Safety First

Process Solutions

Our robots are used for a wide range of industrial applications providing process solutions for material handling, material joining, painting dispensing and spot welding.

- **Material Handling Process Solutions**
  - Glass /panel sheet transfer
  - Machine load /unload
  - Material removal
  - Mechanical /electrical assembly
  - Packing
  - Palletizing
  - Waterjet cutting
- **Material Joining Process Solutions**
  - Arc welding
  - Thermal cutting
- **Painting /Dispensing Process Solutions**
  - Automotive painting and surface finishing
  - General industrial painting and coating
  - Sealing or dispensing
- **Spot Welding Process Solutions**
  - Automotive spot welding and body assembly
  - General industrial spot welding




Safety and Cycle Power Module

- It is critical that operators of robots and robot applications begin with a solid understanding of Robot Safety before attempting to power up a robot. The Robotic Industries Association publishes the Proposed American National Standard for Industrial Robots and Robot Systems. You refer to this document for a comprehensive look at Safety Requirements.
- In this module you should learn about the procedure to safely cycle power from Standard Operator Panel (SOP) observing recommended safety practices.

Module Objectives

- **After successfully completing this module you should be able to:**
  - Recall safety considerations related to operating a robot within a work cell and powering up the controller
  - Demonstrate or explain how to power up the controller
  - Describe safety concerns of powering down the controller
  - Describe pre-defined robot positions (Home, Repair, Bypass)
  - Demonstrate or explain how to power down the controller

Prioritize the Safety of your Robotic System

The safety of people is always of primary importance when operating a Robot. However, equipment must be kept safe too. When applying safety to your robotic system, and given that people will always be #1 consideration, the following order is the recommended safety for robotic equipment.

#1

PEOPLE

#2

ROBOT

#3

EXTERNAL DEVICES

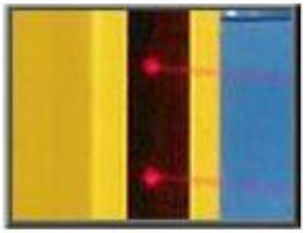
#4

TOOLING

#5

WORKPIECE

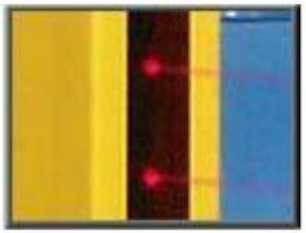
Use Safety Enhancing Devices



Emergency Stop Buttons

The Emergency Stop button is used in emergency situations to stop robot motion. It controls the operation of a circuit which overrides all other robot controls, removes drive power from the actuators, and causes all moving parts to stop. When the Emergency Stop button is pushed, "dynamic" braking is employed on all joints and all electrical brakes are engaged. Both the Standard Operator Panel and the Teach Pendant are equipped with Emergency Stop buttons.

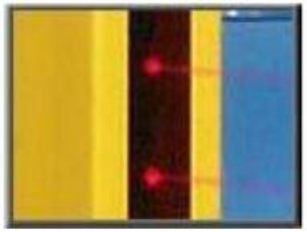
Use Safety Enhancing Devices



DEADMAN Switch

The DEADMAN switch, a pair of handles located on the back of the Teach Pendant, is a control switch that is used in conjunction with other factors to supply servo power. Gripping the DEADMAN switch correctly (middle detent position) while the Teach Pendant is ON will ensure personal safety. When the robot is energized, and the DEADMAN switch is released or gripped harder, servo power is deactivated and robot brakes are applied.

Use Safety Enhancing Devices



Light Curtains

Light Curtains are beams of light set up to travel from transmitter to receiver. This light protects personnel or unwanted objects from entering the restricted work envelope, the work area of the robot. When an interruption of the path of light to the receiver occurs, deactivation of servo power to the robot takes place, brakes are applied, and the robot comes to a stop.

Use Safety Enhancing Devices

Interlocks

Interlocks are any arrangement where the operation of one control or mechanism brings about, or prevents, the initiation of operations of another. These may include safety fences, light curtains, mats, operator controls, etc.

Use Safety Enhancing Devices

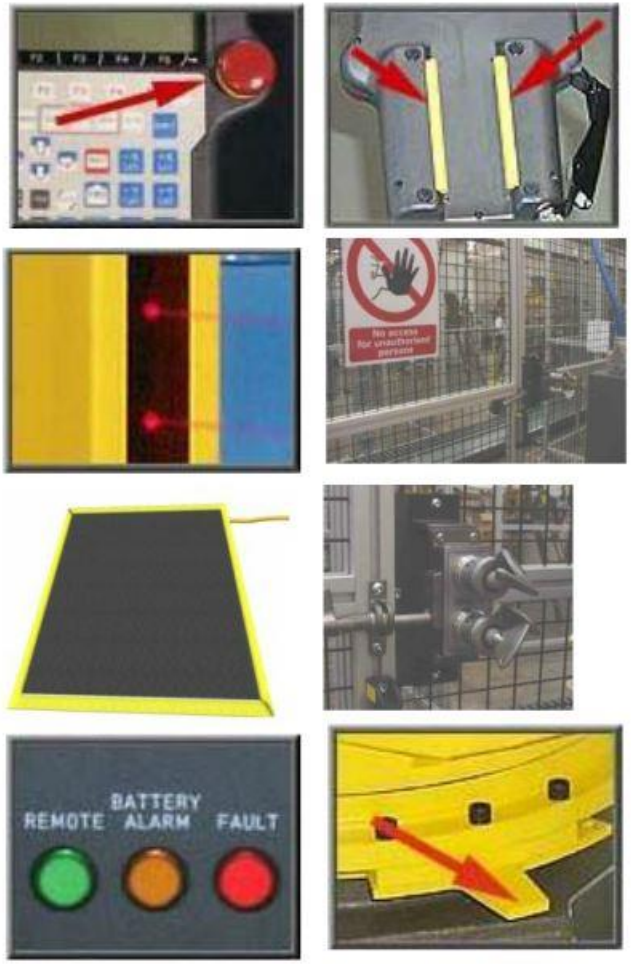
Motion Limits

Mechanical Limits, or hard stops, are physical limitations to joint motion. These hard stops are usually adjustable and are often mounted on the robot.

Over travel Limit Switches (optional)- The Over travel Limit Switch option consists of mechanical switches usually positioned to limit joint motion to just before the mechanical limits. The Over travel Limit Switches are wired to interlock the servo drives so as to drop power off the servos when tripped and generate a JOG-001 Over travel Violation warning.

Software Limits-Software limits are motion limits established in the system software and set by system variables. They are in effect only when the robot is calibrated. Should you attempt to jog beyond the upper or lower software limit, a JOG-013 Stroke Limit warning will be issued.

Use Safety Enhancing Devices



After people, the robot is usually the first thing that comes to a person's mind when talking about safety in a robotic application. Do not forget about the work area surrounding the robot. To enhance the safety of that work area, it is common to install some or all of these devices.

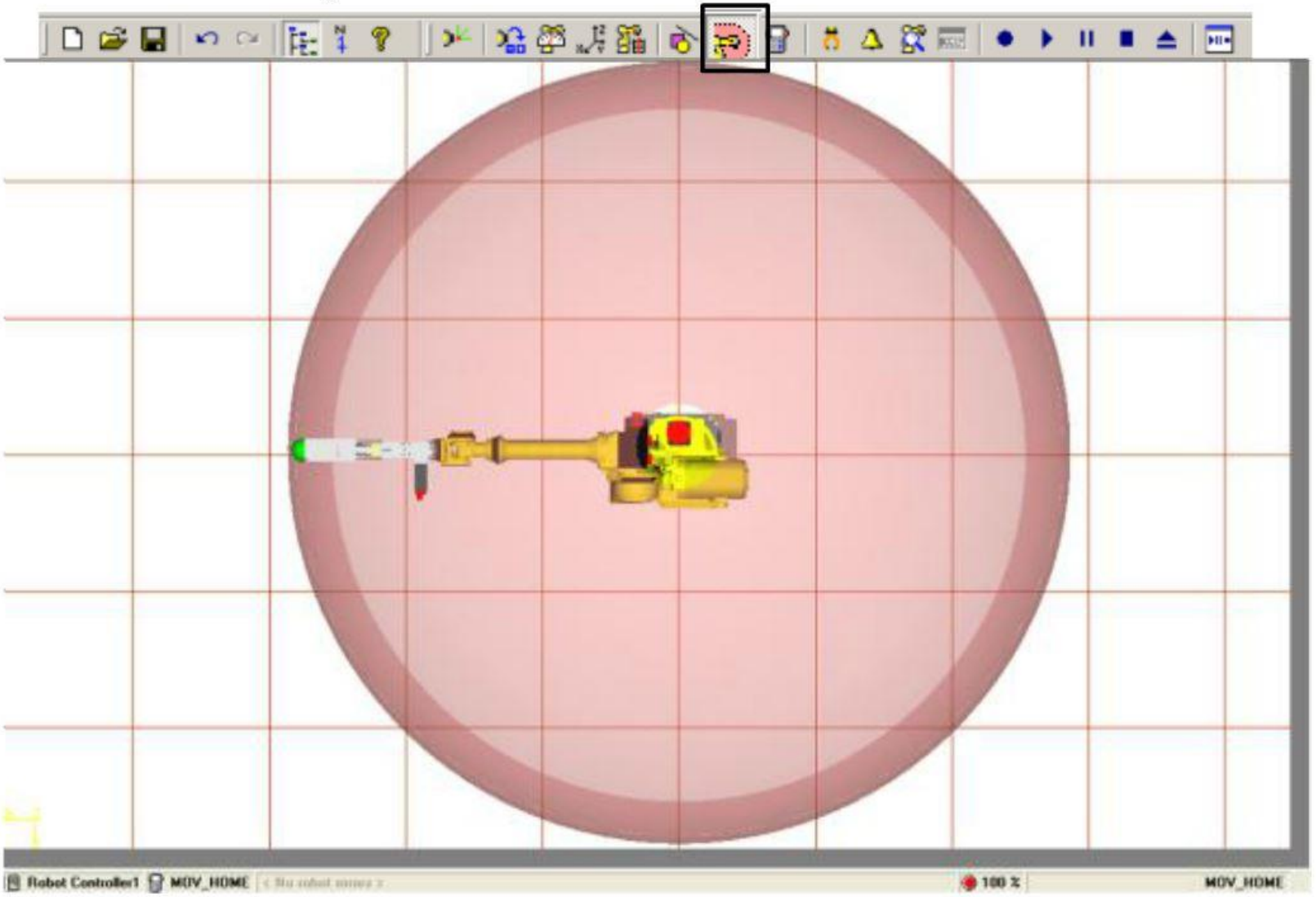
Stay safe while teaching or manually operating the robot

While teaching or manually operating a robot operators should:

- Never wear items or loose clothing that could get caught in moving machinery
- Keep long hair tied back and out of the way to avoid a potentially dangerous accident from occurring
- Visually inspect the robot and work envelope to be sure no potentially hazardous conditions exist
- Immediately report unsafe working conditions to a supervisor or to your safety department

DO NOT ENTER THE WORK ENVELOPE OF A ROBOT THAT IS ON

Work Envelope



Stay safe during inspection

- **Staying safe during inspection requires operators to:**
  - Turn off power at the controller
  - Lock out and tag out the power source at the controller
- **If power is needed to check robot motion or electrical circuit:**
  - You must be prepared to press the Emergency Stop button
  - Release all stored energy
- **Make sure you release all stored energy:**
  - Air and hydraulic pressure
  - Springs
  - Flywheels
  - Capacitors
  - Counterbalances

Mode Select Switch

AUTO MODE – Robot operated at the specified maximum speed. Cannot start programs using the Teach Pendant

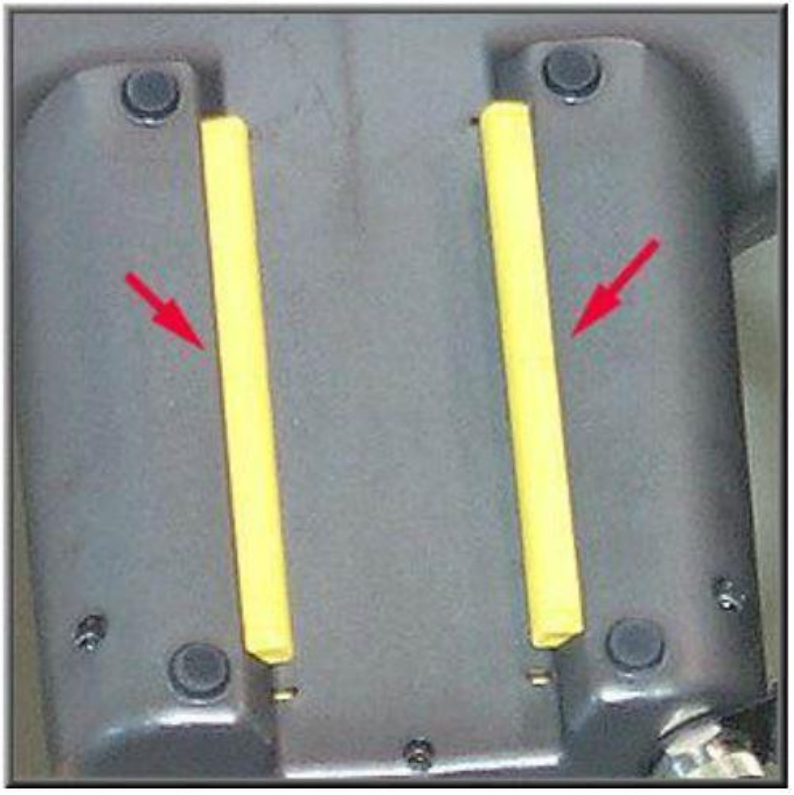
T2 MODE (Test Mode 2 – Full program speed, and override can be changed to 100%

T1 MODE (Teach Mode 1) - Cartesian speed is less than 250 mm/sec and Joint speed is less than 10% of the maximum override speed

Teach Pendant Emergency Stop button

- The Teach Pendant Emergency Stop button is used to stop robot motion and remove power in an emergency situation, regardless of whether the Teach Pendant is ON or OFF.

Teach Pendant DEADMAN Switch



- The Teach Pendant DEADMAN Switch, which is located on the back of the Teach Pendant, is used to:
  - Ensure personal safety when the Teach Pendant is on.
  - Interrupt robot motion in emergency situations.
- In a three-position Teach Pendant, releasing the DEADMAN switch or applying excessive force, when the Teach Pendant is on, will:
  - Remove power.
  - Instantly apply brakes.

NOTE: Always grip and hold the DEADMAN Switch when you want the robot to move.

Stay Safe While Teaching or Manually Operating a Robot

Testing the DEADMAN Switch:

1. Grasp and hold the DEADMAN Switch located on the back of the Teach Pendant
2. Turn the Teach Pendant ON **and jog the robot**
3. Release the DEADMAN Switch

Servo Power to the robot is deactivated and robot brakes are immediately applied (if the robot is in a motion environment)

Stay Safe While Teaching or Manually Operating a Robot

- **While teaching or manually operating a robot, you should:**
  - Know the path you would take to escape a moving robot
  - Make sure the escape path is not blocked in any way
  - Isolate the robot from all remote control signals
  - Test any program being run for the first time
    - Using low motion speed, **single step testing** for at least one full cycle
    - Using low motion speed, **continuously testing** the program for at least one full cycle
    - At production speed for at least one cycle to determine the true motion of the robot and path of the **Tool Center Point**

Power Up the Controller

Step 1: Visually inspect the robot, controller, work cell and surrounding area. Checking that all safeguards are in place and that work envelope is clear of personnel is critical.
You have been asked by your supervisor to power up the robot's controller. You must make sure that all personnel and equipment are out of the workcell. Besides people and equipment, what other things might you need to consider?

Emergency Stops

DEADMAN

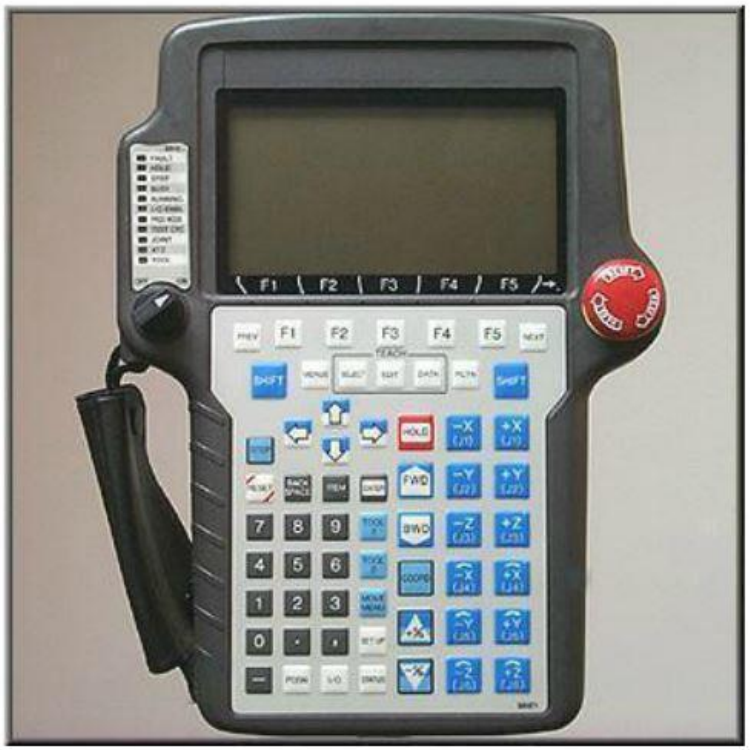
Warning Lights

External Devices

Safety Fences

Cables

Describe the Teach Pendant Device and How it is Used

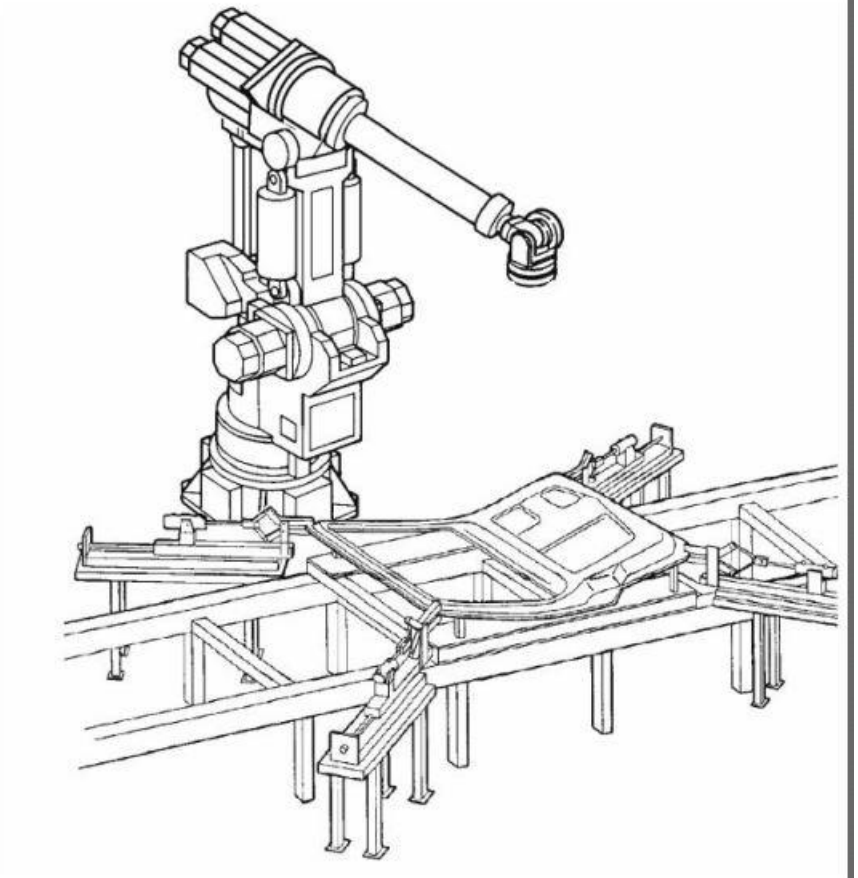


The Teach Pendant (TP) is a hand-held operator interface device that has been designed to make using the software associated with your robot easy. It is used to:

- Move the robot
- Create Teach Pendant Programs (TPP)
- Test programs
- Run programs in production
- Check robot status

Powering Down the Controller

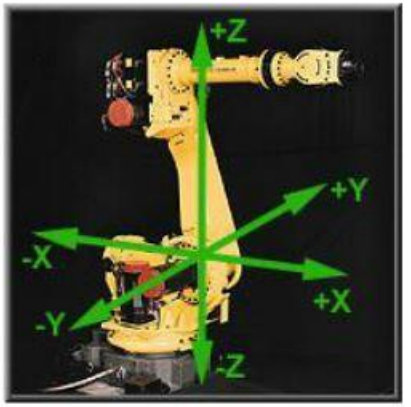
The first step to powering down the robot is to Start and end application programs with the robot in the same position. Using a predefine position called **Home** is some applications will place the robot in the same position. It is recommended that procedures specific to your installation be set in place and followed. Those procedures may involve more than just placing the robot in the Home position, and definitely should include a Lockout/Tagout procedure. Your management should determine all policies and procedures related to safe operation of robots purchased, and have those procedures readily available to operators.

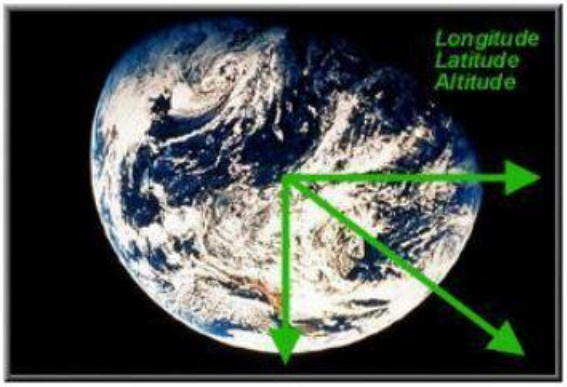


Coordinates, Points, Frames & Jogging

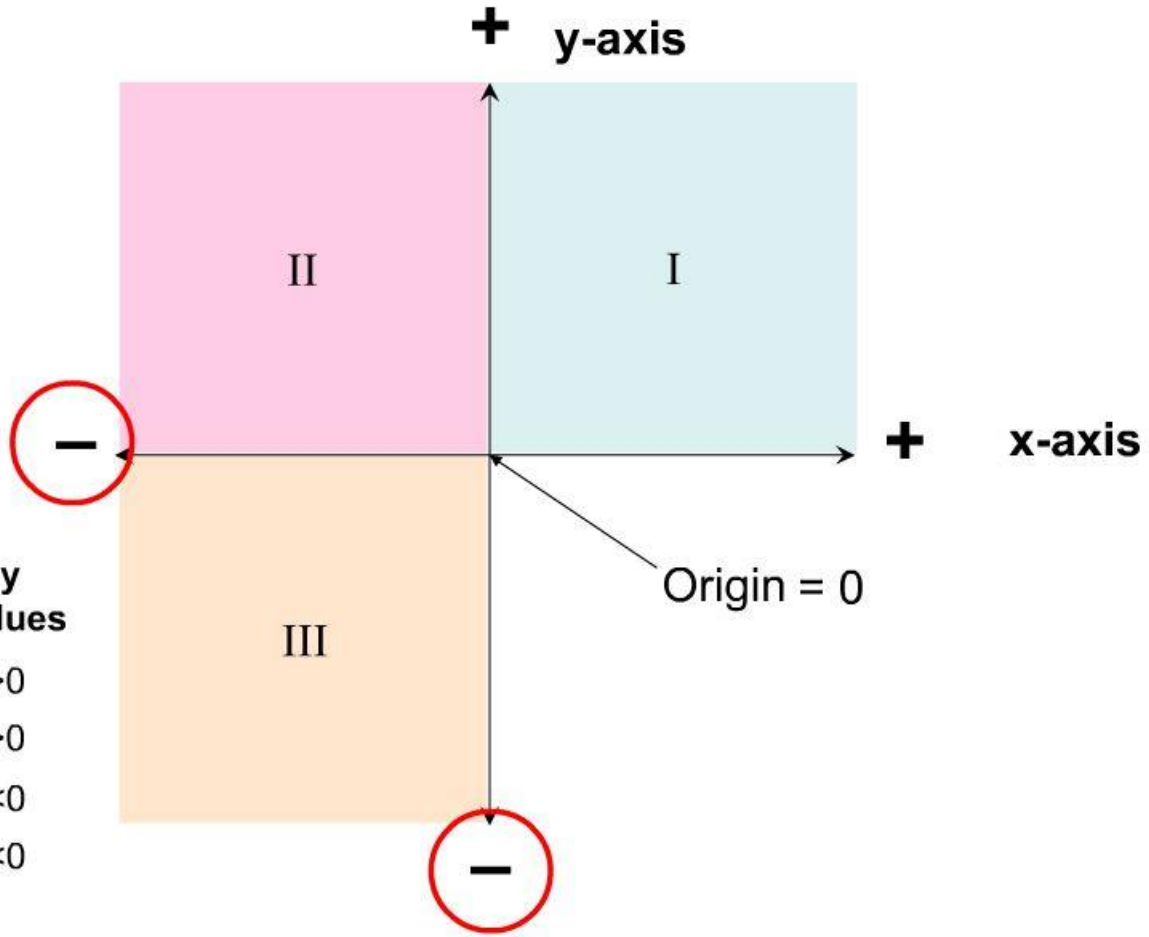
Define a Point

- A basic requirement for creating any Teach Pendant program is for operators to understand what a point is, and to be able to move a robot to a specified point in space in order to carry out a task. Teach Pendant programs commonly consist of movements to and from several points.
- REMEMBER: A point is a position in space which is usually defined based on the WORLD Coordinate System as a number of millimeters from the robot's origin. A point may also be displayed in JOINT with rotational joints being expressed in degrees and linear joints expressed in millimeters.



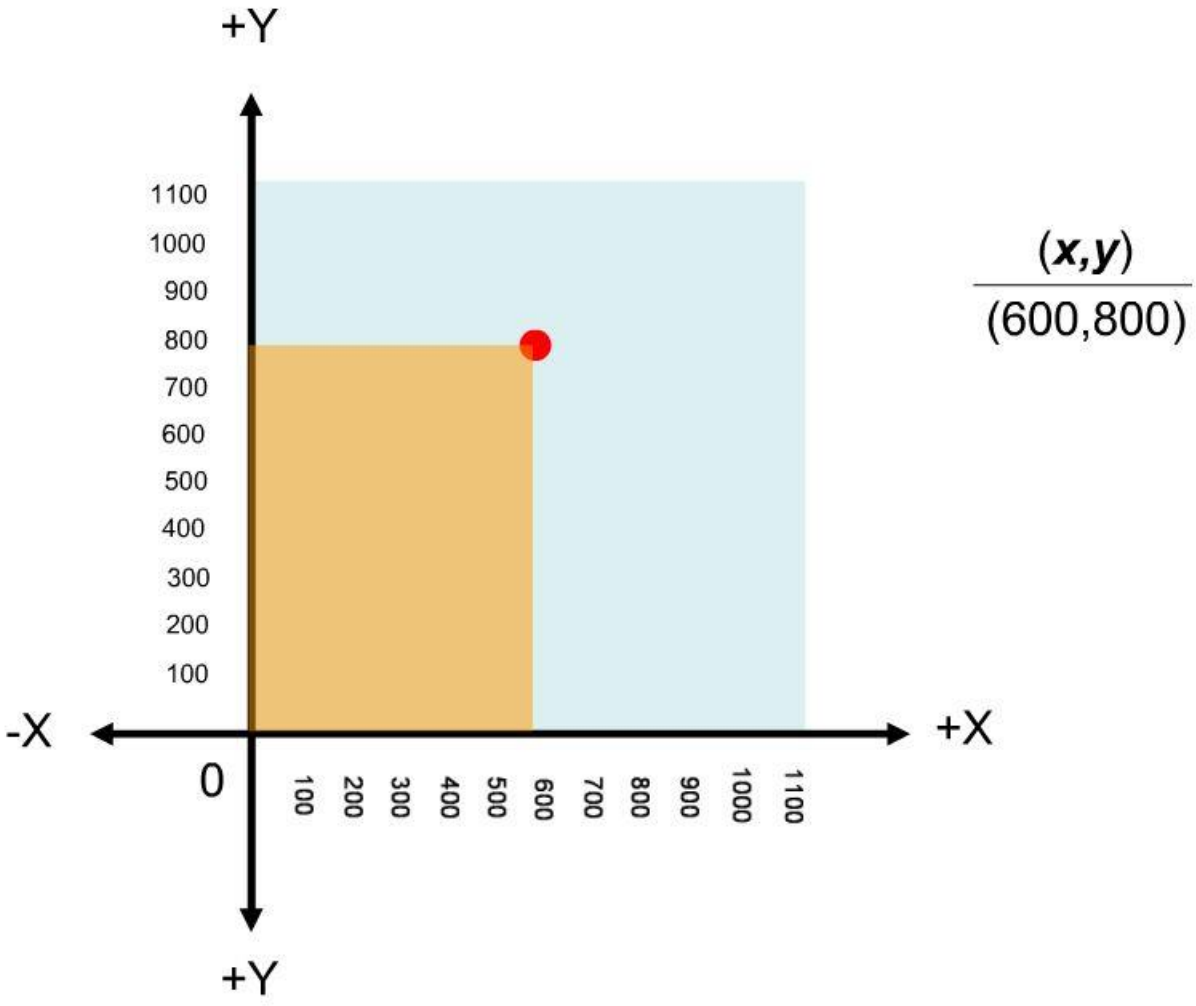


Two Dimensional Cartesian Coordinate



Quadrant	x values	y values
I	>0	>0
II	<0	>0
III	<0	<0
IV	>0	<0

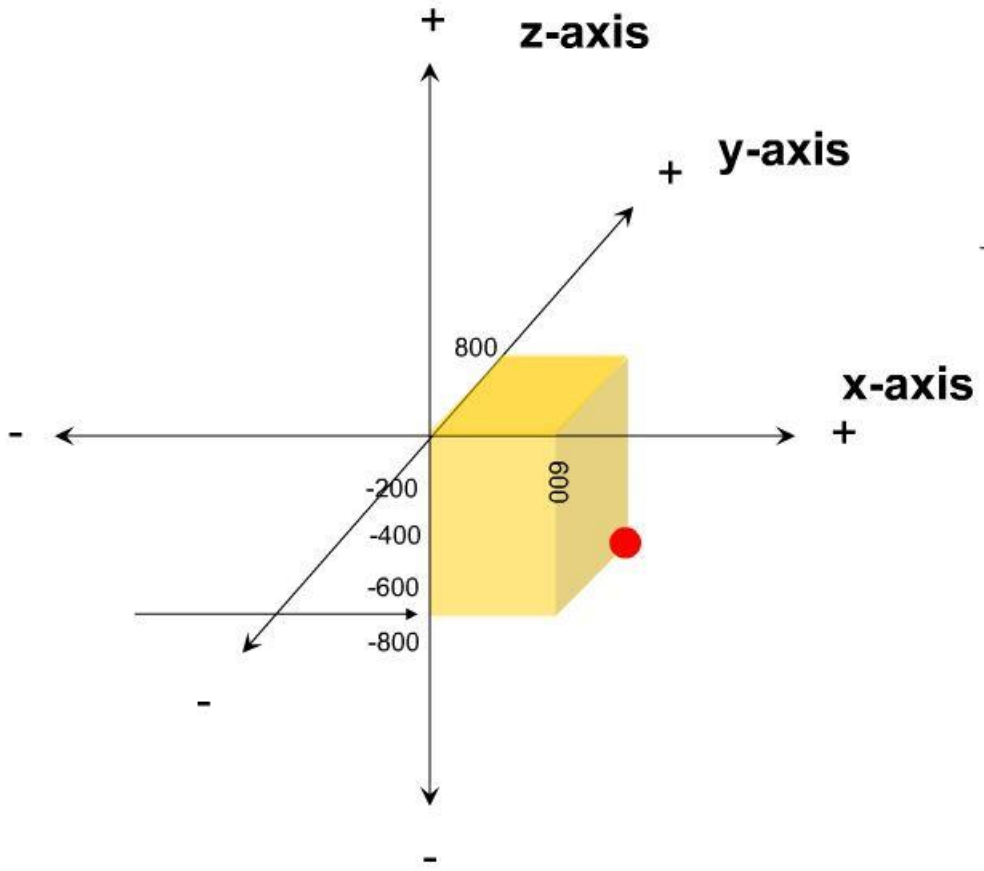
Create and Change Teach Pendant Programs



(*x*,*y*)

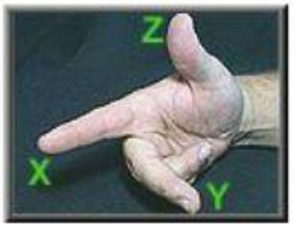
(600,800)

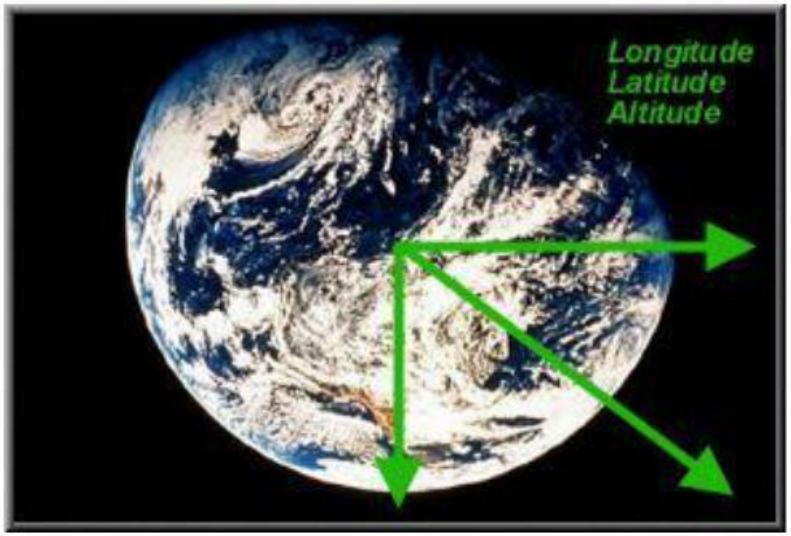
Three Dimensional Cartesian Coordinate



Cartesian Coordinate

- A 3-dimensional system used to define points in space, relative to one point, the origin. Sometimes referred to as the XYZ Coordinate System, this system is one in which we measure a position in space, in terms of X, Y, Z, in the same way we define a position on earth in terms of longitude, latitude and altitude.
- The Cartesian Coordinate System allows for the WORLD jog mode to be one of the methods of moving the robot and is based on the X, Y, and Z axes of the robot.



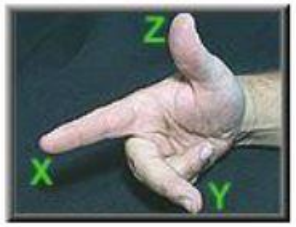


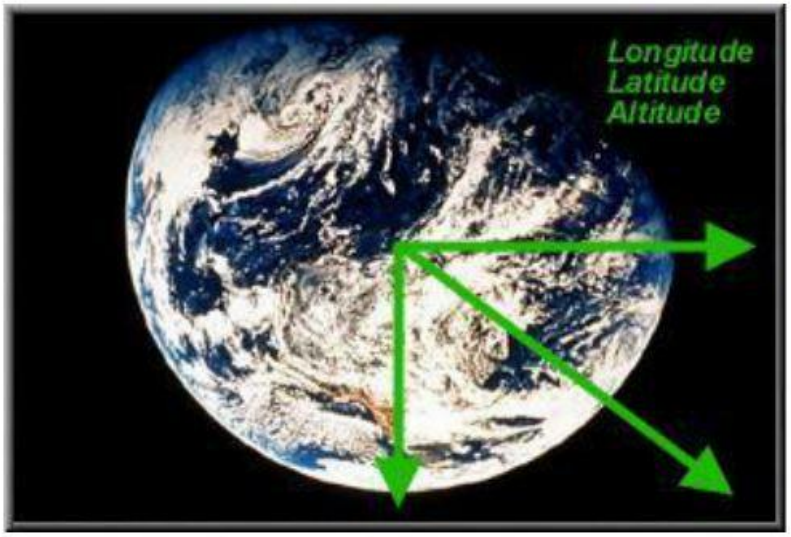
Cartesian Coordinate

- **A 3-dimensional system used to define points in space, relative to one point, the origin. Sometimes referred to as the XYZ Coordinate System, this system is one in which**

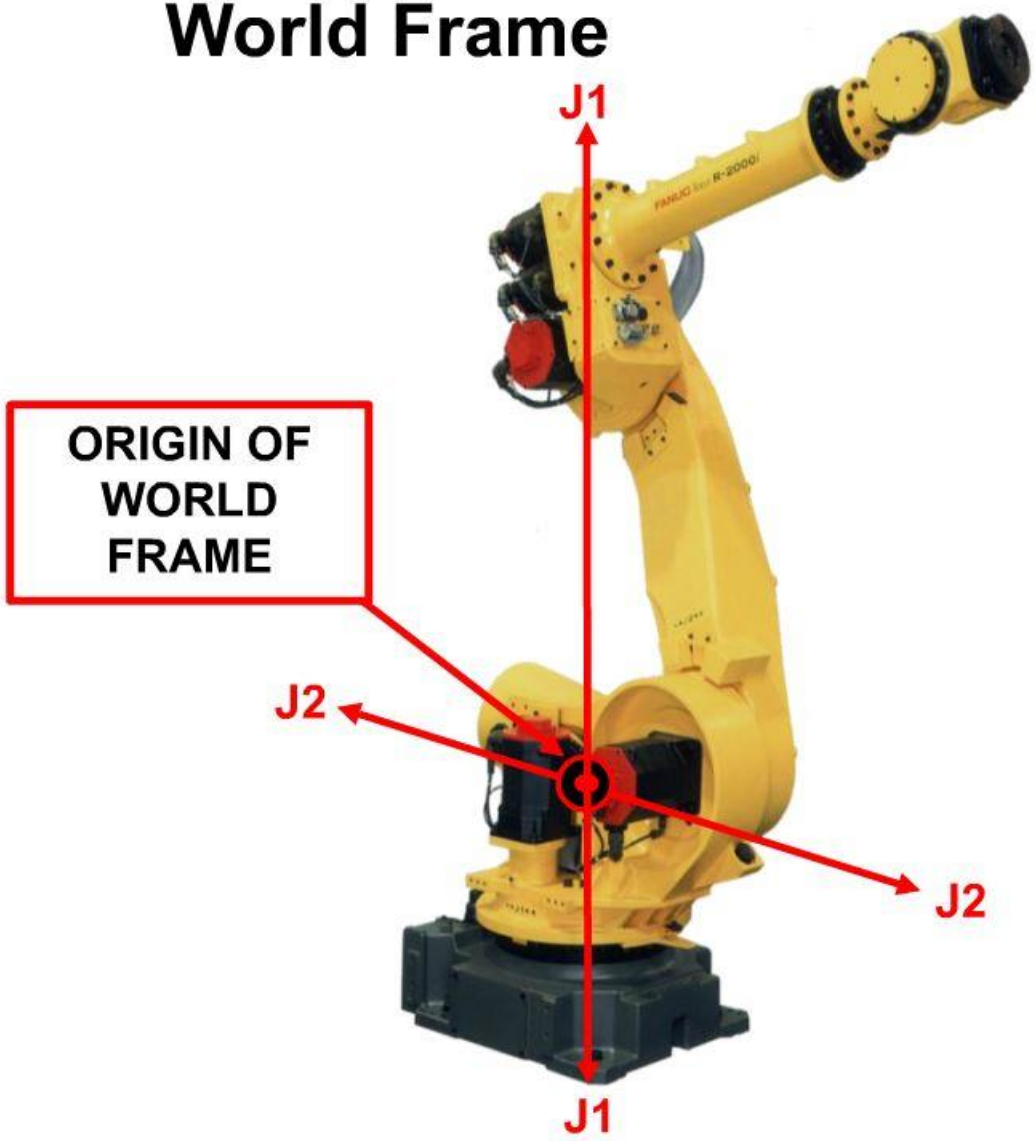
Origin:

The origin for the WORLD Coordinate System in a fully articulated robot lies at a point on the centerline of J1 axis and at the height of the centerline of J2 axis. In other systems, it is located elsewhere. For example, in gantry robots, the origin is in one of the corners.

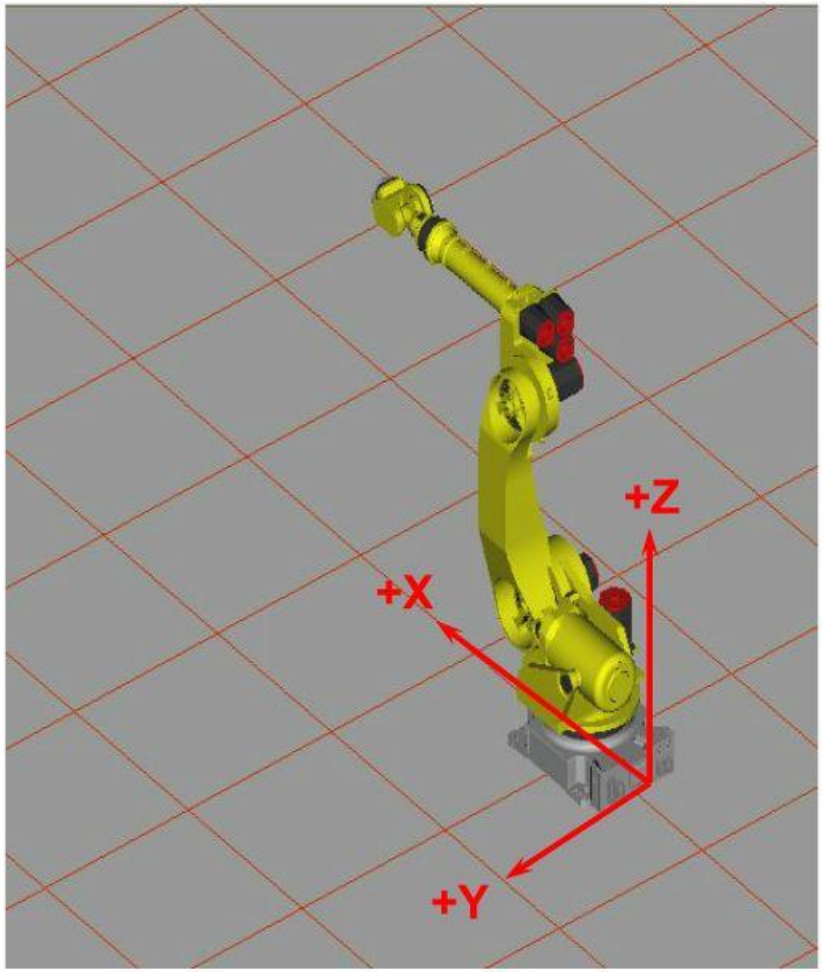


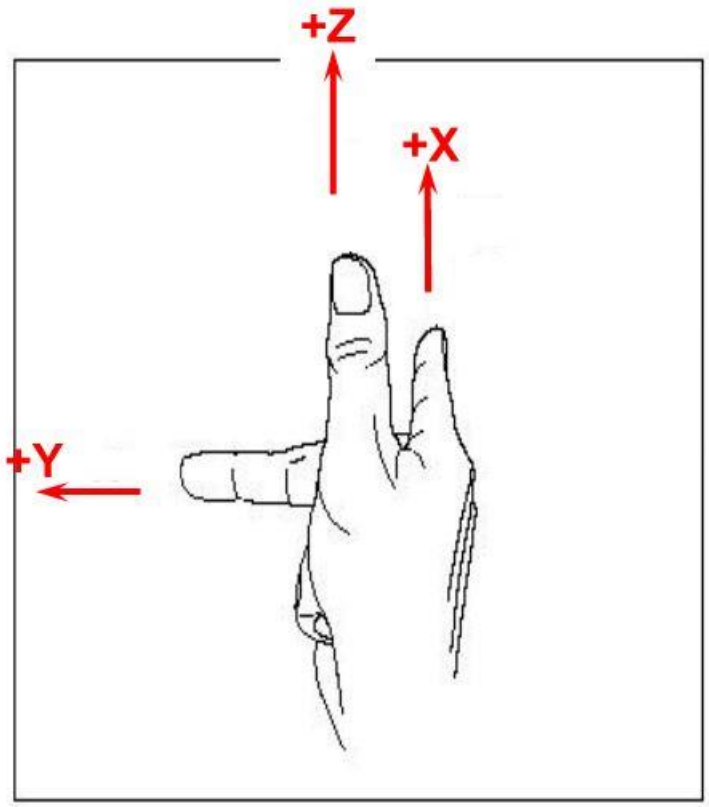


World Frame

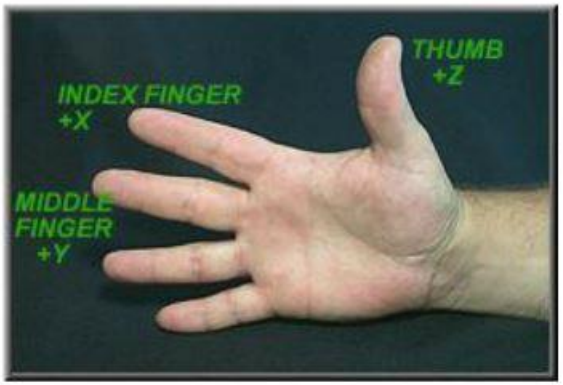


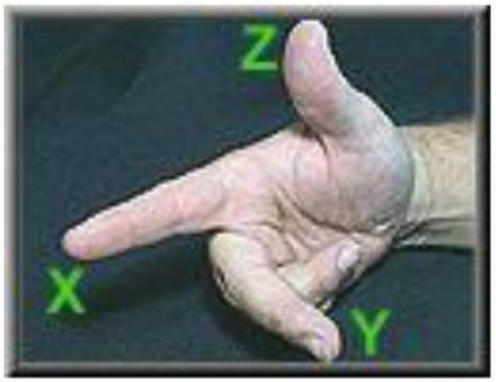
Right Hand Rule





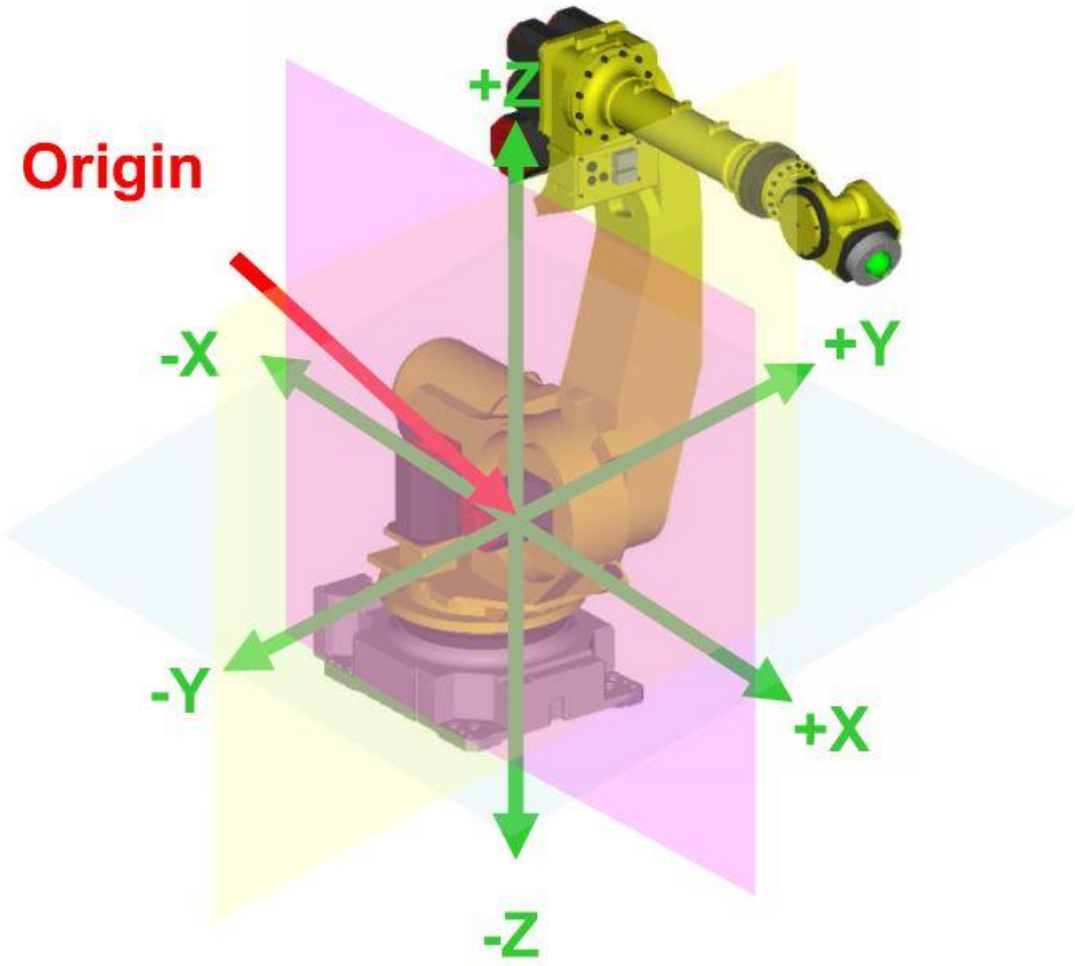
Right Hand Rule



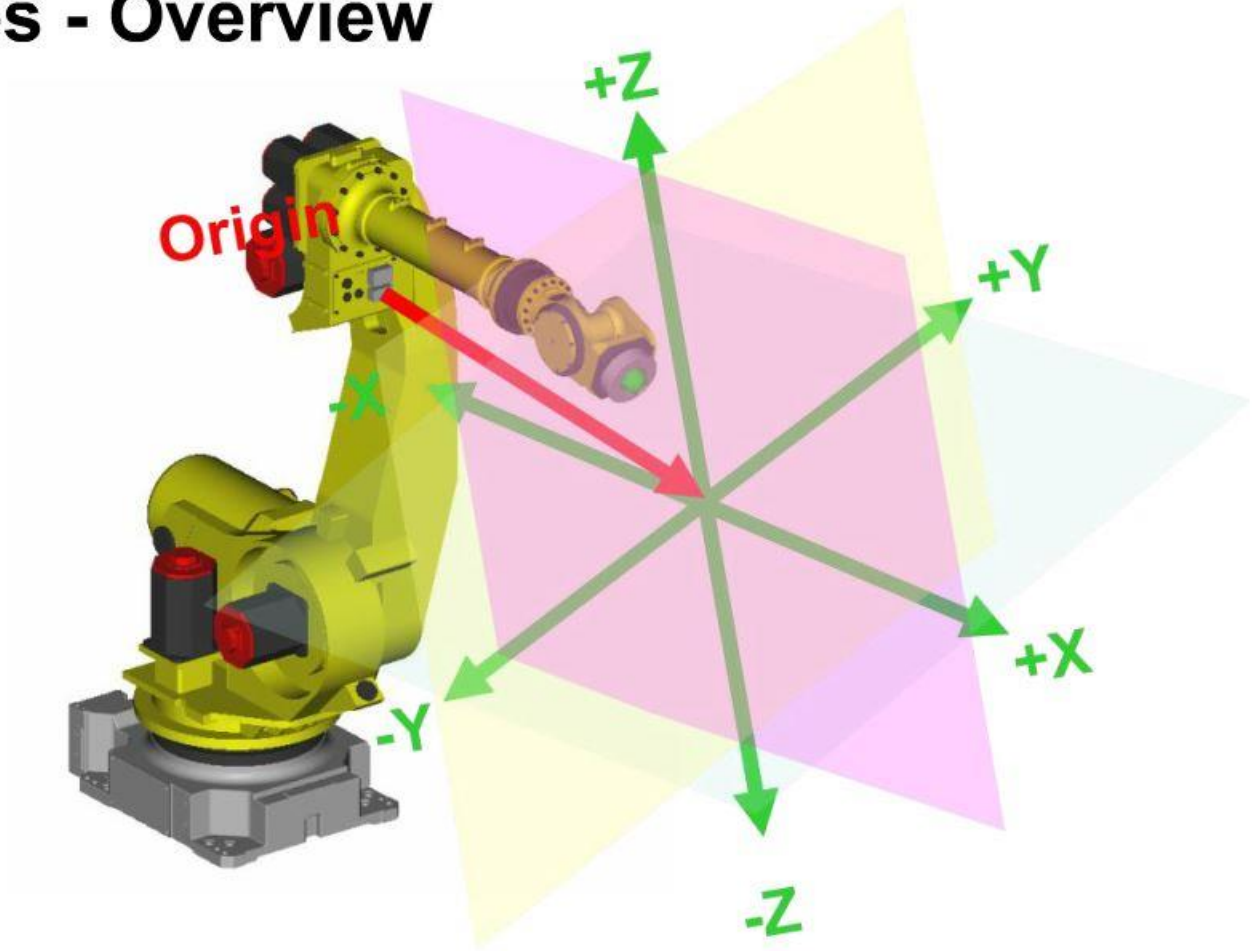


When we discuss the movement of axes in a Cartesian Coordinate System (the XYZ Coordinate System), an understanding of the "right-hand rule" is helpful. To determine the positive direction of movement for each of the axes, follow the direction that each finger points to when your hand is placed in the right hand rule position. The negative direction is just the opposite.

Frames - Overview

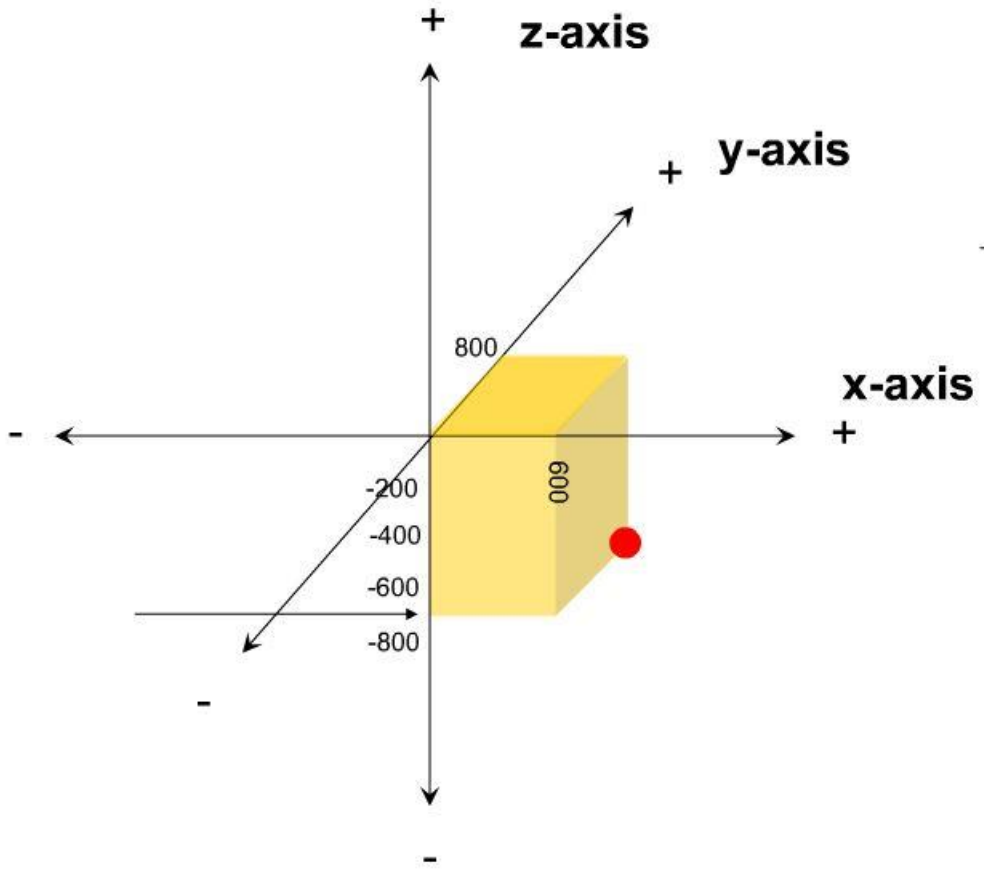


Frames - Overview

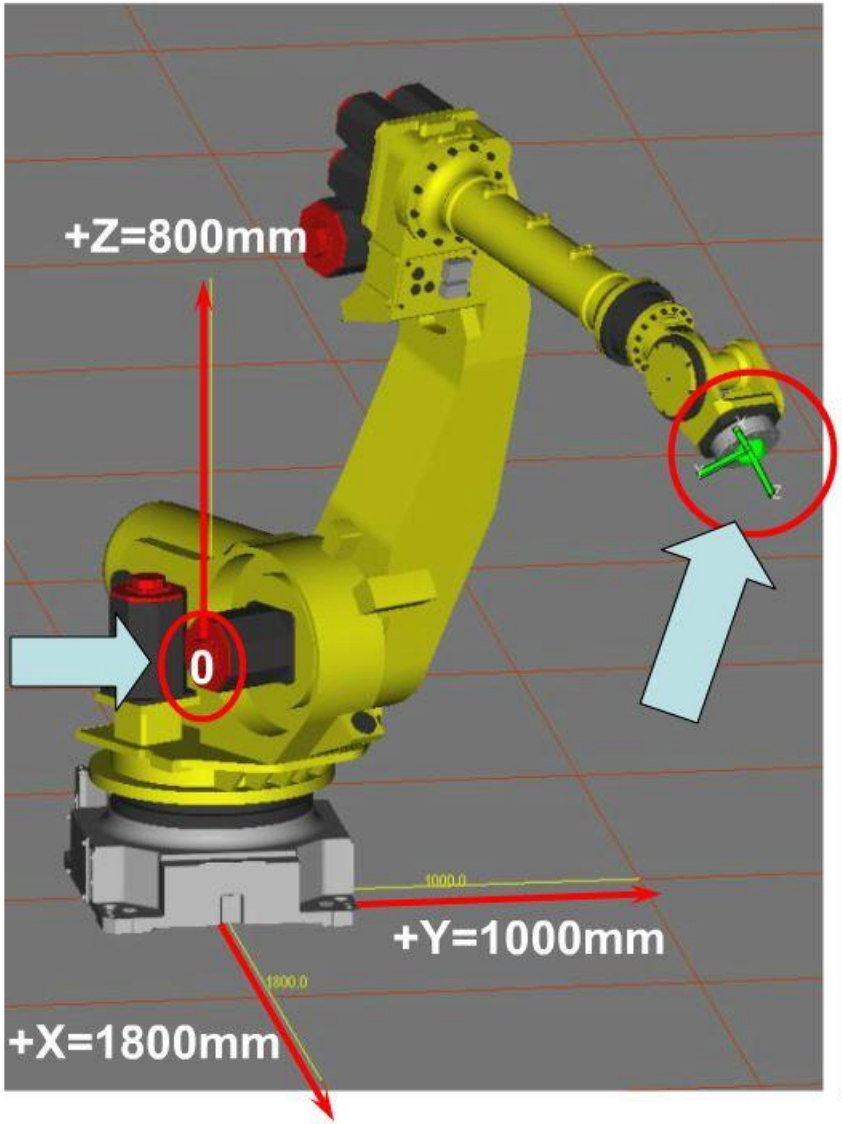


Again, another Frame

Three Dimensional Cartesian Coordinate



Cartesian Coordinate System



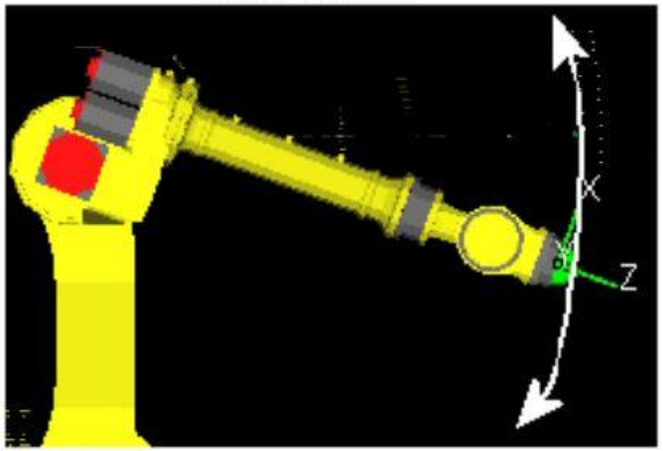
Teach Pendant POSN menu

```
-BCKEDT-          LINE 0     AUTO ABORTED
POSITION                      JOINT 100 %
World                         Tool: 1

 Configuration: N U T, 0, 0, 0
  x: 1800.000  y: 1000.000  z:  800.000
  w: -146.360  p:  -33.432  r:  -22.691


[ TYPE ]   JNT    USER   WORLD
```

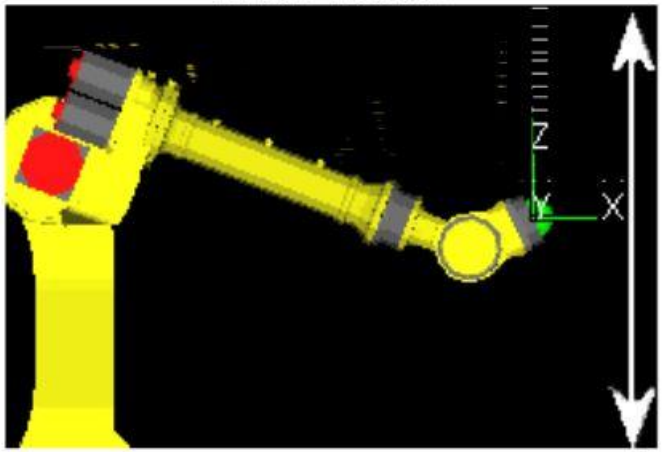
Define Motion Types

- What is Joint motion? **Joint motion is the type used when it is not important how the robot moves from position to position. It is the fastest and most efficient path from one point to another, however it is not predictable.**
- What is Circular motion? **You use circular motion when the positions must be along the arc of a circle**
- What is Linear motion? **Linear motion is used when the robot must move in a straight line between two points, however it is slower and predictable.**

Joint Motion

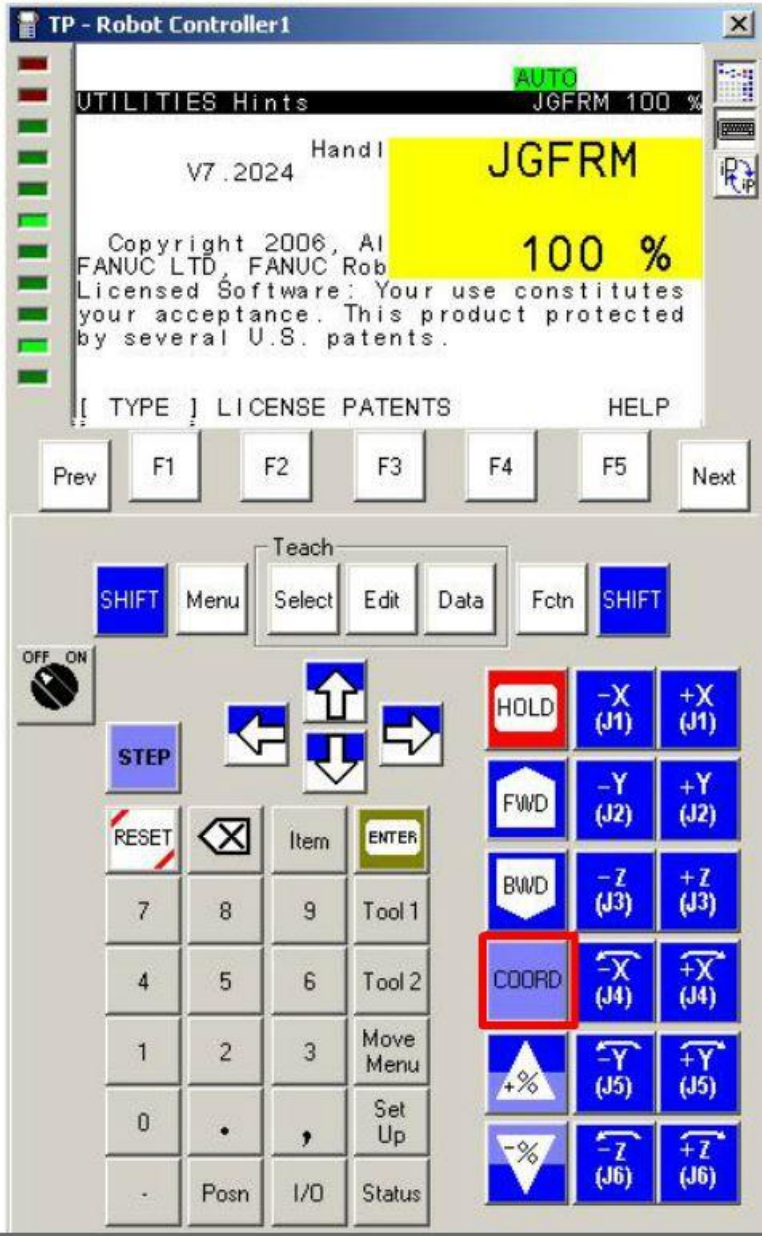


Linear Motion



Types of Frames

- **World frame - default frame of the robot**
- **Tool frame - user defined frame**
- **User frame - user defined frame**
  - **RTCP – Remote Tool Center Point**
    - HandlingTool, DispenseTool, and SpotTool+ only)
- **Jog frame - user defined frame**



Define "Jog" the Robot

- **When jogging, a coordinate system defines how the robot will move. There are five coordinate systems:**
  - Joint – Non Cartesian
  - World - Cartesian
  - User - Cartesian
  - Tool - Cartesian
  - Jog frame - Cartesian

Non-Cartesian Jog Mode:

Movement of the individual joints on the robot, when using the JOINT jog mode, is not based on the XYZ Coordinate System.

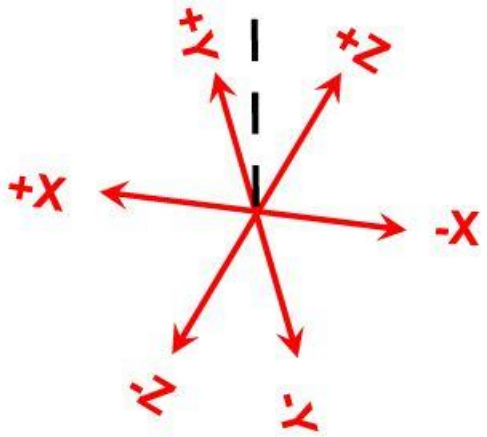
Cartesian Coordinate System:

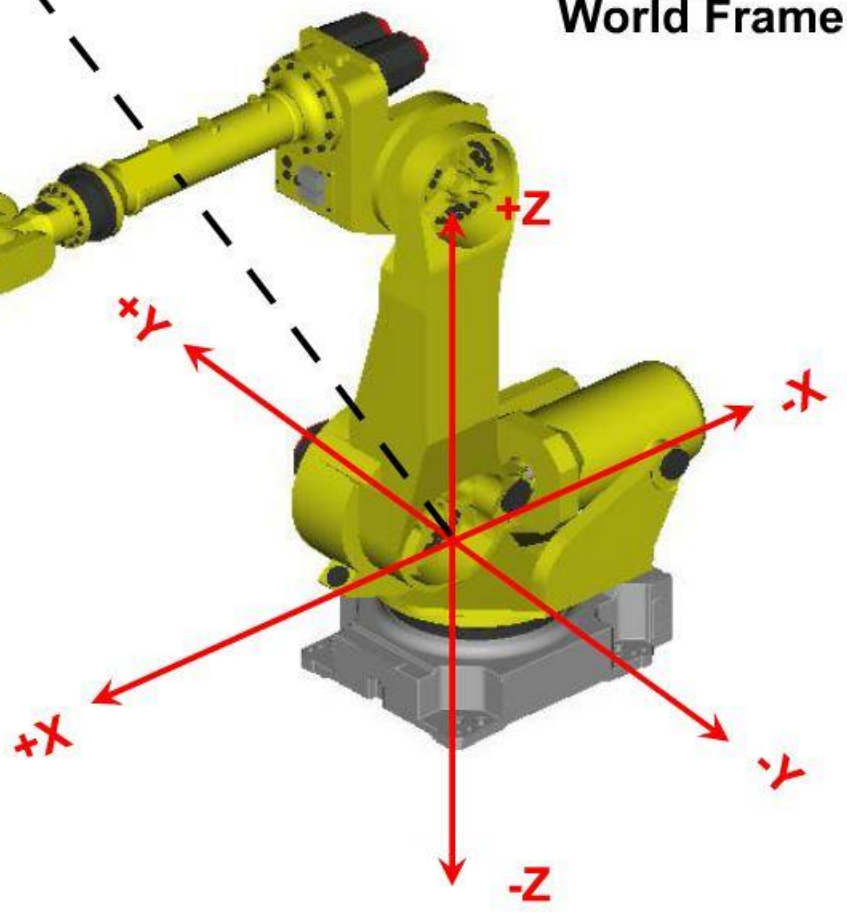
Commonly explained as the movement of the robot's Tool Center Point along the x, y or z axis in either a positive or negative direction, or the rotation of the Tool Center Point around the x, y or z axis.

User Frame

User Frame is this offset in the X,Y,Z,W,P,R

- User frame - user defined frame



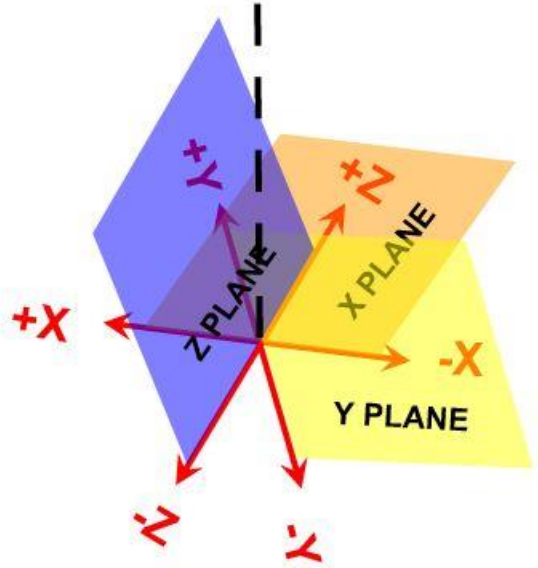


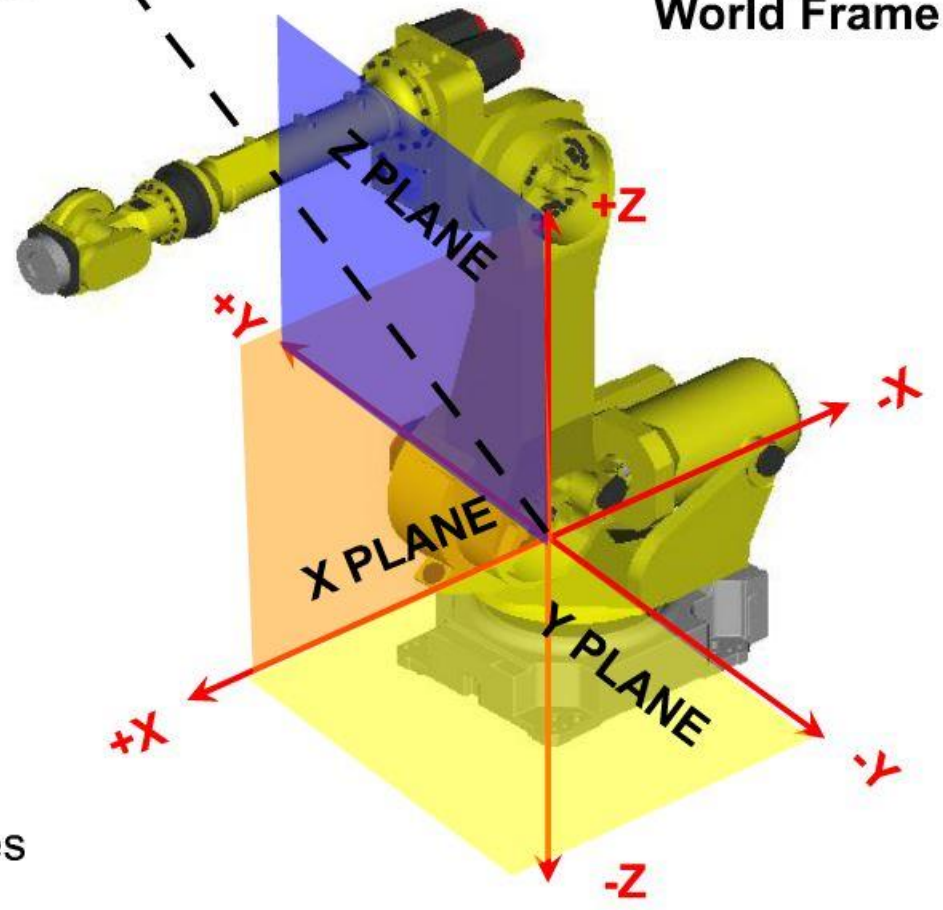
You can define up to 9 user frames within R-J3 controllers

User Frame

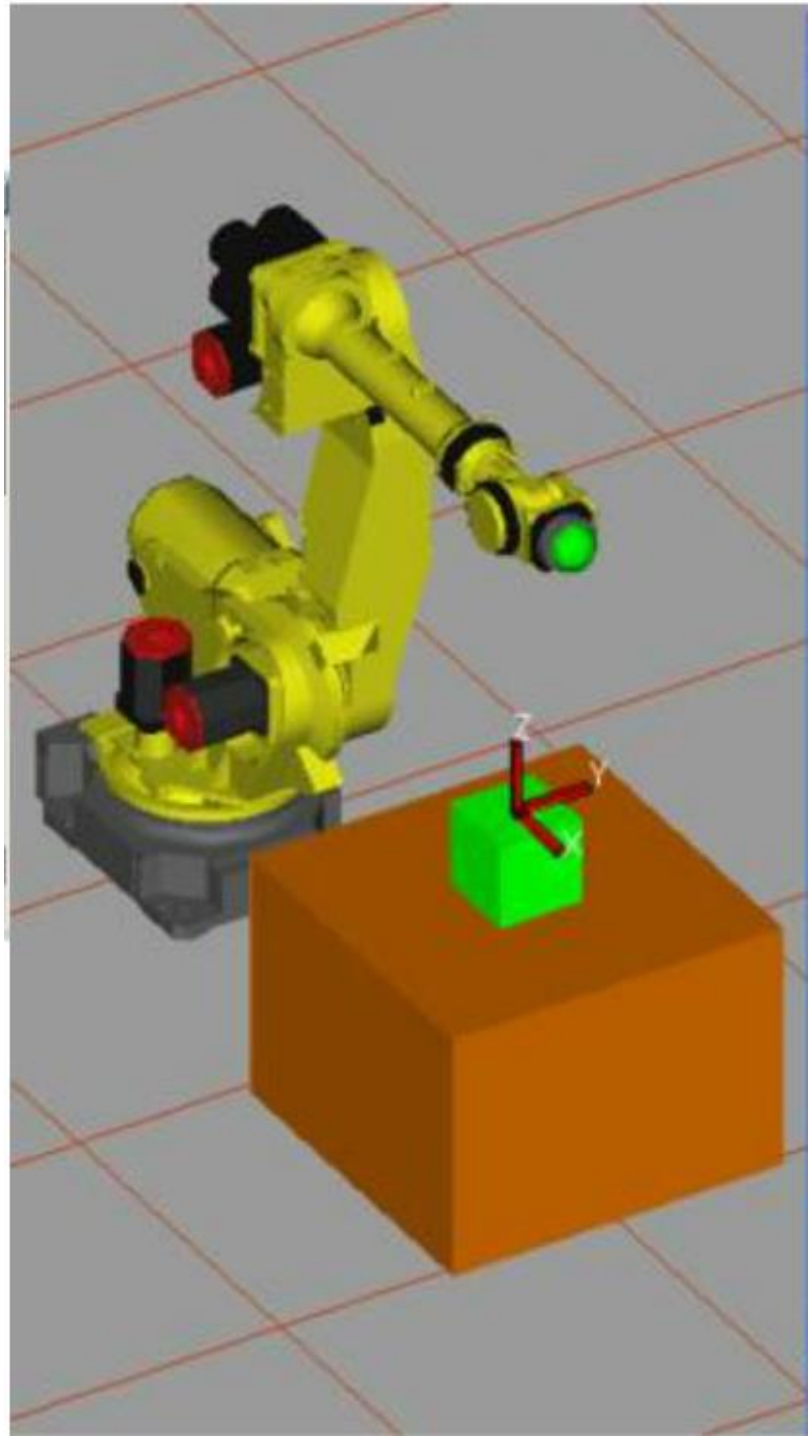
User Frame is this offset in the X,Y,Z,W,P,R

- User frame - user defined frame



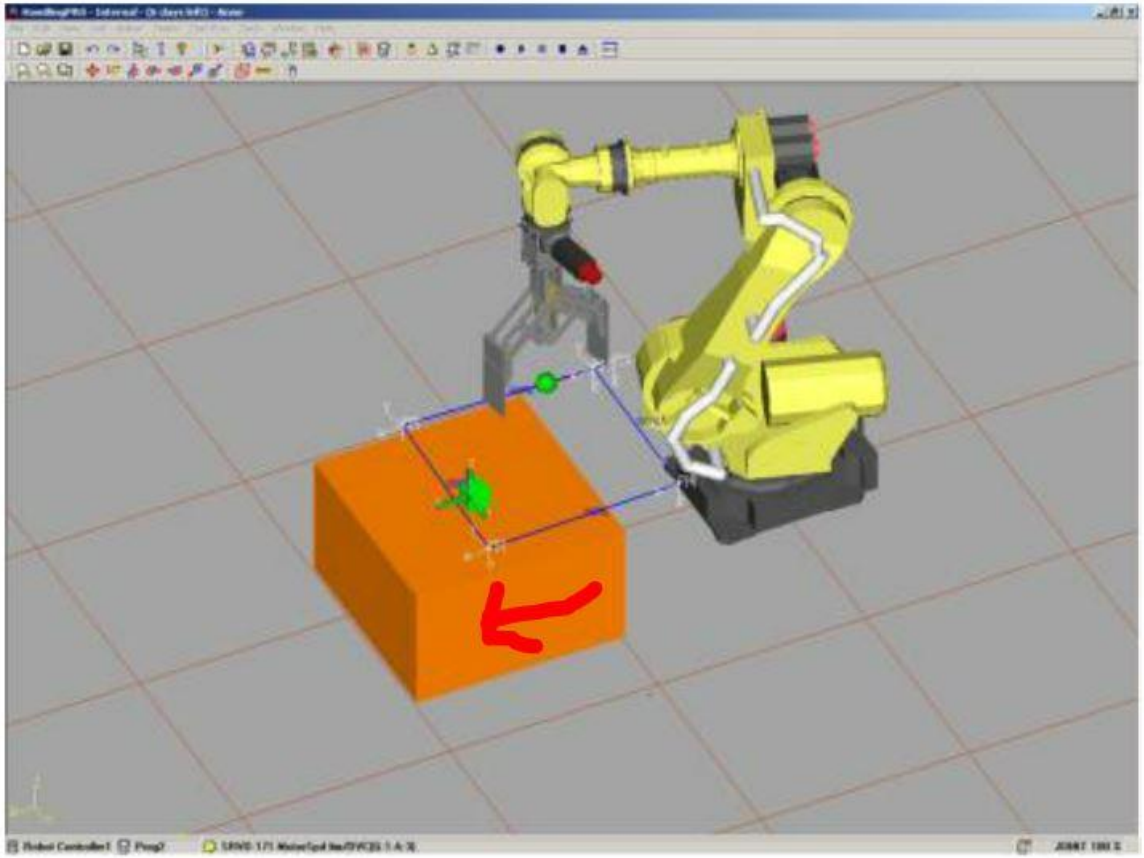


You can define up to 9 user frames within R-J3 controllers


Z
Y
X

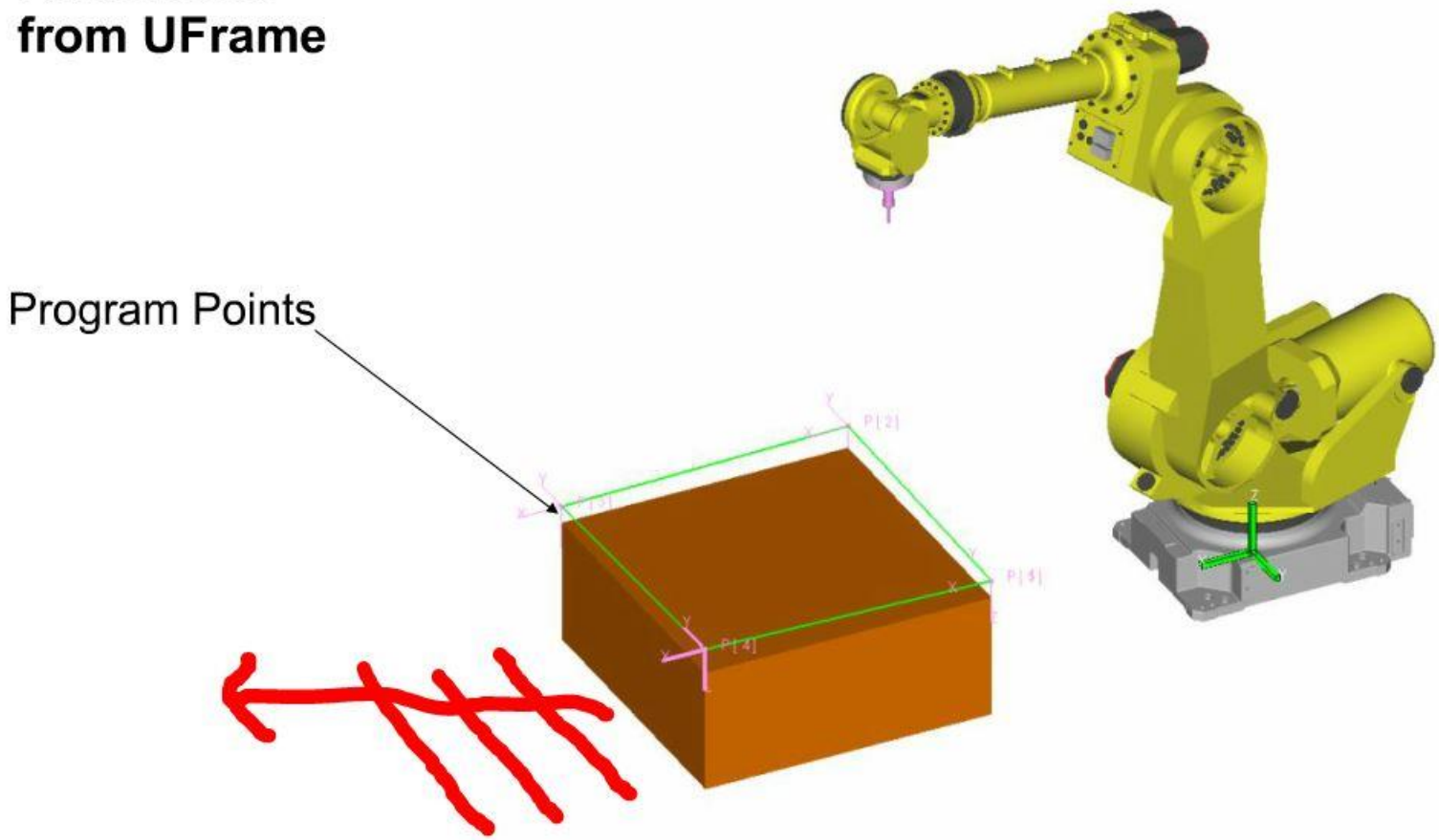
Sample Program using World Frame

Program is referenced from World (Robot) Frame (positions are white)



Sample Program UFrame vs. World Frame

Program is referenced from UFrame



Frames Summary

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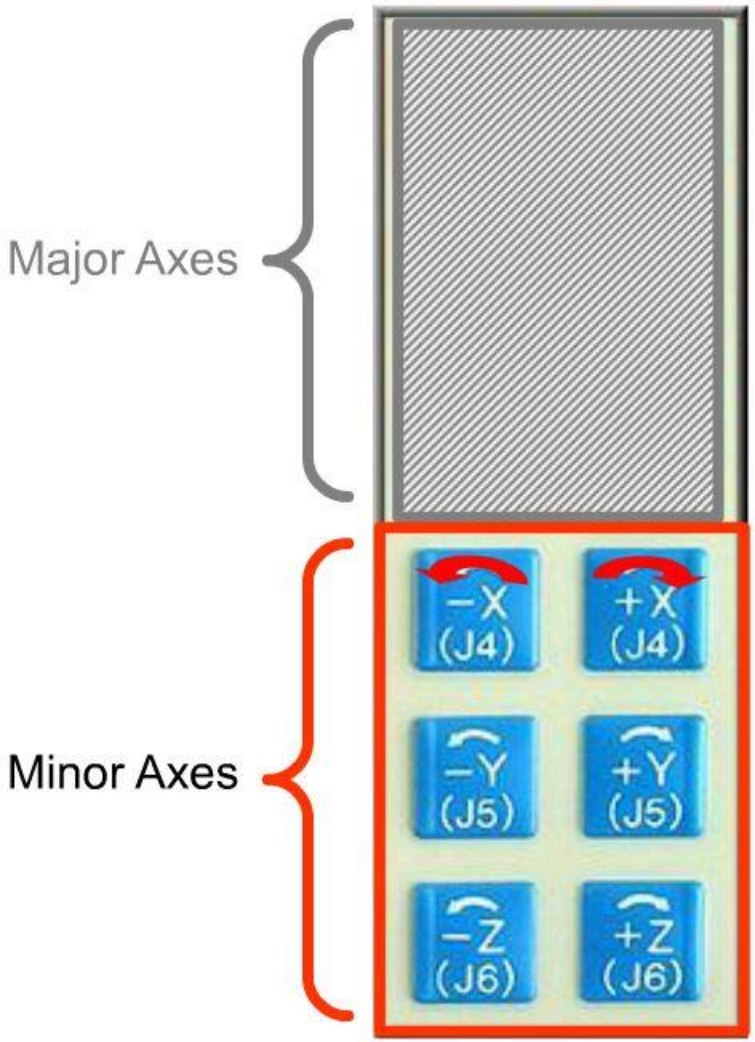
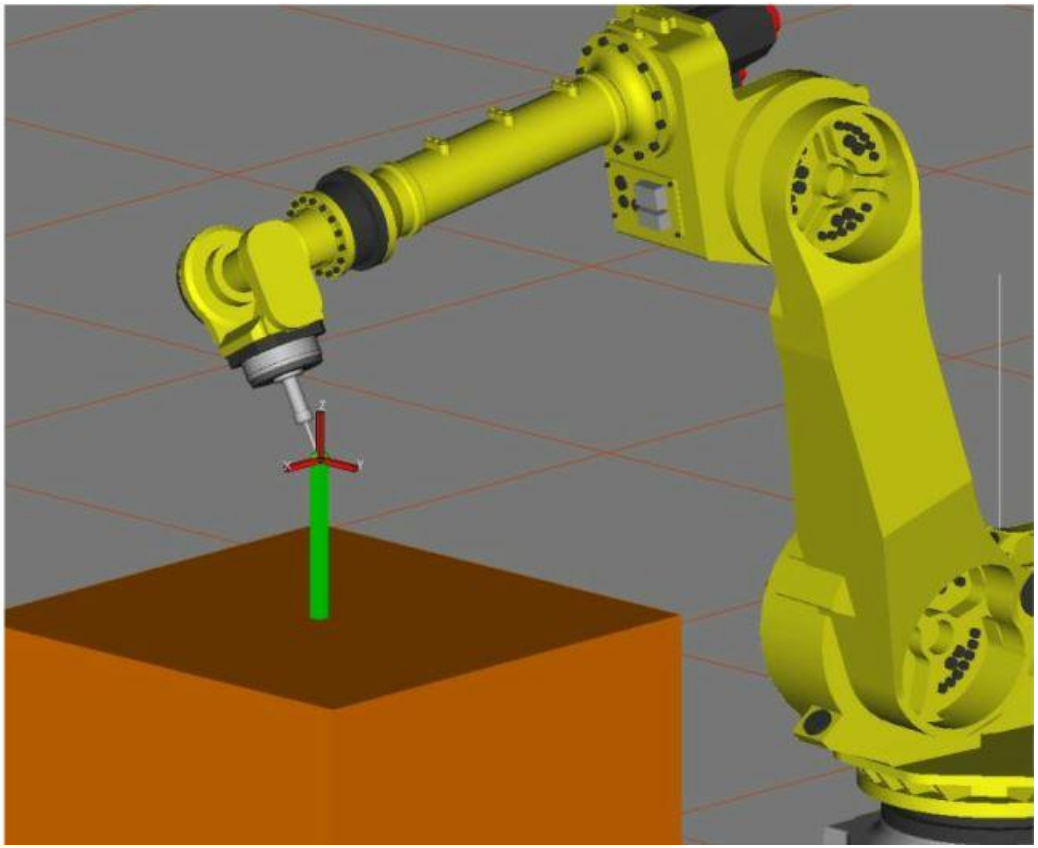
    - HandlingTool, DispenseTool, and SpotTool+ only)
- **Jog frame - user defined frame**

Orientation in WORLD mode – Minor Axes

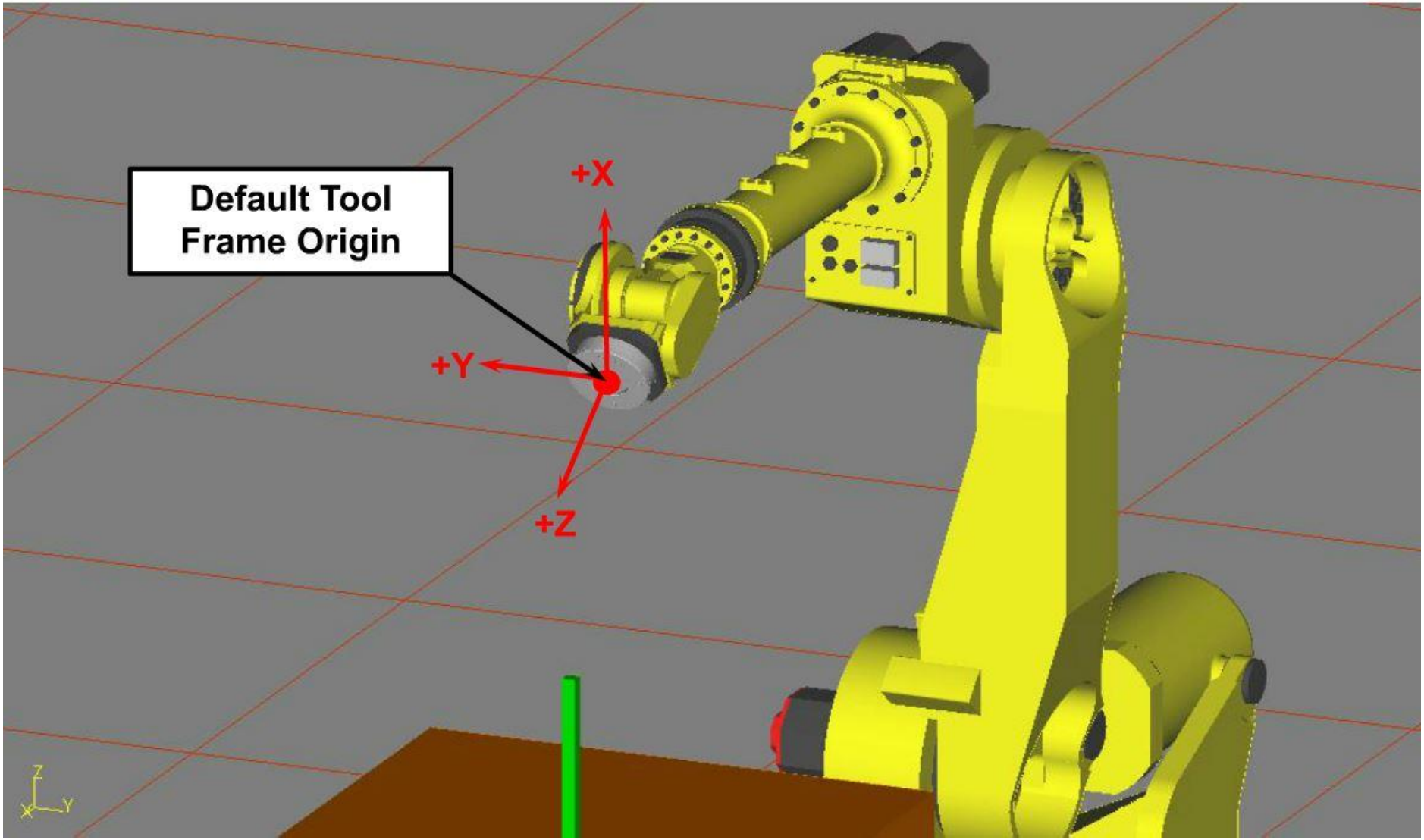


Orientation

Yaw (W) – Rotation around X
Pitch (P) – Rotation around Y
Roll (R) – Rotation around Z



Tool Frame

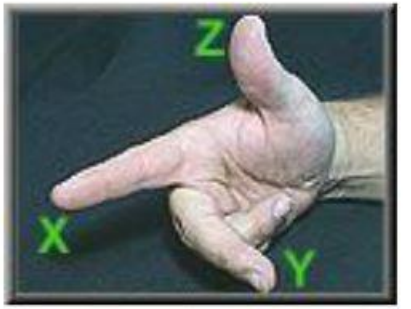


Tool Center Point (X,Y & Z)

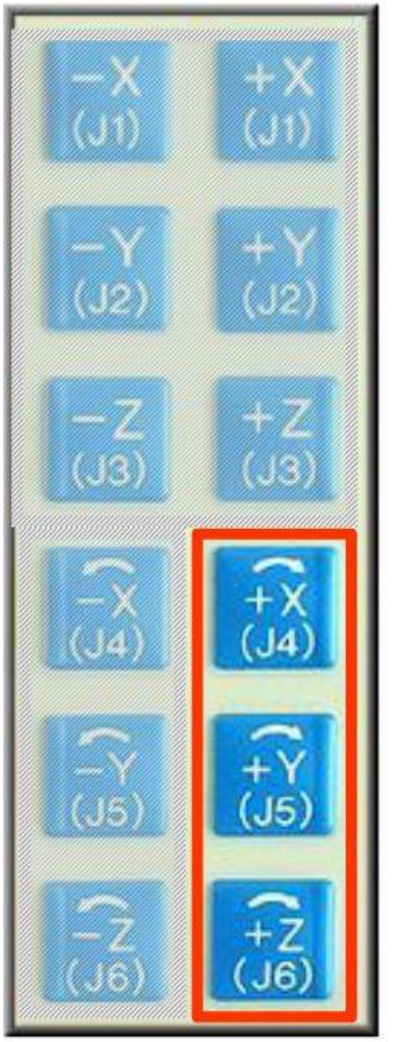
How does the Tool Center Point (TCP) rotate around the X, Y, or Z axis?

Many times it is not only important to have the TCP reach a precise location, but to also turn the TCP in either a positive or negative direction around the x, y, or z axes. This is known as determining the orientation, the **yaw**, **pitch** and **roll** for each axis. How do you determine positive from negative directional rotation.

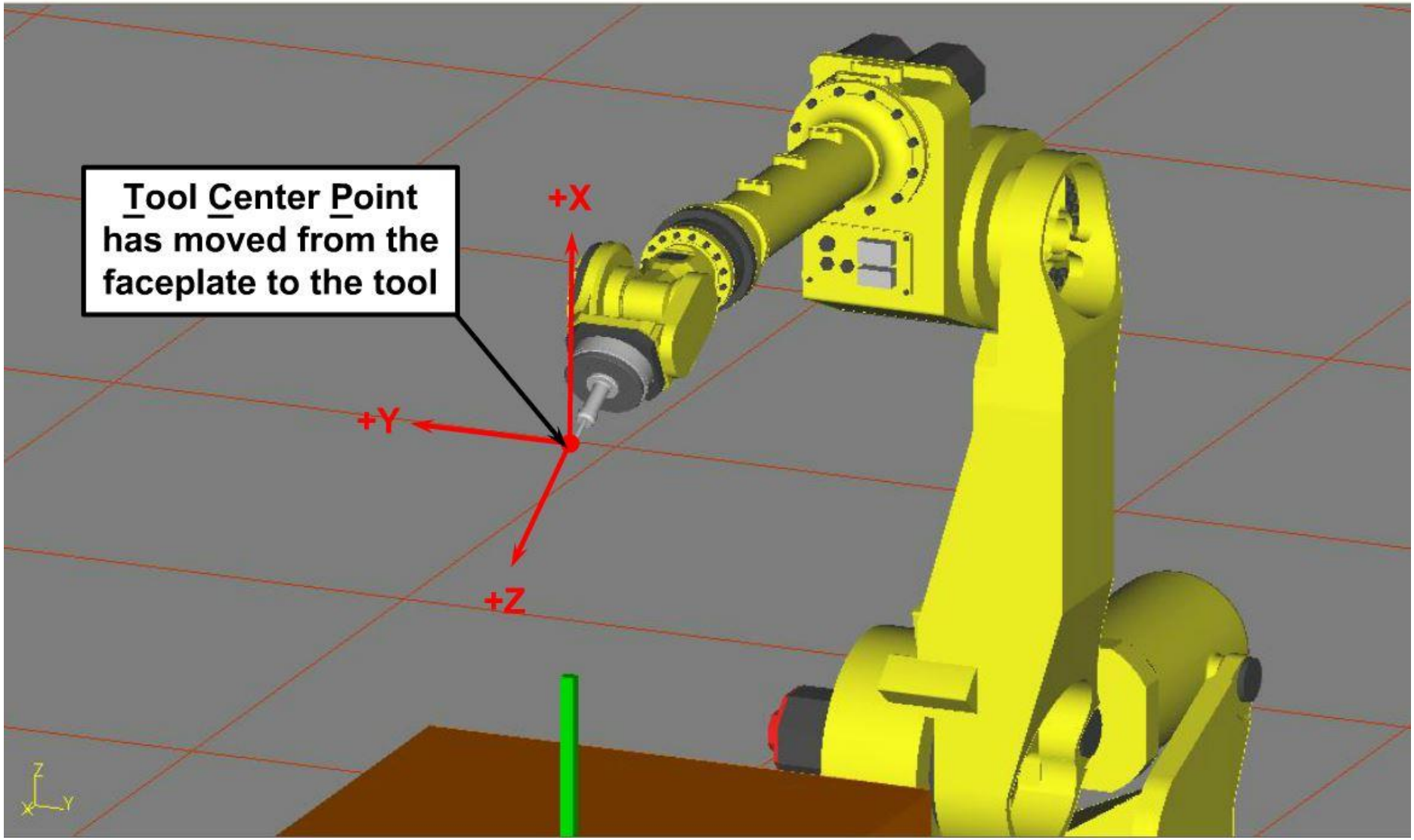
1. Place your hand in the right hand rule position.
2. Replace the finger or thumb, designated in the right-hand rule for the axis you have selected, with your thumb, and let the remaining fingers curl as they naturally would.



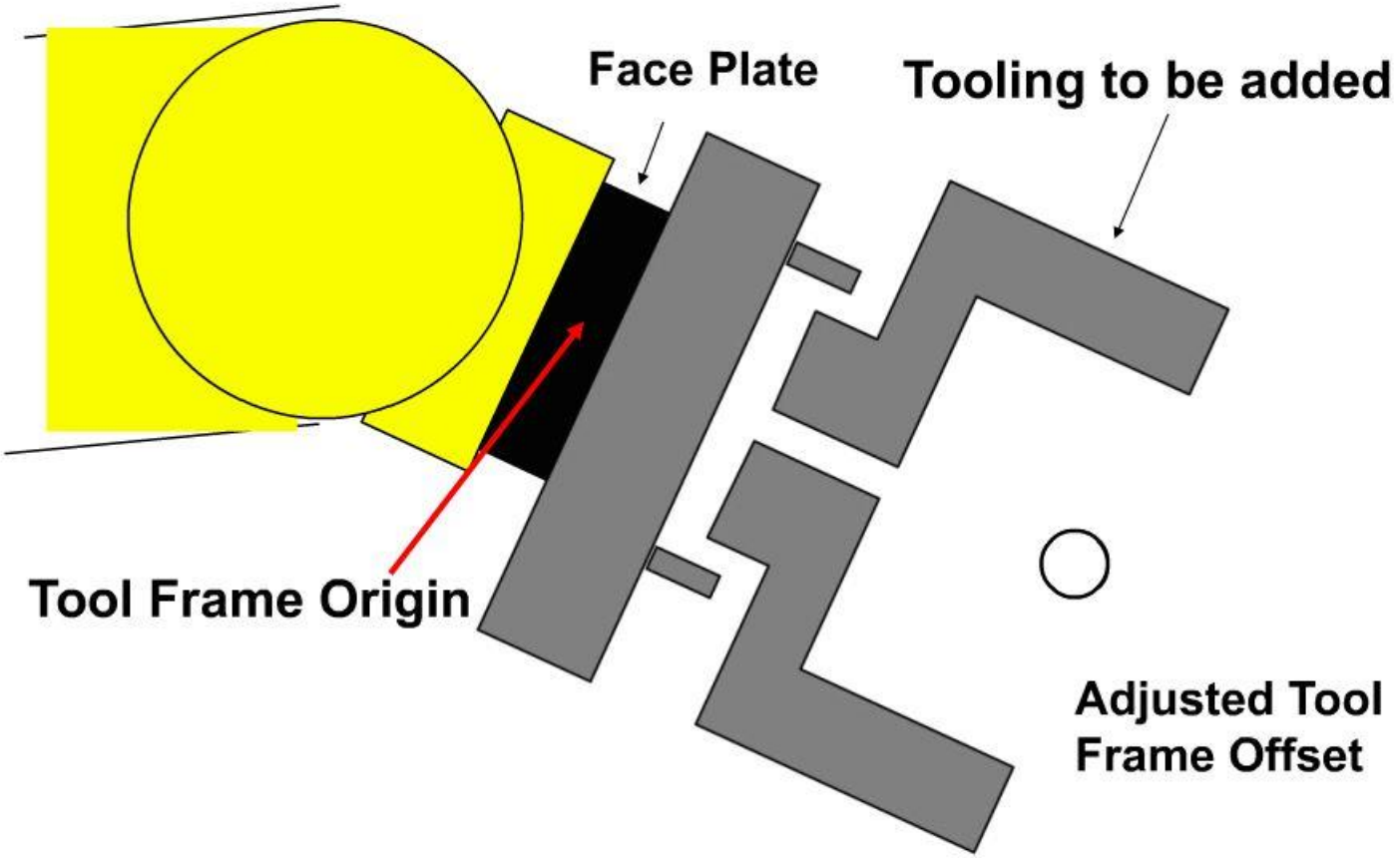
Whatever direction the fingers curl is the positive direction of rotation for the axis chosen. Negative is the opposite.



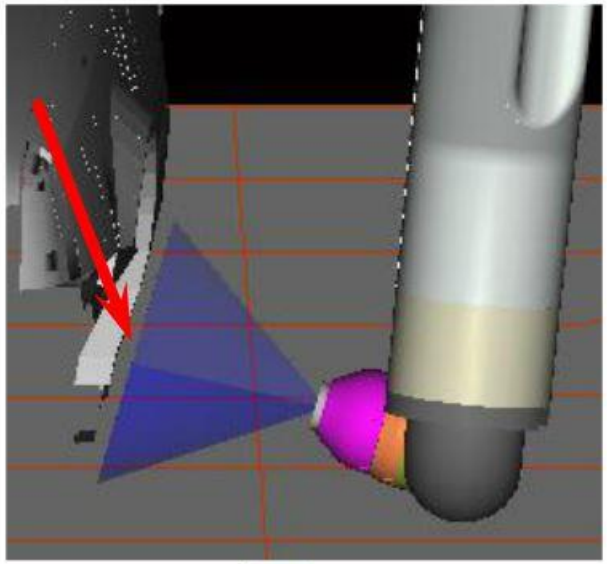
Tool Frame

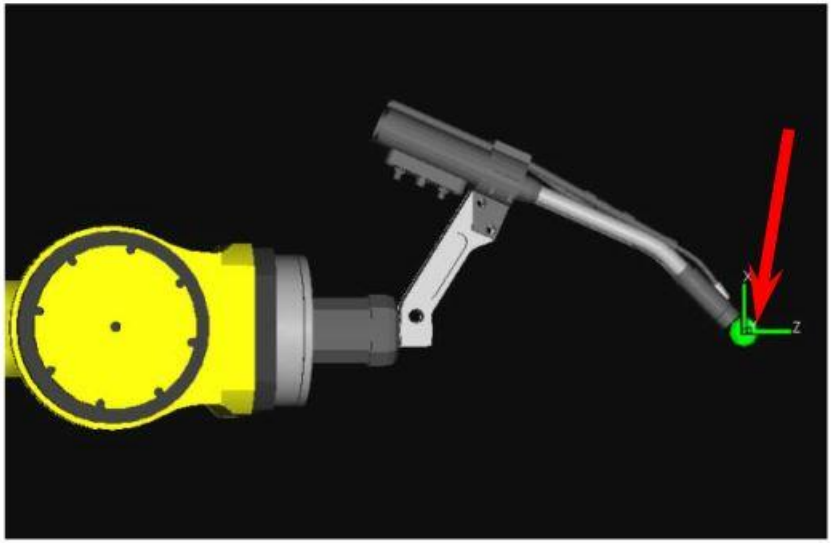

Tool Center Point has moved from the faceplate to the tool
+X
+Y
+Z

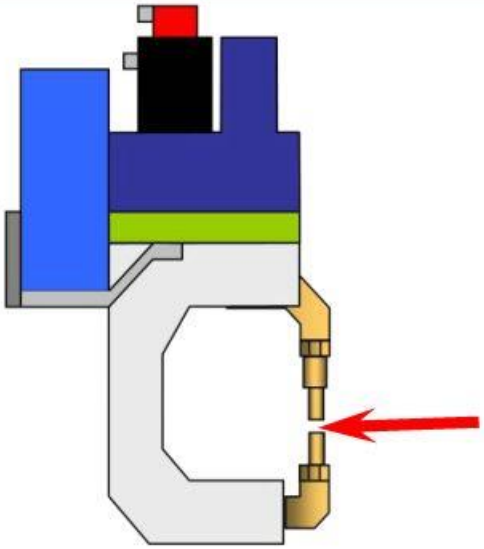
Adjusting Tool Center Point

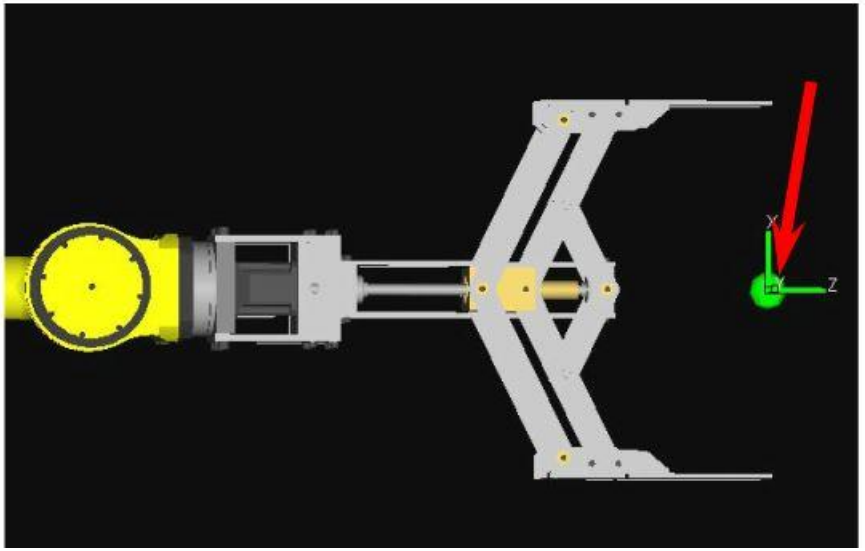


Actual Tool Center Point

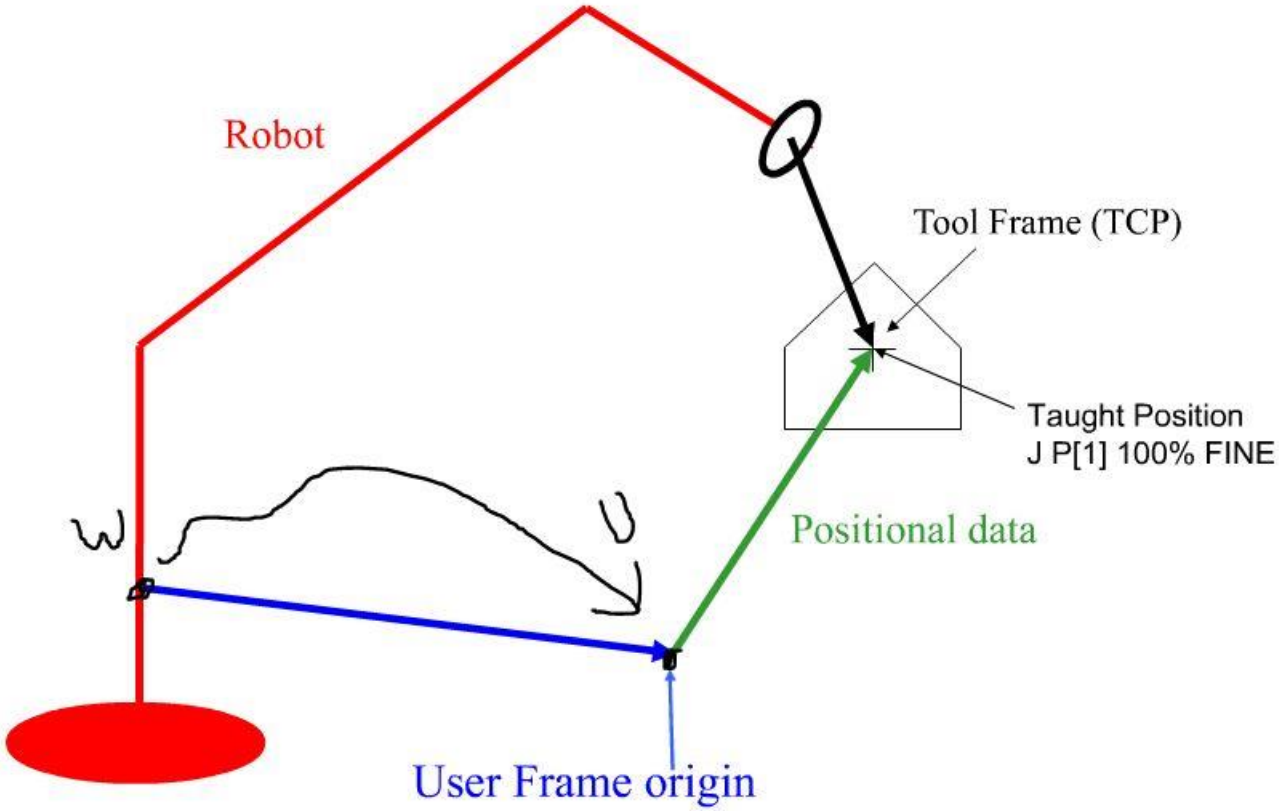






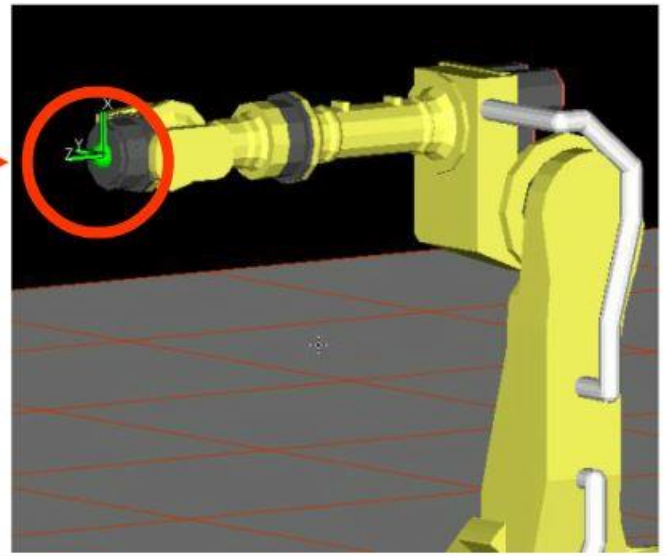


How the Robot frames are linked



Tool Center Point (TCP)

A newly purchased robot's Tool Center Point (TCP) is defined to be located at the center of robot's faceplate.



Once end-of-arm tooling has been put into place, the TCP is relocated to that point where positions will be taught and the work will be performed.