5.5 Tools

5.5.1 What is a tool?

Tool

A tool is an object that can be mounted directly or indirectly on the robot turning disk or fitted in a fixed position within the robot working range.

A fixture (jig) is not a tool.

All tools must be defined with a TCP (Tool Center Point).

Each tool that can be used by the robot must be measured and its data stored in order to achieve accurate positioning of the tool center point.

WARNING

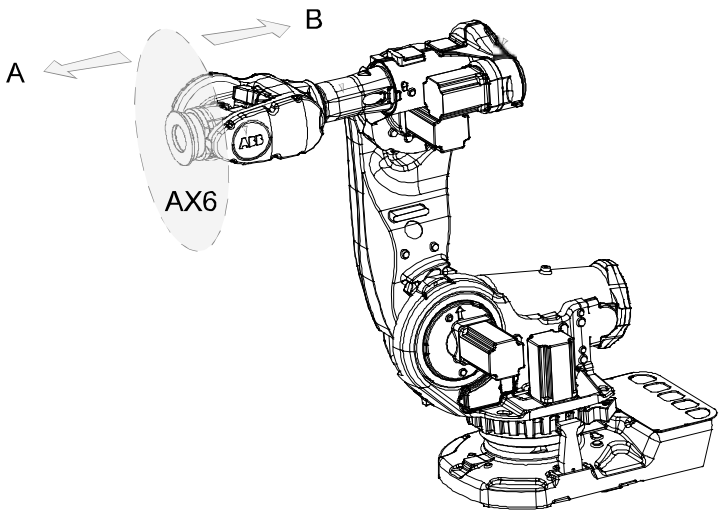
It is important to always define the actual tool load and, when used, the payload of the robot (for example a gripped part). Incorrect definitions of load data can result in overloading of the robot mechanical structure.

When incorrect load data is specified, it can often lead to the following consequences:

- The robot will not be used to its maximum capacity
- Impaired path accuracy including a risk of overshooting
- Risk of overloading the mechanical structure

The controller continuously monitors the load and writes an event log if the load is higher than expected. This event log is saved and logged in the controller memory.

Illustration



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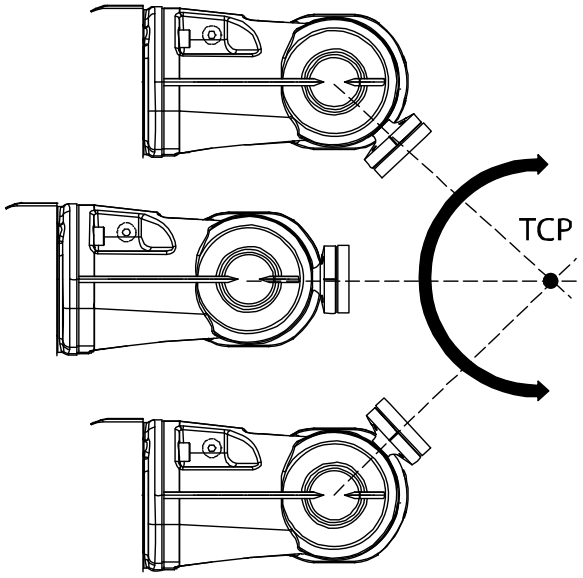
A	Tool side
B	Robot side

5.5.2 What is the tool center point?

Illustration

The illustration shows how the tool center point (TCP) is the point around which the orientation of the tool/manipulator wrist is being defined.



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Description

The tool center point (TCP) is the point in relation to which all robot positioning is defined. Usually the TCP is defined as relative to a position on the manipulator turning disk.

The TCP will be jogged or moved to the programmed target position. The tool center point also constitutes the origin of the tool coordinate system.

The robot system can handle a number of TCP definitions, but only one can be active at any one time.

There are two basic types of TCPs: moveable or stationary.

Moving TCP

The vast majority of all applications deal with moving TCP, i.e. a TCP that moves in space along with the manipulator.

A typical moving TCP can be defined in relation to, for example the tip of a arc welding gun, the center of a spot welding gun, or the end of a grading tool.

Stationary TCP

In some applications a stationary TCP is used, for example when a stationary spot welding gun is used. In such cases the TCP can be defined in relation to the stationary equipment instead of the moving manipulator.

5.5.3 Creating a tool

What happens when you create a tool?

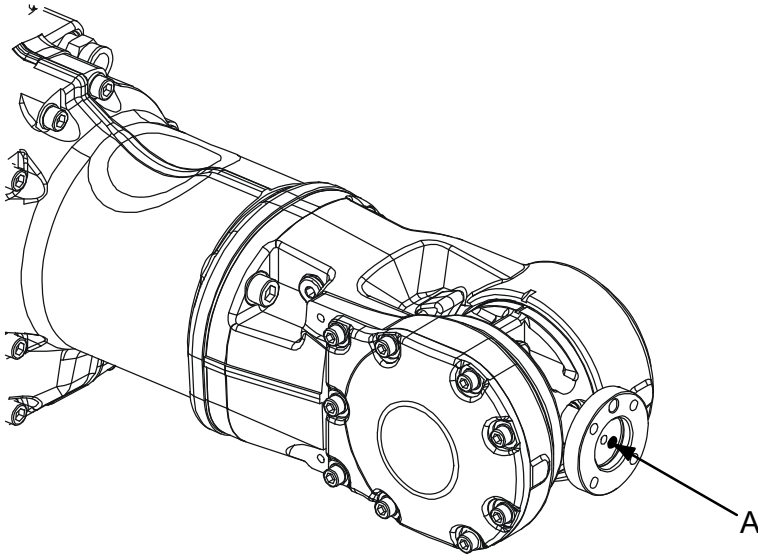
When you create a new tool a variable of the data type `tooldata` is created. The variable name will be the name of the tool. For more information on data types, see *Technical reference manual - RAPID Instructions, Functions and Data types*.

The new tool has initial default values for mass, frame, orientation etc., which must be defined before the tool can be used.

How to create a tool

The tool center point of the default tool (tool0) is in the center of the robot's mounting flange and shares the orientation of the robot base.

By creating a new tool you define another tool center point. For more information about tools and the tool center points see *What is a tool? on page 175*and *What is the tool center point? on page 176*.



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A	Tool center point, TCP, for tool0

	Action
1	On the **ABB** menu, tap **Jogging**.
2	Tap **Tool** to display the list of available tools.

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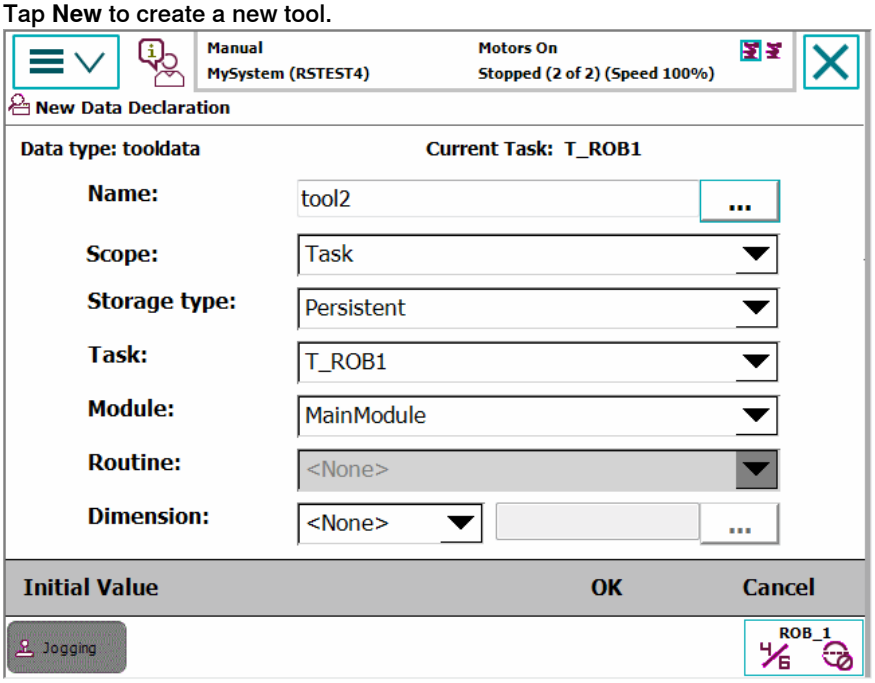
5.5.3 Creating a tool
Continued

	Action
3	Tap **New** to create a new tool.  en0300000544 Enter values for each field, see table below.
4	Tap **OK**.

Tool declaration settings

If you want to change...	then...	Recommendation
the name of the tool	tap ... button next to **Name**	Tools are automatically named `tool` followed by a running number, for example `tool10` or `tool21`. You are recommended to change this to something more descriptive such as gun, gripper or welder. **Note** If you change the name of a tool after it is referenced in any program you must also change all occurrences of that tool.
the scope	select the preferred scope from the menu	Tools should always be global, as to be available to all modules in the program.
the storage type	-	Tool variables must always be persistent.
the module	select the module in which this tool should be declared from the menu	

Continues on next page

If you want to change...	then...	Recommendation
the size of the data array's axes	tap ... button next to **Dimension**	

Note

The created tool is not useful until you have defined the tool data (TCP coordinates, orientation, weight etc.). See *Editing the tool data on page 184* and *LoadIdentify, load identification service routine on page 222* to learn more about how to do it.

5.5.4 Defining the tool frame

Preparations

To define the tool frame, you first need a reference point in the world coordinate system. If you need to set the tool center point orientation, you also need to affix elongators to the tool.

You also need to decide which method to use for the tool frame definition.

Available methods

There are three different methods which can be used when defining the tool frame. All three require that you define the cartesian coordinates of the tool center point. What differs is how the orientation is defined.

If you want to...	...then select
set the orientation the same as the orientation of the robot's mounting plate	**TCP (default orient.)**
set the orientation in Z axis	**TCP&Z**
set the orientation in X and Z axes	**TCP&Z,X**

How to select a method

This procedure describes how to select the method to be used when defining the tool frame.

	Action
1	On the **ABB** menu, tap **Jogging**.
2	Tap **Tool** to display a list of available tools.
3	Select the tool you want to define.
4	In the Edit menu, tap **Define**

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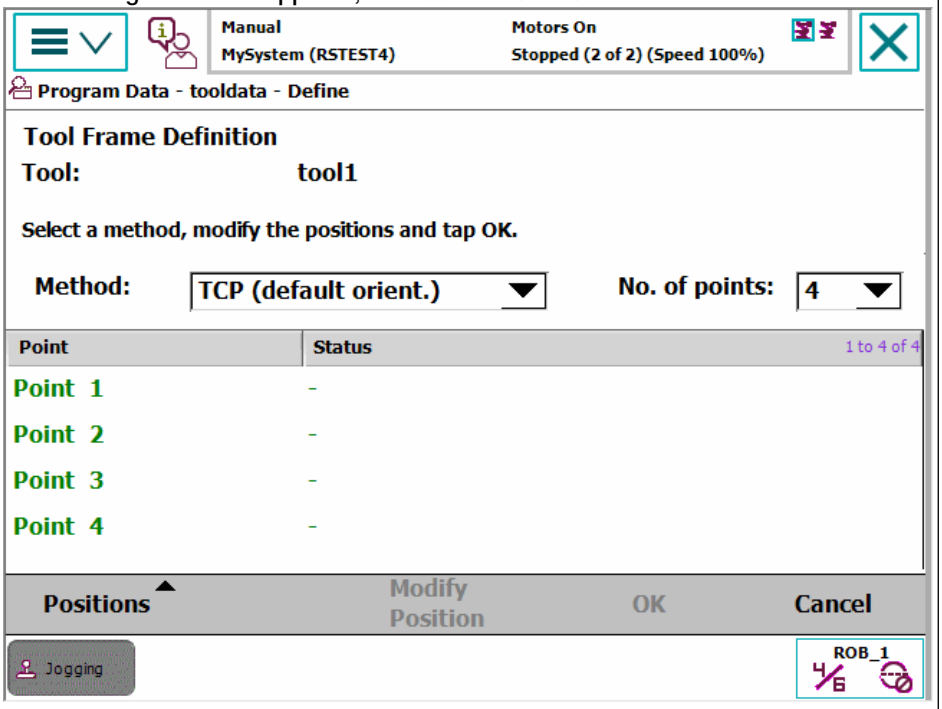
	Action
5	In the dialog box which appears, select the method to use.  en0600003147
6	Select the number of approach points to use. Usually 4 points is enough. If you choose more points to get a more accurate result, you should be equally careful when defining all of them.
7	See *How to proceed with tool frame definition on page 182* for information on how to gather positions and perform the tool frame definition.

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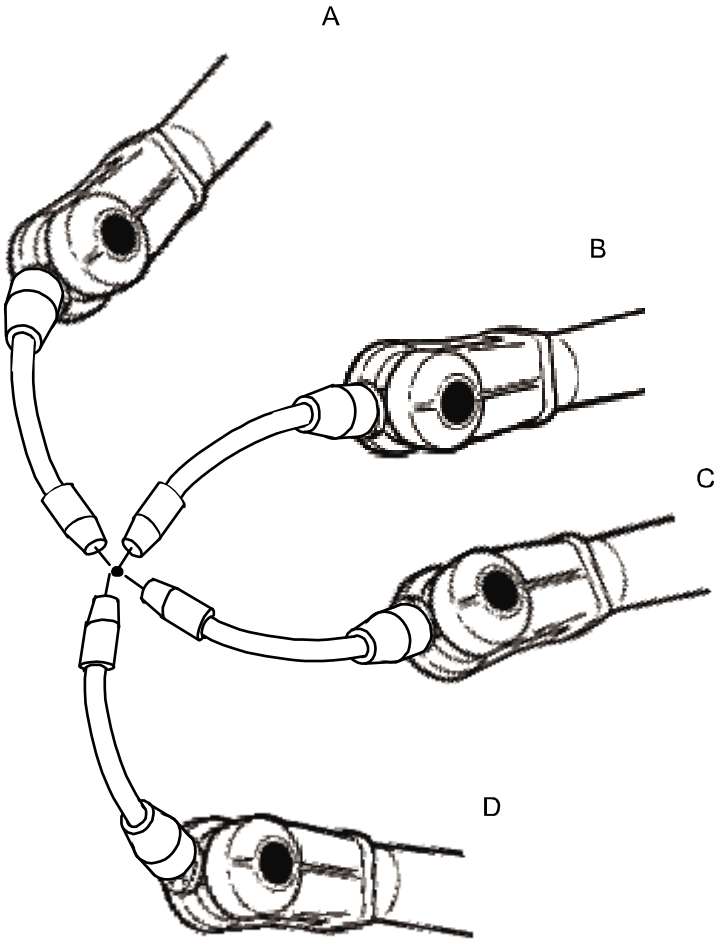
5.5.4 Defining the tool frame
Continued

How to proceed with tool frame definition

This procedure describes how to define the tool center point in Cartesian coordinates.



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	Action	Information
1	Jog the robot to an appropriate position, A, for the first approach point.	Use small increments to accurately position the tool tip as close to the reference point as possible.
2	Tap **Modify Position** to define the point.	
3	Repeat step 1 and 2 for each approach point to be defined, positions B, C, and D.	Jog away from the fixed world point to achieve the best result. Just changing the tool orientation will not give as good a result.
4	If the method you are using is TCP&Z or TCP&Z,X orientation must be defined as well.	Follow the instructions in *How to define elongator points on page 183*.
5	If, for some reason, you want to redo the calibration procedure described in step 1-4, tap **Positions** and then **Reset All**.	

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	Action	Information
6	When all points are defined you can save them to file, which enables you to reuse them later. On the **Positions** menu, tap **Save**.	
7	Tap **OK**. The **Calculation Result** dialog box will now be displayed, asking you to cancel or to confirm the result before it is written to the controller.	For further information see *Is the calculated result good enough? on page 183*

How to define elongator points

This procedure describes how to define the orientation of the tool frame by specifying the direction of the z and/or x axis. You need to do this only if you the tool orientation should differ from that of the robot base. The tool coordinate system by default resembles the coordinate system of tool0, as illustrated in *Measuring the tool center point on page 185*.

	Action
1	Without changing the orientation of the tool, jog the robot so that the reference world point becomes a point on the desired positive axis of the rotated tool coordinate system.
2	Tap **Modify Position** to define the point.
3	Repeat step 1 and 2 for the second axis if it should be defined.

Is the calculated result good enough?

The **Calculation Result** dialog box displays the calculated result of the tool frame definition. You have to confirm that you accept the result before it can take effect in the controller. The alternative is to redo the frame definition in order to achieve a better result. The result **Mean Error** is the average distance of the approach points from the calculated TCP (tool center point). **Max Error** is the maximum error among all approach points.

It is hard to tell exactly what result is acceptable. It depends on the tool, robot type etc. you are using. Usually a mean error of a few tenths of a millimeter is a good result. If the positioning has been undertaken with reasonable accuracy the result will be okay.

As the robot is used as a measuring machine, the result is also dependent on where in the robot's working area the positioning has been done. Variation of the actual TCP up to a couple of millimeters (for large robots) can be found between definitions in different parts of the working area.The repeatability of any following TCP calibrations will thus increase if these are done close to the preceding ones. Note that the result is the optimal TCP for the robot in that working area, taking into account any discrepancies of the robot in the configuration at hand.

Tip

A common way to check that the tool frame has been correctly defined is to perform a reorientation test when the definition is ready. Select the reorient motion mode and the tool coordinate system and jog the robot. Verify that the tool tip stays very close to the selected reference point as the robot moves.

5.5.5 Editing the tool data

Tool data

Use the value settings to set the tool center point position and physical properties of the tool such as weight and center of gravity.

This can also be done automatically with the service routine LoadIdentify. See sections *Running a service routine on page 215*, or *LoadIdentify, load identification service routine on page 222*.

Displaying the tool data

This section details how to display the tool data.

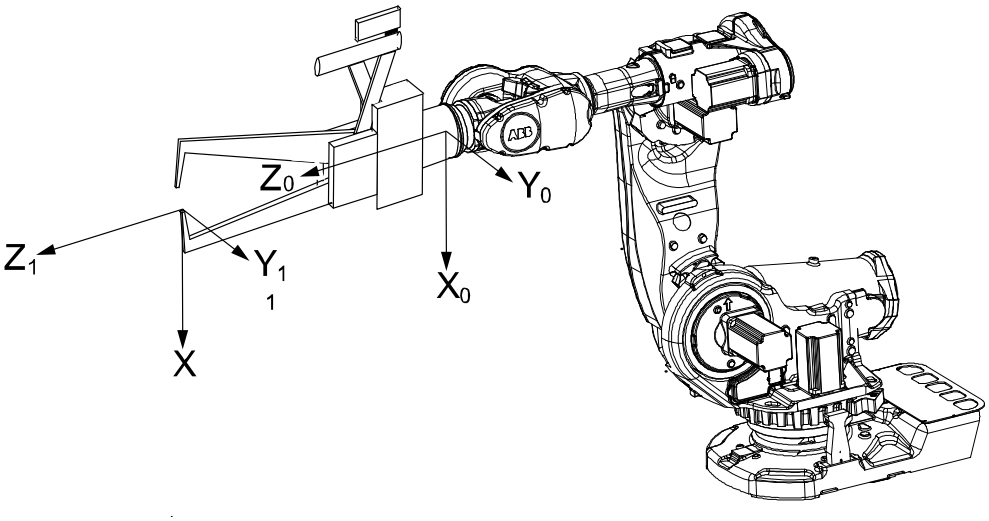
	Action
1	On the **ABB** menu, tap **Jogging**.
2	Tap **Tool** to display the list of available tools.
3	Tap the tool you want to edit, then tap **Edit**. A menu appears. • **Change Declaration** • **Change Value** • **Delete** • **Define**
4	In the menu, tap **Change Value**. The data that defines the tool appears. Green text indicates that the value can be changed.
5	Proceed with changing the data as described below.

Continues on next page

Measuring the tool center point

The easiest way to define the tool center point, TCP, is usually to use the predefined method described in *Defining the tool frame on page 180*. If you use this method, you do not have to write any values for the frame as these are supplied by the method.

If you already have the measurements of the tool, or for some reason want to measure them manually, the values can be entered in the tool data.



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X	X axis for tool0
Y	Y axis for tool0
Z	Z axis for tool0
X	X axis for the tool you want to define
Y	Y axis for the tool you want to define
Z	Z axis for the tool you want to define

	Action
1	Measure the distance from the center of the robot's mounting flange to the tool's center point along the X axis of tool0.
2	Measure the distance from the center of the robot's mounting flange to the tool's center point along the Y axis of tool0.
3	Measure the distance from the center of the robot's mounting flange to the tool's center point along the Z axis of tool0.

Editing the tool definition

	Action	Instance	Unit

1	Enter the cartesian coordinates of the tool center point's position.	`tframe.trans.x`
		`tframe.trans.y`
		`tframe.trans.z`
			[mm]

Continues on next page

5.5.5 Editing the tool data
Continued

	Action	Instance	Unit

2	If necessary, enter the tool frame orientation.	`tframe.rot.q1`
		`tframe.rot.q2`
		`tframe.rot.q3`
		`tframe.rot.q4`
			None

3	Enter the weight of the tool.	`tload.mass`	[kg]

4	If necessary, enter the tool's center of gravity.	`tload.cog.x`
		`tload.cog.y`
		`tload.cog.z`
			[mm]

5	If necessary, enter the orientation of the axis of moment	`tload.aom.q1`
		`tload.aom.q2`
		`tload.aom.q3`
		`tload.aom.q4`
			None

6	If necessary, enter the tool's moment of inertia.	`tload.ix`
		`tload.iy`
		`tload.iz`
			[kgm^2]

7	Tap **OK** to use the new values, **Cancel** to leave the definition unchanged.		

5.5.6 Editing the tool declaration

Tool declaration

Use the declaration to change how the tool variable can be used in the program's modules.

Displaying the tool declaration

	Action
1	On the **ABB** menu, tap **Jogging**.
2	Tap **Tool** to see the list of available tools.
3	Tap the tool you want to edit, then tap **Edit**. A menu appears. • **Change Declaration** • **Change Value** • **Delete** • **Define**
4	In the menu, tap **Change Declaration**. The tool's declaration appears.
5	Edit the tool declaration as listed in section *Creating a tool on page 177*.

Note

If you change the name of a tool after it is referenced in any program you must also change all occurrences of that tool.

5.5.7 Deleting a tool

Deleting a tool

For more information about deleting a **tool**, see *Deleting a data instance on page 172*.

5.5.8 Setup for stationary tools

Stationary tools

Stationary tools are used, for instance, in applications that involve large machines such as cutters, presses and punch cutters. You may use stationary tools to perform any operation that would be difficult or inconvenient to perform with the tool on the robot.

With stationary tools, the robot holds the work object.

Make a tool stationary

This section describes how to make a tool stationery.

	Action
1	On the **ABB** menu, tap **Jogging**.
2	Tap **Tool** to display the list of available tools.
3	Tap the tool you want to edit, then tap **Edit**. A menu appears.
4	In the menu, tap **Change value**. The data that defines the tool appears.
5	Tap the instance `robhold`.
6	Tap **FALSE** to make this tool stationary.
7	Tap **OK** to use the new setup, **Cancel** to leave the tool unchanged.

Make a work object robot held

This section describes how to make a work object robot held.

	Action
1	In the Jogging window, tap **Work object** to display the list of available work objects.
2	Tap the work object you want to edit, then tap **Edit**. A menu appears.
3	In the menu, tap **Change value**. The data that defines the work object appears.
4	Tap the instance `robhold`.
5	Tap **TRUE** to indicate that this work object is held by the robot.
6	Tap **OK** to use the new setup, **Cancel** to leave the work object unchanged.

Differences in coordinate system referencing

This section describes differences in coordinate system referencing.

The...	...normally references the...	...but now references the...
work object coordinate system	user coordinate system	user coordinate system (no change)
user coordinate system	world coordinate system	robot's mounting plate
tool coordinate system	robot's mounting plate	world coordinate system

Continues on next page

5.5.8 Setup for stationary tools
Continued

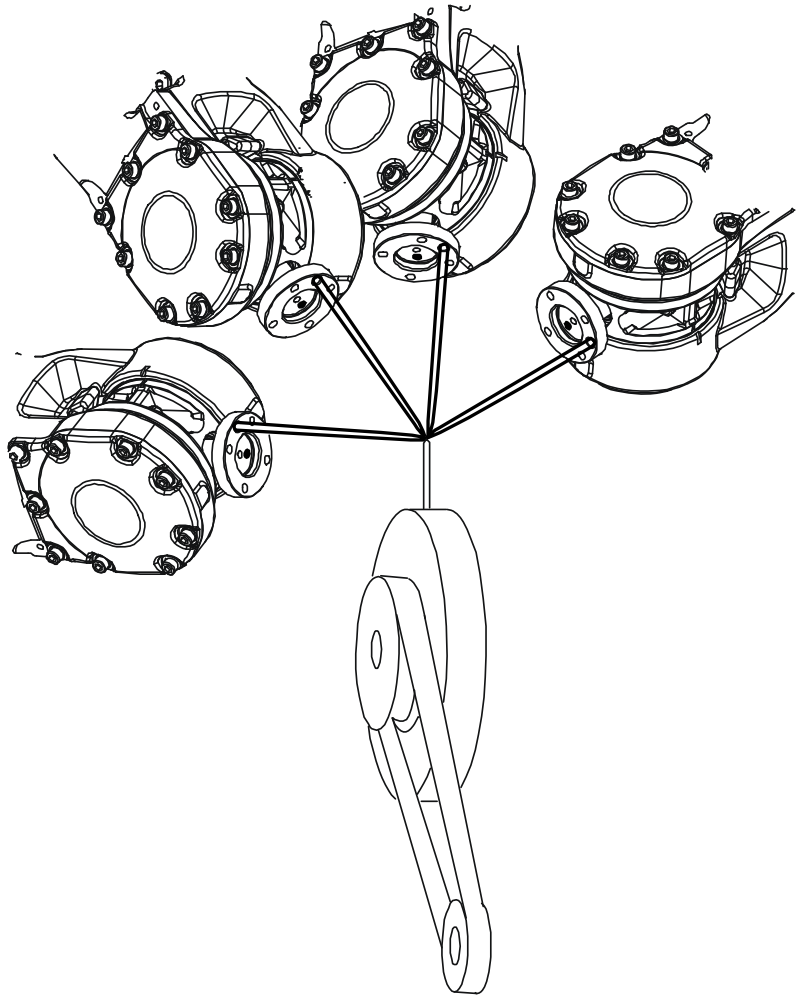
Set up the tool coordinate system

You use the same measurement methods to set up a stationary tool coordinate system as with tools mounted on the robot.

The world reference tip must, in this case, be attached to the robot. Define and use a tool with the reference tip's measurements when you create approach points. You also need to attach elongators to the stationary tool if you need to set up the orientation.

You should enter the reference tip's tool definition manually to minimize errors when calculating the stationary tool's coordinate system.

You may enter the stationary tool's definition manually.



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