Overview

This overview summarizes topics described in detail later in this chapter.

Describing Space

A coordinate system is a way to describe the space around the arm. CRS robots can use any of four coordinate systems: world, joint, cylindrical, and tool. Coordinates of any of these systems can describe any point in robot space.

Coordinate System
World
Joint
Cylindrical
Tool

Identifying Locations

A location is a specific point in space that is stored by the robot for use in an application. There are two types of locations: cloc (cartesian location) that stores coordinates based on the world coordinate system, and ploc (precision location) that stores coordinates based on the joint coordinate system.

Coordinate System	Location Type
World	cloc (cartesian location)
Joint	ploc (precision location)

Robot Motion

The robot arm can move relative to the coordinate system along a particular axis. The robot motion can be continuous or incremental. The types of arm motion available also depends on the robot tool you are using. As an example, you can move the robot using the cylindrical coordinate system using the teach pendant but not ash.

Straight Line Motion

One type of motion is straight line motion, in which several joint s motions are synchronized so that the tool axis moves along a straight line. In straight line motion, the motion of each robot axis is coordinated so that the end effector moves in a straight line. You can move in a straight line in from any position along specified world or tool axis. You can also move in a straight line to a specified variable if the variable is a cloc (cartesian location). You cannot move in straight line mode to a precision location.

Straight line movements are useful when you must maintain the level or orientation of the payload. For example, if you are moving liquids you could use straight line movements to prevent the liquid from spilling.

Moving Along or Around Axes

You can move the tool along most axes of coordinate systems. For straight motion, a number of joints rotate at the same time to move the tool in a straight line along the axis.

Coordinate System	Axis	Motion Availability and Description
World	X	straight motion (positive or negative)
	Y	straight motion (positive or negative)
	Z	straight motion (positive or negative)
Joint	any arm joint	rotation (positive or negative)
Cylindrical	θ	rotation (positive or negative)
	R	straight motion (positive or negative)
	Z	straight motion (positive or negative)
Tool	X	straight motion (positive or negative)
	Y	straight motion (positive or negative)
	Z	straight motion (positive or negative)

Note: In the world and tool coordinate systems, you can move in straight line motion. Straight line motion is not available in the joint and cylindrical coordinates systems.

Moving Continuously or Incrementally

Some motions, along or around an axis, are available in a continuous or incremental type of motion. Some of these are available only using certain robot system tools, such as ash, or the teach pendant. The following table highlights motion types available with specific system tools.

Coordinate System	Motion	Tool		
		Teach Pendant	Application Shell	RAPL-3 Program
World	continuous motion along axis	velocity	[no equivalent]	[no equivalent]
	incremental motion along axis	jog	wx, wy, wz	jog()
	alignment to specified axis	align	align	align()
	straight line motion parallel to an axis	[no equivalent]	wxs, wys, wzs	wxs(), wys(), wzs()
Joint	continuous motion around axis	velocity	[no equivalent]	[no equivalent]
	incremental motion (deg.) around axis	jog	joint	joint()
	incremental motion (pulses) around axis	[not available]	motor	motor()
Cylindrical	continuous motion along axis	velocity	[no equivalent]	[no equivalent]
Tool	continuous motion parallel to tool axis	velocity	[no equivalent]	[no equivalent]
	specified distance motion parallel to a tool axis	[no equivalent]	tx, ty, tz depart	jog_t() tx,(), ty(), tz() depart
	straight line motion parallel to a tool axis	[no equivalent]	txs, tys, tzs departs	jog_ts() txs(), tys(), tzs() departs()

Note: Refer to the teach pendant and application shell sections of this manual for details on the teach pendant and ash motion features. For RAPL-3 motion command details see the *RAPL-3 Language Reference Guide*.

Moving the Arm When Limp

Robot motion is controlled by servo motors for all motion initiated from the robot controller or robot system tools. However, you can disengage servo motor control of the robot joints with the limp command. When limp, the

robot joints can be moved by hand. Individual joints can be limped, or all of the joints can be limped at once.

Limp motion is similar to joint motion; however, in joint motion the servo motor moves the joint, and in limp motion the joint movement is human or other external force. The motion however can be considered to be joint motion.

When an axis is limp, the encoders still supply feedback to the controller.

Warning! Caution must be used when limping joints, because a limped joint will fall due to gravity or inertia, resulting in robot collisions which can damage the robot or other equipment.

Moving the Tool Center Point

When moving along an axis or to a specified location, the robot moves the tool center point (TCP). To ensure that the TCP is the point that you want, such as the tip of a dispenser or the point halfway between two gripper fingers, you describe the tool's size and orientation to the software with a tool transform.

Tool Transform

A tool transform informs the controller of the position of the tool (tool center point -TCP). Without a tool transform, the controller moves the arm as if the TCP is the center point of the tool flange surface. A tool transform is the measurements in the tool coordinate system of the mounted tool s TCP. The tool transform also includes the yaw, pitch, and roll coordinates which define the tool s orientation.

Base Offset

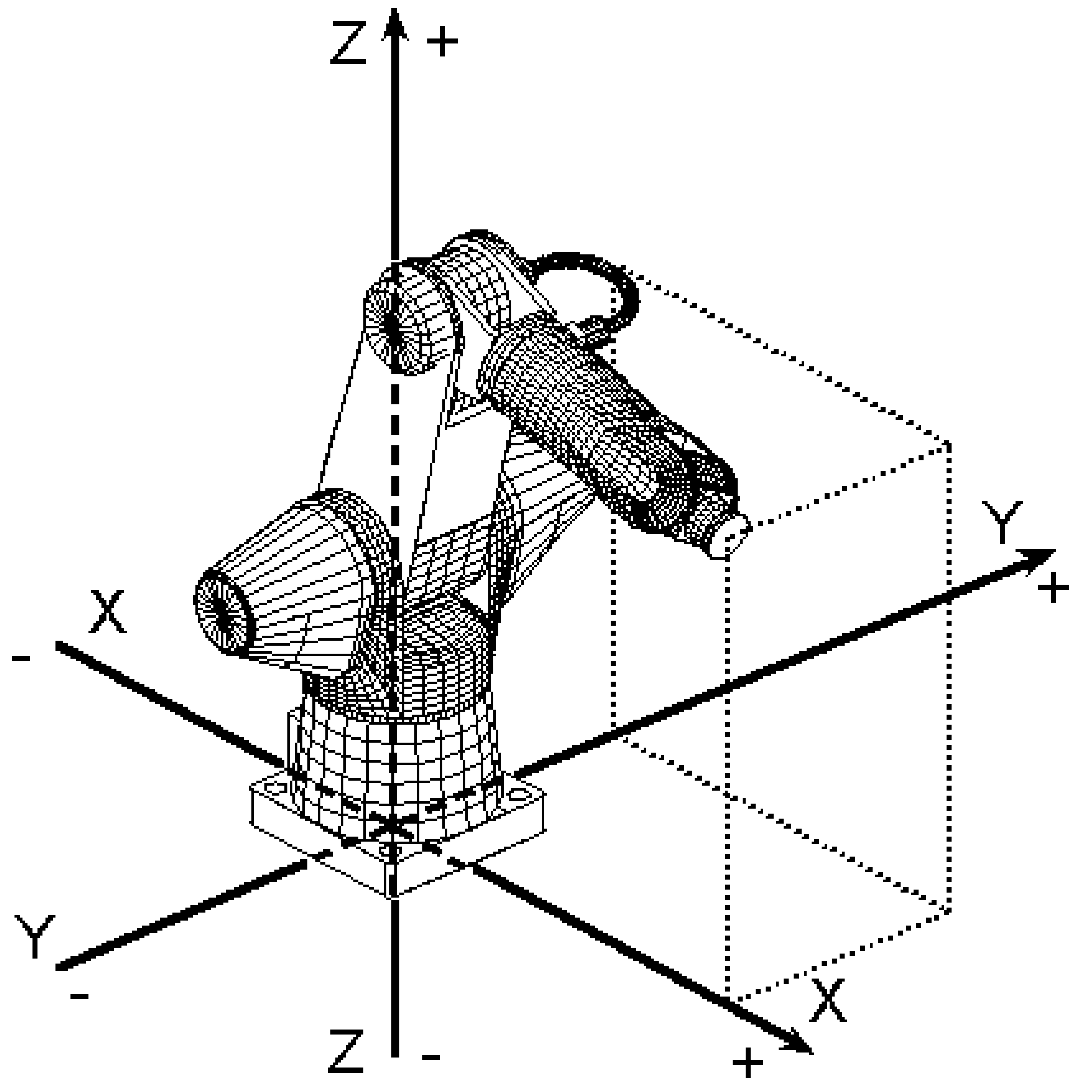
The origin of the world coordinate system is the center of the base of the robot. In some cases, for instance if the robot is to be hung suspended above the workspace, you may need to change this origin. To do so, set a base offset. A base offset is a set of coordinate values which re-defines the new origin. Refer to the *Application Development* section of this *Application Development Guide* for the details on setting a tool transform.

Cartesian Space, Locations, and Motion

One way to describe the arm workspace is the world coordinate system. With this system, points in space are identified by cartesian locations, and motion parallel to any axis is available from the teach pendant, the application shell and RAPL-3 programs.

World Coordinate System

The world coordinate system is based on an axis system with three axes: X, Y, and Z at right angles to each other which intersect at the origin. The origin is the center of the robot mounting flange when a base offset is not set. The following figure shows the axis orientation. The Z axis is vertical with positive Z up. The X and Y axes are horizontal, with positive X forward away from the front of the arm and positive Y to the side as shown. The relationship of X, Y, and Z follows the right-hand rule of thumb, index finger, and middle finger with your palm facing upwards.

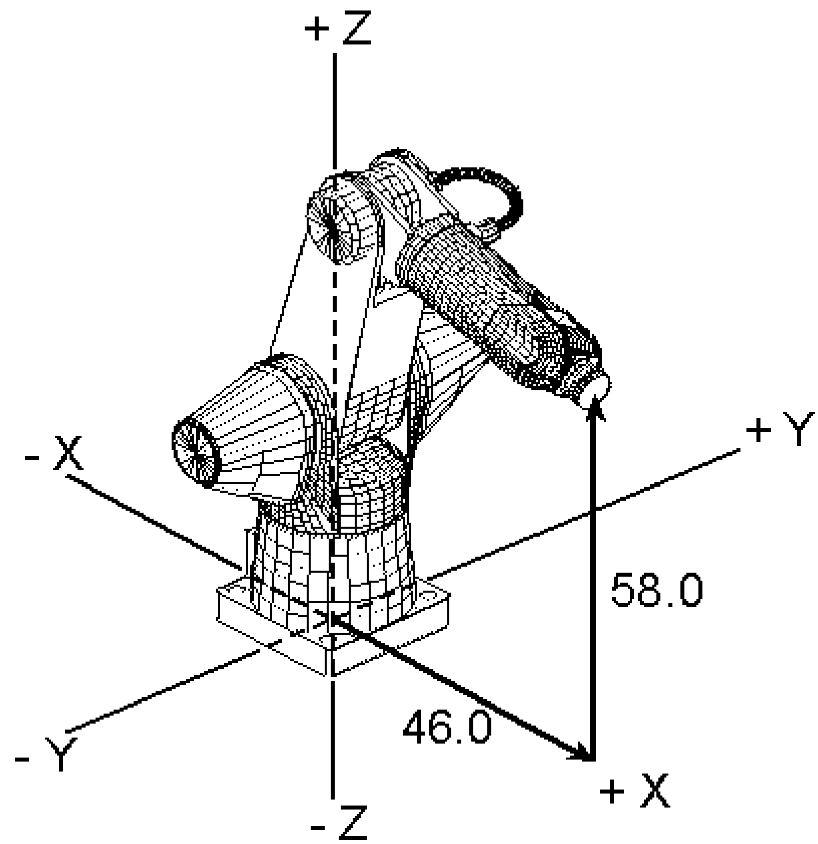


World coordinates can describe any point in the world coordinate system. To store world coordinate data, the software uses cartesian locations. Coordinates contain data about position and orientation.

Position

The position of a point in the workspace is identified by distances (positive or negative) along the X, Y, and Z axes from the origin.

For example, in the diagram with the A465, the center of the mechanical interface can be described as 46.0 cm. in a positive X direction, 0.0 in a Y direction, and 58.0 in a positive Z direction, or (46.0, 0.0, 58.0).



Orientation

When your tool is at a point in space, it could be oriented in different ways. For example, it could be pointing downward, parallel to the negative Z axis, or pointing forward, parallel to the positive X axis.

The orientation of a tool is identified by a rotation (positive or negative) around the X, Y, and Z axes (or around axes that are parallel to the X, Y, and Z axes). Rotation around the X axis is called roll, around the Y axis, pitch, and around the Z axis, yaw. By convention, these are written in the order: yaw, pitch, roll.

For example, in the diagram with the A465, the mechanical interface is oriented with no yaw, a 15.0 degree pitch, and a 35.0 degree roll, or (0.0, 15.0, -35.0).

Motion around an axis follows the right-hand rule. When your thumb is pointing in the positive direction of the axis and your fingers are curled into your palm, your fingers are pointing in the positive direction of rotation.

Full Coordinates

The full coordinates for a tool point are written in the order: X, Y, Z, yaw, pitch, roll. The example is (46.0, 0.0, 58.0, 0.0, 15.0, -35.0).

Note: A tool on an A255 with five degrees of freedom has five coordinates: X, Y, Z, pitch, and roll. It does not have yaw.

Cartesian Locations

In RAPL-3, a cartesian location, a cloc, represents a point in the arm workspace defined by cartesian-style world coordinates.

The data in a cloc correspond to dimensions in the workspace and are independent of arm type. The location is the same whether accessed by an F3 or an A465.

The data are also independent of robot pose. The location might be accessible by the arm in different poses. In other words, a cloc location variable does not necessarily define unique robot axis positions.

Motion with World Coordinates

You can move the tool center point (TCP) parallel to the world X, Y, and Z. You can also align the axis of the tool to a world axis.

Note: The axis of the tool is defined as the axis perpendicular to the plane of the mechanical interface pointing away from the interface. For the A series robots, the tool axis is by definition the tool X axis. For the F3, the tool axis is defined as the tool Z axis. Refer to the *Tool Space and Motion* section.

Motion	Tool		
	Teach Pendant	Application Shell	RAPL-3 Program
continuous motion along axis	velocity	[no equivalent]	[no equivalent]
incremental motion along axis	jog	wx, wy, wz, xrot, yrot, zrot	jog()
straight line motion	[not available]	wxs, wys, wzs, xrots, yrots, zrots	zrots(), yrots(), xrots() jog_ws()
alignment to axis	align	align	align()

Continuous Motion

You can move the TCP by continuous motion along any axis of the world coordinate system, but only with the teach pendant.

With the teach pendant, you select Vel (velocity) type of motion and World mode. You set the speed with the Speed Up and Speed Down keys. Pressing a coordinate key (X, Y, Z, yaw, pitch, or roll, positive or negative) moves the TCP continuously as long as the key is pressed.