Using an External TCP

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A robot can use and move around a static tool. For example, you can attach a tool frame/tool center point to a stationary tool and refer to it when teaching robot positions for deburring and polishing applications.

In this tutorial, you will learn how to:

- Attach robot base and tool frames to other components.
- Edit tool frames in a robot used for grasping actions.
- Teach a robot to move around a tool frame attached to another component.
- Edit the interpolation mode of individual motion statements.
- Edit the interpolation mode for base and tool frames.

This tutorial assumes you have a basic understanding of layout configuration and robot programming in a Visual Components product.



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Load Layout

This tutorial comes with a predefined layout, **External TCP Tutorial (start).vcmx**.

- 1. Download the layout from the Visual Components Academy.
- 2. Open the layout in the 3D world.

The layout includes a robot with a mounted tool, a table with a part, and an external tool.



Attach Base Frames

A base frame is a robot coordinate system used for simplifying robot positions. To show base frames in the 3D world, use the Frame Types, Robot Bases option in the 3D world toolbar.



BASE_1

The robot will need to move to the table to pick up its part. To simplify this solution, attach BASE_1 in the robot to the table. That allows you to reference positions local to the table. Be aware that you can use an external base frame without specifying a tool frame.

- 1. Click the **Program** tab, and then use the Jog panel to select the robot.
- 2. In the Jog panel, Robot section, use the Base property to select **BASE_1** in the 3D world.



The Manipulation mode should change from Jog to Move and the manipulator should be at the location of BASE_1 in the robot. The Base Properties panel should also be showing in the main window.

3. In the Base Properties panel, set Node to **Table:Table**. The parent node of BASE_1 is now the root node of the table.



The Base frame is still at the World frame of the robot, so you need to move it to the origin of the table. Remember, the Manipulation mode should be Move and BASE_1 should be the selected object in the 3D world.

4. On the Program tab, in the Tools group, click **Snap**. Notice that you are snapping BASE_1 not the robot. For snapping, you need to set the position and orientation and use a Snap Type of Origin.



5. In the 3D world, point at the table to preview the new location of BASE_1, and then click the **table** to confirm the selection.



BASE_2

The robot will need to pick up the part on the table. To simplify this solution, attach BASE_2 in the robot to the part. That allows you to reference positions local to the part.

1. At the upper-left corner of the Base Properties panel, use the drop-down menu to select **BASE_2**. You are now manipulating BASE_2, which is still attached to the robot.



You can move BASE_2 before attaching it to the origin of the part.

2. Snap BASE_2 to the origin of the part on the table.



3. In the Base Properties panel, set Node to **Part::Part**. BASE_2 should now be attached to the part and located at its origin.

Name	BASE_2	
Transform		
Node	Part::Part	v 🗸 🕅
InterpolationM	#NONE	∿3 ⊸

Edit Tool Frame for Grasp/Release Action

When a tool component is mounted on a robot, the imported tool frames are available to the robot and listed as options in the Jog panel, Tool property.



Any adjustments you make to an imported tool frame are temporary and only valid if the tool component is connected to the robot. To workaround this issue, you can use a native tool frame of the robot and move it to the same location as the imported tool frame. Why? A native tool frame is mapped to an output signal in a robot and used to perform actions. For example, tool frames 1-6 are mapped to output signals 1-16 to perform grasp and release actions.

 Actions Configuration 				
Signal Actions				
Output	1	Ŧ		
On True	Grasp	Ŧ		
On False	Release	Ŧ		
Grasp				
DetectionVolu	X 20 Y 50 Z 20			
Using tool	TOOL[1]	▼		
Release GravityDirection	25			

To show base frames in the 3D world, use the Frame Types, Robot Tools option in the 3D world toolbar.



TOOL[1]

To pick up the part on the table, the robot will use GripperTCP, an imported tool frame. TOOL[1] in the robot is already mapped to its output signal 1, so it can be used for grasp and release actions.

- 1. On the Program tab, in the Manipulation group, click **Jog**. The Manipulation mode should change from Move to Jog and the manipulator should be at the end of the robot arm. The Jog panel should also be showing in the main window. That is, you are now jogging the robot.
- In the Jog panel, Robot section, use the Tool property to select TOOL[1] in the 3D world.

Jog			Ŧ×
▼ Robot GenericRob			
Coordinates	🔘 World	O Parent	Object
X 1102.5	Y 777.531	Z 137	7
<mark>Rx</mark> -90	Ry 90	Rz 0	
Base	BASE_1		▼ ¢
Tool	TOOL[1]		- 🔅
Approach Axis	+Z		13

3. Snap TOOL[1] to the same position and orientation as GripperTCP.

For snapping, you can use a Snap Type of Frame, which allows you to select coordinate systems/frame types in the 3D world.



The tool component has a lot of tool frames, so use the Preview option and tooltip to make sure you are selecting GripperTCP



Attach Tool Frame

A tool frame is a tool center point (TCP) used for positioning a robot. That is, where the TCP goes, the robot arm follows it. With an external TCP, the position of the tool frame is usually fixed/stationary and the robot arm moves around it.

TOOL[2]

After the robot picks up the part from the table, the robot will move the part around the tip of the external tool. To move the robot not the tool, TOOL[2] in the robot will be attached to the external tool and be used as an external TCP.

1. In the upper-left corner of the Tool Properties panel, use the drop-down menu to select **TOOL[2]**. You are now manipulating TOOL[2], which is still attached to the mount plate of the robot.



2. In the Tool Properties panel, set Node to **Feeder::Feeder**. TOOL[2] should now be attached to the external tool and located at its origin.

Name	TOOL[2]		
Transform			
Node	Feeder::Feeder		- 🖾
InterpolationM	#NONE	13	Ŧ

3. Snap TOOL[2] to the face center at the tip of the external tool.

We recommend you first change the Render mode to Face edges shaded to help with seeing the edges and faces of the external tool geometry.



For snapping, you can use a Snap Type of Face.



Zoom in and center the camera on the tip to make selection easier. Use the Preview option and tooltip to make sure you are selecting the face center.



Teach Pick Routine

You are now ready to teach the robot how to pick up the part on the table.

- 1. On the Program tab, in the Manipulation group, click **Jog**. You are now jogging the robot.
- 2. In the Jog panel, use the **Parent** coordinate system, and then set Base to **BASE_1** and Tool to **GripperTCP**.
- **3.** Snap the robot to the top face center of the part. If you are using the Jog tool/ manipulator, instead of the Snap tool, you might need to change the Snap Type in the Jog panel to Edge & Face.



4. In the Program Editor panel, create a new sequence and name it **Pick**.



- 5. In the Pick sequence, add a Linear motion statement. This is the pick location.
- 6. Add a **Set Binary Output** statement that uses an OutputPort of **1** and an OutputValue of **True**. This signals a grasp action that uses TOOL[1], which is at the same location as GripperTCP.
- **7.** Jog the robot away from the part along the Z-axis, and then add a **Linear** motion statement. This is the retract position.
- **8.** Add a **Point-to-Point** motion statement, and then drag it to the beginning of the sequence. This is the approach position.

Program Editor	Ŧ	>	٢
Subprograms		ß	Ô
Main Se Pick			
ペパパ -T -B ● ⊡ := ♬ ◇ 🚪 🌀 目 🖶 +8 8+			
ໍ້ PTP P3 GripperTCP BASE_1 100% ູ 7° LIN P1 GripperTCP BASE_1 2500mm/s ອີ→ Set OUT[1] == True ູ 7° LIN P2 GripperTCP BASE_1 2500mm/s			

- **9.** Select the **Main** routine, and then add a **Call Subroutine** statement that calls the **Pick** sequence.
- **10.** Run the simulation, verify the robot picks up the part, and then reset the simulation.



Teach Part Position

You can teach the robot to position the part at the tip of the external tool. In this case, you will use a linear motion and align a top face corner/vertex of the box with the tool tip.



- 1. Run the simulation until it stops. It should stop when the robot completes its program and is still grasping the part.
- 2. On the Program tab, in the Tools group, click **Align**. Notice that you are aligning the robot to the external tool. The part is considered an extension of the robot. For aligning, you need to set the position but not the orientation and use a Snap Type of Edge or Edge & Face.



3. In the 3D world, click the top face corner point of the part that is closest to the external tool. This is the point to align with the next selection.



4. Change the Snap Type to **Frame**, and then select **TOOL[2]** in the 3D world. This is the point of alignment. The part should now be touching the tip of the external tool.



- 5. In the Program Editor panel, select the **Main** routine, and then add a **Linear** motion statement at the end of the sequence.
- **6.** Reset the simulation and run it again, verify the robot picks the part and moves it to the tool, and then reset the simulation.



Adjust Tool Path

Before you teach the robot to move around the external TCP, take some time to review which axis of the TCP the part will move along in its path.

- **1.** Run the simulation until it stops.
- 2. Select **TOOL[2]** in the robot, switch the coordinate system to **Object**, and then notice the orientation of the tool's coordinate system.



3. Rotate **TOOL[2]** around the Z-axis by -**90** degrees to align its X-axis along the edge of the part.



Teach Tooling Routine

You can now teach the robot to move the part around the external TCP.

- **1.** Run the simulation until it stops.
- 2. In the Jog panel, use the **Object** coordinate system, and then set Base to **BASE_2**, the base frame attached to the part, and Tool to **TOOL[2]**, the tool frame attached to the external tool component. Notice this base-tool configuration automatically changes External TCP to True.

Jog			Ŧ	×
▼ Robot GenericRob				
Coordinates	🔿 World	O Parent	O Ob	ject
<mark>×</mark> 0	Y 0	Z 0		
Rx 0	Ry 0	Rz 0		
Base	BASE_2		Ŧ	✿
ТооІ	TOOL[2]	~	•	₽
Approach Axis	+Z	13		Ŧ
Configuration	FRONT ABOV	/E NOFLIP		Ŧ
External TCP	True			

3. In the Program Editor panel, add a new sequence and name it **Tooling**.



4. Add a **Linear** motion statement. Notice the robot position inherits the orientation of TOOL[2]. This happens because the interpolation of the motion statement is from the base frame to the tool frame.



You can reverse the interpolation of a motion statement to be from tool frame to base frame. In that case, the robot position inherits the orientation of its base frame.

5. In the Statement Properties panel, select **ExternalTCP**. Notice the motion statement is now at BASE_2. This might be impractical in cases where you want to reference the orientation of a TCP and apply that orientation to robot positions.



6. Clear ExternalTCP to move the robot position back to the location of TOOL[2].

Statement Properties			Ŧ×
Р5			
Coordinates	◯ World	Parent	Object
X 500	Y 0	Z 1	00
Rx 180	Ry 0	Rz 9	0
Name	P5		
Base	BASE_2		Ŧ
Tool	TOOL[2]		Ŧ
ExternalTCP			
MaxSpeed	2500		mm/s

7. In the 3D world, use the **Jog** tool and **Object** coordinate system to move the robot approximately **500mm** along the X-axis.



8. Next, rotate the robot approximately -90 degrees around the Z-axis to have the same configuration as before.



9. In the Program Editor panel, add a **Linear** motion statement to the end of the Tooling sequence.



10. Repeat steps 7, 8 and 9 three times to make a path of linear motions along the edges of the top face of the part. There should be a total of five statements.



11. Reset the simulation and notice robot positions for the Tooling sequence are at the part not the external tool. This is because the parent of the positions is BASE_2, which you attached to the part. Objects move with their parent object.



Test

1. In the Program Editor panel, select the **Main** routine, and then add a **Call Subroutine** statement that calls the **Tooling** sequence.



2. Run the simulation, verify the robot moves the part around the external TCP, and then reset the simulation.



Define Interpolation Orientation Mode

Every base and tool frame in a robot has an interpolation orientation (IPO) mode, which affects the orientation of a robot position. Generally, a robot position inherits the orientation of a tool frame (TCP) and references the coordinate system of a base frame (BASE). This relationship can be switched — see page 4, steps 4 to 6.

In most cases, you do not need to edit the IPO mode for individual frames because you can use the External TCP option in the Jog panel or the ExternalTCP property of a motion statement. However, you might edit the IPO mode of a frame to require a valid base-tool relationship when teaching a robot.



1. In the Jog panel, set Tool to **TOOL[2]**.

Notice the Jog tool/manipulator is locked in the 3D world. You can still use forward kinematics by changing the joint values of the robot. For inverse kinematics, we recommend a workflow where you start and stop a simulation, and then teach the robot, which is what you have done in this tutorial.

The manipulator is located at the mount plate of the robot. Why? The default IPO mode for base and tool frames is NULL, which means the relationship refers to the current robot configuration. In this case, the robot is interpolating from base to tool. TOOL[2] is attached to a node in another component, so the kinematics solver of the robot knows its robot needs to move around TOOL[2].

Figure 1. Kinematic Solutions



2. In the Jog panel, set External TCP to **True**. The manipulator moves to the Robot World Frame, which is the base frame in the current configuration. In this specific case, TOOL[2] is acting as a base frame.



- 3. In the Jog panel, select **TOOL[2]**.
- **4.** In the Tool Properties panel, set InterpolationMode to **#TCP**. This mode means the tool frame acts as a tool center point not a base frame.



5. Click the **Jog** panel, and then notice the External TCP option automatically changed to False.



Review

In this tutorial you learned how to change the location of robot base and tool frames and how to attach them to other components. You used base frames to simplify robot positions at work areas and individual parts. You used a native tool frame and an imported tool frame to teach robot positions and signal grasp actions. You also used a tool frame as an external tool center point, so a robot could move a workpiece around a stationary tool. Finally, you learned how to affect the orientation of robot positions by editing the relationship of base and tool frames.