ROBOT OPERATIONS

EET 4144

FANUC Robotics

CERTIFIED EDUCATION ROBOT TRAINING

Material Handling

Palletizing and Packing

Material Removal

Arc and Spot Welding

Painting

Dispensing and Assembly

FANUC Robotics

CERTIFIED EDUCATION ROBOT TRAINING

Process Solutions

- **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




R-J3, R-J3*i*B and R-30*i*A Controller

This training focuses on the FANUC Robotics R-J3, R-J3*i*B and R-30*i*A controller. The R-J3 series uses advanced technology packaged in a proven, reliable third-generation controller design. Process capability and open architecture features improve application and motion performance while simplifying system integration. SYSTEM R-J3 series incorporates FANUC Robotics' unique "plug-in-options" concept which allows the flexibility for applications specific configurations.

R-30*i*A

A-size Cabinet

B-size Remote

Objectives

- 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

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

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

Work Envelope

Identify the Controller

The controller contains the computer that operates the robot. It houses the application software, power supply, operator control like the Teach Pendant, control circuitry and memory that direct the operation and motion of the robot. The controller is responsible for communication to external devices.

R-J3*i*B Controller

Identify the Standard Operator Panel (SOP)

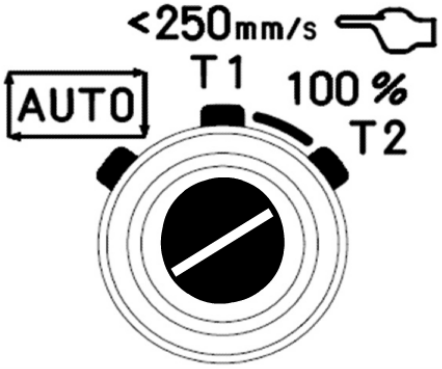
R-30*i*A
B-size cabinet

Standard Operator Panel (SOP)

R-J3
A-size cabinet

R-J3*i*B
B-size cabinet

Mode Select Switch

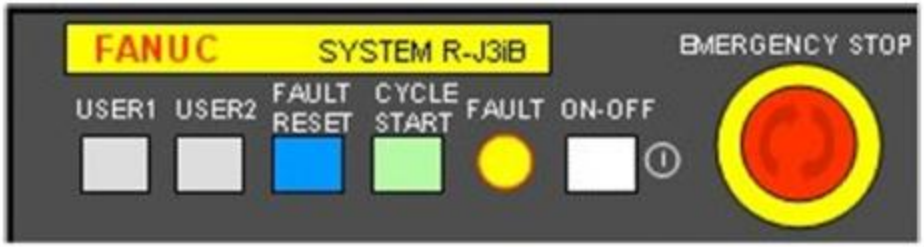


AUTO MODE – Robot operated at the specified maximum speed. Cannot start programs using the Teach Pendant

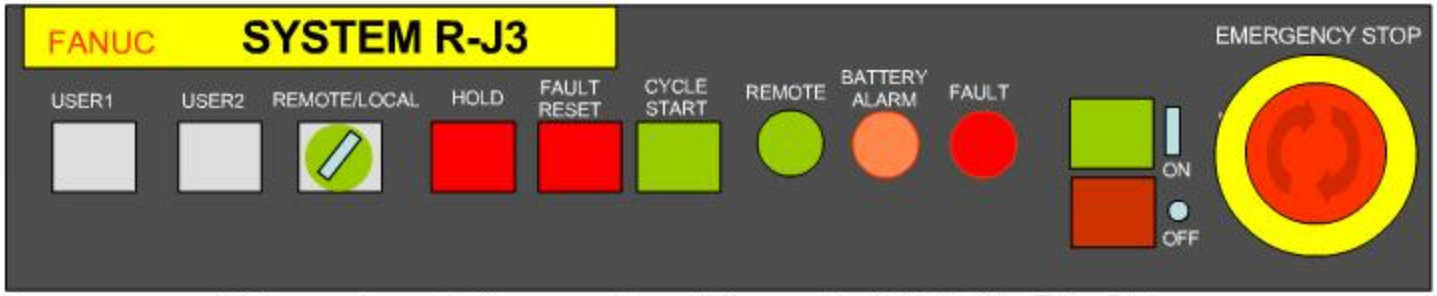
T1 MODE (Teach Mode 1) - Cartesian speed is less than 250 mm/sec and Joint speed is less than 10% of the maximum override speed

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

Standard Operator Panel (SOP) **R-30*i*A**



Standard Operator Panel (SOP) **R-J3*i*B**



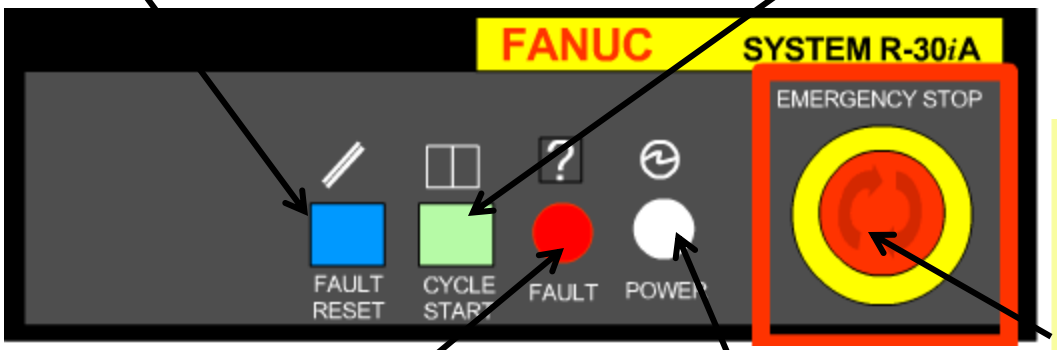
Standard Operator Panel (SOP) **R-J3**

Fault Reset Button

The Fault Reset Button is used to reset error alarms and upon resetting an alarm the fault light will go off

Cycle Start

The Cycle Start button will start the currently selected program. During execution of a program, this button is illuminated.



Emergency Stop

The emergency stop button is used in emergency situations to stop robot motion and remove power. This button 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 brakes are engaged.

Fault LED

When an alarm occurs, the fault LED is illuminated. The messages detailing the alarm are found on the Teach Pendant Error Message field. More detailed information including a date and time stamp may be found by choosing the alarm option from the menus screen.

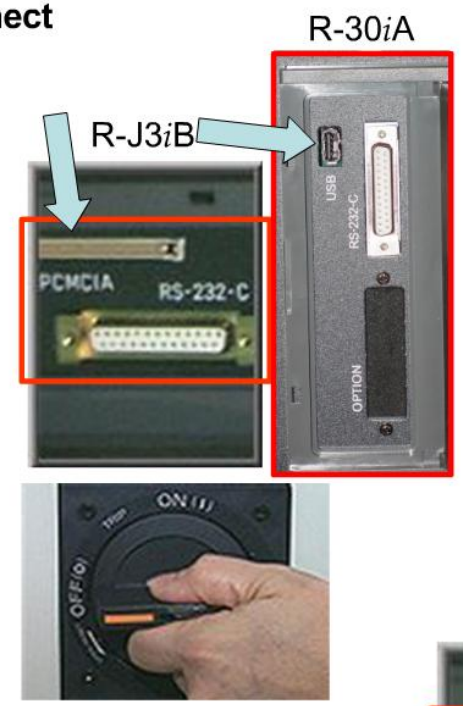
Power ON (LED)

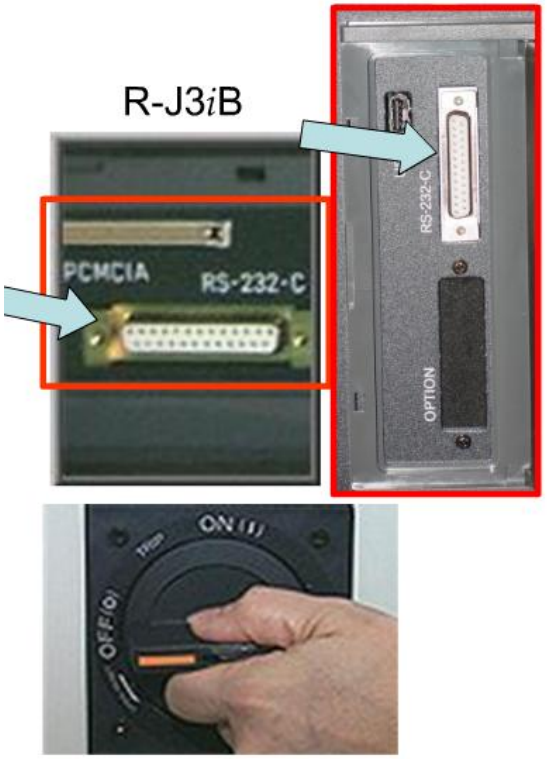
When the power is on, this button is illuminated.

The controller is powered up when you switch the circuit breaker to the ON position

Communication Ports and Circuit Breaker/Disconnect

Communication Ports
The PCMCIA and USB ports provide the ability to insert the storage media directly. These Communication Ports are used for saving to or loading from a memory device. Saving and loading from these ports is much faster than from the RS232-C port.
The RS-232-C serial interface is a Communication Port that is also used for saving and loading files. Although, this port can be used to connect to an external communication device such as a floppy disk drive, printer, PC etc.





Communication Ports and Circuit Breaker/Disconnect

Circuit Breaker/Disconnect

The Circuit Breaker is used for power source connection and disconnection. The R-J3 and R-J3iB controllers have an additional ON/OFF button on the Standard Operator Panel, whereas, the R-30iA Circuit Breaker is used to power up the controller without the need of an ON/OFF button.

R-30*i*A

R-J3*i*B

R-30*i*A

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

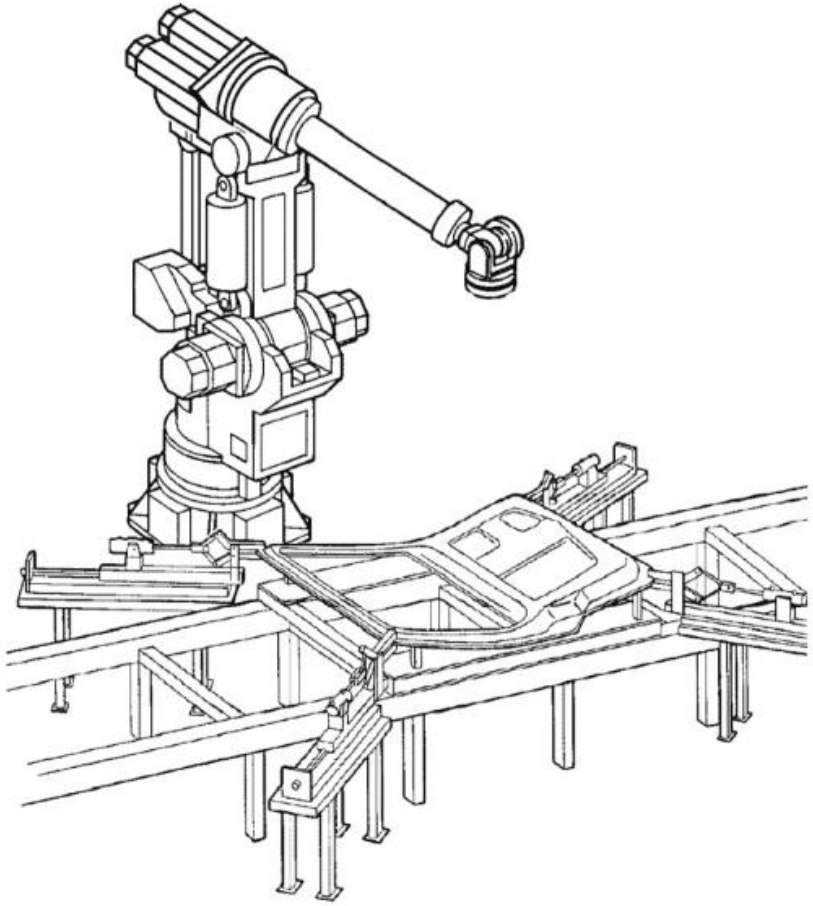
Cables

Step 2: Locate the Circuit Breaker. Turn the Circuit Breaker clockwise to the ON position

Step 3: The final step you must take to power up the controller is to press the Power ON button located on the Standard Operator Panel, for R-J3 and R-J3iB controllers. The R-30iA controller power is already on when you turn the circuit breaker to the On position. When the Standard Operator Panel is powered on a series of diagnostic and software tests takes place. This is evident by Teach Pendant screen changes that occur. The Power ON button remains illuminated until the controller is powered down.

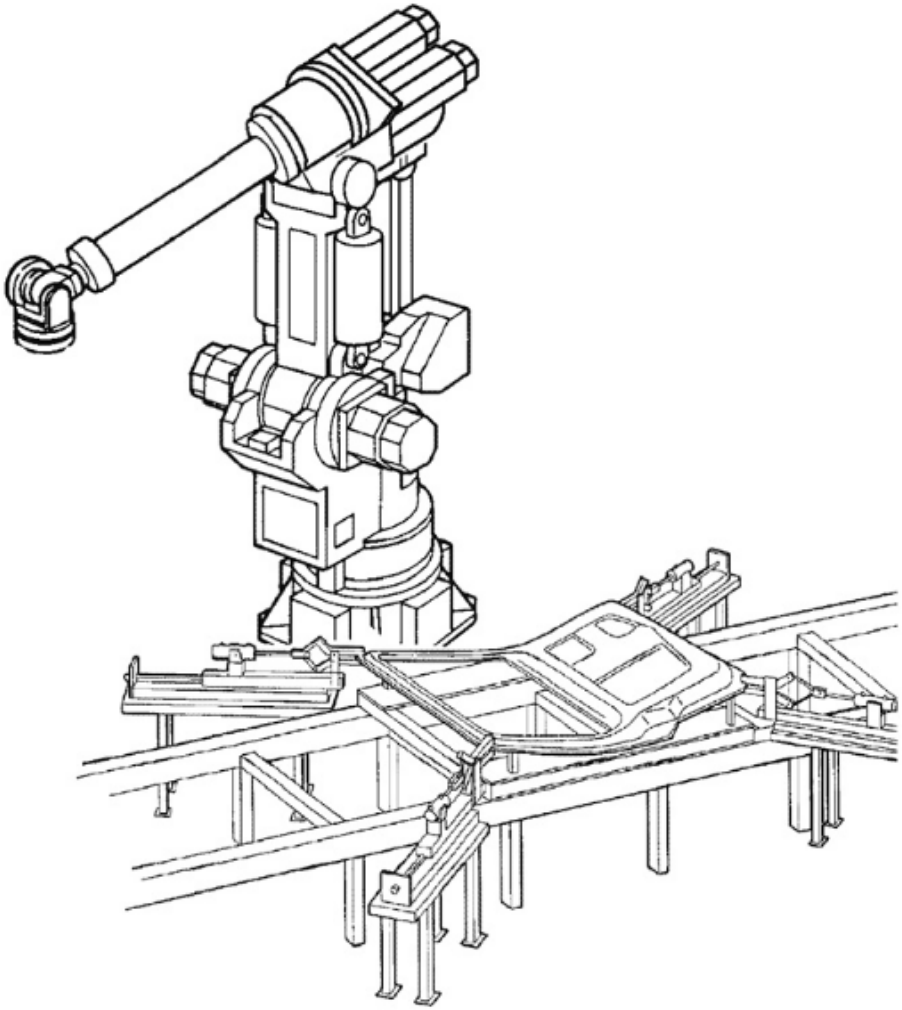
Predefined Positions

- Predefined positions are teach pendant programs with specific names that are resident within the robot software. Initially, the programs are empty and require the user to teach the positions. Not every software package requires predefined positions (e.g. HandlingTool) to operate whereas other do. Predefined position names used are specific to the software that is installed, for an example:
- SpotTool uses: Home, Repair, Safe, etc.
- PaintTool uses: Home, Purge, Cleanin and Cleanout, Bypass, etc.
- DispenseTool uses: Home, Purge, Maintenance, etc.



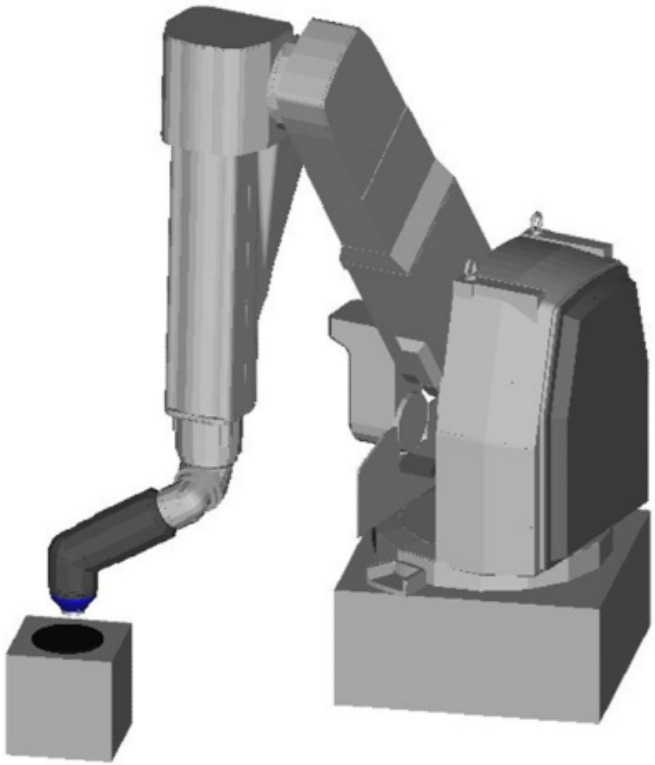
Home

The Home position is a position away from the workpiece transfer area, or the area where work is being performed. It is very common to program the robot to move to the Home position before the first position in a program, between cycles, and at the end of an application program before powering down the controller.



Repair/Maintenance

The Repair/Maintenance position is position where robot repair operations are performed. Program the robot to move to the Repair position any time repair operations must be performed. Repair positions are recorded away from other equipment and the areas where materials are transferred.

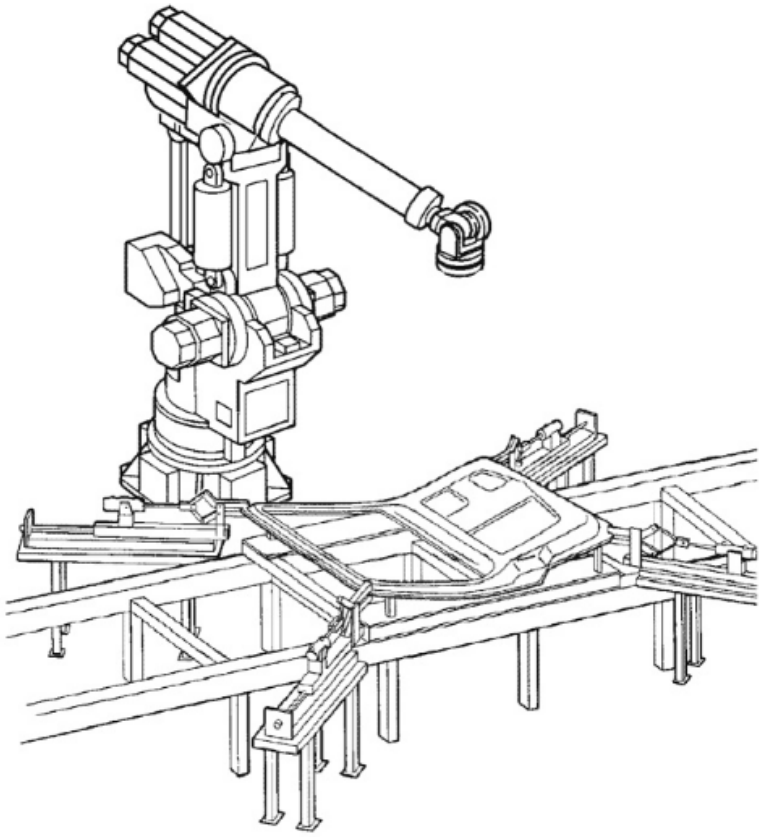


Purge:

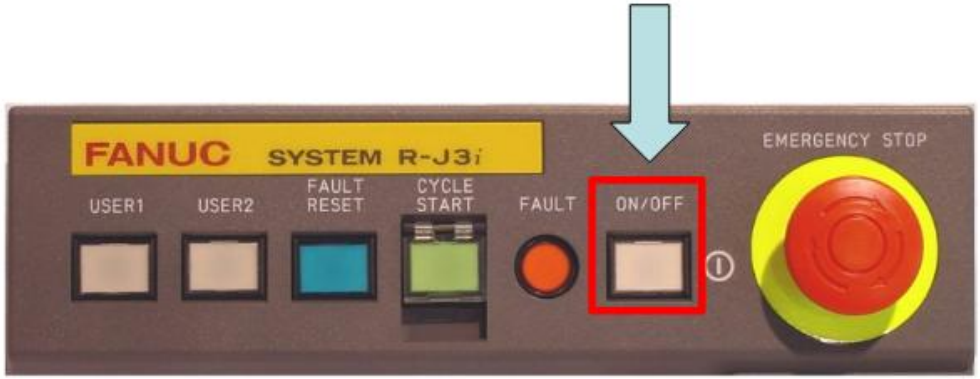
The purge position is used to purge any paint from the applicator into the gun box. It typically consists of one position that is located directly above the gun box

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.



The second step to powering down the robot is to press the power off button on the Standard Operator Panel. For the R-30*i*A controller, turn the circuit breaker to the OFF position.



The third and final step for the R-J3 and R-J*i*B controllers is to turn the circuit breaker to the OFF position.

Robot Operations

1 – Safety and Cycle Power

2 – Moving a Robot in JOINT and WORLD Jog Modes

3 – Create and Change Teach Pendant Programs

4 – Abort, Access, Test and Run Programs

Jog a Robot

- The Teach Pendant and Standard Operator Panel are examples of primary components in any robotic system.
- A basic understanding of the pertinent elements of these components, as well as robot motion makes robot operation simple.
- In this module you should learn how to move the robot in the JOINT and WORLD jog modes anticipating the robot's direction and speed, using a fully functional Teach Pendant.

After successfully completing this module you should be able to:

- Describe the function of the Teach Pendant
- Define the term "jog" as it relates to robots
- Define JOINT jog mode Explain what is meant by an "axis system"
- Define WORLD jog mode
- Compare and contrast robot motion in JOINT versus WORLD jog mode
- Describe or demonstrate how to jog the robot in JOINT versus WORLD mode
- Describe or demonstrate the right-hand rule as it applies to robot axes

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

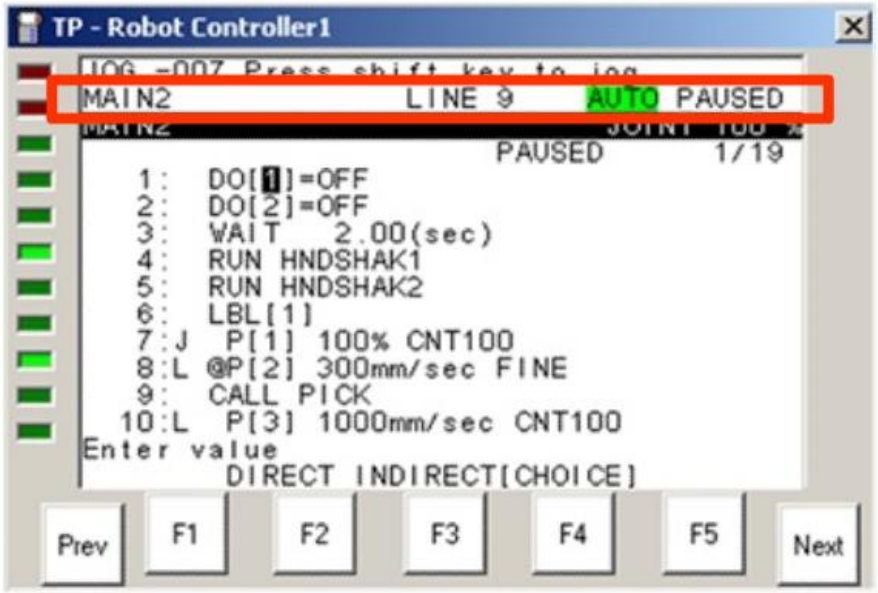
Describe Physical Elements of the Teach Pendant

The Teach Pendant consists of six key elements. Those elements are:

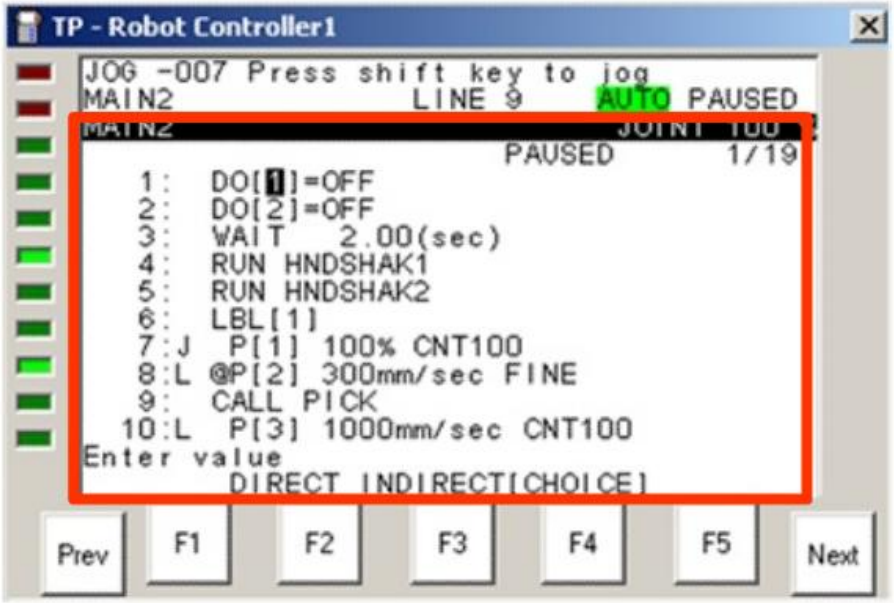
1. LCD Screen Display

2. Status Indicators
   Status Indicators for the iPendant

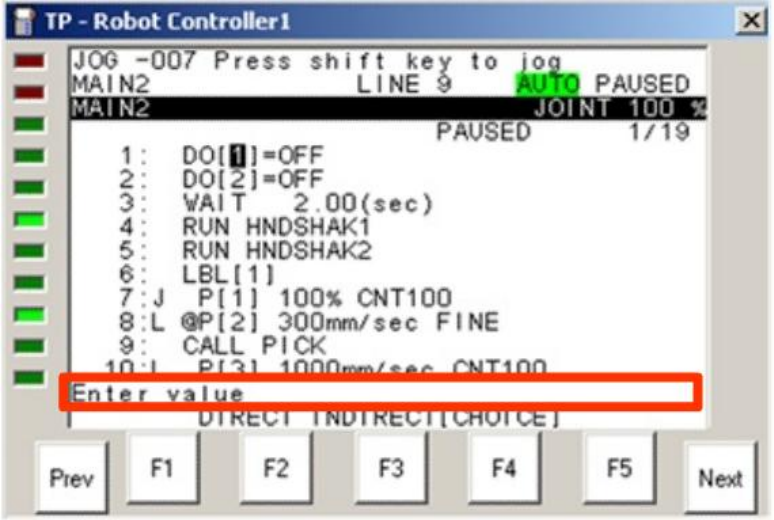
3. ON/OFF Switch



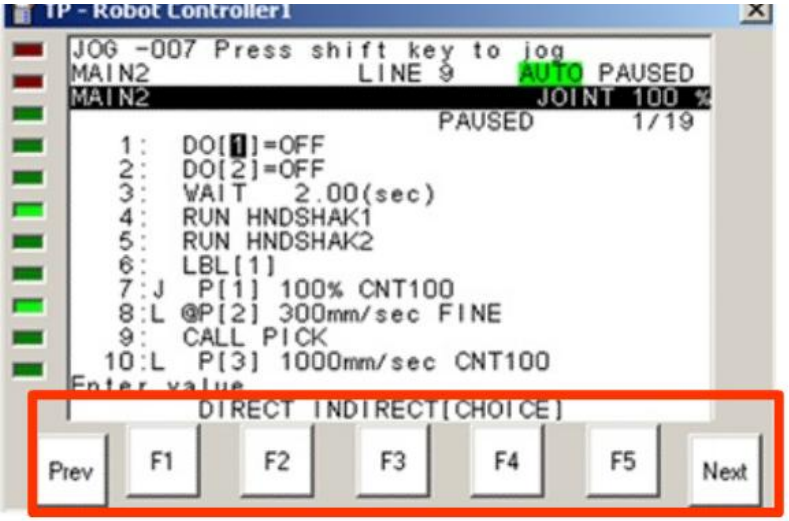
Status Bar-For robot status and controller messages.



Display or User Area-For menu options, program display, and a working area for the user.



Prompt Line-Assists users when the software is requiring user input.



Function Key Menu-Provides all software functions available to users at different stages of utilizing the software program.

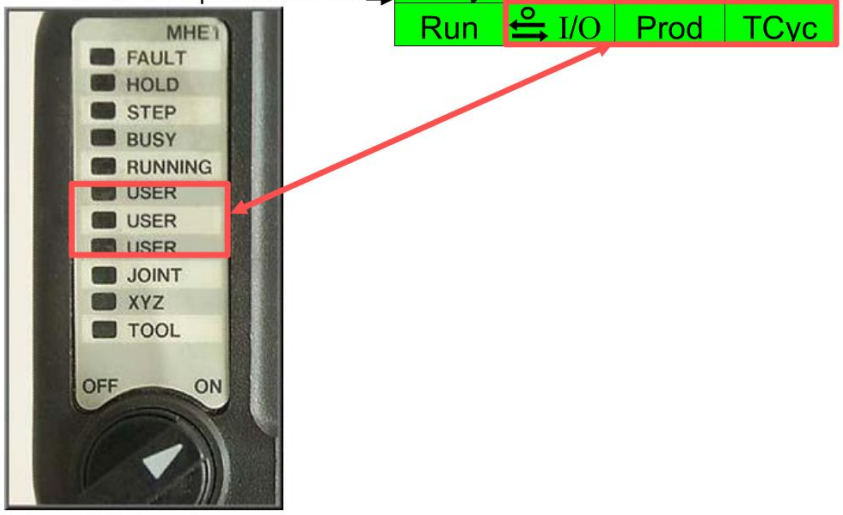
Teach Pendant Status Indicators

Status Indicators for the iPendant are at the top of the screen

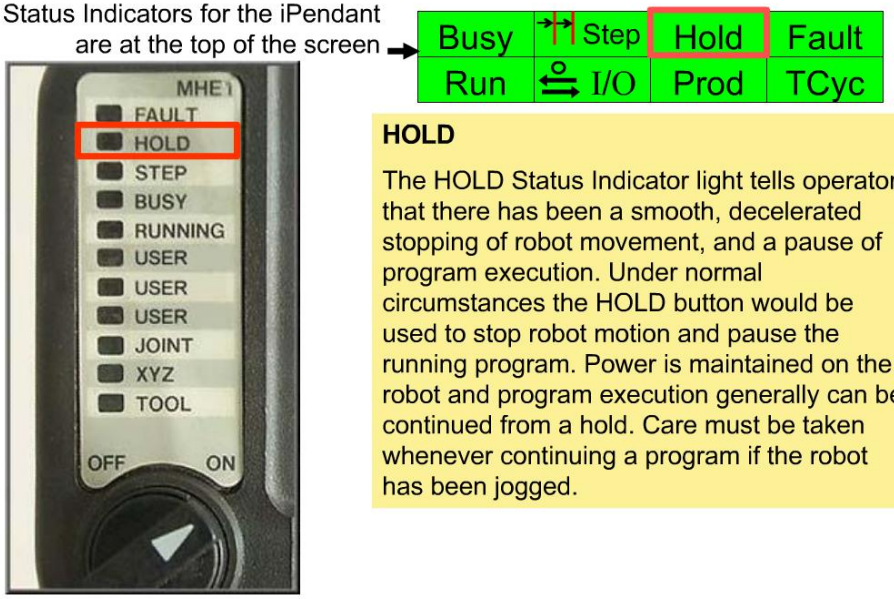
Busy	Step	Hold	Fault
Run	I/O	Prod	TCyc

There can be up to 11 Status Indicator lights located on the Teach Pendant to the left of the LCD screen display. **The status indicator for the iPendant is at the TOP of the LCD screen display.** The lights are designed to indicate the current status of the robot to the operator. This graphic is representative of the common indicators appearing on your Teach Pendant. Notice that three of the available slots, those named USER, are dependent on the specified application and are user defined.

Status Indicators for the iPendant are at the top of the screen



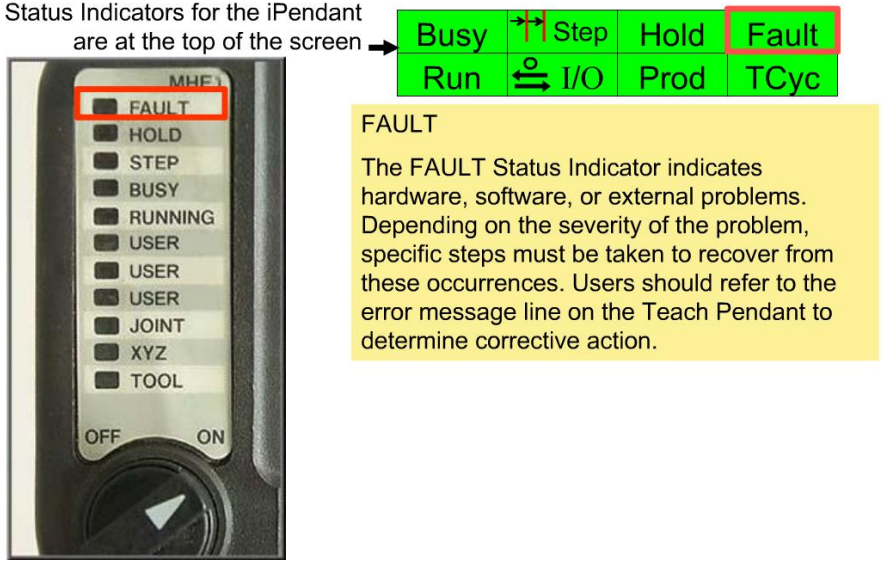
Status Indicators for the iPendant are at the top of the screen



HOLD

The HOLD Status Indicator light tells operators that there has been a smooth, decelerated stopping of robot movement, and a pause of program execution. Under normal circumstances the HOLD button would be used to stop robot motion and pause the running program. Power is maintained on the robot and program execution generally can be continued from a hold. Care must be taken whenever continuing a program if the robot has been jogged.

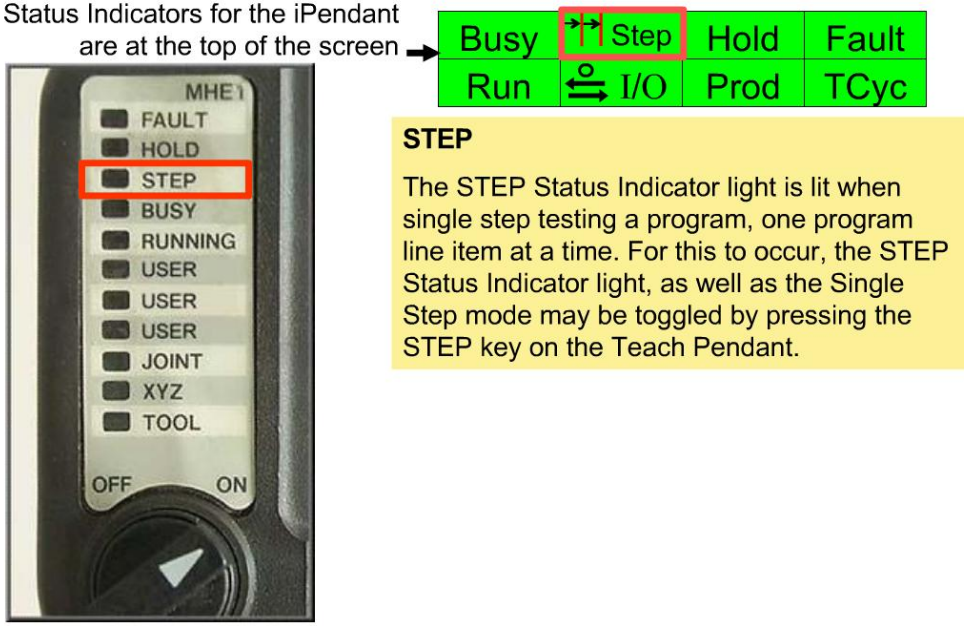
Status Indicators for the iPendant are at the top of the screen



FAULT

The FAULT Status Indicator indicates hardware, software, or external problems. Depending on the severity of the problem, specific steps must be taken to recover from these occurrences. Users should refer to the error message line on the Teach Pendant to determine corrective action.

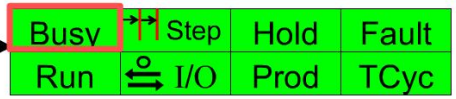
Status Indicators for the iPendant are at the top of the screen



STEP

The STEP Status Indicator light is lit when single step testing a program, one program line item at a time. For this to occur, the STEP Status Indicator light, as well as the Single Step mode may be toggled by pressing the STEP key on the Teach Pendant.

Status Indicators for the iPendant are at the top of the screen

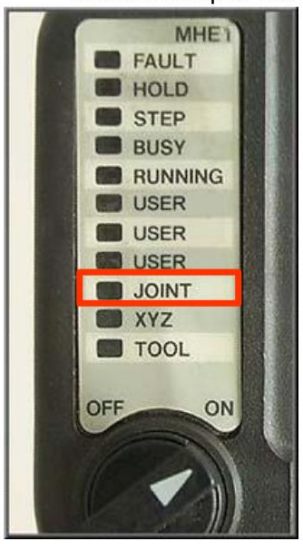


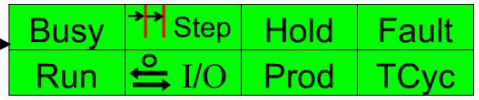
BUSY

The BUSY Status Indicator light is lit whenever a program is running.

NOTE: Some programs, usually those that do not contain motion, may be programmed not to light this indicator.

Status Indicators for the iPendant are at the top of the screen





JOINT

The JOINT Status Indicator light will be lit when selecting the JOINT mode for jogging or moving the robot to a position manually. JOINT mode allows manual jogging of one axis at a time, using the jog keys on the Teach Pendant.

Status Indicators for the iPendant are at the top of the screen

RUNNING

The RUNNING Status Indicator light is lit whenever a program is running, regardless of whether tasks involve motion.

Status Indicators for the iPendant are at the top of the screen

XYZ

The XYZ Status Indicator light is lit when selecting a Cartesian Coordinate System (WORLD, JOG or USER) for jogging or moving the robot. When using an XYZ coordinate system, the x, y and z axes are three intersecting perpendicular straight lines.

Status Indicators for the iPendant are at the top of the screen

Busy	Step	Hold	Fault
Run	I/O	Prod	TCyc

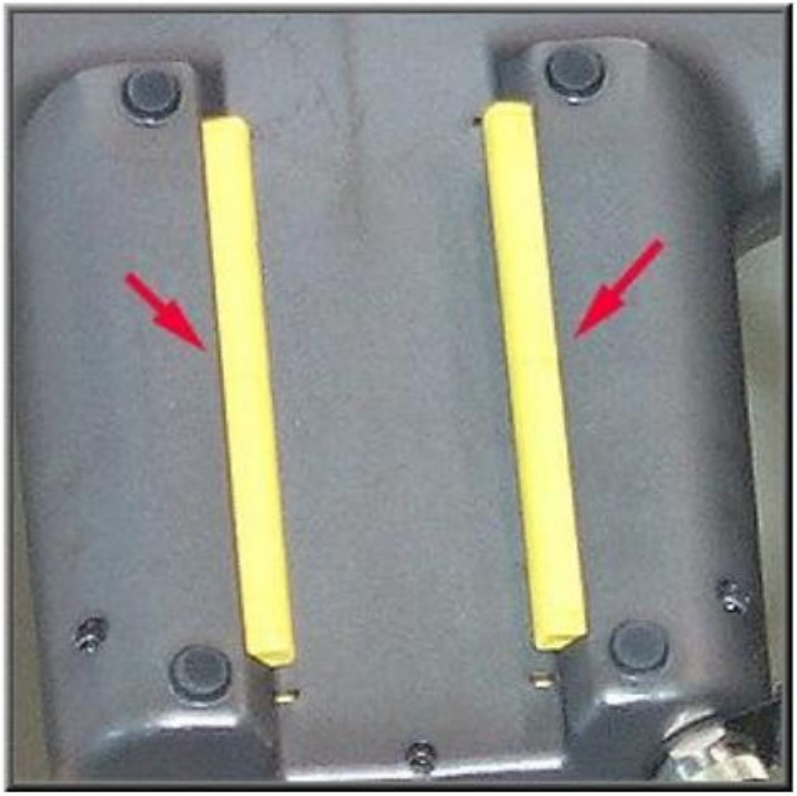
TOOL

The TOOL Status Indicator light is lit when using a tool frame to move or jog the robot. When using the TOOL frame, the robot's jog reference frame is located at the center of the robot's mounting flange.

- **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.**

- **The Teach Pendant ON/OFF Switch is used to enable or disable the Teach Pendant in preparation to jog the robot. It is also enabled while editing a teach pendant program and recording additional data**

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.

Teach Pendant Keypad

The Teach Pendant keypad consists of additional keys and buttons that are designed and displayed in a way that makes using the software easy

TP Keypad

Jogging a Robot

- **To manually move the robot's Tool Center Point (TCP) in a desired direction, at a predetermined speed. This is accomplished by using the Teach Pendant.**

Tool Center Point:

1. The location on the end-effect or tool of a robot hand whose position and orientation define the coordinates of the controlled object.
2. Reference point for position control, that is, the point on the tool that is used to teach positions. Abbreviated TCP.

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.

JOINT Coordinate System

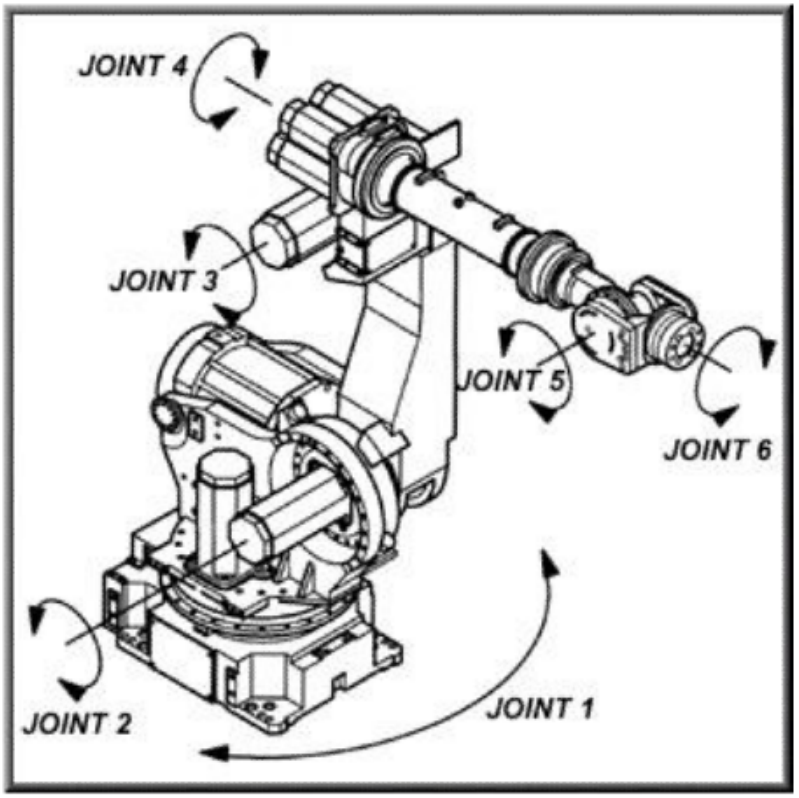
The JOINT Coordinate System is a non-cartesian jog mode. The movement of individual joints on the robot is not based on the XYZ Coordinate System. Each individual joint on the robot may be "jogged" or moved independently, or simultaneously with other joints. Joint numbers and directional movement markings are located directly on the mechanical unit.

WORLD Coordinate System

The WORLD Coordinate System is a Cartesian coordinate system. The movement of joints on the robot is based on the movement of the Tool Center Point along the x, y, or z axis in either the positive or negative direction, or rotation of the Tool Center Point around the x, y, or z axis.

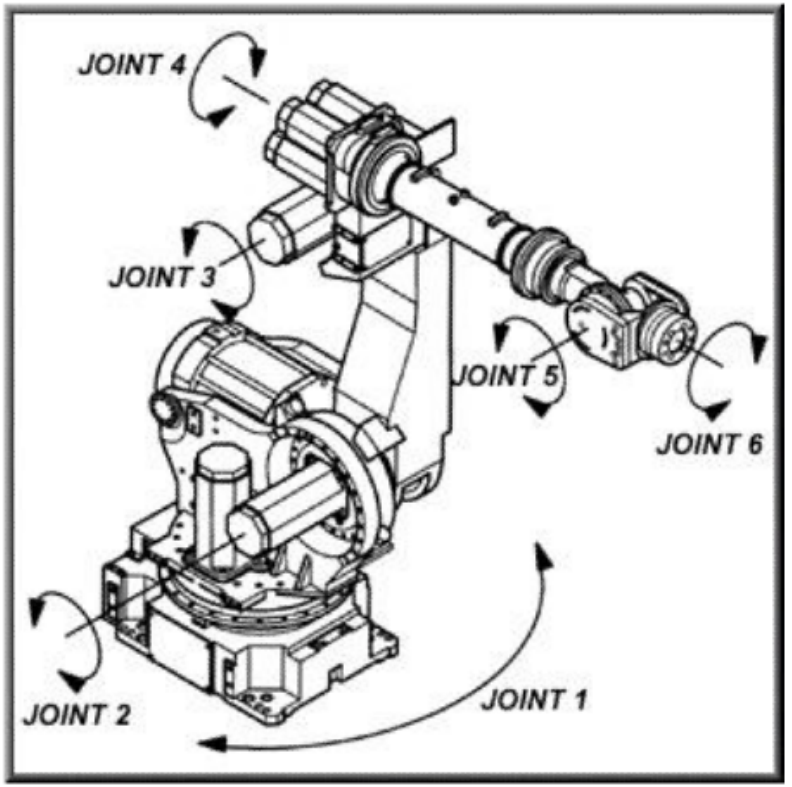
Define JOINT Jog Mode

- Robot motion is accomplished by a series of mechanical links driven by servomotors. Those links are commonly referred to as Joint 1 through Joint 6 (J1 - J6).
- Major joints = J1 - J3. Responsible for primary large movements that define the robot's maximum work space.
- Minor joints = J4 - J6. Responsible for more precise movements of the end-of-arm tooling. Typical robot = 6 joints



Jogging in "JOINT"

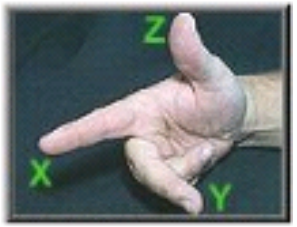
- When jogging in JOINT, the operator can move each joint individually, one at a time, or move more than one joint simultaneously be pressing more than one jog key.
- In the JOINT jog mode, the robot moves in a positive or negative direction from the center of rotation. Since the center of rotation can differ for each robot, look for the positive and negative markings at the front of the robot to determine direction.
- The motion that takes place in the JOINT jog mode has been compared to the motion seen when moving the human arm.

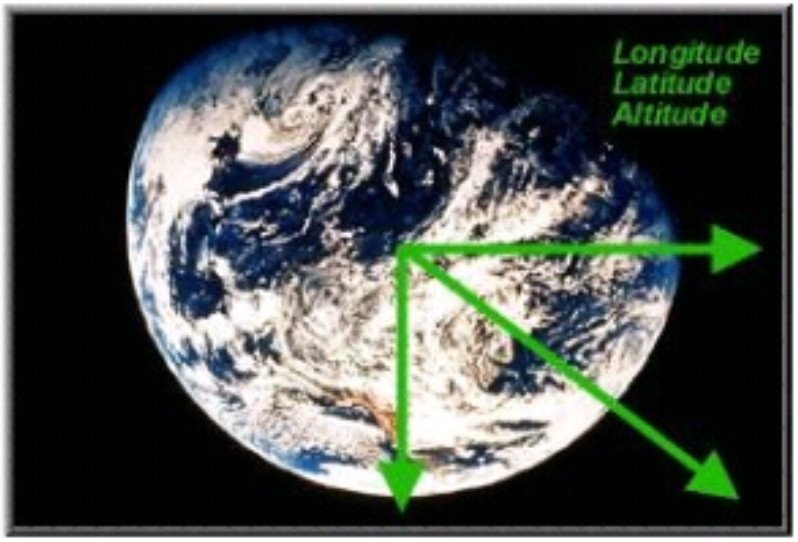


Jogging in “Joint 1” Jogging in “Joint 2”

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.





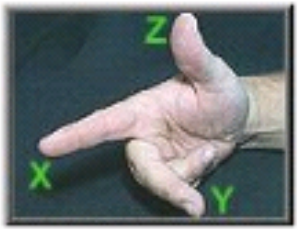
Cartesian Coordinate

- **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**

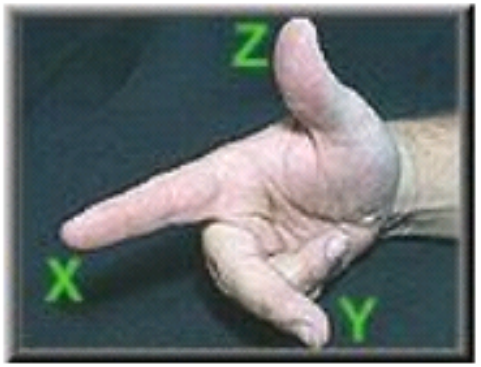
Origin:

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.

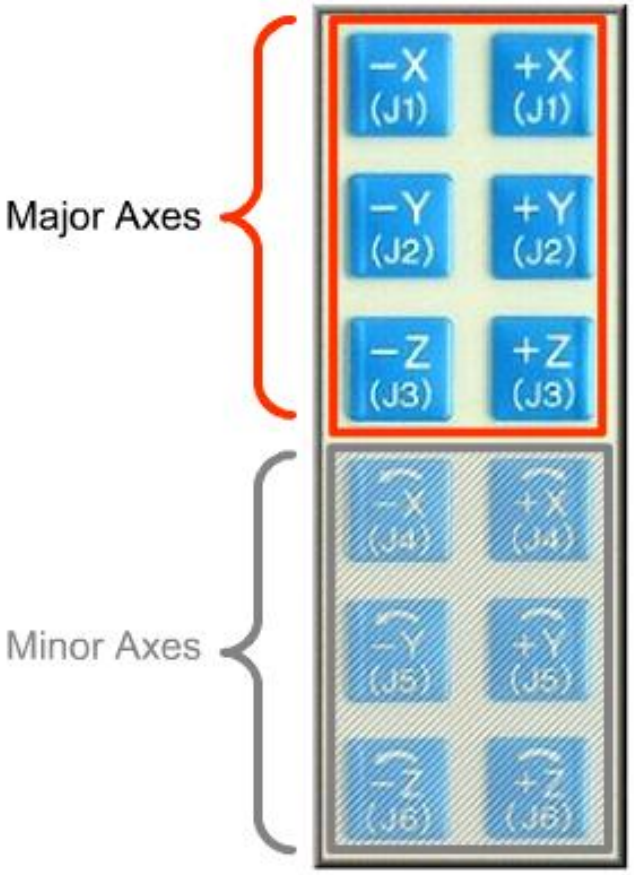


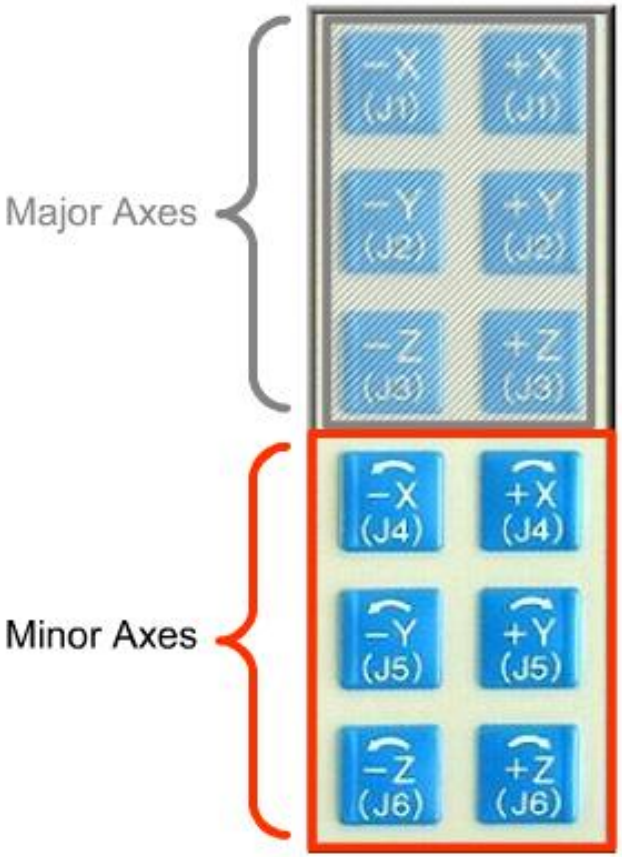
Right Hand Rule



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.

Type of Motion in WORLD jog mode – Major Axes



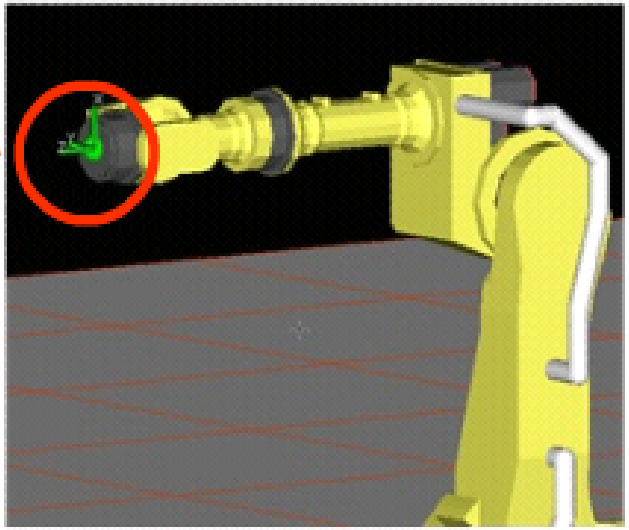


Major vs Minor Axes 1

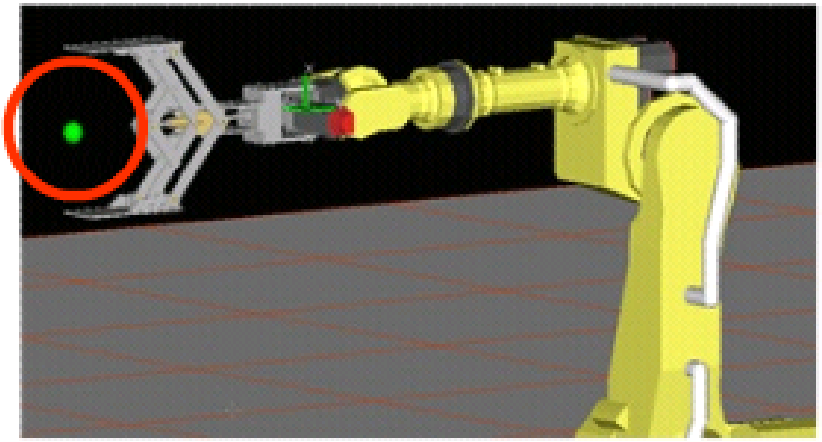
Major vs Minor Axes 2

Tool Center Point (TCP)

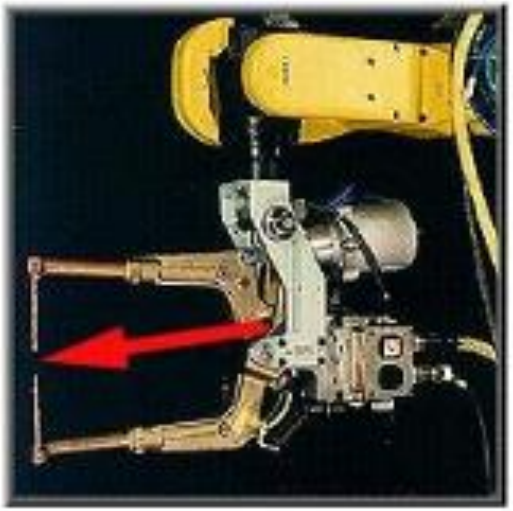
A newly purchased robot's Tool Center Point (TCP) is defined to be located at the center of robot's faceplate.



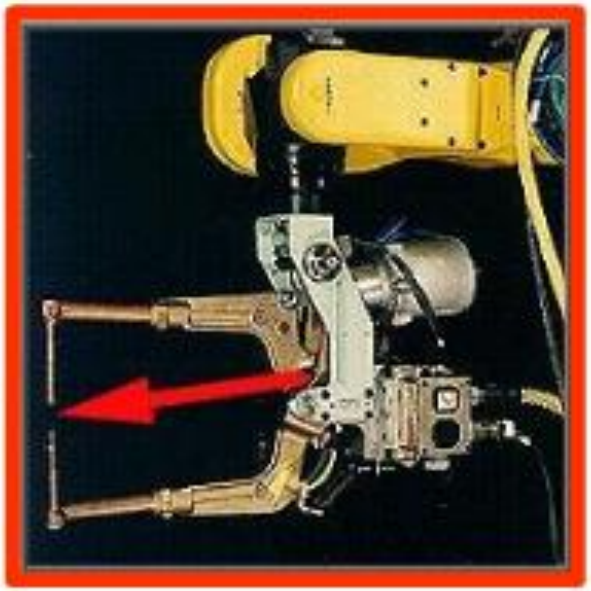
Once end-of-arm tooling has been put into place, the TCP is relocated to that point where positions will be taught and the work will be performed.



Tool Center Point (TCP)



Do you know which of these drawings correctly defines the Tool Center Point for the end-of-arm tooling being used?



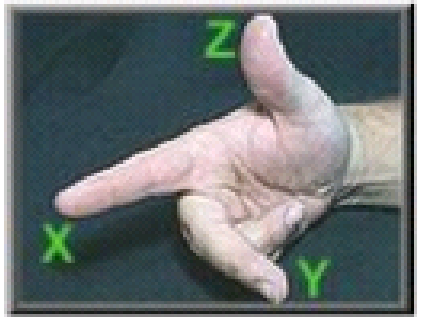
Did you get it correct?

Tool Center Point (X,Y & Z)

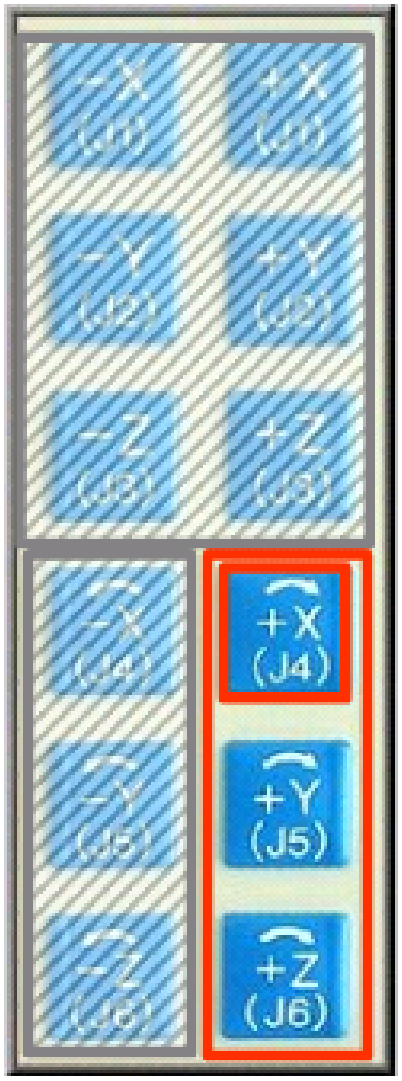
How does the Tool Center Point (TCP) rotate around the X, Y, or Z axis?

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.

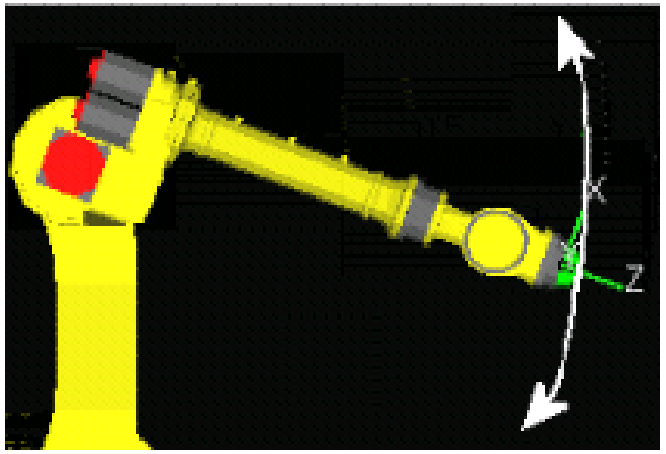


TCP

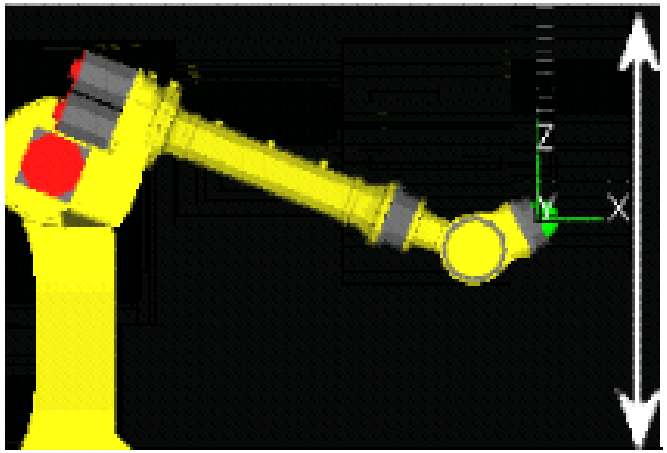
Jogging in World

- Any end-of-arm tooling mounted on the robot will move in a straight line
- Movements while in WORLD are based on the Cartesian (XYZ) Coordinate System
- The robot will move in whatever fashion possible even if that means several axes move simultaneously to reach a designated point in space
- When precision is necessary while jogging, WORLD is the jog mode to select

Joint Motion



Linear Motion



Jogging in World