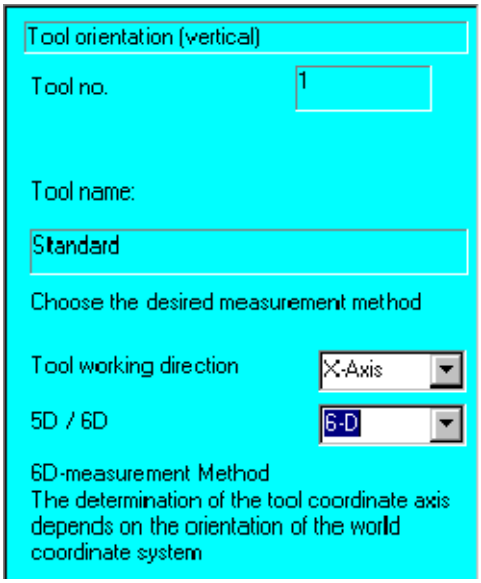


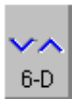


Select the tool number (1...16) which can be altered by means of the +/– keys of the corresponding status keys . The current values for the selected tool are displayed in the bottom part of the status window.

You can use the arrow keys to access the input box “Tool name” and there enter a name for the tool.

OK Press the softkey “OK” in order to enter data for this tool.

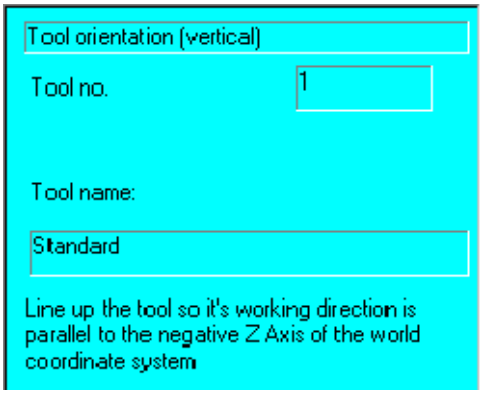


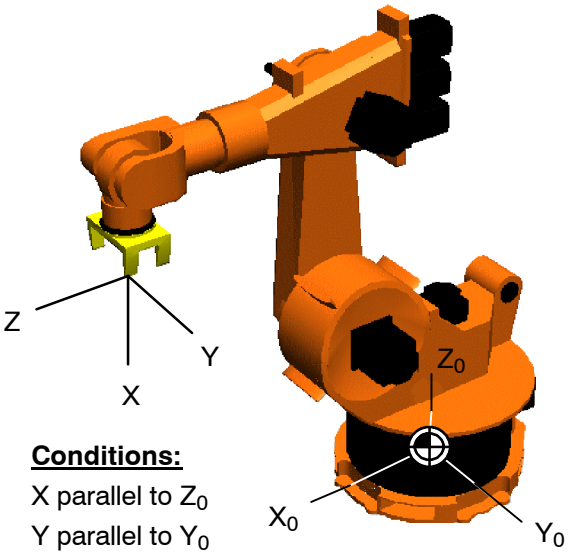


If the “5D” option is activated, you must select the “6D” method using the status key.

OK

Then press the softkey “OK” in order to be able to edit the tool data. You will now be prompted to align the tool.





Conditions:

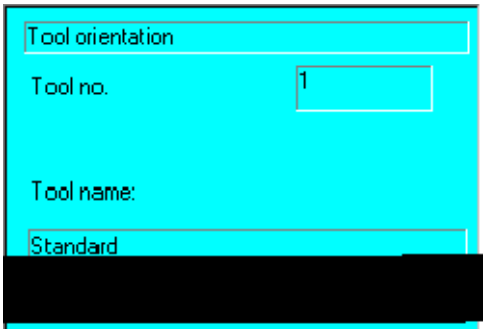
X parallel to Z_0

Y parallel to Y_0

Z parallel to X_0

OK

When all entries have been made, confirm them by pressing the softkey “OK”.



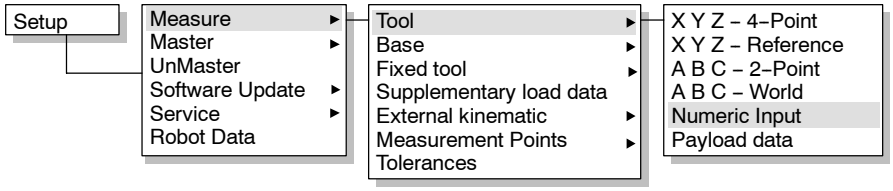
Save

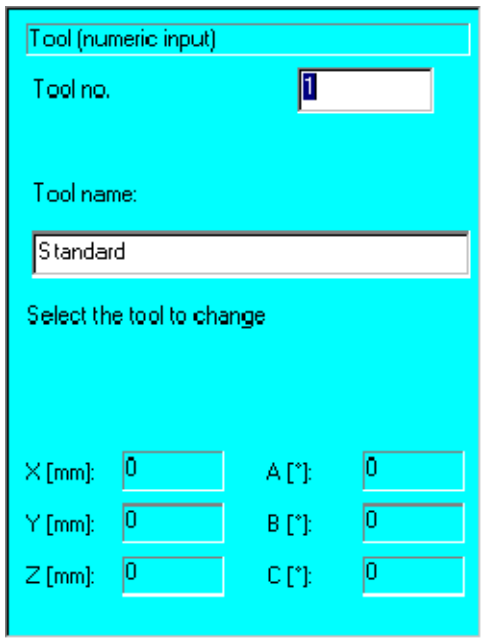
Save the tool data by pressing the softkey “Save”.

At this point you can open the corresponding subprograms by means of the softkeys “Load data” or “Meas. Pt.”.

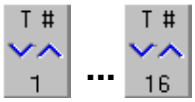
2.2.5 Numeric Input

This menu item enables you to enter the numeric values of a fixed tool.





The corresponding dialog window is then opened:

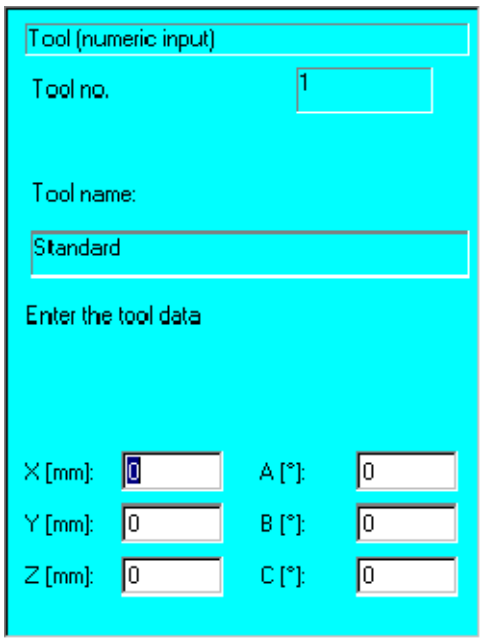


Select the tool number from 1...16 using the status key at the bottom right of the display.

You can use the arrow keys to access the input box “Tool name” and there enter a name for the tool.

OK

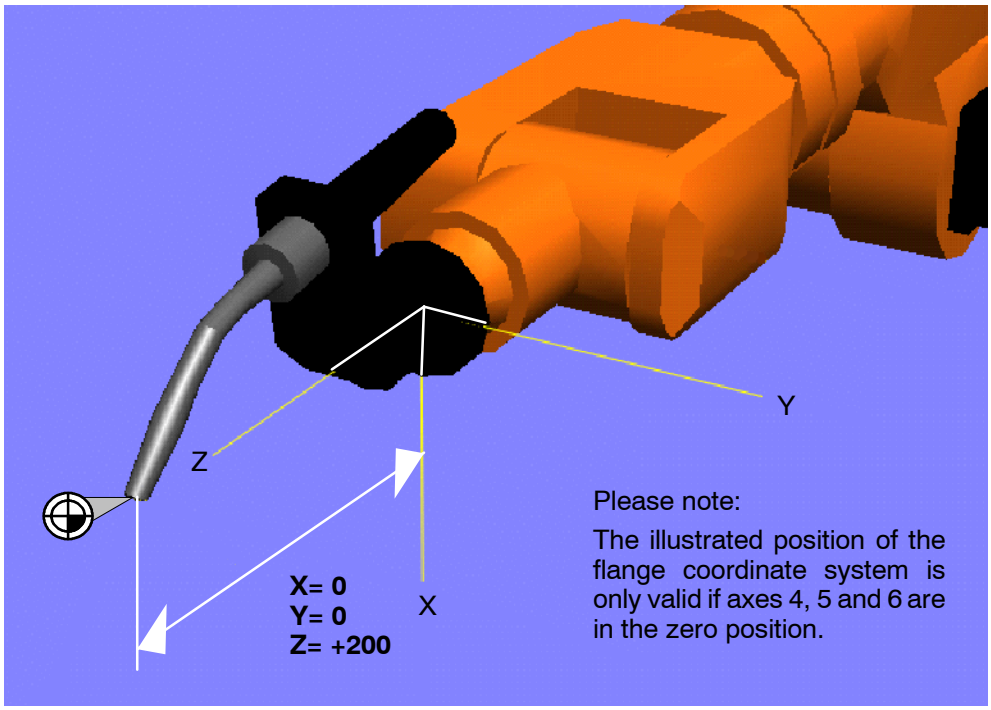
Press the softkey “OK” in order to edit the data for this tool. The dialog window for data entry is opened.



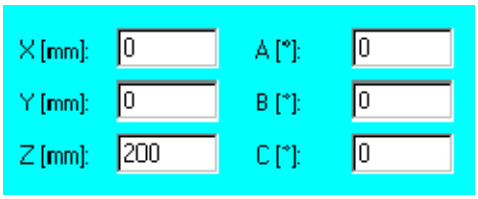
You can move between the input boxes using the “↓” and “↑” arrow keys and enter the desired values.

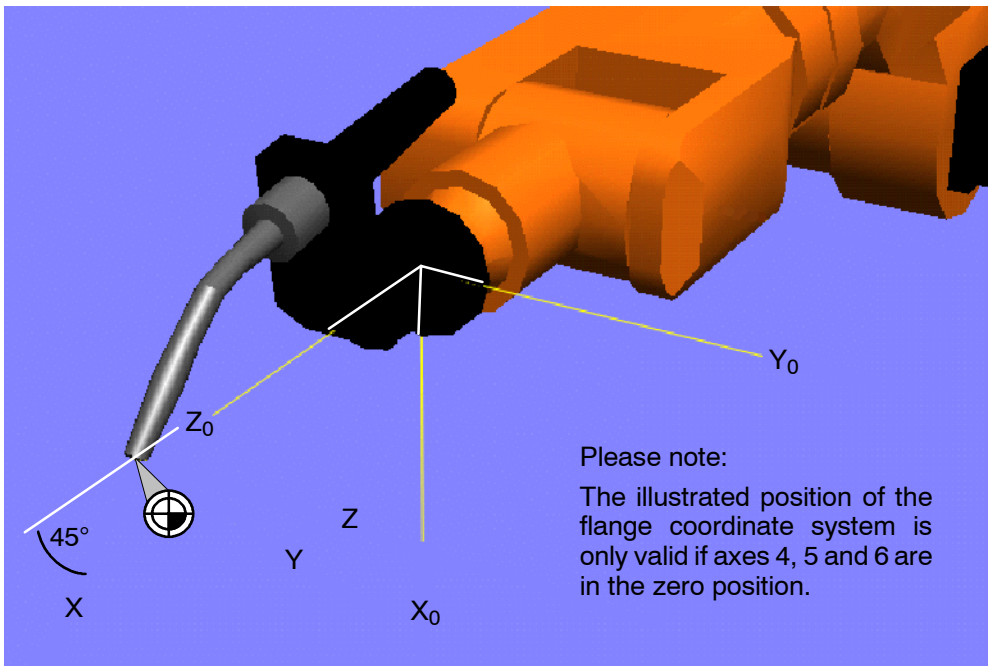
The abbreviations in the dialog window have the following meaning:

X, Y, Z Position of the TCP relative to the origin of the robot flange coordinate system (located at the center of the flange).

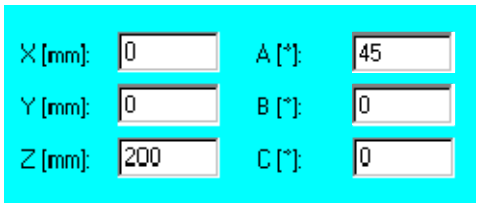


In the example:



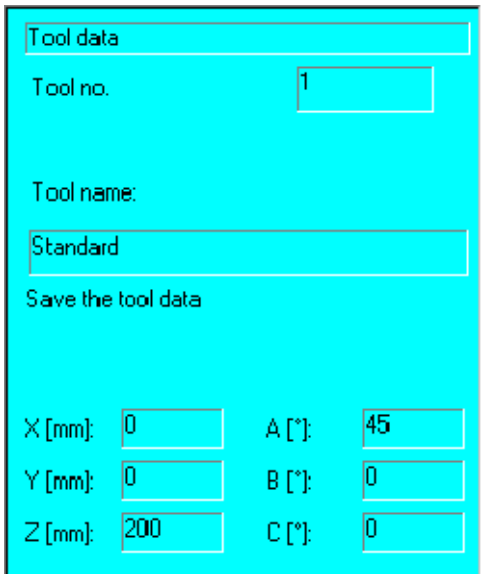


In the example:



OK

When all entries have been made, confirm them by pressing the softkey “OK” and save the entries that have just been made.



Save

The tool number and tool data are displayed in the form. These data are saved and the form is closed by pressing the softkey “Save”.

At this point you can open the corresponding subprogram by means of the softkey “Load data”.

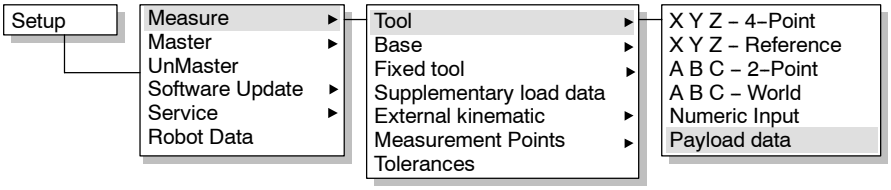
2.2.6 Payload data

In order to optimize use of the available maximum moments of acceleration of the robot axes, it is possible to enter the load data of the tool that is being used.

If loads lower than those actually existing are programmed, the robot system is liable to be mechanically or electrically overloaded.

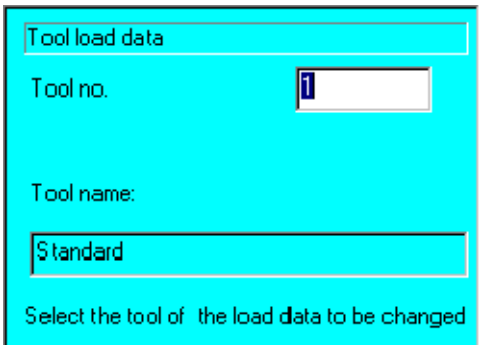
If the tool load is greater than the permissible rated load given in the payload diagram of the robot specification, mechanical or electrical overloads of the robot system are liable to occur in the case of LIN and CIRC motions. This is dependent on the programmed path velocity and the position of the robot.

No liability will be accepted for any resultant damage!

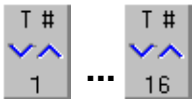


It is possible to branch directly to the tool load data from the calibration programs “X Y Z – Reference”, “A B C – 2–Point”, “A B C – World” and “Numeric Input”. It is not possible, in this case, to enter a tool number.

The relevant dialog window is then opened in which you can enter the number of the tool to be changed:



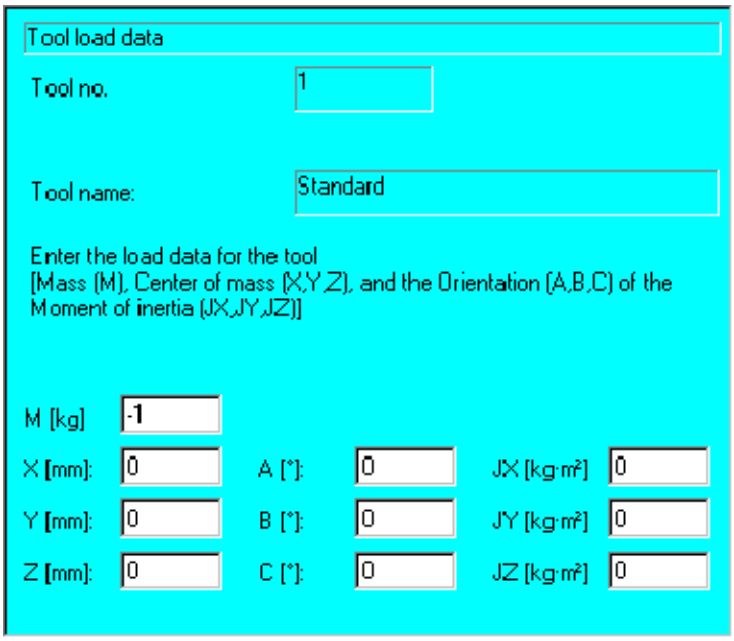
The relevant dialog window is then opened in which you can enter the number of the tool to be changed:



Here also a total of 16 different tools can be entered.

OK

Press the softkey “OK” in order to be able to edit the data for the selected tool. The status window for data entry is then opened.



You can move between the input boxes with the aid of the "↓" and "↑" arrow keys and enter the desired values using the number keys in the numeric keypad.

or

Default — Press the softkey "Default" in the bottom part of the display to accept the standard load data defined in the basic settings of the system.

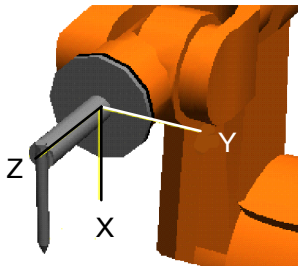
The default setting in the box "M [kg]" is –1 (load specified in the machine datum). If 0 is entered here, there is no tool load on the robot arm.

Check beforehand by referring to the payload diagram in the robot specification whether the tool lies within the permissible range for standard loads!

The abbreviations in the dialog window have the following meaning:

M Weight of the tool.

X, Y, Z Distance between the center of gravity of the tool and the origin of the robot flange coordinate system (located at the center of the flange) in relation to the robot flange coordinate system.

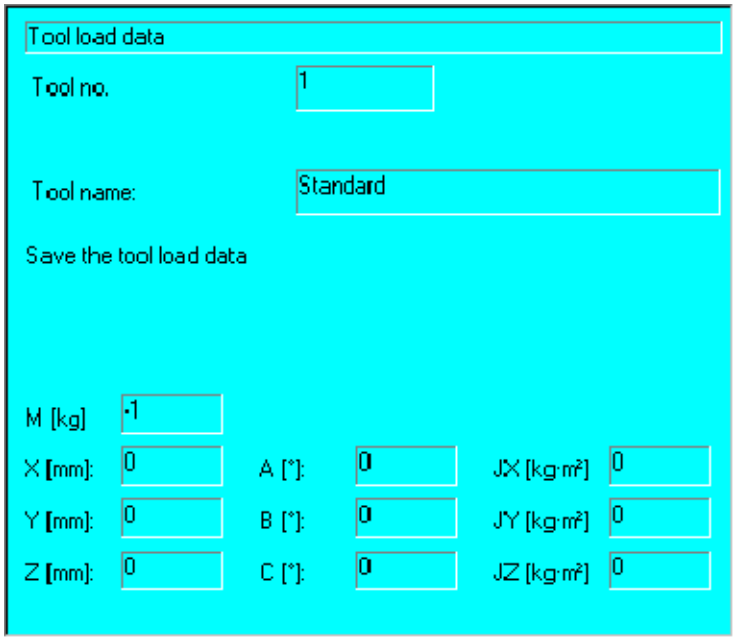


A, B, C Rotational offset of the principal inertia axes of the tool (Z–Y–X Euler angles) from the robot flange coordinate system.

JX, JY, JZ Mass moments of inertia about the principal inertia axes of the tool.

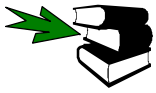
OK

When all entries have been made, confirm them by pressing the softkey “OK”. The tool load data are displayed for control purposes.



Save

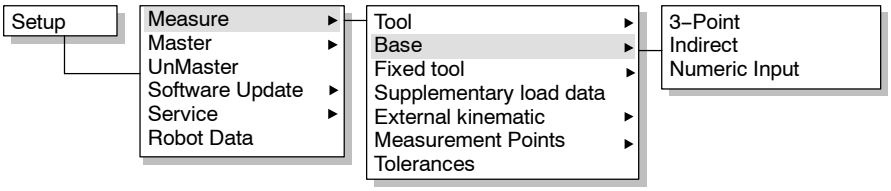
The softkey “Save” is then used to save the data and close the dialog window.



Further information on the calculation of tool load data can be found in the separate documentation **Load Data Determination**.

2.3 Base

This submenu is used for calibrating a workpiece which is not guided by the robot.



The submenu “Base” contains the following subprograms:

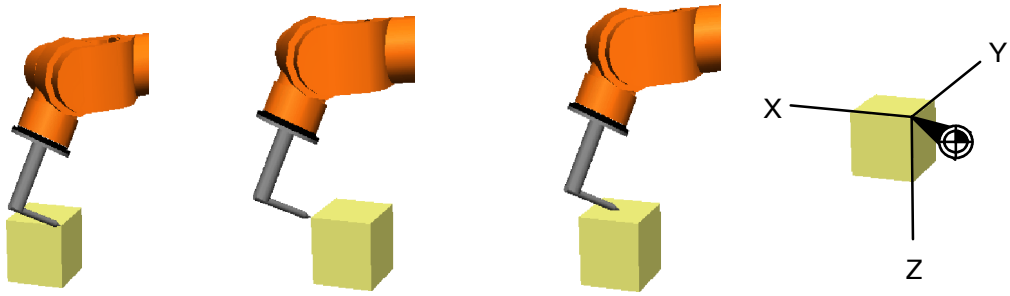
Program	Calibration by...
3–Point	moving to the reference point of a workpiece
Indirect	entering the inaccessible reference point of a workpiece
Numeric Input	entering a reference point manually

Each of these calibration programs is assigned forms that guide you interactively through the program.

2.3.1 3–Point

This method is used to determine the reference point of a workpiece (BASE).

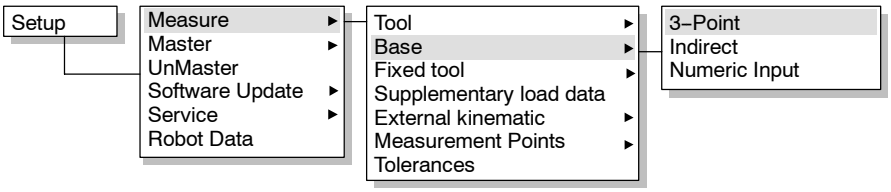
This is done by positioning a tool whose dimensions are known to the controller to three specific points, which are then programmed. These three points determine both the position of the origin and the orientation of the base coordinate system.

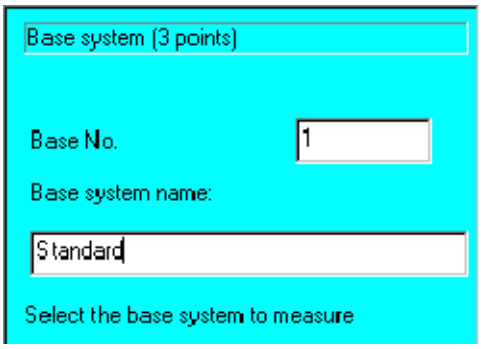


Origin | Point on the X–axis | Point in the XY plane with a positive Y value | Result

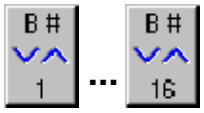
Procedure

Mount a tool whose dimensions are known to the controller onto the robot flange.





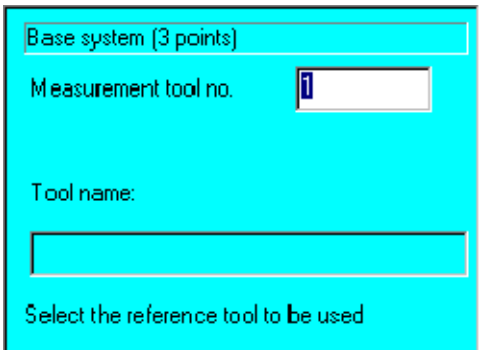
The input window for the base system is opened.



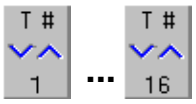
Use the +/– status key to select the base coordinate system.

You can use the arrow keys to access the input box “Base system name” and there enter a name for the base system.

OK Press the softkey “OK” to open the next input window.

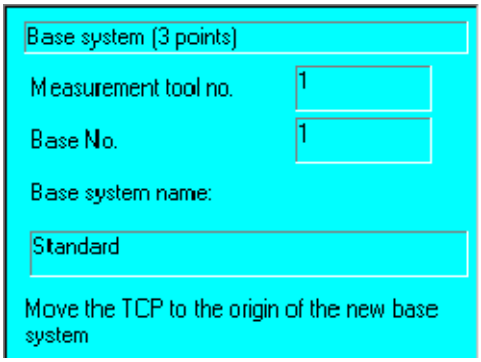


The input window for selecting the reference tool is opened.



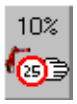
Use the +/– status key to select the tool number.

OK Press the softkey “OK” in order to perform the calibration with this tool. The next window is then opened.



You are prompted to position the TCP to the future origin of the base coordinate system (BASE).

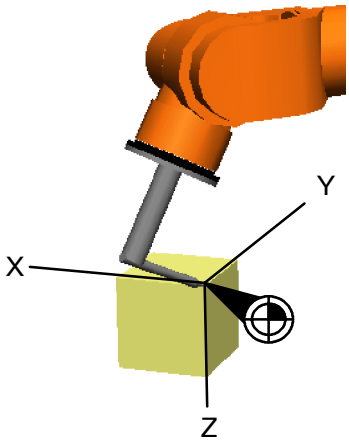
Reduce the path velocity in the vicinity of the workpiece in order to avoid a collision.

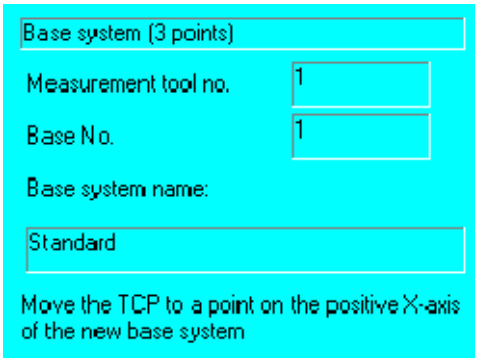


To do so, repeatedly press the override status key.

OK

When the TCP is located exactly at the desired origin of the base coordinate system (BASE), save this position by pressing the softkey “OK”.



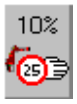


The next window is opened.

You are prompted to show the controller the orientation of the X axis by positioning a specific point to the TCP.

First move the tool away from the reference object.

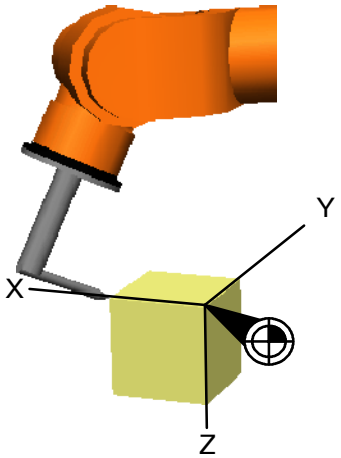
Reduce the path velocity in the vicinity of the workpiece in order to avoid a collision.

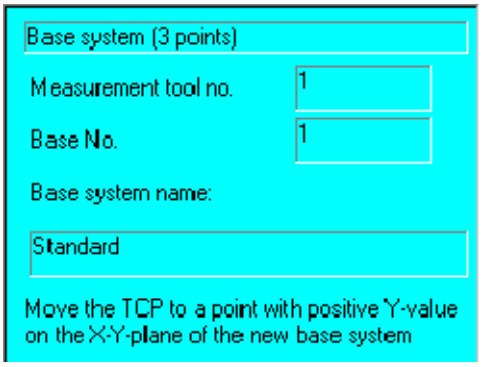


To do so, repeatedly press the override status key.

OK

When the TCP is located exactly on the desired point, save this position by pressing the softkey “OK”.



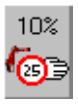


The dialog window illustrated here is opened.

You are prompted to show the controller the orientation of the XY plane by moving the tool to a point with a positive Y value.

First move the tool away from the workpiece:

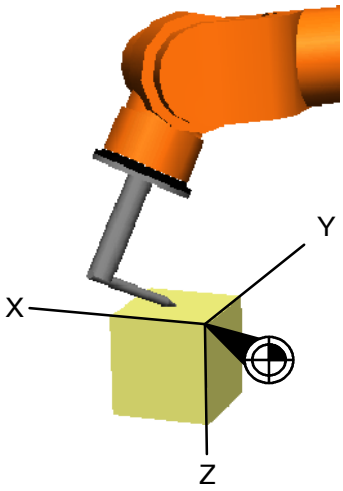
Reduce the path velocity in the vicinity of the workpiece in order to avoid a collision.

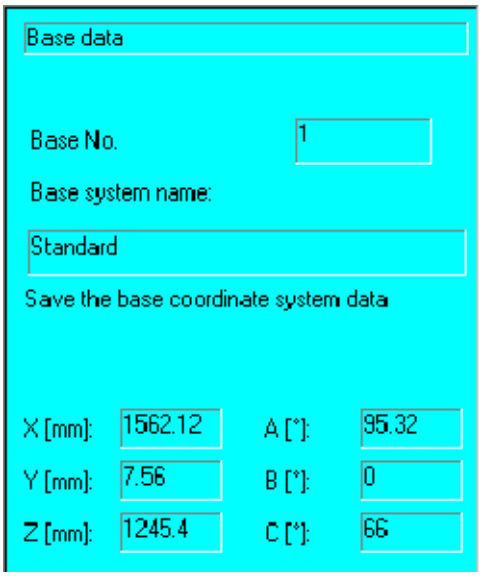


To do so, repeatedly press the override status key.

OK

When the TCP (tool center point) is located exactly at the point with a positive Y value on the XY plane, save this position by pressing the softkey “OK”.





Save

Save the base coordinate system data by pressing the softkey “Save”. The function is terminated.

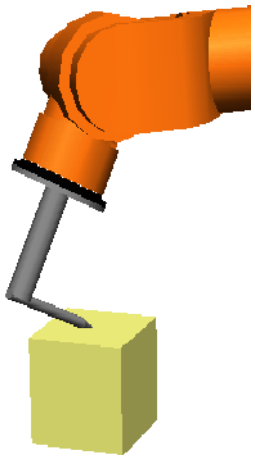
Meas. Pt.

When the softkey “Meas. Pt.” is pressed, a window appears in which the values of the individual measurements are listed once again.

2.3.2 Indirect

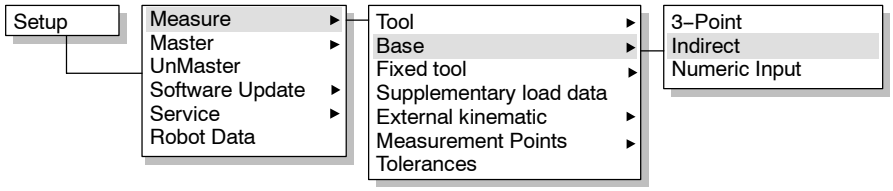
This method is used if the reference point of the workpiece (BASE) is not located inside the work envelope of the robot (in the case of very large workpieces) or cannot be reached by the robot (workpieces of complex shape).

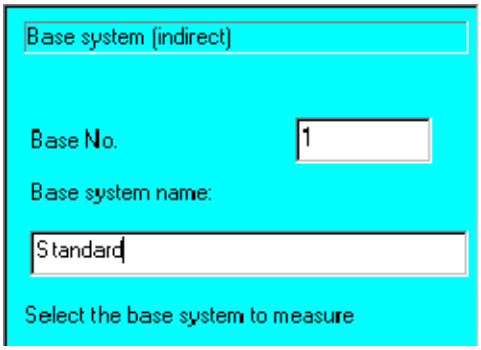
In this method, the robot is moved to four points whose positions are known (manufacturing drawing, CAD data, etc.). The tool dimensions must be known to the controller.



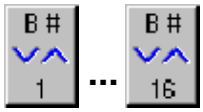
Procedure

Mount a tool whose dimensions are known to the controller onto the robot flange.



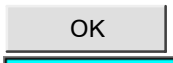


The input window for selecting the base coordinate system is opened.

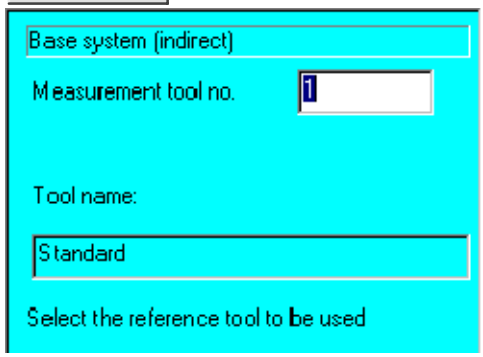


Use the status key to select the workpiece number.

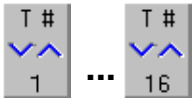
You can use the arrow keys to access the input box “Base system name” and there enter a name for the base system.



Press the softkey “OK” in order to enter data for this workpiece.

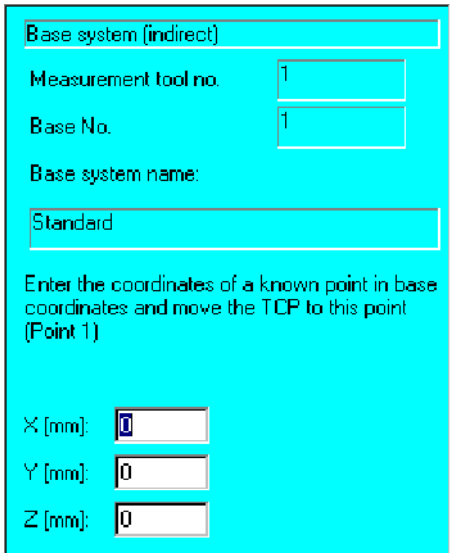


The input window for selecting a tool is opened.



Use the +/– status key to select the tool number.

OK Press the softkey “OK” in order to perform the calibration with this tool.



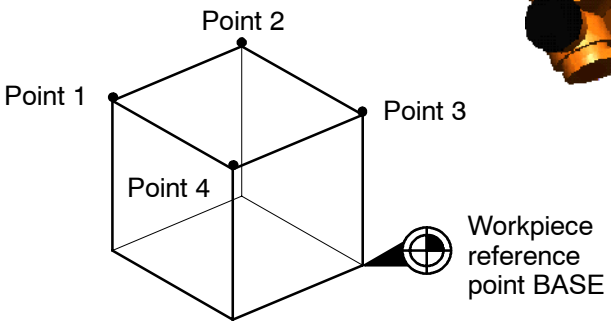
The window illustrated here is opened.

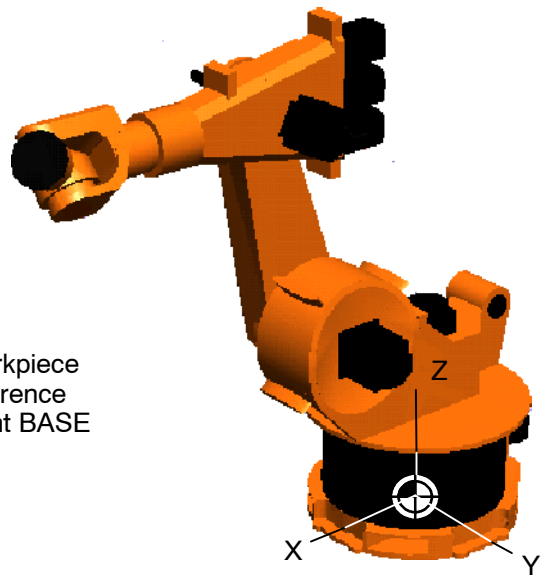
You are prompted to enter the coordinates of points known to you and then to position the TCP to these points. To do so, carry out the following procedure:

Step 1 – Enter the values by means of the numeric keypad.

You can move between the input boxes using the “↓” arrow key.

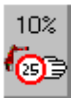
X, Y, Z Distance between the calibration point and the workpiece reference point (BASE).





Step 2 – Move the TCP to the specified point.

Reduce the path velocity in the vicinity of the workpiece in order to avoid a collision.



To do so, repeatedly press the jog override status key.

Step 3 – Save the point

OK

When the TCP is located exactly at the point you specified beforehand, save this position by pressing the softkey “OK”.

After the point has been accepted by the controller, you are prompted to move the TCP to the next three points. Repeat steps 1 to 3 until all four points have been addressed.

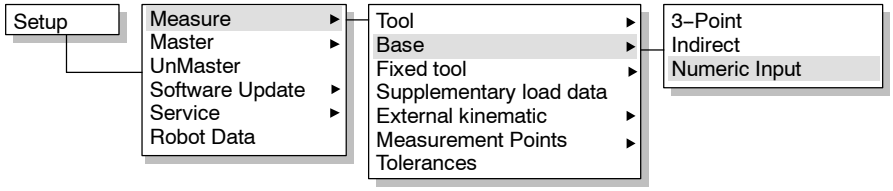
Meas. Pt.

When the softkey “Meas. Pt.” is pressed, a window appears in which the values of the individual measurements are listed once again.

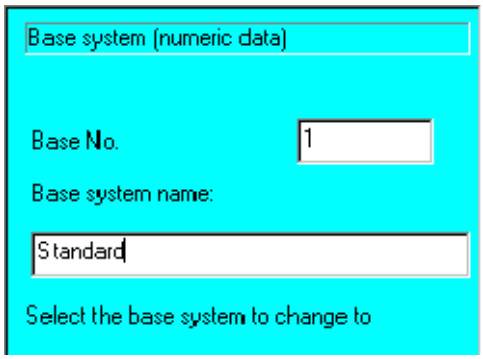
Save

At the end of the calibration procedure, you will be offered the softkey “Save” (at the bottom of the display). **Save the workpiece data by pressing this softkey.** The function is then terminated.

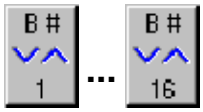
2.3.3 Numeric Input



The input window for the base coordinate system is opened.



The input window for the base coordinate system is opened.

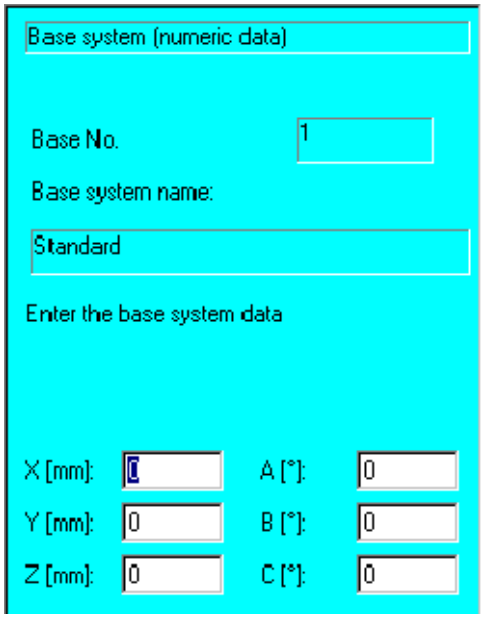


Use the +/– status key to select the desired coordinate system.

You can use the arrow keys to access the input box “Base system name” and there enter a name for the base system.

OK

Press the softkey “OK” in order to enter the corresponding data.



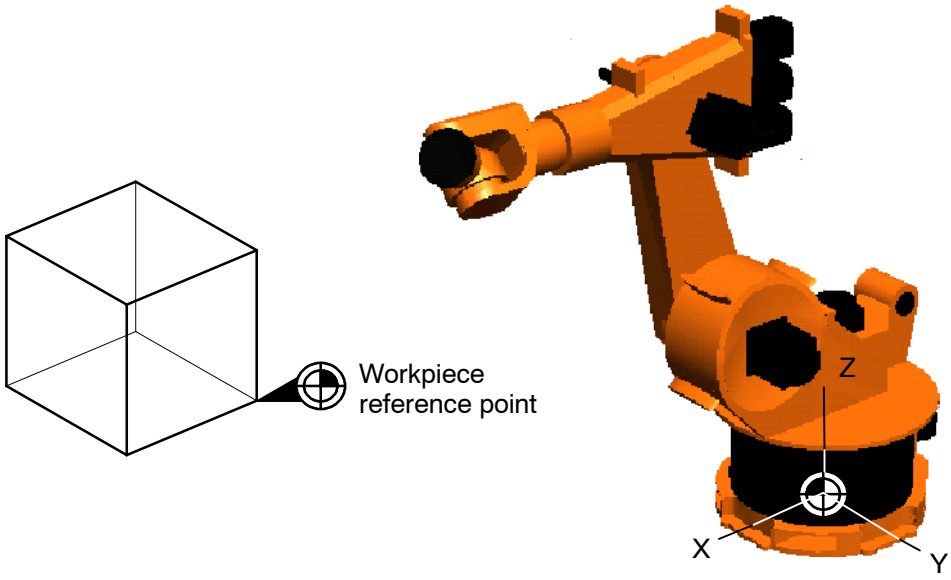
The window illustrated here is then opened.

Enter the values by means of the numeric keypad.

Enter the values by means of the numeric keypad.

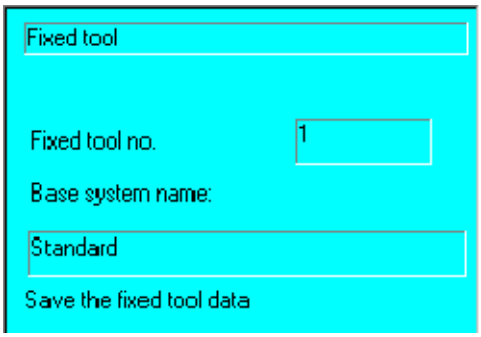
You can move between the input boxes using the "↓" arrow key.

X, Y, Z Distance between the origin of the world coordinate system and the workpiece reference point (BASE) in relation to the world coordinate system.



A, B, C Rotational offset of the base coordinate system (Z–Y–X Euler angles) from the world coordinate system.

OK When all entries have been made, confirm them by pressing the softkey "OK".

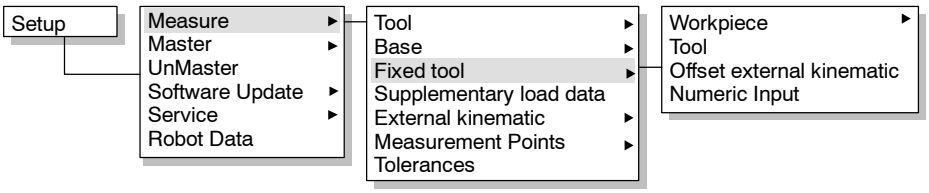


Save

Save the workpiece data by pressing the softkey “Save”. The function is terminated.

2.4 Fixed tool

This menu can be used for calibrating a workpiece guided by the robot or a tool that is not mounted on the robot.



The submenu “Fixed tool” contains the following subprograms:

Program	Calibration by...
Workpiece	Moving with a workpiece mounted on the robot flange
Tool	moving the robot to a fixed tool
Offset external kinematic	moving the robot to a fixed tool on an external kinematic system
Numeric Input	entering a fixed tool manually

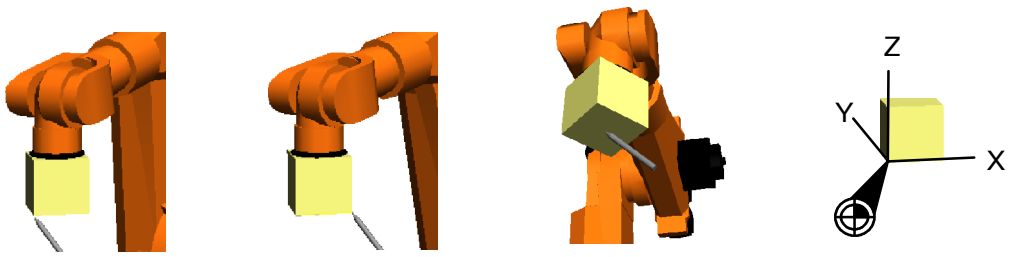
Each of these calibration programs is assigned forms that guide you interactively through the program.

2.4.1 Workpiece

2.4.1.1 Direct measuring

This method is used to determine the reference point of a workpiece mounted on the robot flange.

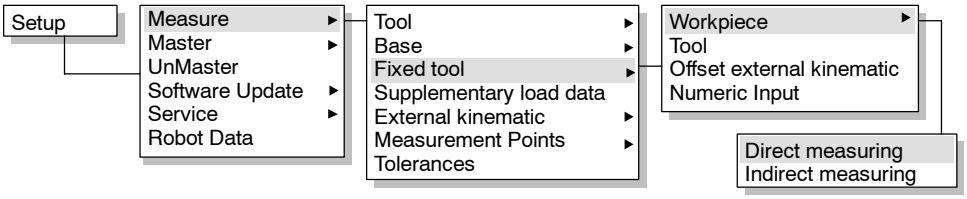
This is done by positioning and saving three specific points on the workpiece to a fixed tool whose dimensions are known to the controller. These three points determine both the position of the origin and the orientation of the base coordinate system.

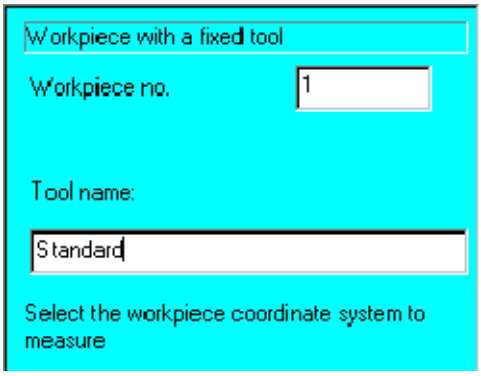


Origin | Point on the X–axis | Point in the XY plane | Result

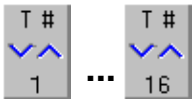
Procedure

Install a fixed tool whose dimensions are known to the controller.





The input window illustrated here is opened.

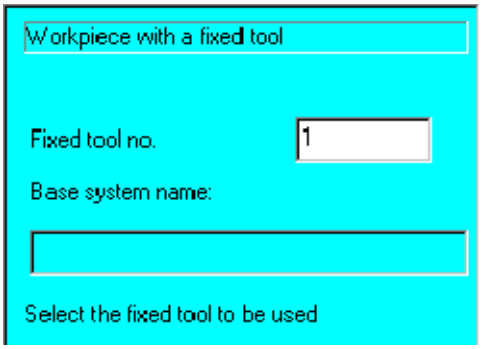


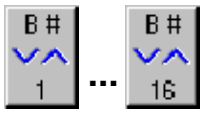
Use the +/– status key to select the workpiece coordinate system.

You can use the arrow keys to access the input box “Tool name” and there enter a name for the tool.

OK Press the softkey “OK” to access the next input window.

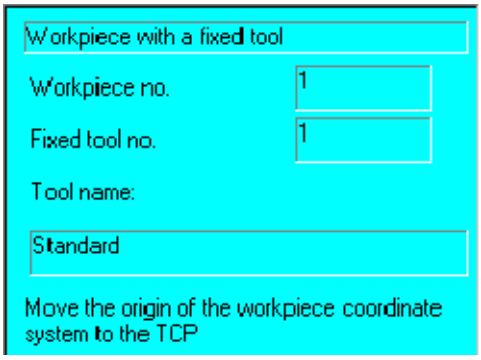
The next window is then opened.





Use the +/– status key to select the tool number.

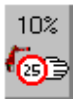
OK Press the softkey “OK” in order to perform the calibration with this tool.



The window illustrated here is opened.

You are prompted to position the future origin of the base coordinate system (BASE) to the TCP (center point) of the fixed tool.

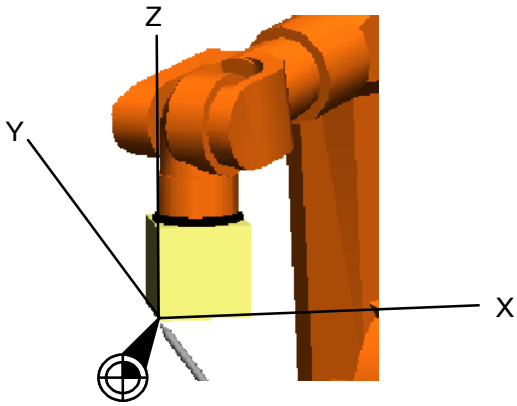
Reduce the path velocity in the vicinity of the fixed tool in order to avoid a collision.

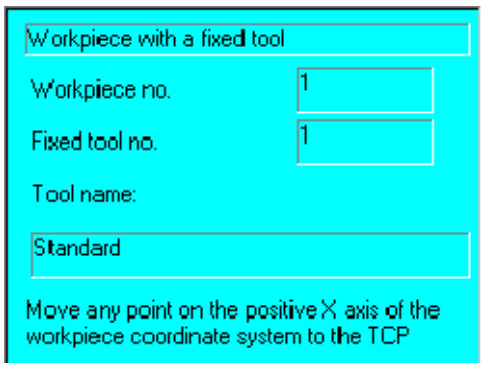


To do so, repeatedly press the override status key.

OK

When the TCP is located exactly on the desired origin (BASE), save this position by pressing the softkey “OK”.



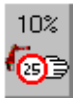


The next window is opened.

You are prompted to show the controller the orientation of the X axis by positioning a specific point to the TCP.

First move the workpiece away from the TCP.

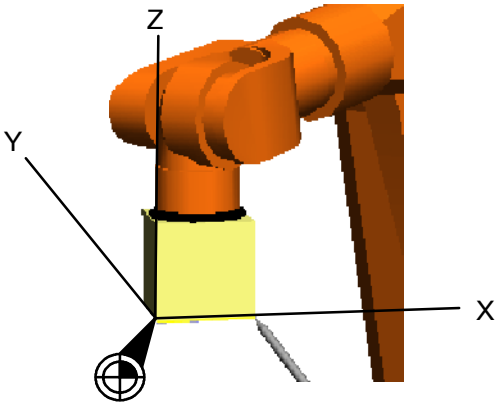
Reduce the path velocity in the vicinity of the fixed tool in order to avoid a collision.

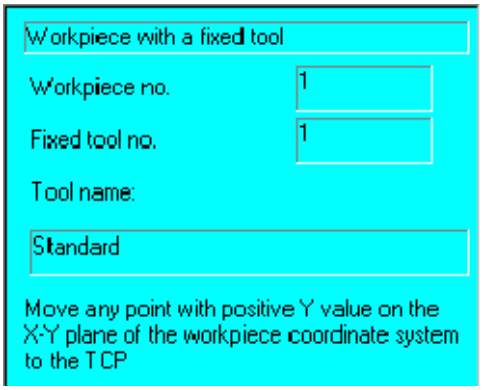


To do so, repeatedly press the override status key.

OK

When the TCP is located exactly on the desired point, save this position by pressing the softkey “OK”.





You are prompted to show the controller the orientation of the XY plane by positioning a specific point to the TCP.

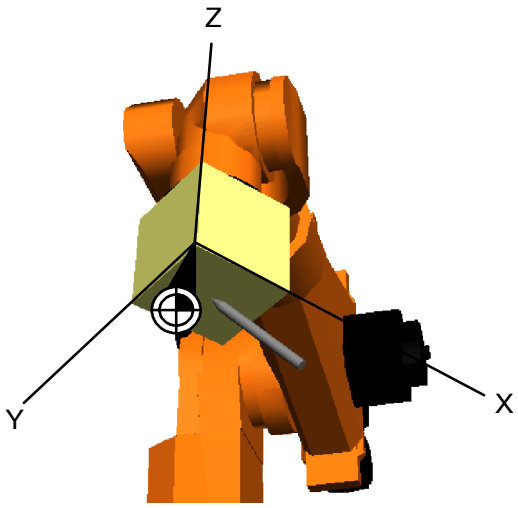
First move the workpiece away from the TCP.

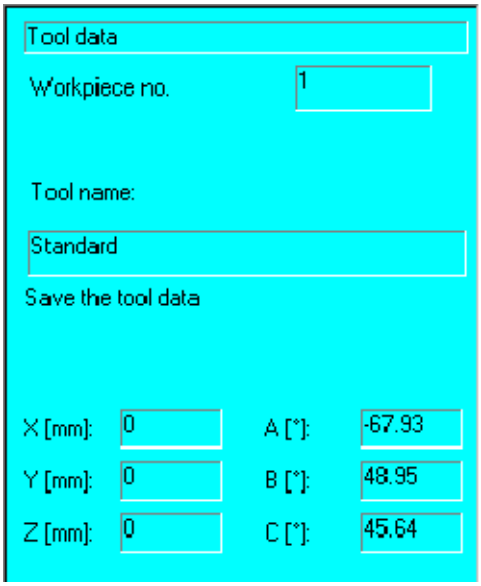
Reduce the path velocity in the vicinity of the fixed tool in order to avoid a collision.

To do so, repeatedly press the jog override status key.

OK

When the TCP is located exactly at the point with a positive Y value on the XY plane, save this position by pressing the softkey “OK”.





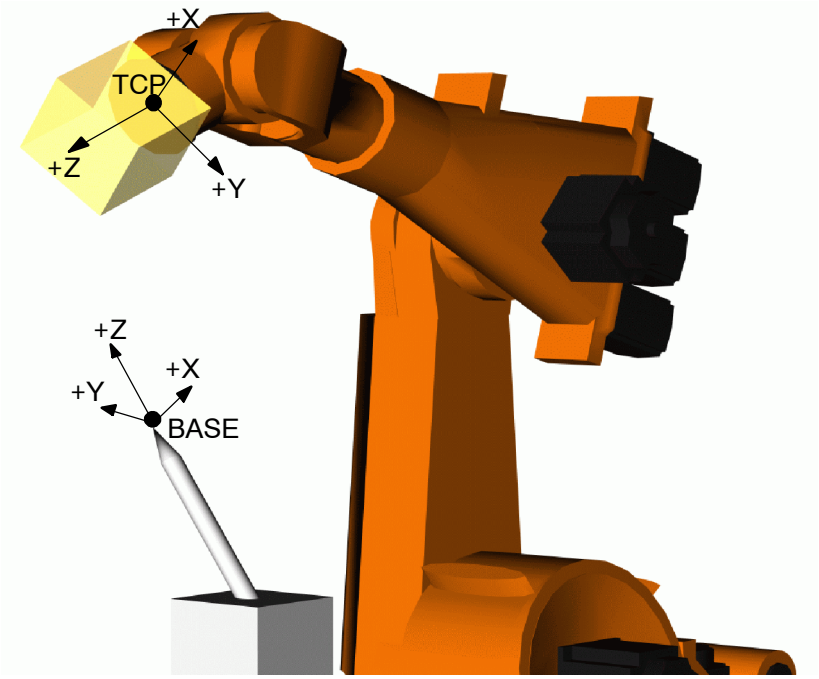
At this point you can open the corresponding subprograms by means of the softkeys “Load data” or “Meas. Pt.”.

Save

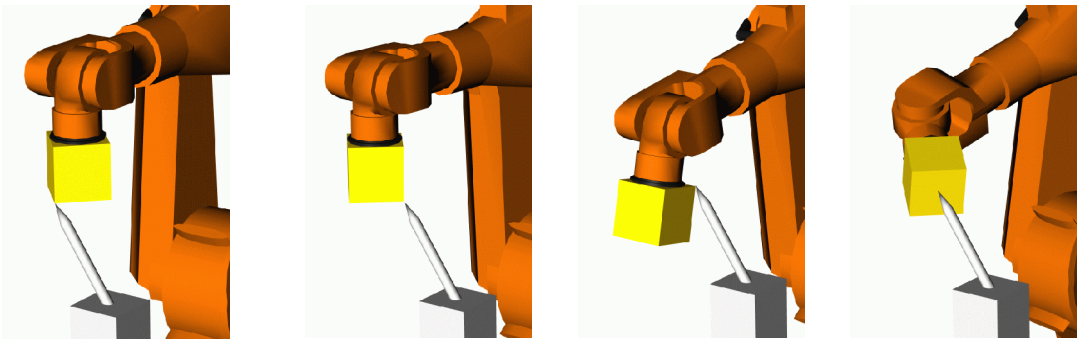
Save the workpiece data by pressing the softkey “Save”. The function is then terminated.

2.4.1.2 Indirect measuring

This method is also used to determine the reference point of a workpiece mounted on the robot flange. Unlike with direct measuring, it is not necessary to address the TCP. This method is thus highly suited in situations when it is not possible to address the TCP.



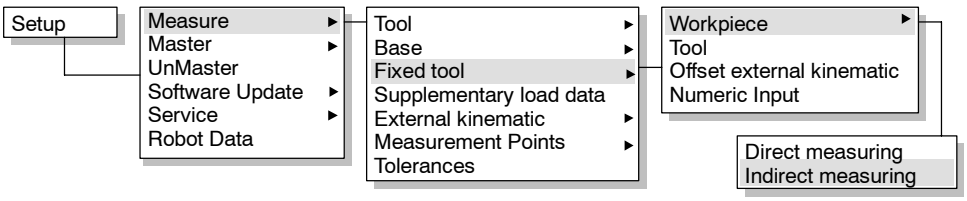
Four different points on the workpiece are addressed one after the other and their coordinates relative to the TCP are entered numerically.

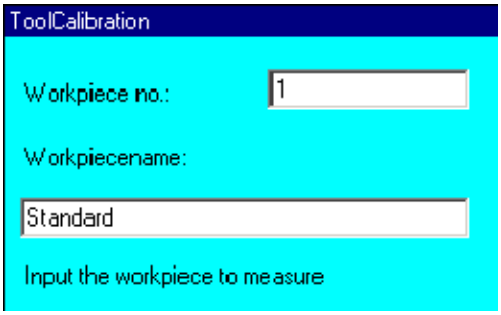


Any four points on the workpiece

Procedure

If necessary, install a fixed reference tool whose dimensions are known to the controller.





The status window illustrated here is opened.

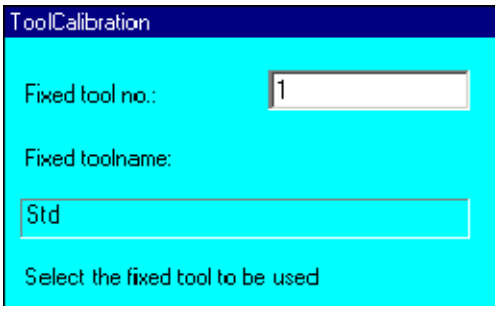
Using the numeric keypad, enter the number of the desired workpiece coordinate system. You can use the arrow keys to access the input box “Workpiecename” and there enter a name for the tool.

OK

Press the softkey “Continue” in order to continue the calibration and call the next status window.

Cancel

The softkey “Cancel” can be used at any time to terminate the calibration without saving the data that have been calculated.



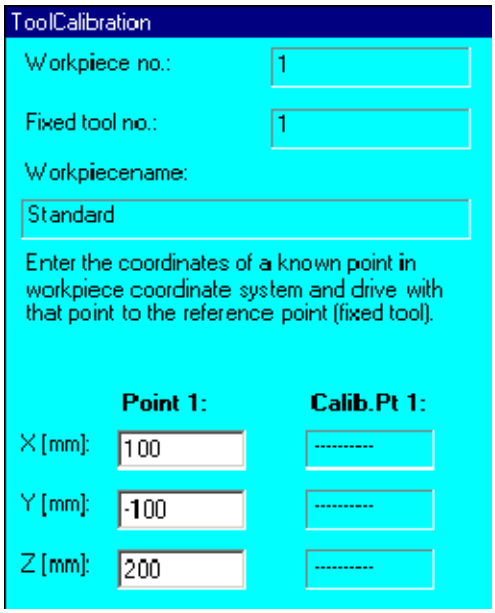
In the next status window, use the numeric keypad to enter the number of the fixed tool to be used.

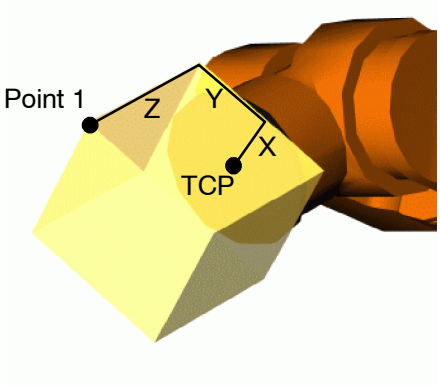
Back

Pressing “Back” returns you to the previous status window.

OK

Press the softkey “Continue” to open the next status window.

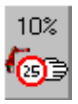




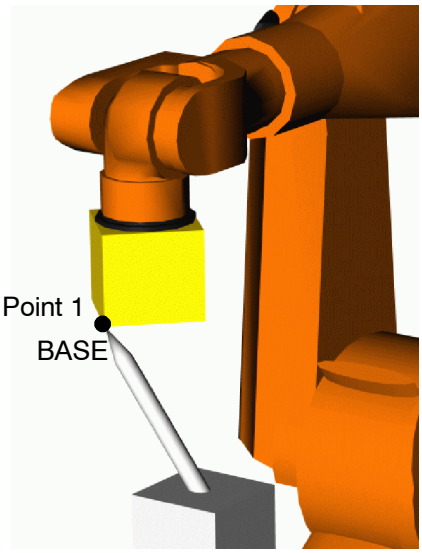
Enter, in the corresponding input boxes, the coordinates of the first point on the workpiece relative to the TCP.

Then move the robot so that this point comes to rest on the reference point of the fixed tool (BASE).

Reduce the path velocity in the vicinity of the fixed tool in order to avoid a collision.

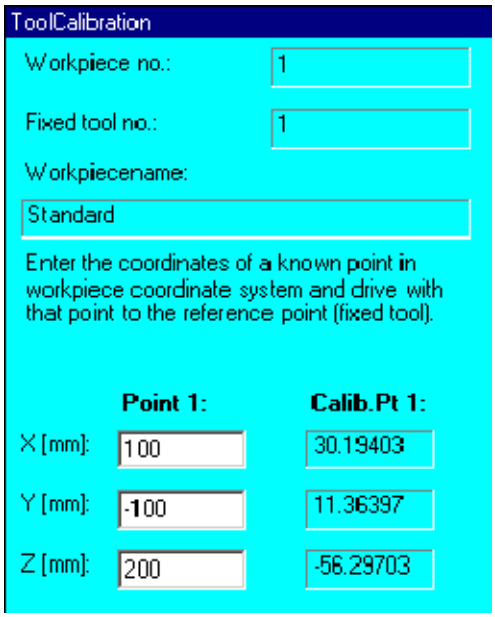


This can be done by pressing the jog override status key.



First point on the workpiece and reference point are touching

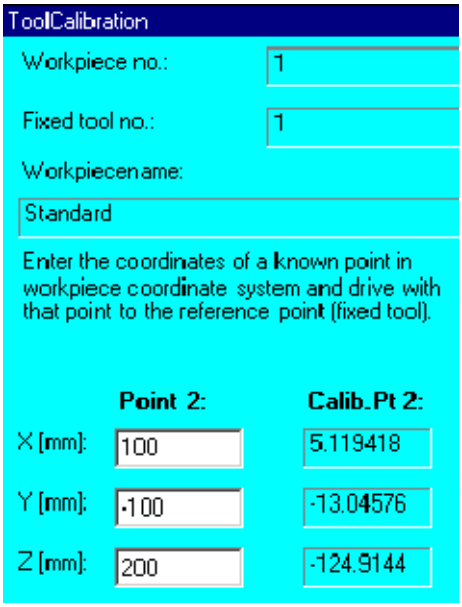
Measure — Once the two points are touching, press the softkey “Measure”. The coordinates of the first point are then displayed under “Calib. Pt. 1:”.

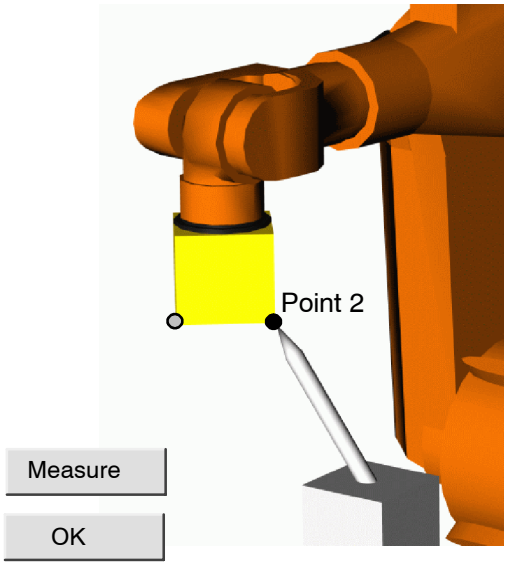


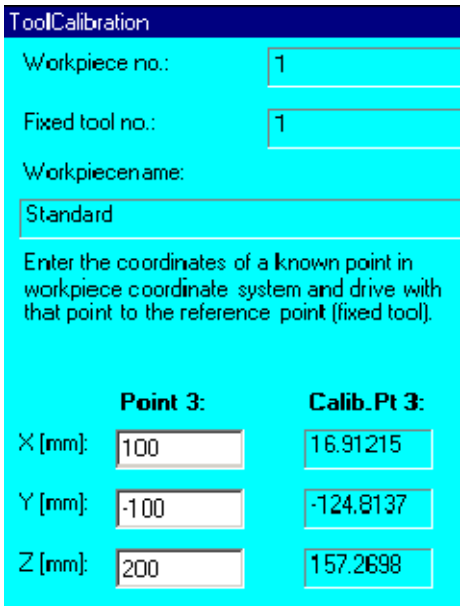
Back — Pressing “Back” returns you to the previous status window.

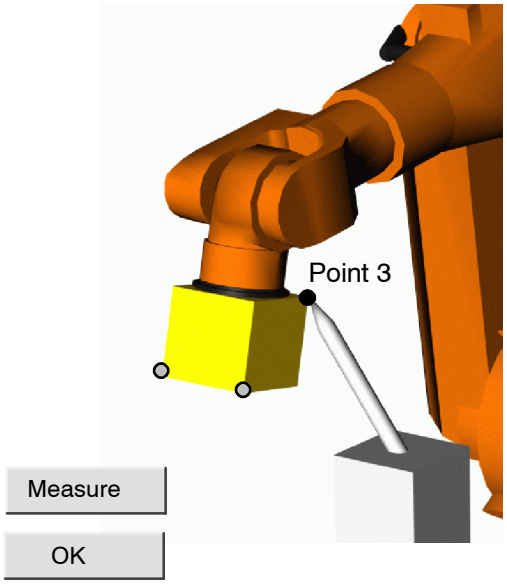
OK — The softkey “Continue”, which opens the next status window, is only available if the softkey “Measure” has been pressed.

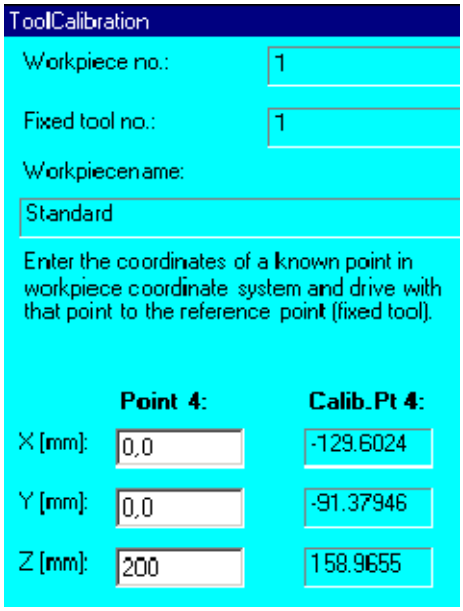
Repeat the same procedure for the remaining points.

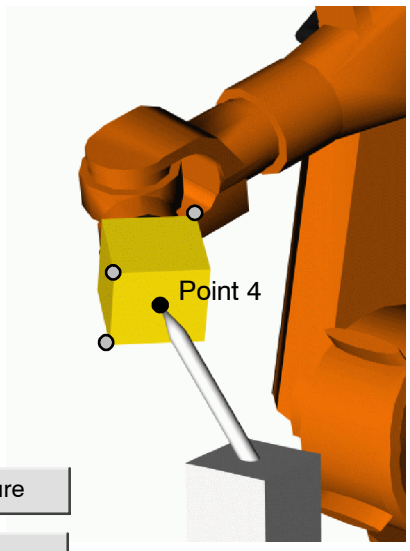

ToolCalibration
Workpiece no.:
1
Fixed tool no.:
1
Workpiecename:
Standard
Enter the coordinates of a known point in workpiece coordinate system and drive with that point to the reference point (fixed tool).
Point 2:
Calib.Pt 2:
X [mm]:
100
5.119418
Y [mm]:
-100
-13.04576
Z [mm]:
200
-124.9144


Point 2
Measure
OK


ToolCalibration
Workpiece no.:
1
Fixed tool no.:
1
Workpiecename:
Standard
Enter the coordinates of a known point in workpiece coordinate system and drive with that point to the reference point (fixed tool).
Point 3:
Calib.Pt 3:
X [mm]:
100
16.91215
Y [mm]:
-100
-124.8137
Z [mm]:
200
157.2698

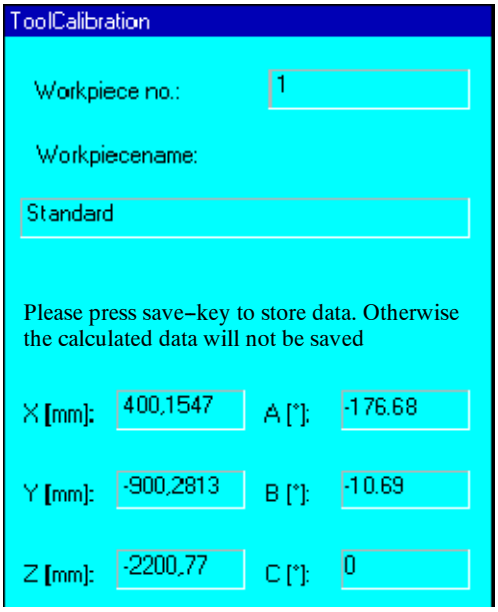

Point 3
Measure
OK





Measure

OK



The calculated coordinates of the TCP are then displayed.

Save

The softkey “Save” is used to accept the entries and terminate the calibration.

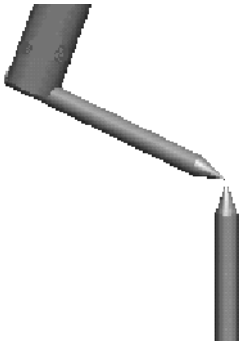
The following problems may occur, due to the fact that each entered point is checked against certain criteria when “Continue” is pressed:

Cause	Remedy
Entered point is situated too close to another entered point	Enter a point on the workpiece that is far enough away from the previously entered point
Measured point is too close to another measured point	
Measurement error too big	The difference between the entered coordinates and the measured coordinates exceeds permissible tolerances
All points in one plane	In order to allow correct calculation of the coordinates, the points must not all be situated in the same plane

In each of these cases, press the softkey “Back” to reopen the previous status window and repeat the necessary steps.

2.4.2 Tool

This method is used to determine the TCP of a tool that is stationary rather than handled by the robot.

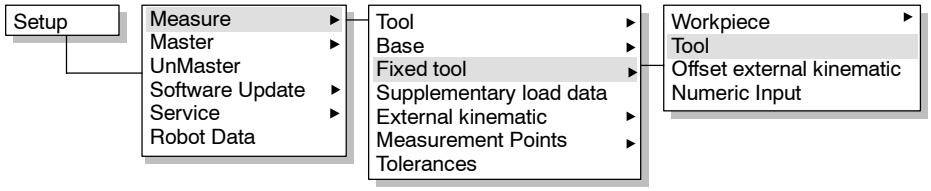


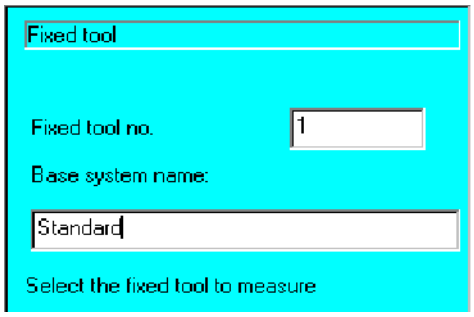
First of all, a tool of known dimensions is moved to the TCP (tool center point) of the fixed tool.

In the second step, the robot flange is then aligned perpendicular to the working direction of the tool.

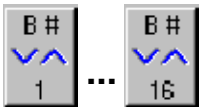
Procedure

Mount a tool whose dimensions are known to you onto the robot flange.





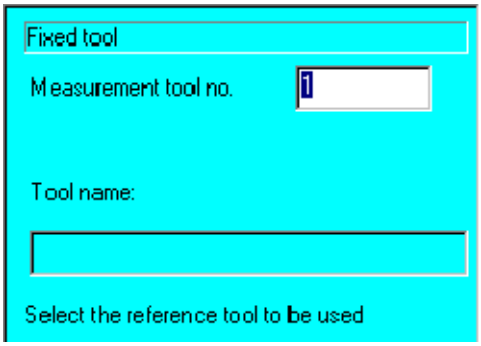
The dialog window illustrated here is opened.

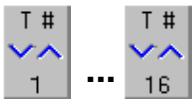


Use the +/– status key to select the tool number (1...16) of the tool to be calibrated.

You can use the arrow keys to access the input box “Base system name” and there enter a name for the base system.

Press the softkey “OK” to open the next dialog window.

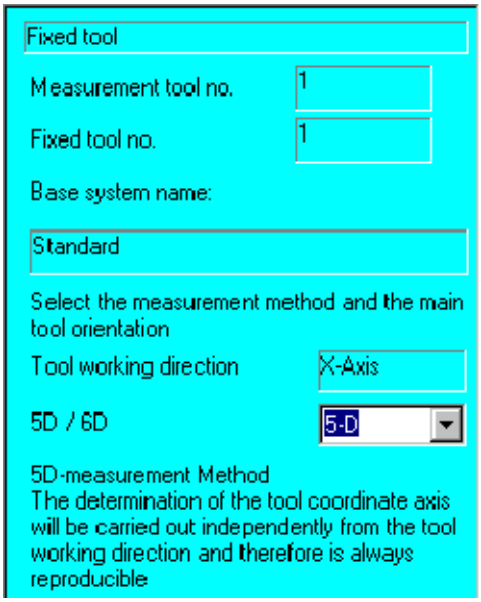




Use the status key to select the number of the reference tool mounted on the robot.

OK

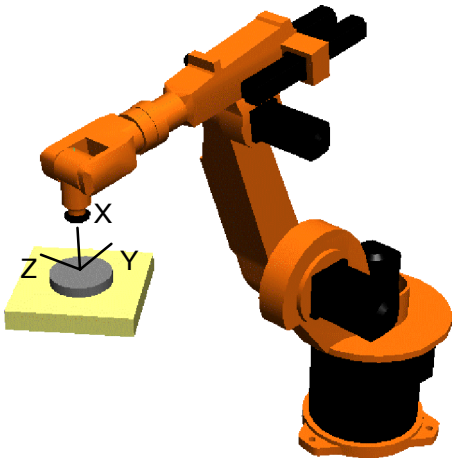
When you have selected both tools by pressing the softkey “OK” you can choose between the measurement methods 5–D and 6–D.



It is possible to switch between the 5–D and 6–D measurement methods by pressing the softkey at the bottom, right edge of the display.

5–D method

This method is used if only the working direction of the tool is required for its positioning and manipulation (MIG/MAG welding, laser or waterjet cutting).

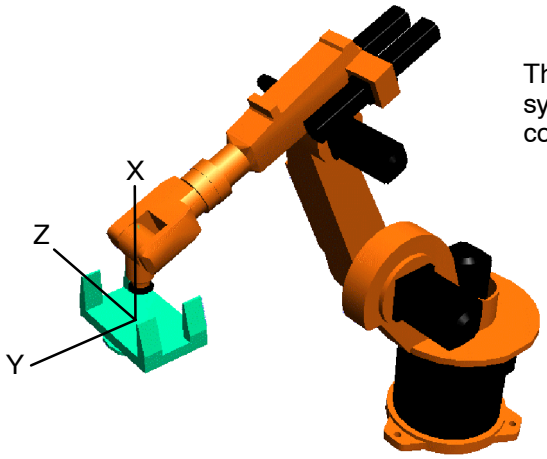


The working direction of the fixed tool is determined by the position of the robot flange alone. It is perpendicular to the flange. The orientation of the Y and Z axes of the tool coordinate system is now determined by the robot controller. The orientation of these axes is not readily foreseeable in this instance, but it is exactly the same in each calibration procedure.

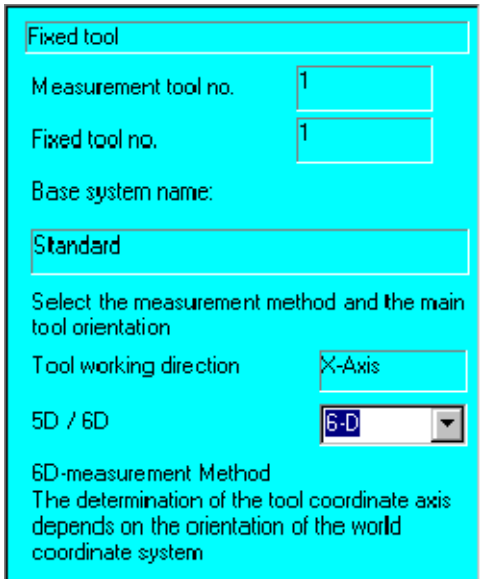
In the event of 5D calibration, the angle “C” (corresponding to a rotation about the X–axis of the tool direction) is set by default to “0”.

6–D method

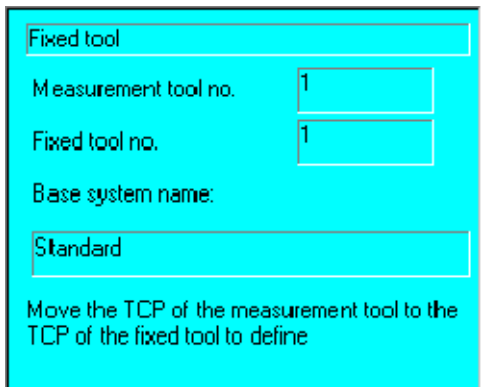
This method is used if the orientation of all three tool axes is required for positioning and manipulation (for example with welding guns, grippers, adhesive nozzles).



The orientation of the tool coordinate system is parallel to the robot flange coordinate system.



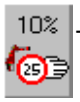
OK Use the softkey “OK” to confirm your selection and open the form for defining the TCP.



Define the working direction of the tool for the controller.

You are now prompted to move the reference tool on the robot to the fixed tool. This can be done using the axis jog keys or the Space Mouse.

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

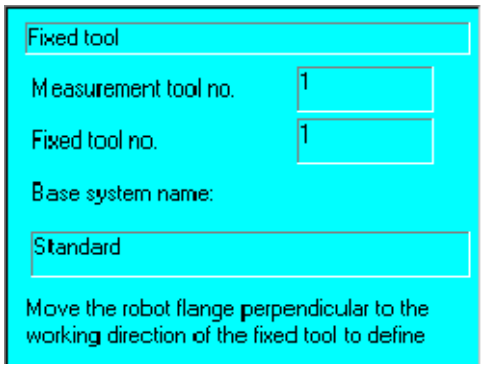


To do so, repeatedly press the jog override status key.

Now carry out the following steps in the order given:

- Set the desired tool orientation.
- Move the TCP of the reference tool until it coincides with the point on the fixed tool.
- The data are saved by pressing the softkey “OK”.

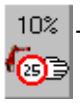
OK



After the point has been accepted by the controller, the status window for orientating the wrist flange is then opened.

First move the tool away from the reference point.

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

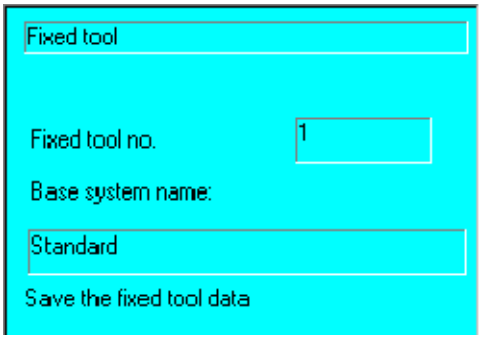


To do so, repeatedly press the jog override status key.

Now move the axes in such a way as to align the wrist flange perpendicular to the fixed tool with the axis jog keys or with the Space Mouse.

OK

The data are adopted and the form for saving the data is opened by pressing the softkey “OK”.



Meas. Pt.

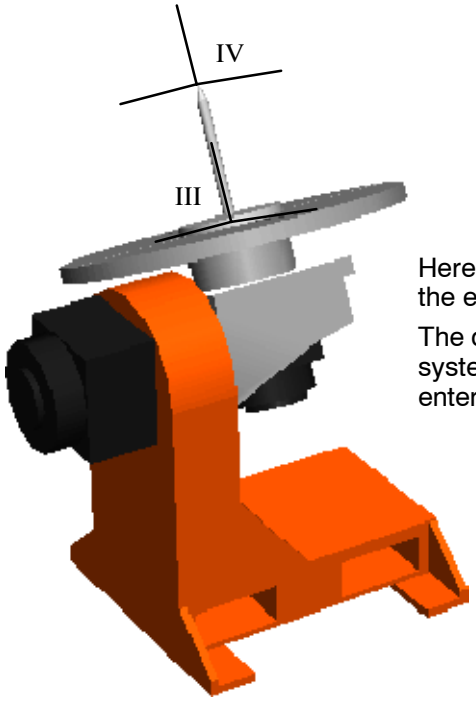
When the softkey “Meas. Pt.” is pressed, a window appears in which the values of the individual measurements are listed once again.

Save

Save the tool data by pressing the softkey “Save”. The function is then terminated.

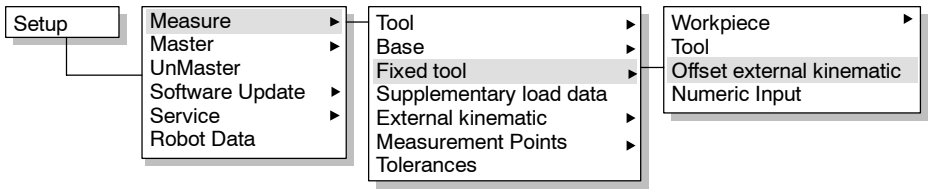
2.4.3 Offset external kinematic

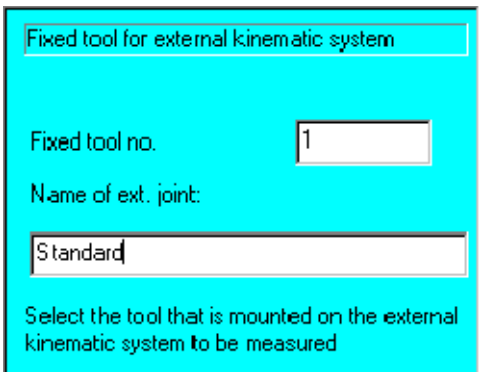
With this calibration procedure, you can calibrate a tool on an external kinematic system.



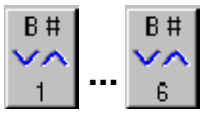
Here, a tool has been mounted on the external kinematic system.

The distance between coordinate systems III and IV must be entered manually or calibrated.





The form illustrated here is then opened.

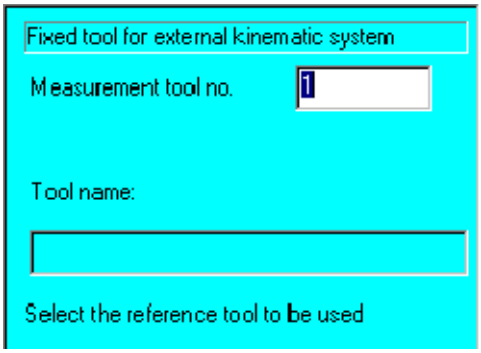


Use the +/– status key to select the tool number (1...6) of the tool to be calibrated on the external kinematic system.

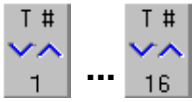
You can use the arrow keys to access the input box “Name of the ext. kinematic” and there enter a name for the external axis.

OK

Press the softkey “OK” to calibrate the external tool.



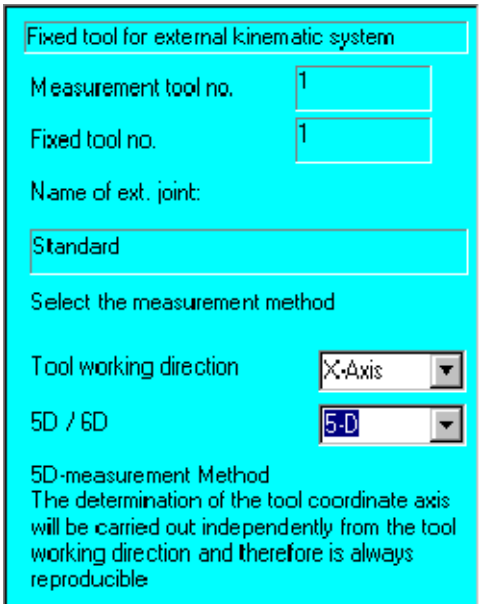
The window for selecting the reference tool is opened.



Now select the number of the desired reference tool (1...16).

OK

Press the softkey “OK” in order to specify the calibration method for this tool.



The window illustrated here is opened.

Here you can select the measurement method that is to be used. The selected method affects the orientation of the tool coordinate system.

The **5D method** is used if only the working direction of the tool is required for its positioning and manipulation (MIG/MAG welding, laser or waterjet cutting).

The **6D method** is used if the orientation of all three tool axes is required for positioning and manipulation (for welding guns, grippers, adhesive nozzles, etc.).

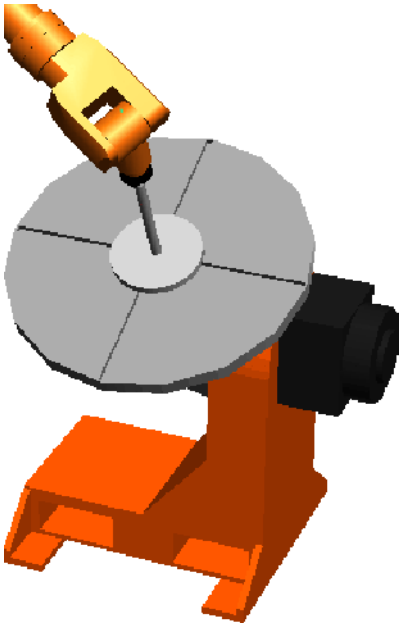
5D method

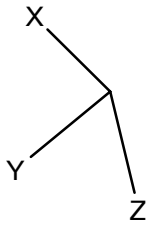
In this method, the Z axis of the robot flange coordinate system tool must be oriented parallel to the future working direction of the tool. The Y and Z axes are oriented by the robot controller. The orientation of these axes is not readily foreseeable in this instance, but it is exactly the same in each calibration procedure.

In the event of 5D calibration, the angle “C” (corresponding to a rotation about the X–axis of the tool direction) is set by default to “0”.

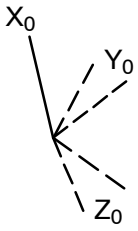
Condition:

Z parallel to X_0





Robot flange coordinate system



Resulting tool coordinate system, orientation of Y and Z not readily foreseeable.

6D method

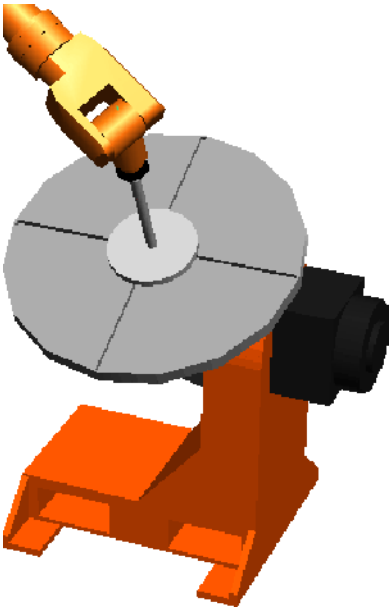
In this method, the robot flange must be oriented in alignment with the tool. The axes of the robot flange coordinate system must be parallel to the future axes of the tool coordinate system.

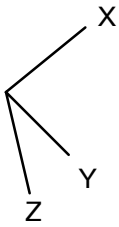
Conditions:

X parallel to Z_0

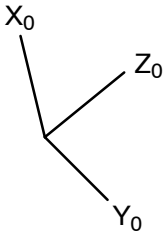
Y parallel to Y_0

Z parallel to X_0

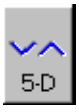




Robot flange coordinate system



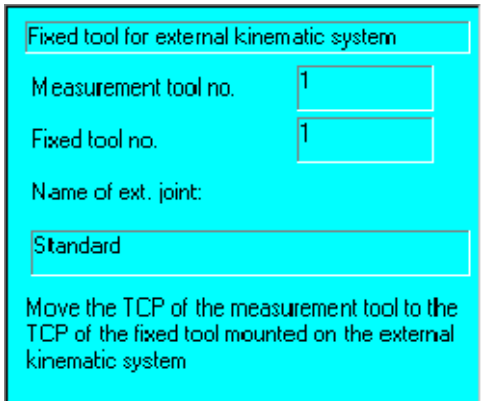
Resulting tool coordinate system



Use the status key to select the best method for your particular application.

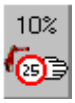
OK

Use the softkey “OK” to confirm your selection and open the form for defining the TCP.



You are prompted to move the TCP of the selected reference tool to the future TCP of the tool attached to the external kinematic system.

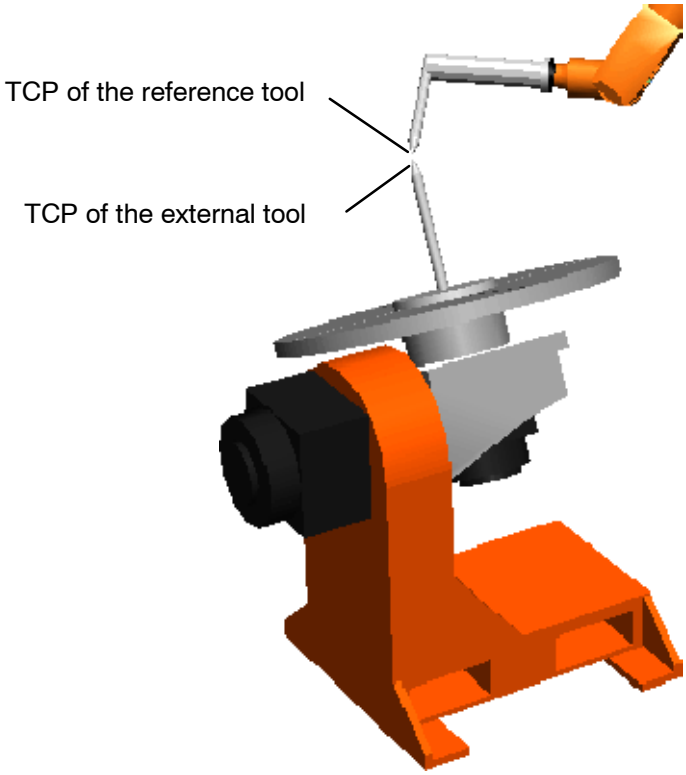
Reduce the jog velocity in the vicinity of the tool in order to avoid a collision.

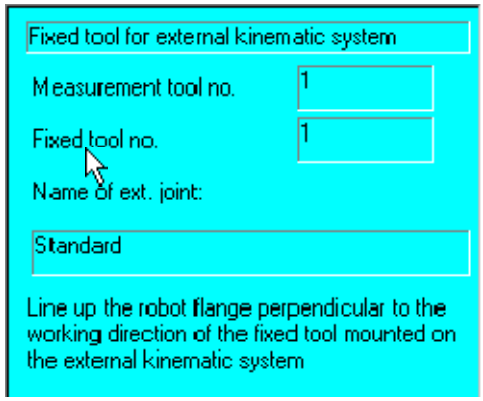


To do so, repeatedly press the +/– key of the status key “HOV”.

OK

When the two TCPs coincide exactly, save this position by pressing the softkey “OK”.

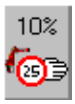




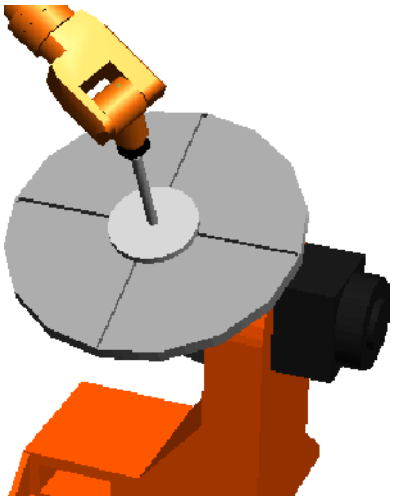
The next status window asks for a change in the orientation of the wrist flange.

Now align the robot flange perpendicular to the future working direction of the tool attached to the external kinematic system using the axis jog keys or the Space Mouse.

Reduce the jog velocity in the vicinity of the tool in order to avoid a collision.

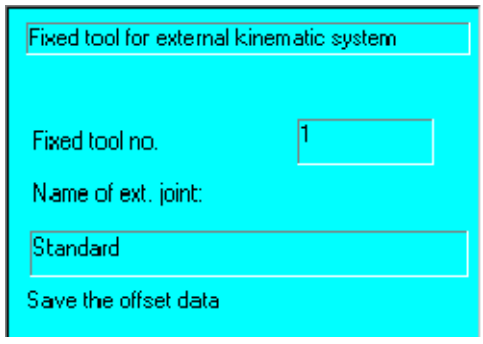


To do so, repeatedly press the status key “HOV” again.



OK

When the robot flange is exactly perpendicular to the working direction of the tool, save this position by pressing the softkey “OK”. The next dialog window shows the number and the data of the calibrated tool:



Meas. Pt.

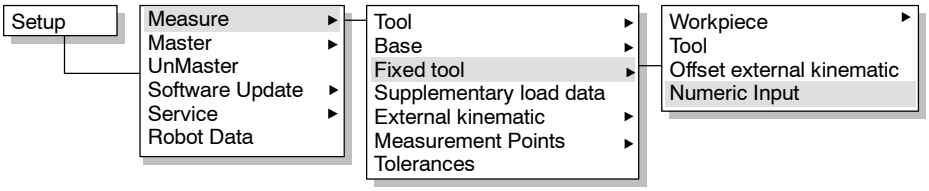
When the softkey “Meas. Pt.” is pressed, a status window appears in which the values of the measuring points are listed once again.

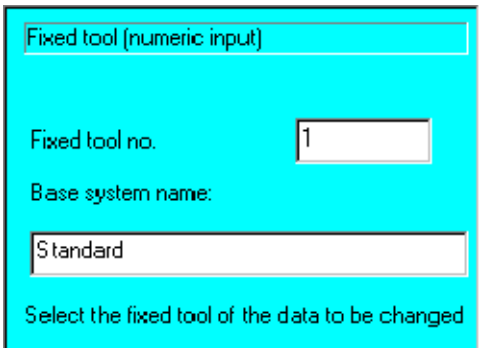
Save

The data are saved and the calibration program is ended by pressing the softkey “Save”.

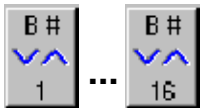
Further information on this can be found in the documentation **Start–up**, chapter **[Calibration – External kinematics].**

2.4.4 Numeric Input





After selecting this menu item, the first dialog window for entering the tool number is opened.

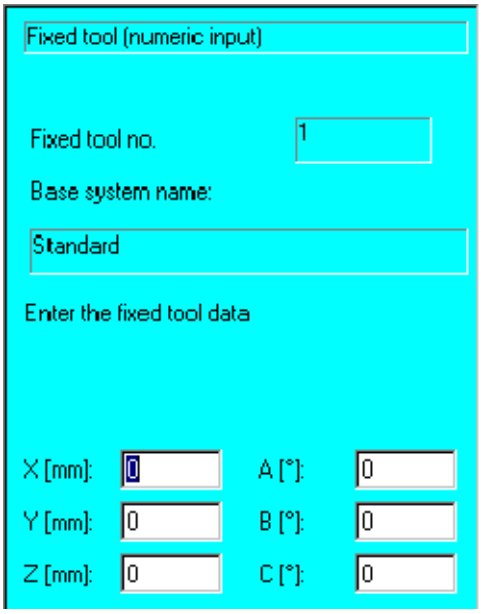


It is possible to activate the relevant tool number (1...16) using the +/– status key at the bottom right of the display.

You can use the arrow keys to access the input box “Base system name” and there enter a name for the base system.

OK

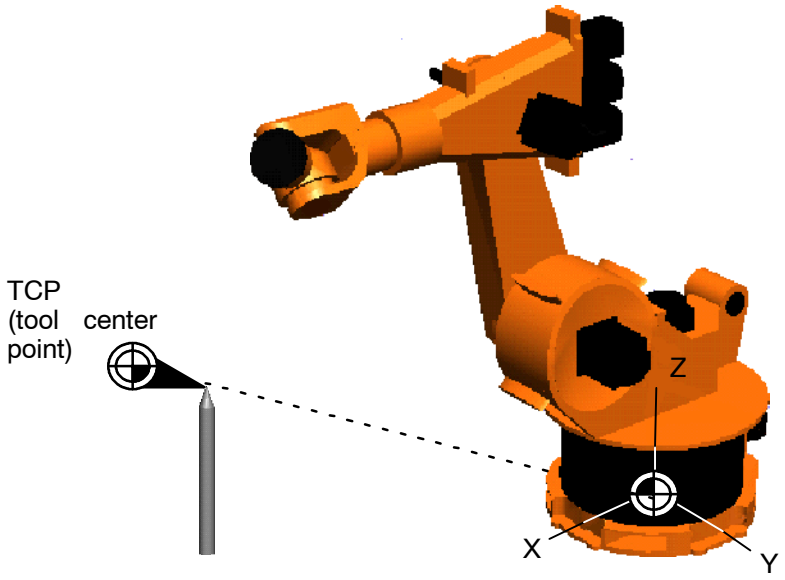
Press the softkey “OK” in order to enter data for this tool. The status window then changes:



Move to the desired input box with the aid of the “↓” and “↑” arrow keys and enter the tool data using the numeric keypad.

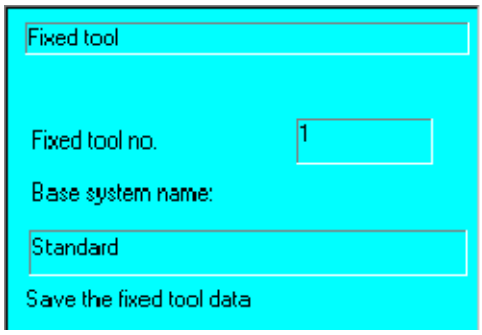
The abbreviations in the dialog window have the following meaning:

X, Y, Z Distance between the TCP and the origin of the world coordinate system in relation to the world coordinate system.



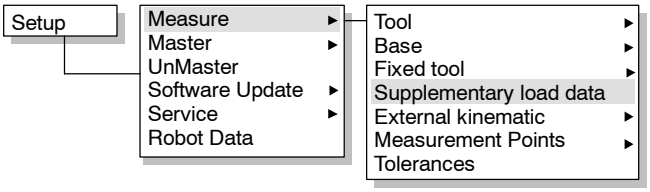
A, B, C Rotational offset of the tool coordinate system (Z–Y–X Euler angles) from the world coordinate system.

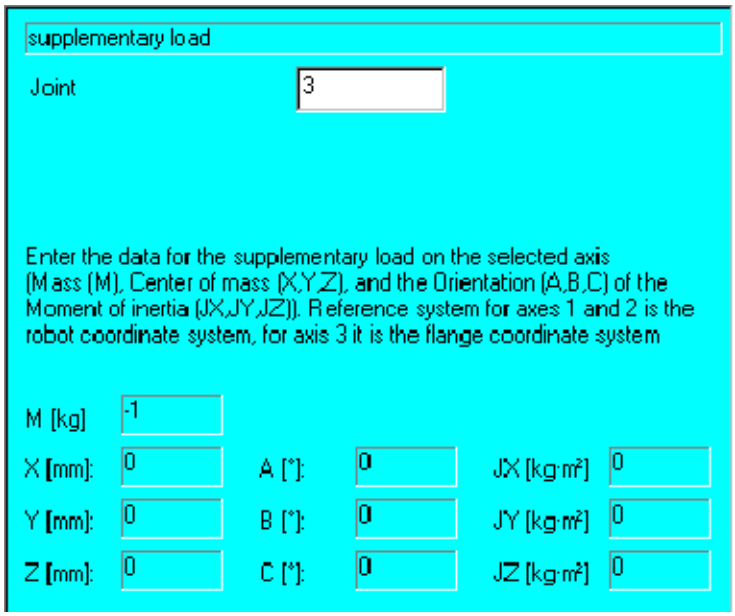
OK When all entries have been made, confirm them by pressing the softkey “OK”.



Save Save the tool data by pressing the softkey “Save”. The function is terminated and the dialog window closed.

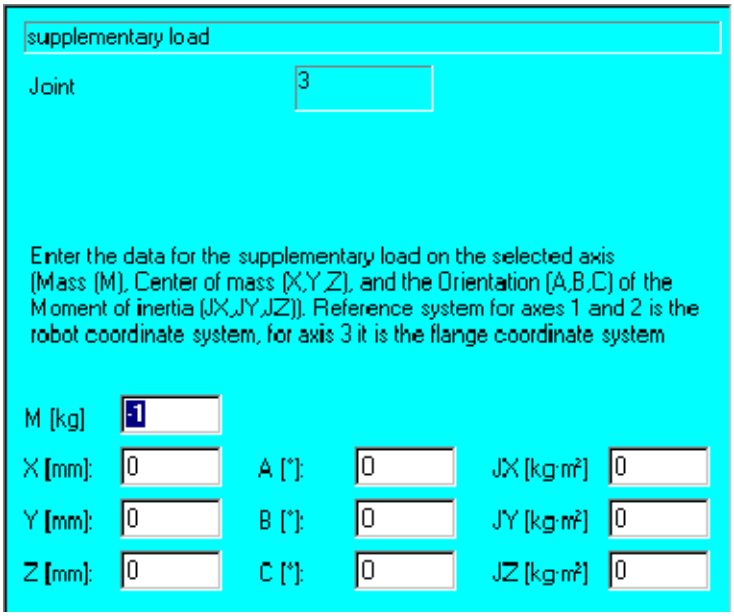
2.5 Supplementary load data





For entry of the supplementary load, axis 3 is displayed as standard. The desired axis (1...3) for entry of the supplementary load can be selected using the +/– status key at the bottom right of the display.

Confirm your choice of axis by pressing the softkey “OK”.
It is now possible to enter the supplementary load data for your chosen axis.

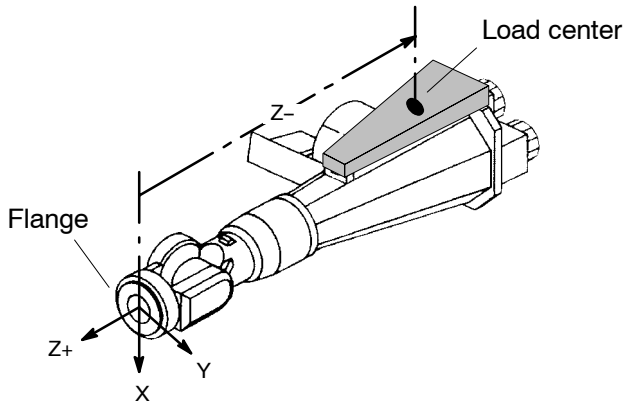


You can move between the individual input boxes with the “↓” and “↑” arrow keys and enter the necessary data by means of the alphanumeric keypad.

or

Default — Press the softkey “Default” in the bottom part of the display to accept the standard load data defined in the basic settings of the system.

The default setting in the box “M [kg]” is –1 (load specified in the machine datum). If 0 is entered here, there is no supplementary load on the robot arm.



The abbreviations in the dialog window have the following meaning:

M	Weight of the supplementary load.
X, Y, Z	Distance between the center of gravity of the supplementary load and the origin of the robot flange coordinate system (located at the center of the flange) in relation to the robot flange coordinate system.
A, B, C	Rotational offset of the principal inertia axes of the supplementary load (Z–Y–X Euler angles) from the robot flange coordinate system.
JX, JY, JZ	Mass moments of inertia about the principal inertia axes of the supplementary load.

Check beforehand by referring to the payload diagram in the robot specification whether the supplementary load lies within the permissible range for standard loads!

OK — When all entries have been made, confirm them by pressing the softkey “OK”. This closes the form and opens the form for saving the data.

Save — The softkey “Save” is used to save the data and close the dialog window.

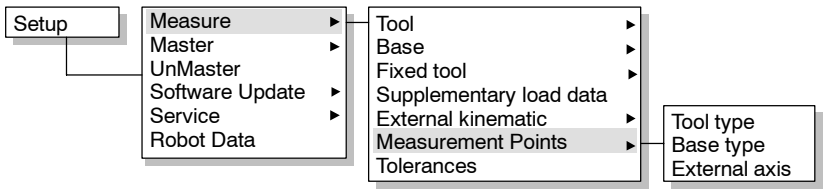
Further information on the calculation of load data can be found in the documentation **Load Data Determination**.

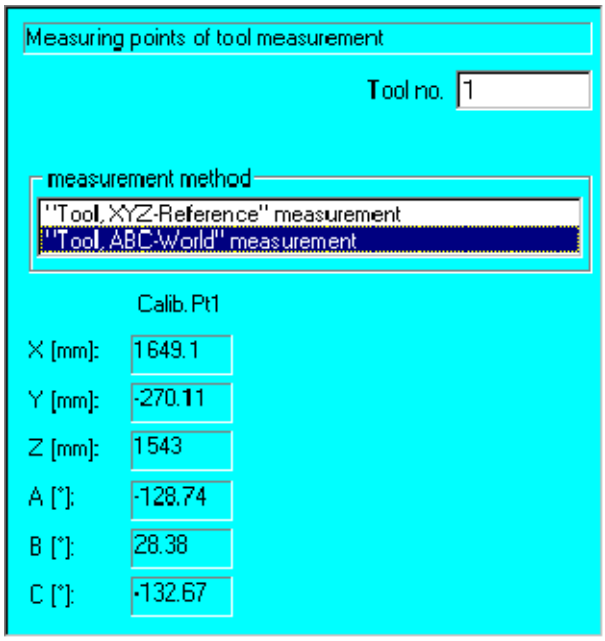
2.6 External kinematic

Information on this can be found in the chapter **[Calibration – External kinematic]**.

2.7 Measurement Points

With this menu item, you can view the saved calibration data.



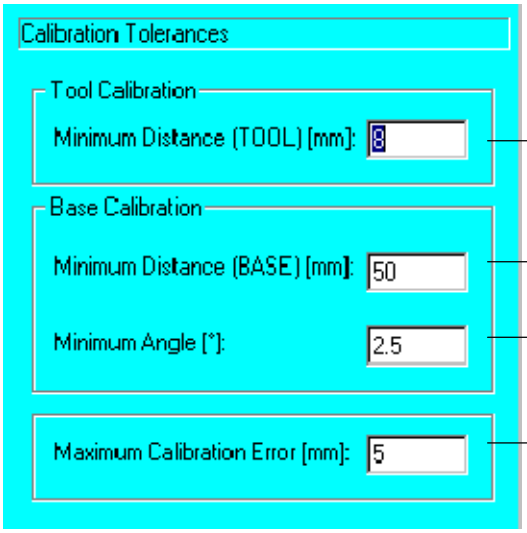


After this selection has been made, a status window is opened displaying the respective calibration methods used and listing the coordinates of all measurement points.

You can toggle between the various tools or workpieces using the status key.

2.8 Tolerances

Here, you can use the numeric keypad to enter the tolerance limits for the tool calibration.



The minimum distance for tool calibration. Range of values 0...200 mm.

The minimum distance for base calibration. Range of values 0...200 mm.

The minimum angle between the straight lines through the three calibration points in base calibration. Range of values 0...360°.

Maximum error in calculation. Range of values 0...200 mm.

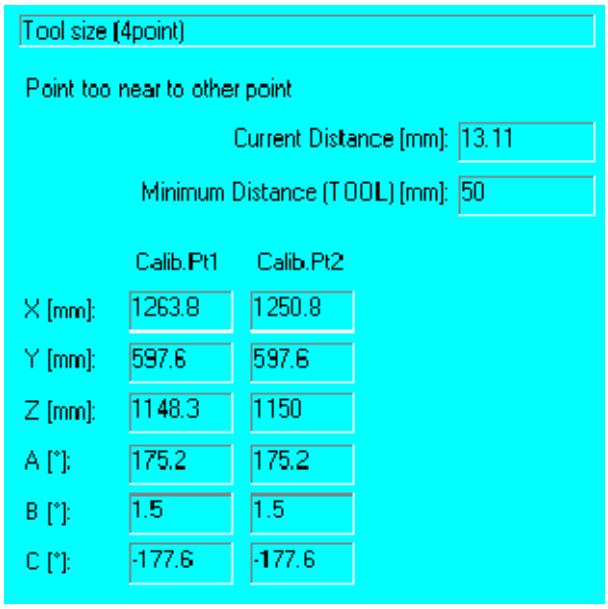
OK — The data in the input boxes are saved by pressing the softkey “OK”.

Default — The default settings are restored by pressing the softkey “Default”. **The data must then be saved by pressing the softkey “OK”.**

Retain the preset values where possible and only modify them in exceptional cases! Otherwise, increased error messages and inaccuracy may result.

2.9 Error treatment

If an error occurs during a calibration procedure, a status window is opened containing detailed information about the error that has occurred.



In the adjacent example, the fourth point of the X Y Z – 4–Point tool calibration was impermissibly close to the first point.

Error message	Remedy
Point too near to reference point	Move to a point that is further away from the reference point.
Point too near to origin point	Move to a point that is further away from the origin.
Point too near to other point	Move to a point that is further away from other points.
Measurement error too big	Positioning was too inaccurate. Repeat with greater precision. Further possibilities: – the robot was not mastered or incorrectly mastered – the machine data are incorrect/no longer correct – mechanical defect of the robot
All points in a line	Make sure that the calibration points are not all in a straight line.
All points in one plane	The robot flange must have a greater change in orientation.

Repeat — Pressing the softkey “Repeat” repeats the calibration that has been queried.

Repeat All — If you want to repeat the whole calibration procedure from the beginning, press the softkey “Repeat All”.

Meas. Pt. If you want to view the coordinates of the calibration points, press the softkey “Meas. Pt”.

Tool size (4point)

Measurement error too big

Current Calibration Error [mm]: 105.06

Maximum Calibration Error [mm]: 5

	Calib.Pt1	Calib.Pt2	Calib.Pt3	Calib.Pt4
X [mm]:	1263.8	1106	952.2	1250.8
Y [mm]:	597.6	556.42	423.4	597.6
Z [mm]:	1148.3	1173	1147.7	1150
A [°]:	175.2	39.36	51.6	175.2
B [°]:	1.5	-14.53	1	1.5
C [°]:	-177.6	132.95	177.3	-177.6

Measurement error too big

Tool size (4point)

Measurement error too big

Current Calibration Error [mm]: 105.06

Maximum Calibration Error [mm]: 5

Special feature of 4–point calibration

With 4–point calibration it is possible to refer back to previously measured points, thus simplifying the calibration process. The following additional softkeys are available for this purpose:

Move to Pt. Automatically moves to the previously measured point, as defined in the table, when the start key is pressed.

OK The calibration program saves the coordinates of the current robot position.

To move to a previously measured point by means of the softkey “Move to Pt.” the operating mode “T1” must be set.

The robot moves to previously measured points with a PTP motion when the softkey “Move to Pt.” is pressed. No check is made to see whether it is possible to move to this point from the current robot position.

3 Calibration – External kinematics

If the robot is mathematically coupled to an external kinematic system, such as a turntable or a two–axis positioner, the robot controller must know the exact position of this kinematic system to ensure correct operation. The fixed, invariable data of this kinematic system are entered in the machine data of the robot system.

Data that depend on the installation and setup are individually determined by calibrating the external kinematic system with the robot. The data for up to 6 external kinematic systems can be stored. These data are called up in the user program by means of their number.

For reasons of safety, the calibration programs can only be executed in “T1” or “T2” mode.

Prerequisites

Using the calibration functions requires adequate knowledge of operating the robot system. The following preconditions must be met on the part of the robot:

- The data of the external kinematic system must be correctly entered in the machine data;
- all axes must be correctly mastered;
- no program may be selected;
- mode “T1” or Single Step “T2“ is selected.

Overview

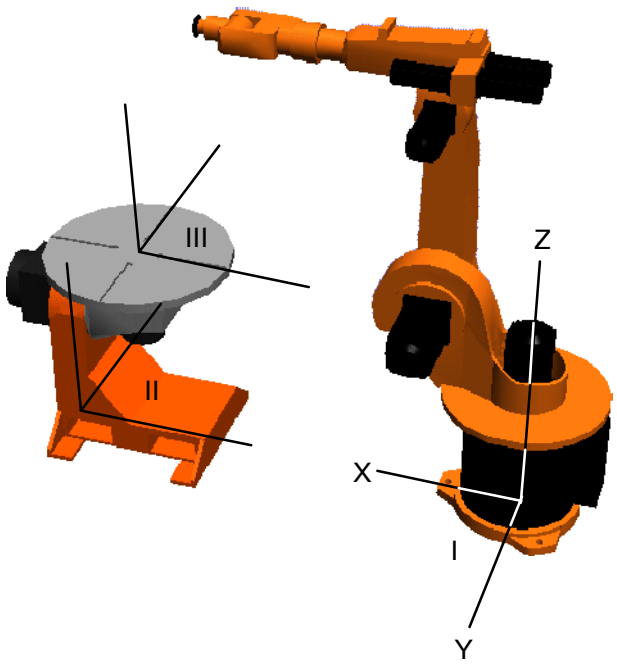
The submenu “External kinematic” contains the following subprograms:

Program	Calibration by...
Root point	moving the distance between World and the external kinematic system
Root point (numeric)	manual entry of the distance between World and the external kinematic system
Offset	moving the distance between the external kinematic system and the workpiece
Offset (numeric)	manual entry of the distance between the external kinematic system and the workpiece

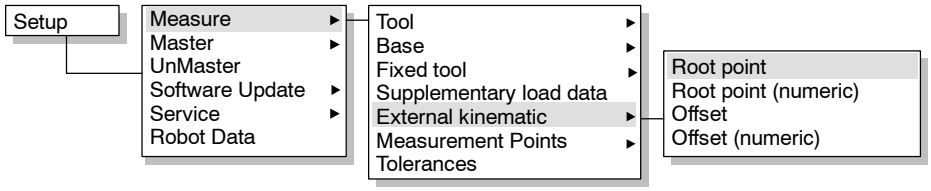
Each of these calibration programs is assigned forms that guide you interactively through the program.

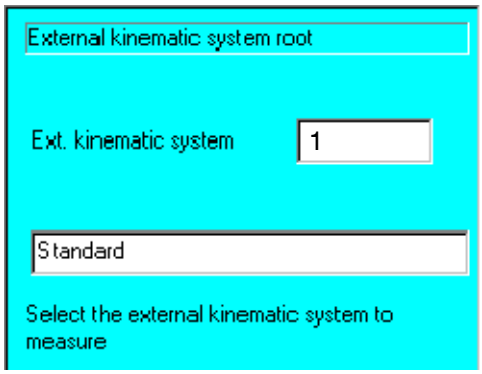
3.1 Root point

The distance between the robot coordinate system and the external kinematic coordinate system is calibrated.

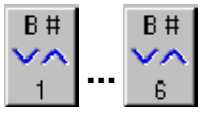


Coordinate system I = World coordinate system, which is identical to the robot coordinate system.
Coordinate system II = External kinematic coordinate system
Coordinate system III = Workpiece coordinate system





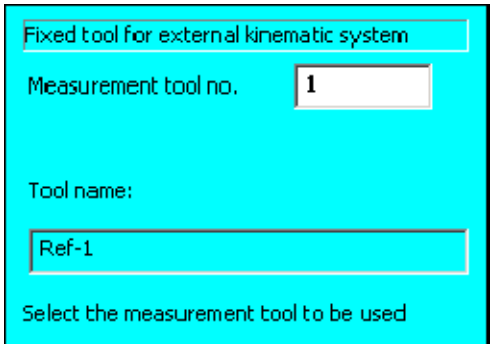
The input window for selecting the kinematic system is opened:



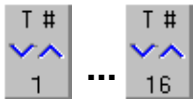
Use the +/– status key to select the desired kinematic number (1...6).

You can use the arrow keys to access the input box “Name of ext. kinematic:” and there enter a name for the axis.

ExtBase OK Press the softkey “ExtBase OK” in order to enter data for this kinematic system.



The dialog window for entering the reference tool of the external machine is then opened:

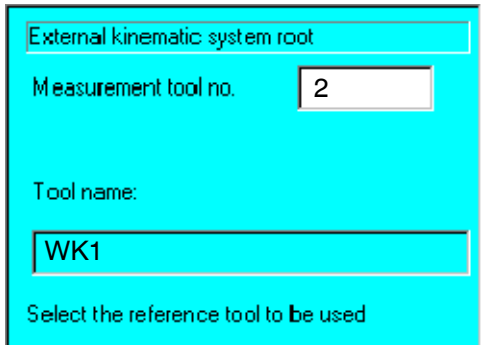


Use the +/– status key to select the tool number (1...16).

A reference tool is a tool which has already been calibrated and is used to calibrate the external kinematic.

OK

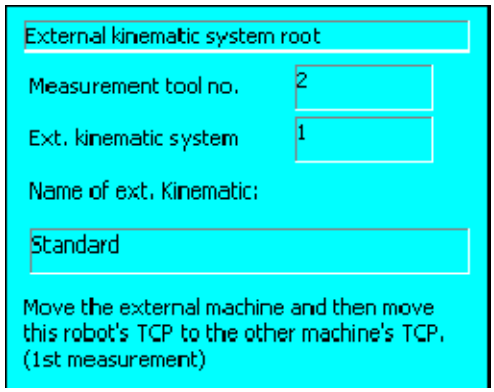
Press the softkey “OK” in order to perform the calibration with this tool.



You are prompted to select the calibration tool.

OK

Press the softkey “OK”.

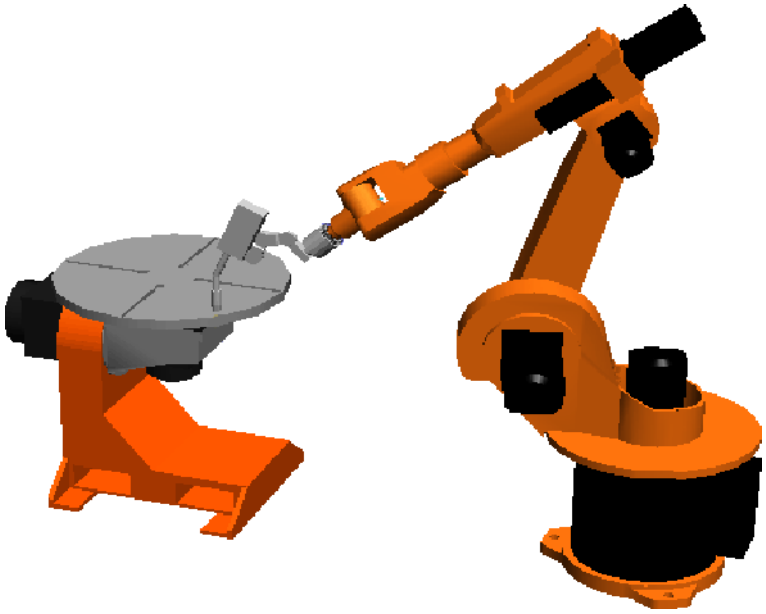


You will then be prompted to move the axes of the external kinematic system and to position the TCP of the reference tool to the reference mark in a number of different positions.

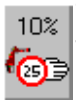
A total of 4 measurements must be made.

The following steps are necessary for this:

1. **Move the external kinematic system.**
2. **Move to the reference mark on the external kinematic system.**



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



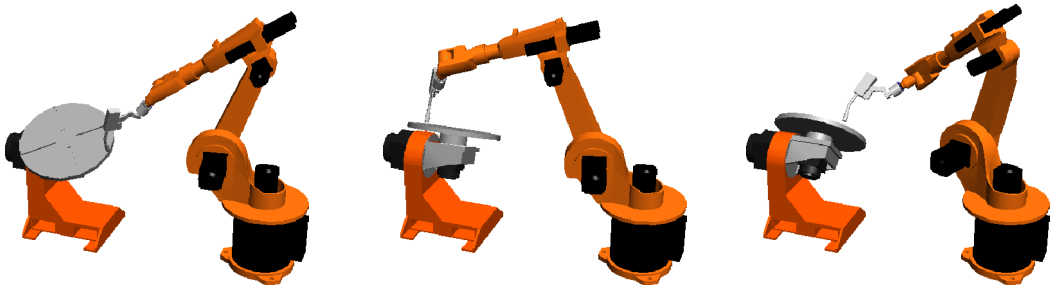
To do so, repeatedly press the status key “HOV”, which is depicted here, and can be found on the right of the display.

3. **Save the point**

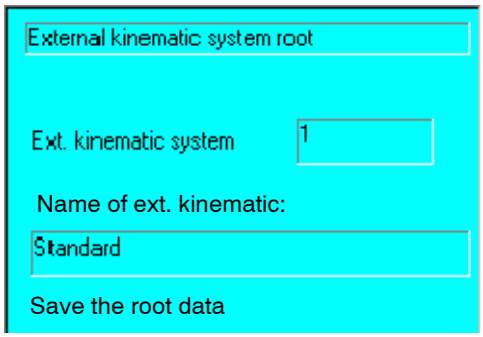
OK

When the TCP is located exactly on the reference mark, save its position by pressing the softkey “OK”.

Repeat steps 1 to 3 until the reference mark has been addressed in a total of four different positions of the external kinematic system.



After all necessary measurements have been successfully completed, the dialog window for saving the root data is opened:

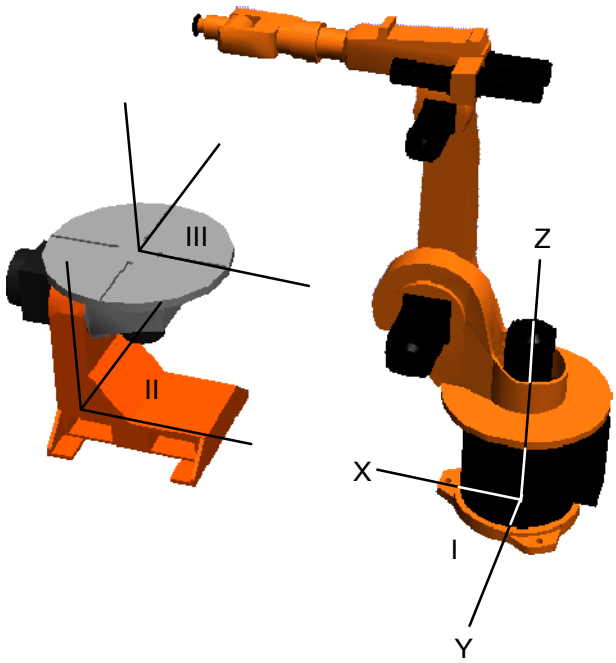


Save

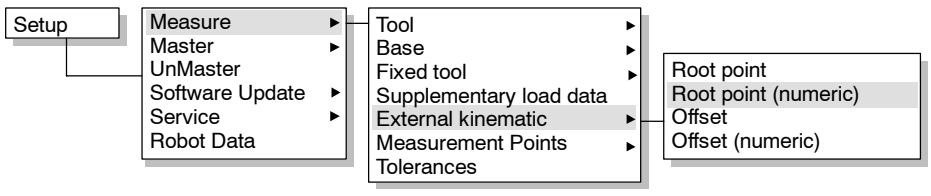
At the end of the calibration procedure, you will be offered the softkey “Save”. Save the data of the kinematic system by pressing this softkey. The function is then terminated.

3.2 Root point (numeric)

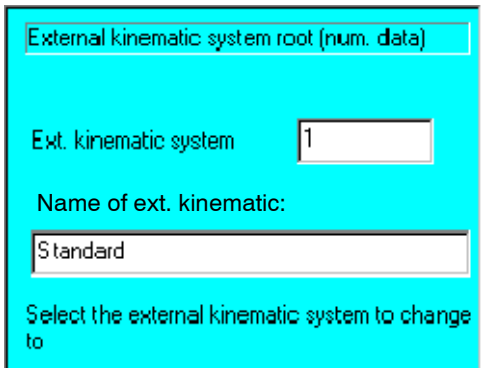
The distance between the robot coordinate system and the external kinematic coordinate system is entered.

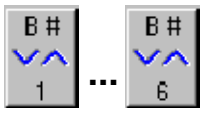


Coordinate system I = World coordinate system, which is identical to the robot coordinate system.
Coordinate system II = External kinematic coordinate system
Coordinate system III = Workpiece coordinate system



The input window for selecting the kinematic system is opened.



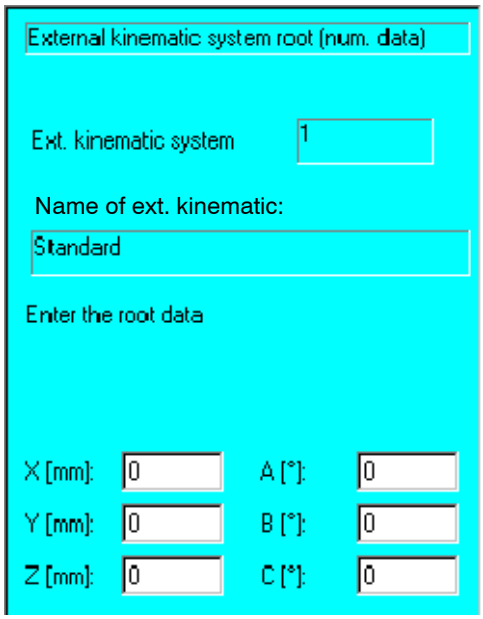


Select the desired kinematic number (1...6) using the +/– status key at the bottom right of the display.

You can use the arrow keys to access the input box “Name of ext. kinematic” and there enter a name for the axis.

ExtBase OK

Press the softkey “ExtBase OK” in order to enter data for this kinematic system. A window is opened for entering the root point data:



Now enter the values by means of the numeric keypad. You can move between the input boxes using the “↓” and “↑” arrow keys.

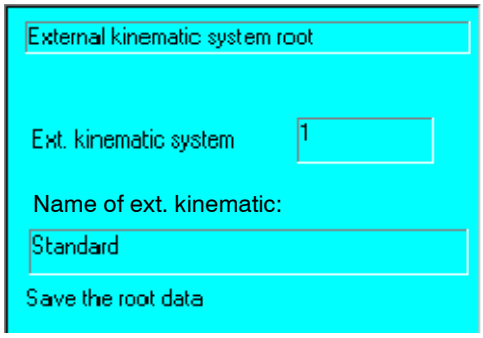
The abbreviations in the dialog box have the following meaning:

X, Y, Z Distance between the root point of the kinematic system and the world coordinate system. In the basic setting, the world and robot coordinate systems coincide.

A, B, C Rotational offset of the kinematic coordinate system from the world coordinate system. In the basic setting, the world and robot coordinate systems coincide.

Base OK

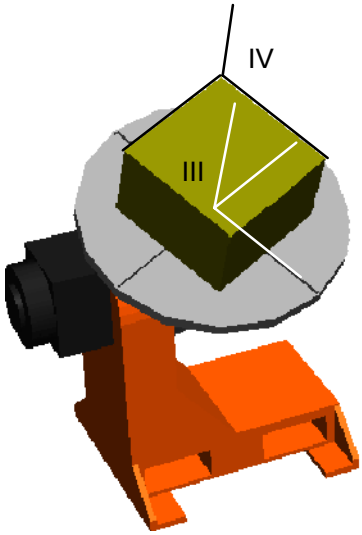
When all entries have been made, confirm them by pressing the softkey “Base OK”.



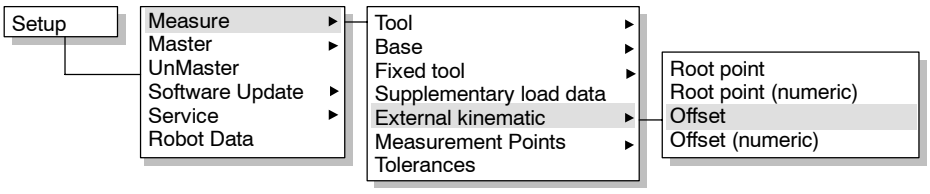
Save

Save the kinematic data by pressing the softkey “Save”. The function is then terminated.

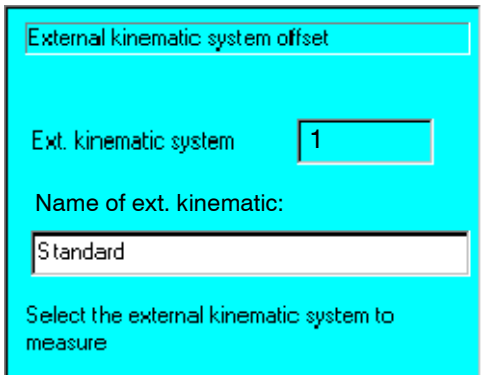
3.3 Offset

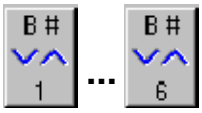


The distance between coordinate systems III and IV must be entered manually or calibrated.



The input window for selecting the kinematic system is opened.

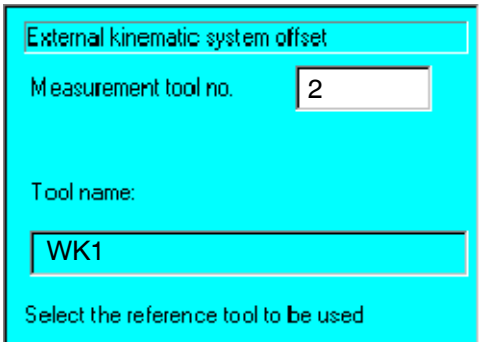




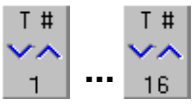
Use the +/– status key to select the desired kinematic number (1...6).

You can use the arrow keys to access the input box “Name of ext. kinematic:” and there enter a name for the axis.

ExtBase OK Press the softkey “ExtBase OK” in order to enter data for this kinematic system.

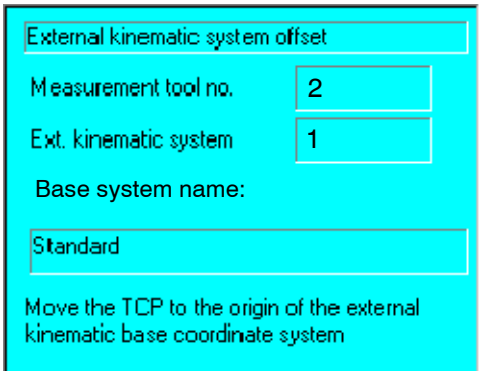


The following window is opened for entering the calibration tool:



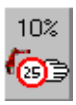
Use the +/– status key to select the tool number (1…16).

OK Press the softkey “OK” in order to perform the calibration with this tool. The following window is then opened:



You are prompted to position the TCP (tool center point) to the future origin of the base coordinate system (BASE). This can be done using either the jog keys or the Space Mouse.

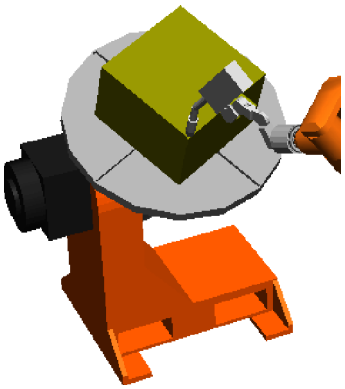
Reduce the jog velocity in the vicinity of the workpiece in order to avoid a collision.

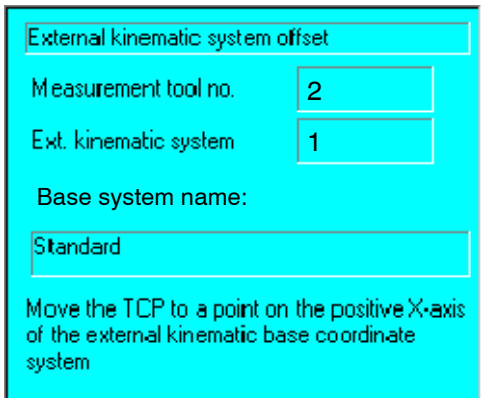


To do so, repeatedly press the +/– status key “HOV”.

OK

When the TCP is located exactly at the desired origin of the base coordinate system (BASE), save this position by pressing the softkey “OK”.





The next dialog window is then opened.

You are prompted to show the controller the positive side of the X axis by positioning the TCP to a specific point.

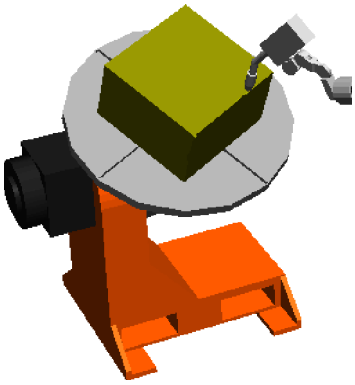
First move the tool away from the workpiece:

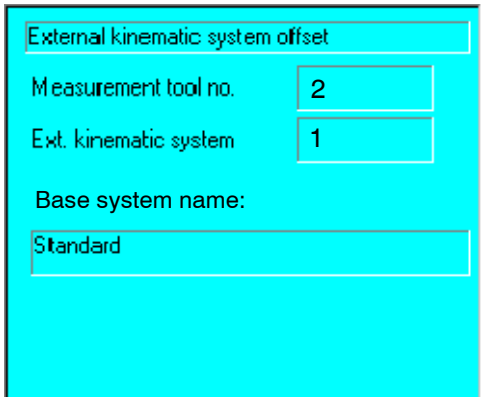
Reduce the jog velocity in the vicinity of the workpiece in order to avoid a collision.

To do so, repeatedly press the +/– status key “HOV” again.

OK

When the TCP is located exactly on the desired point, save this position by pressing the softkey “OK”.





You are prompted to show the controller the orientation of the XY plane by moving the tool to a point with a positive Y value.

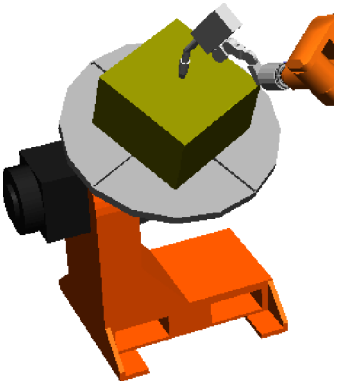
Here also, move the tool away from the workpiece first.

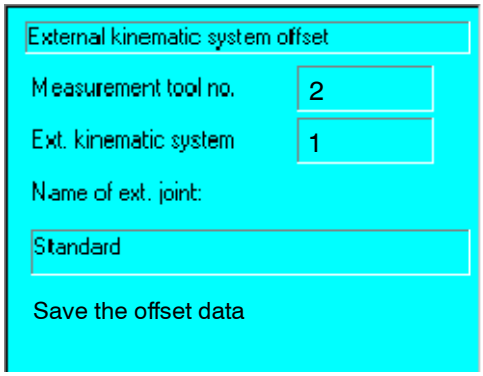
Reduce the jog velocity in the vicinity of the workpiece in order to avoid a collision.

To do so, repeatedly press the status key “HOV”.

OK

When the TCP is located exactly at the point with a positive Y value on the XY plane, save this position by pressing the softkey “OK”.

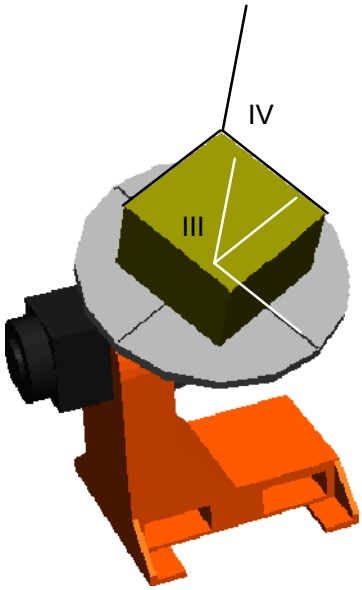




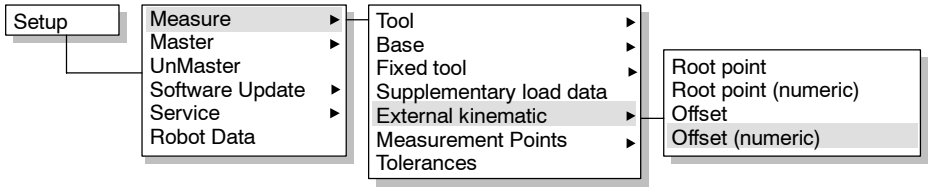
Save

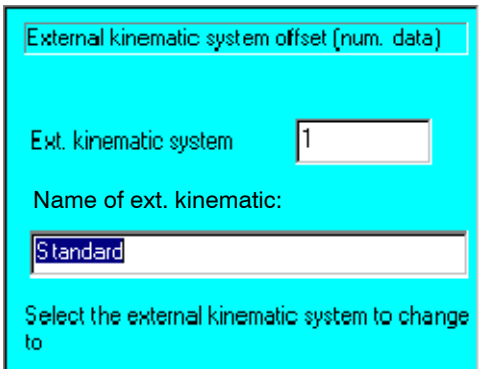
At the end of the calibration procedure, you will again be offered the softkey “Save” situated at the bottom of the display. Save the kinematic data by pressing this softkey. The function is then terminated.

3.4 Offset (numeric)

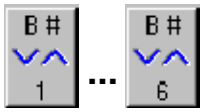


The distance between coordinate systems III and IV must be entered manually or calibrated.





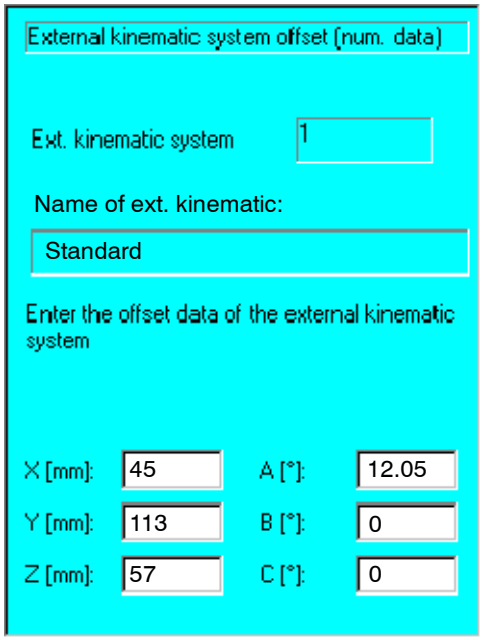
The input window for selecting the kinematic system is opened.



Use the +/– status key to select the kinematic number (1...6).

You can use the arrow keys to access the input box “Name of ext. kinematic:” and there enter a name for the axis.

ExtBase OK Press the softkey “ExtBase OK” in order to enter data for the selected kinematic system.



The following dialog window for entering the offset data is then opened.

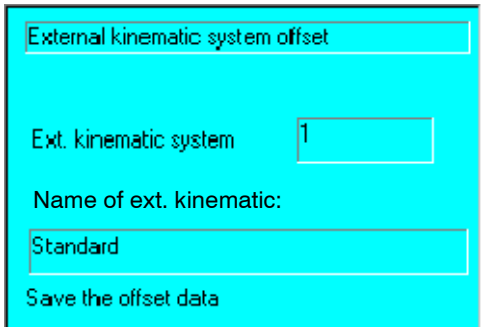
Enter the desired values by means of the numeric keypad. You can move between the input boxes using the “↓” and “↑” arrow keys.

The abbreviations in the status window have the following meaning:

X, Y, Z Distance between the workpiece reference point (BASE), IV in the illustration, and the kinematic coordinate system, III in the illustration.

A, B, C Rotational offset of the workpiece coordinate system from the kinematic coordinate system.

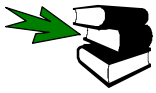
OK When all entries have been made, confirm them by pressing the softkey “OK” situated at the bottom of the display.



Save

Save the offset data by pressing the softkey “Save”. You will find this softkey at the bottom right of the display. The function is thus completed.

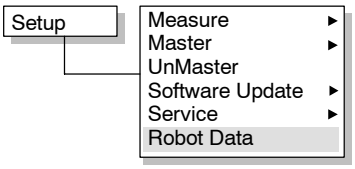
3.5 Offset external kinematic



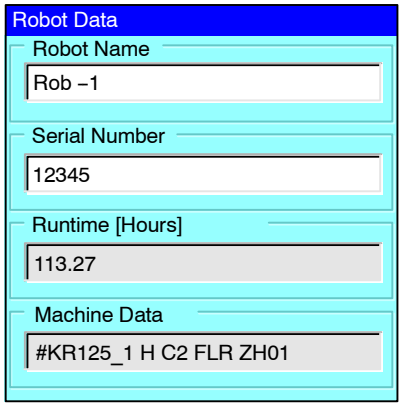
Further information can be found in the documentation **[Start–up]**, chapter **[Calibration]**, section **[Fixed tool]**.

4 Robot Data

This option allows you to view the robot name, the serial number, the length of time the robot has been in operation and the machine data being used:



The following status window is opened:



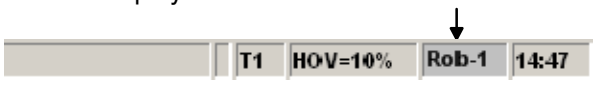
In the box “Robot name”, a name can be entered for the connected robot that clearly identifies it.

For positionally accurate robots, the serial number is important. The program can thus establish whether the robot (RDC component) or the controller (DSE component) has been changed (e.g. use of the controller with another robot). The serial number can only be changed in the user group “Expert”.

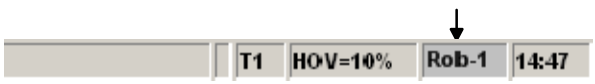
“Runtime” indicates the length of time the drives are switched on and the robot is under servo control. It is not possible to change the runtime value.

The machine data that are being used are indicated in the box “Machine data”. It is similarly not possible to change the machine data.

PID Import	Opens a file selection window for importing a PID file for a positionally accurate robot.
OK	The changes are saved and the status window is closed. The current robot name is displayed in the status line.

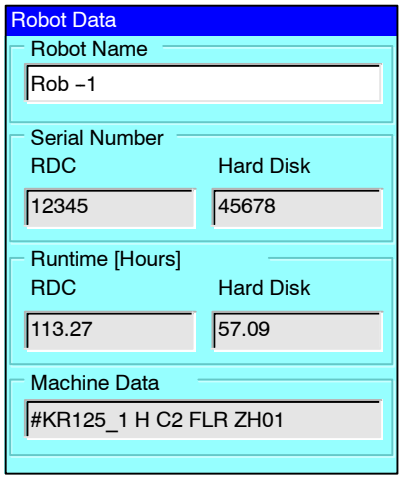


Apply	The changes are saved. If the robot name is changed, this is displayed in the status line.



Cancel	Changes that have not been saved are rejected and the status window is closed.

If inconsistencies between the data on the RDC and those on the hard drive are discovered when the system is booted, a corresponding message is displayed. The robot cannot be moved as long as there is a data inconsistency.



The user must decide whether the RDC data are correct or those on the hard drive. This option is not available in the user group “User”.

The RDC hardware is not designed for frequent write access.

Information about saving the robot serial number in the RDC (Resolver–Digital Converter) and checking the serial number for the purposes of the correct assignment of robot and controller can be found in the **Electrical Servicing** handbook.

NOTES:

Numbers

A

B

C

D

E

F

H

I

J

K

L

M

N

O

P

R

S

T

U

V

W

X

Z