YASKAWA

Making Industrial Robots User Friendly & Safe

Smart Pendant & FSU

motoman.com

Industrial Robots in The Past

- Complex to program
- Significant expense for users to support
- Lengthy deployment times
- Fixed use of the asset

Industrial Robots in the Future

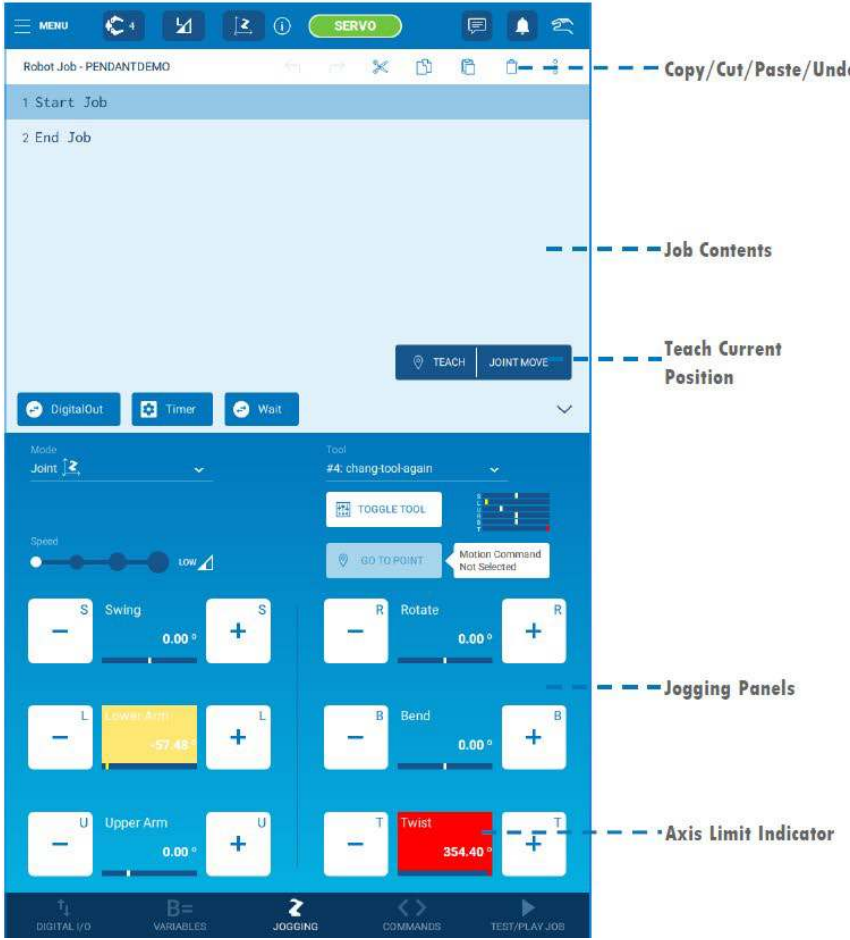
- Simple to program for basic applications
- May not require a dedicated robotics staff to support it
- Shorter times to deploy means a more attractive ROI
- Re-deploying for alternate uses becomes a possibility

Here is a new tool that is changing the paradigm

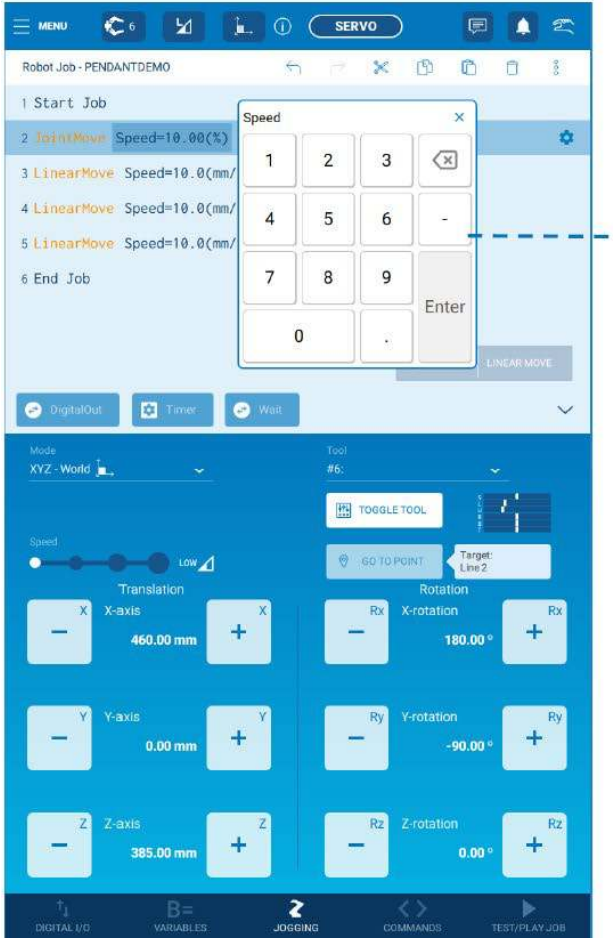
Yaskawa Motoman Smart Pendant

- Yaskawa's Smart Pendant creates an:
  - Easy to use solution that utilizes a Graphical User Interface for robot programming
  - Intuitive and simple environment that helps the user to understand, learn and implement robot programming much faster when compared with the traditional robot user interfaces
  - Opportunity for a wider range of skillsets to support your automation investments

A quick tour of the Smart Pendant

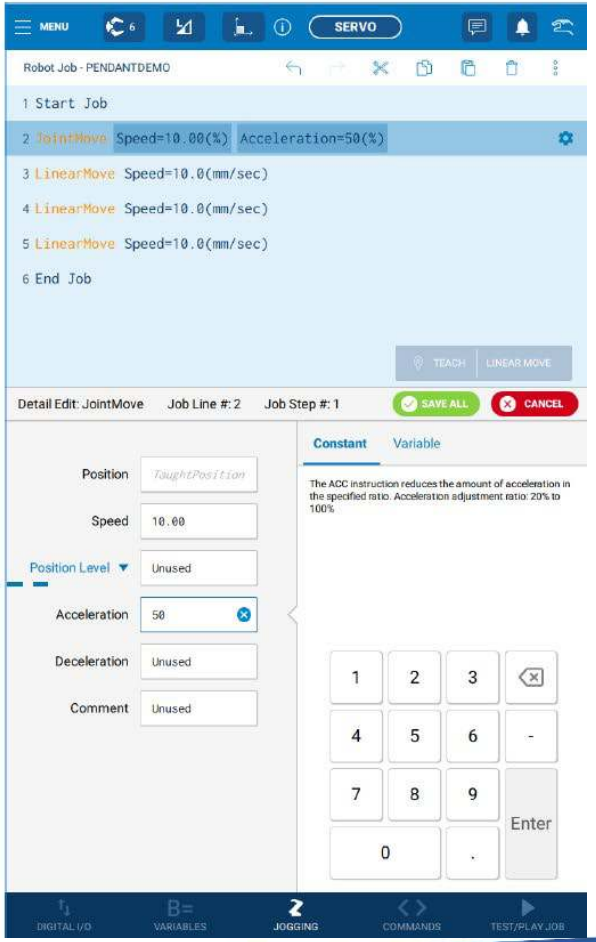


- **Key Features**
- Split Screen Setup
  - Job Contents on Top
  - Jogging Controls on bottom
- Easy Access to Copy/Cut/Paste
- Axis Limit Indicators

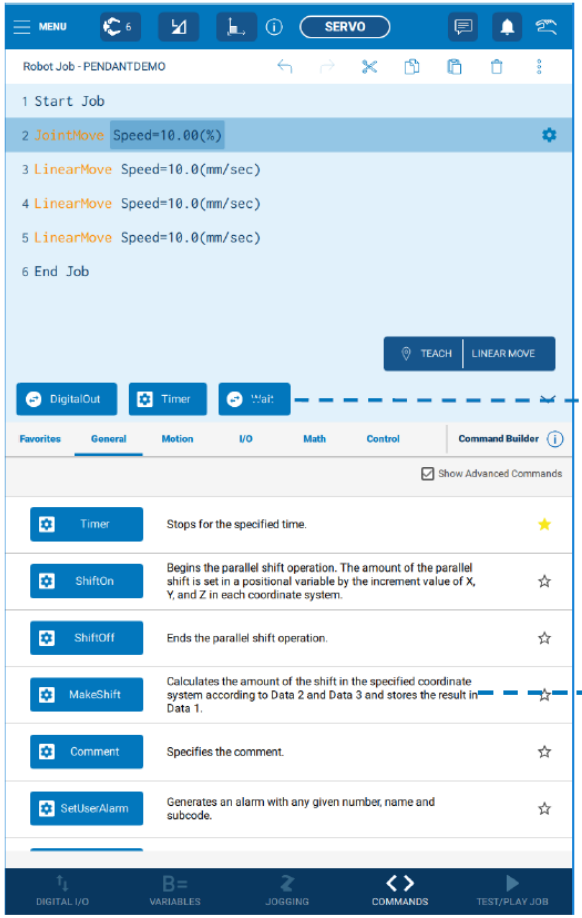


Inline Parameter Editing

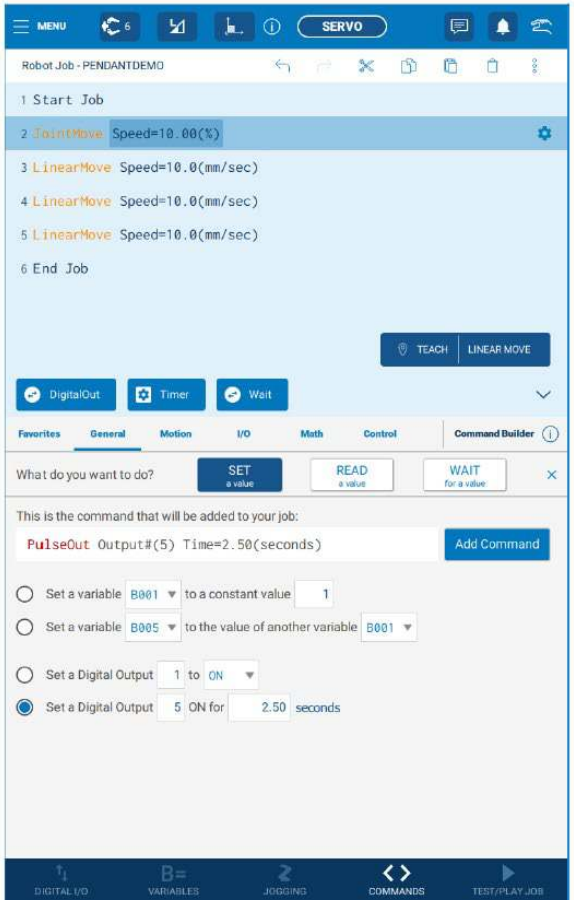
Detailed Parameter Editing



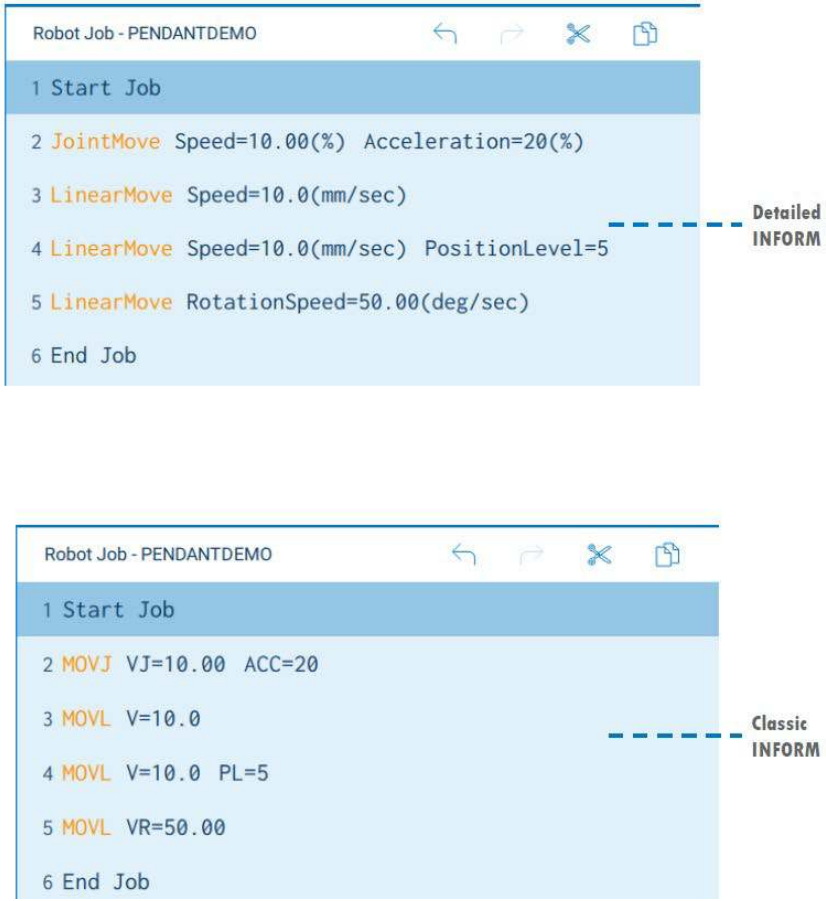
YASKAWA



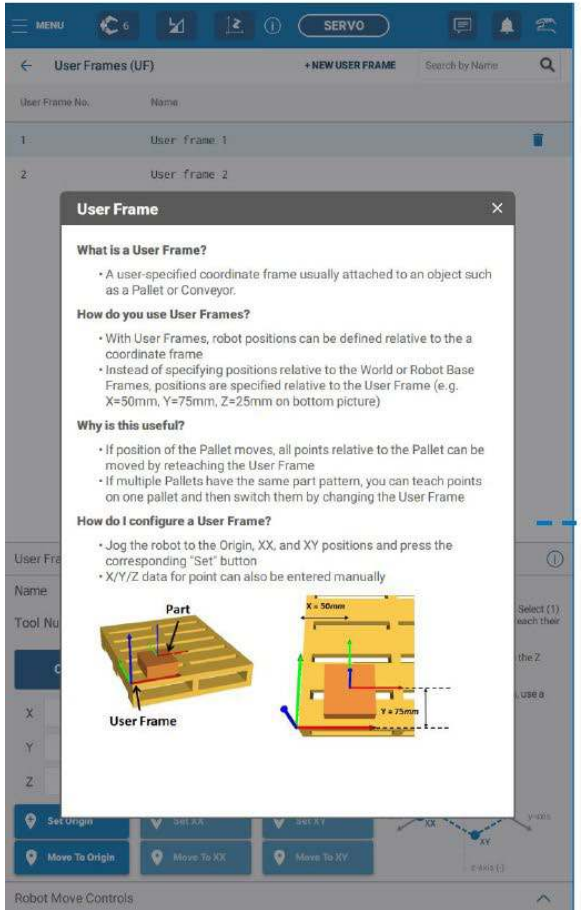
- **Key Features**
- Instruction Descriptions
- Favorite Instructions
  - Easy Access from Favorites Bar
- Show/Hide Advanced Commands
- Touch any button to insert



- **Key Features**
- Tutorial Mode for Basic Operations
  - Setting Values
  - Reading Values
  - Waiting for Values
- User can see INFORM code while changing parameters



- **Key Features**
- Detailed Inform
  - More descriptive instruction and parameter names
  - Units (e.g. mm/sec) Displayed
- Switch between Detailed and Classic

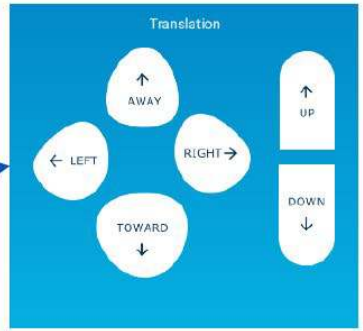


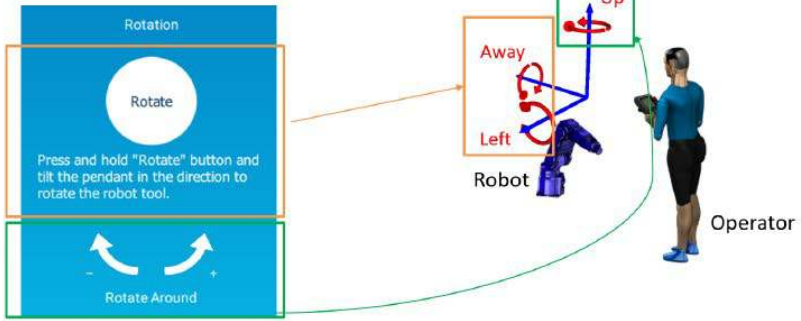
Contextual Help

- **Key Features**
- Detailed help available by pressing the "i" icon
- Present user with inline help (i.e. prevent searching for Manual)

SMART FRAME JOGGING

- Allows Jogging of Robot In Human Coordinates
- Use IMU/Compass to determine operator position relative to robot
- System is calibrated by standing in front of robot
- Two methods of jogging:
  - Translation: Left/Right/Away/Toward buttons
  - Rotation: Tilt the pendant to rotate the robot tool





SUMMARY

SMART PENDANT

YASKAWA SMART PENDANT offers:

- Shorter learning curve for new users
- Ability of non-robot programmers to do basic troubleshooting
- A rich graphical interface that is much more intuitive for the ‘occasional’ user
- Makes basic applications simple and complex applications approachable
- Brings ease of use to industrial robots

Making Industrial Robots Safe to Interact With

Why does it matter?

- Human Scale vs. Super Human
- New Machine vs. Add On Automation
- Safe vs. Dangerous Applications

Conclusion?

There is no “One Size Fits All” solution

Let’s clear up some confusion

What do we mean when say “Collaborative Robot”?

- Collaborative Robot is technically a “misnomer”
  - Robotic Applications can be Collaborative, the robot by itself is not useful
- Collaborative Applications can fall into several categories
  - Human’s working in proximity to a robot without physical guarding
  - Human’s working in conjunction with a robot
  - Human’s interacting directly with a robot
- There are four officially recognized modes of collaborative operation per ISO 10218
  - Hand Guiding
  - Safety Monitored Stop
  - Power and Force Limiting
  - Speed and Separation Monitoring

Hand Guiding

- Popular form of teaching robots “process” applications
- Normally limited to having the robot in ‘programming mode’
- Requires the use of a Force Transducer

Safety Monitored Stop

- Normally used when there needs to human interaction in a robot cell to perform a secondary process
- The robot does not shut down, but comes to a complete stop and joint brakes are applied
- The robot controller is monitoring to ensure this condition is maintained while the interaction is taking place
- Requires safety rated devices to trigger this condition

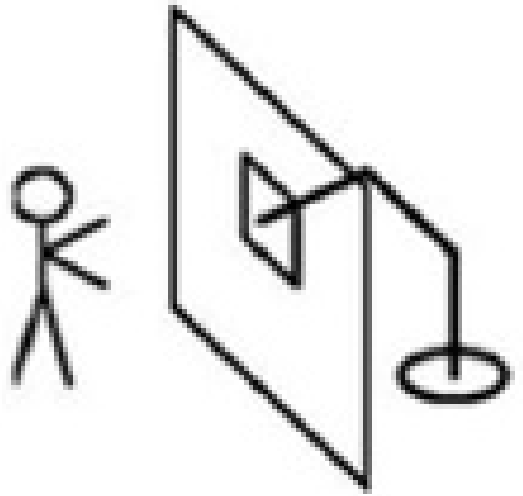


Photo from ISO 10218-2: 2011

Power and Force Limiting

- What typically is thought of as a Collaborative Robot
- Robot is designed to look for and react to ‘abnormal’ forces in order to limit resultant impact forces to a safe level
- The robot may be safer but that doesn’t change anything beyond the robot
- Requires the used of specific technologies to **safely** monitor the power and force of the robot

Speed and Separation Monitoring

- System consists of a safety rated device that monitors intrusions into specific work cell zones causing the robot respond accordingly
- The use of two to three zones is common. Intrusion into the:
  - furthest results in a warning with robot maintaining normal operations
  - Mid range results in the robot slowing
  - Closest results in the robot slowing drastically or coming to a full stop
- Could allow users to take advantage of super human automation in places previously off limits

Real World Speed and Separation Monitoring

Introducing the Yaskawa Functional Safety Unit (FSU)

Safety For Humans

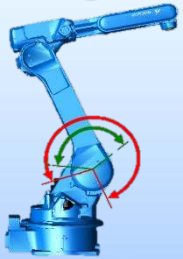
Two parallel Central Processing Units (CPUs) run **concurrently** on the functional safety board

Processors function **independently** to acquire the manipulator encoder feedback in pulse counts

Based on that position feedback, the functional safety unit can **monitor the manipulator and tool's position, speed, and posture**.

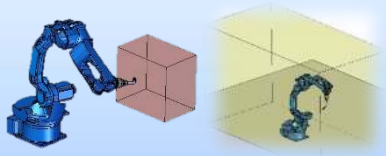
FSU improves the safety of the manipulator's motion and allows the minimization of nearby overall equipment footprint as well as human accessible areas.

Axis Range Limiting

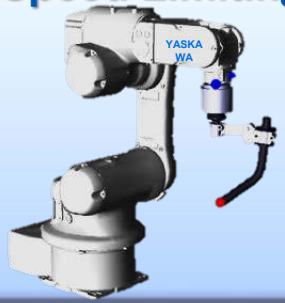


Axis Speed Monitor

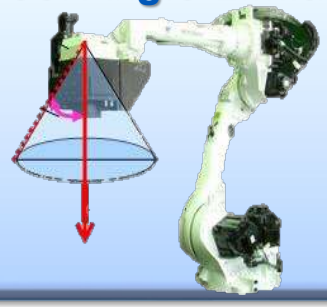
Robot Range Limiting



Speed Limiting



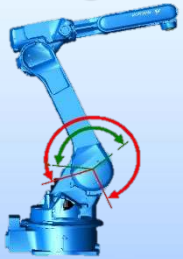
Tool Angle Limiting



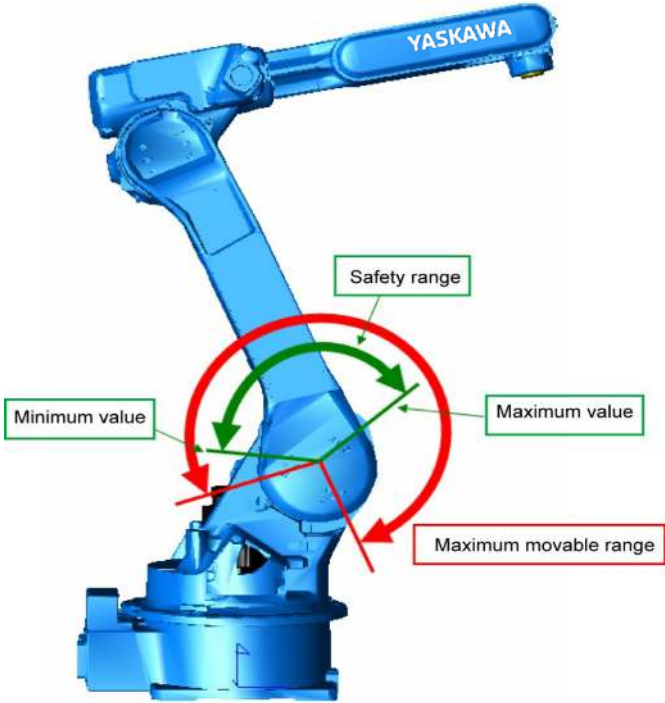
Tool Change Monitor

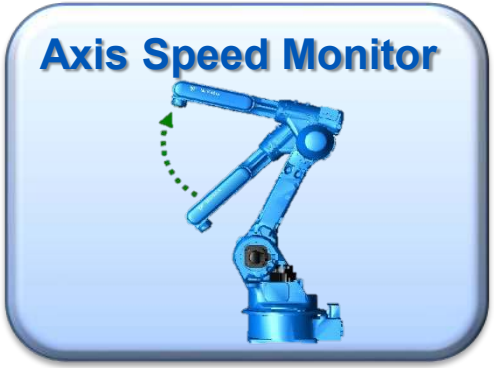
- **Pre FSU**
  - ✓Zone Rings
  - ✓In position switches
- **FSU**
  - ✓Range Limiting
  - ✓Axis Limiting

Axis Range Limiting



- *User can set and monitor each axis of the robot and/or auxiliary axes to maintain position within the set limits*
- 32 range files available
  - Each file can monitor up to a 6-axis robot and 3-external axes.
- **Application Uses:**
  - Alarm=ON → Limit robot range much **like hard-stops** but infinitely adjustable and can be enabled/disabled via “SIGNAL”
  - Alarm=OFF → Monitor external axis or robot position.
    - External axis → “**At Side A/B**” without switches
    - Robot → “**Robot At Home**” without switches (safety-rated cube)



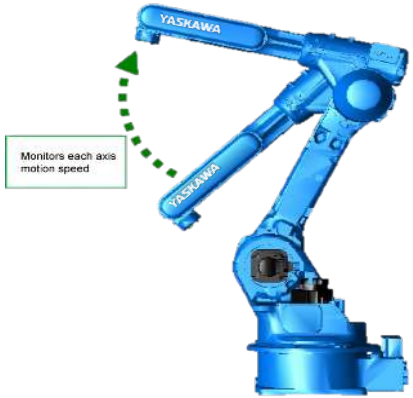

Axis Speed Monitor

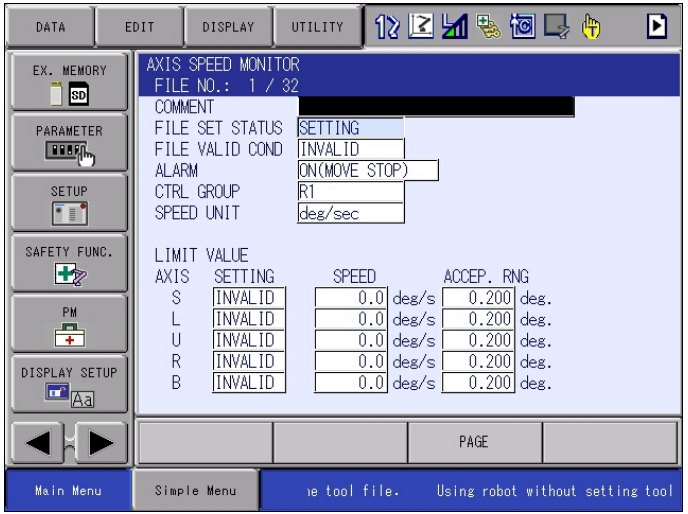
- *Set individual **axis upper limit speed** range for the robot and auxiliary axes and monitors the axes to maintain set limits. Each file can be configured for a single robot, base, or station axis.*
- *One file includes 6-axis robot and 3-auxilliary axes for a single control group.* 32 file settings available.

– Application Uses

- Ensuring robot/external axis speed when operator is in a collaborative space.

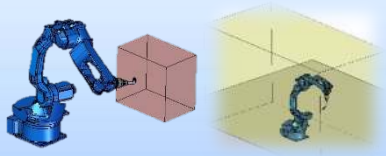
○ This function will not “Command” the robot/external axis to travel at a lower speed. Instead the robot must already be below the set speed. If the axes are moving faster than the setting, an alarm will occur.



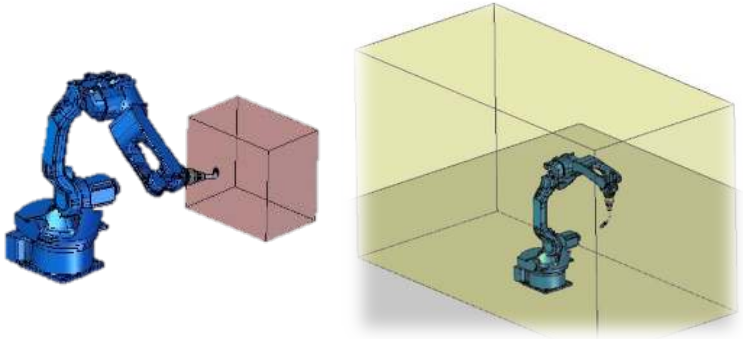


Note: Use the “Speed Limit” function to actively change operating speed.

Robot Range Limiting



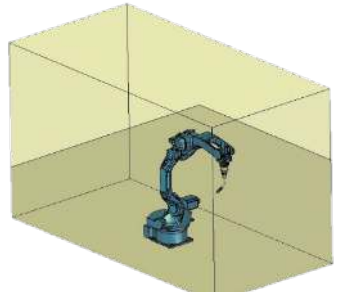
- *Function is used to monitor robot flange center point (FCP) and **allow motion inside or outside a user defined shape**. If a tool interference is defined, the TCP will be monitored.*
- 32 file settings available for an individual robot or base.



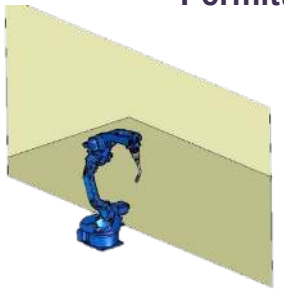
– **Application Uses**
  - Inside or Outside of zone monitoring

- **User Defined Shapes**
  - Planar
  - Cuboid
  - Prism
- **CPU Usage**
- **Combining safety areas**

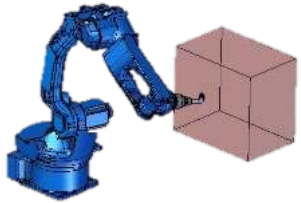
– **Inside Range Monitoring**
  - The function is used to monitor the robot and its tool to remain “inside” a user defined shape.
– **Outside Range Monitoring**
  - The function is used to monitor the robot and its tool to remain “outside” a user defined shape.
– **Planar Monitoring**
  - Define a plane in the XY, YZ, or ZX coordinates. The function is used to monitor the robot and its tool to not allow the robot to pierce the user defined plane.



Permitted work area



Restricted area



Restricted area

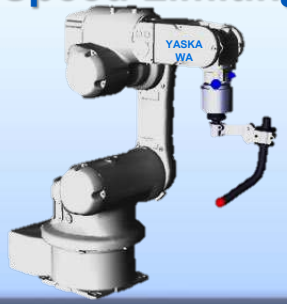
Demonstration

[Inside the range monitoring]

Demonstration

[Planar interference monitoring]

Speed Limiting

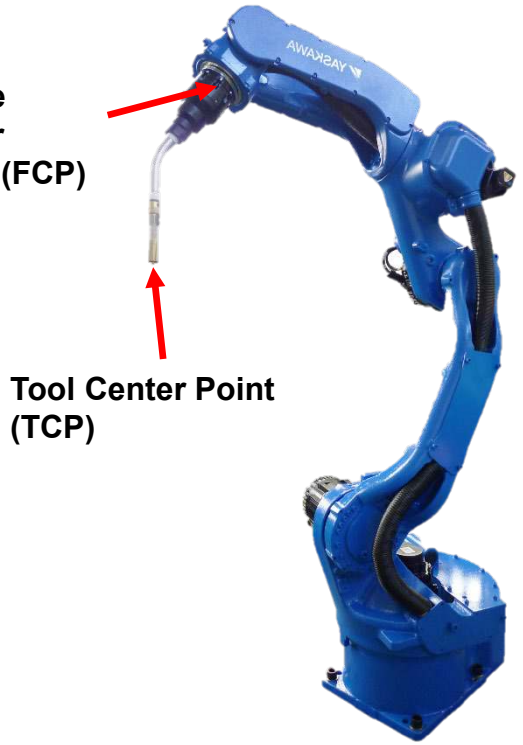


–Controls TCP/FCP Speed

- Limits robot's tool center point (TCP) speed or flange center point (FCP) to maintain set limits.
- When "zero" is set as the speed limit for the robot or auxiliary axes. This is referred to as **stop state monitoring**.

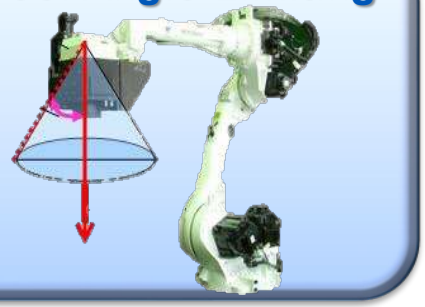
–Application Uses

- Provide a safe stop state for operators to interface with the equipment for purposes of loading/ unloading part fixtures or tip-change/dress for arc/spot welding applications.
- Stop-state monitor "Operator side" of positioner while part processing takes place on robot side of positioner (similar to servo disconnect but power still remains on operator side).

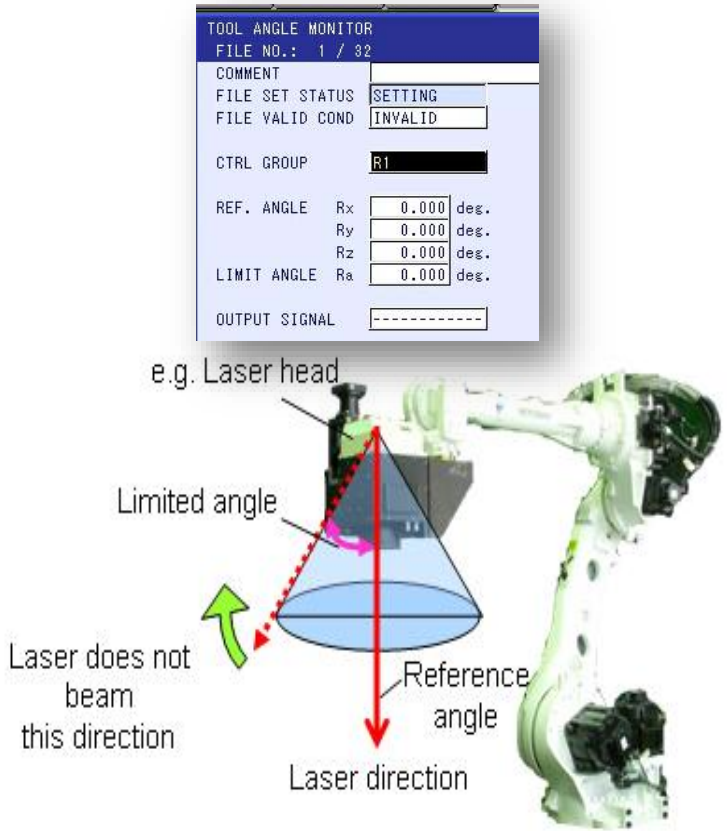


Demonstration

Tool Angle Limiting



– **Restrict Undesirable Angles**
  - Provides the ability to set tool angle limits and monitors the tool to maintain position **within the set limits**.
  - Function can maintain multiple tools of different shapes and sizes when using the robot range limit function.
– **Application Uses**
  - Tools with **dangerous end effectors** (lasers, nail guns, etc.)
  - Tools which must maintain a specific angle (paint, glue application, etc.)
– **Backup file**
  - TLANGMON.DAT



Demonstration

[Tool angle : within ±20°]

Tool Change Monitor

Monitors the tool file used in the functional safety function to be consistent with the user specified tool file.

– Prevent Undesirable Tool Use

- Ability to switch between multiple tools of different shapes and sizes when using the robot range limit function.
- 16 individual rule “file” settings available.

– Steps to use function

- Set the tool file
- Set the tool interference file
- Set the tool change monitor function
- Confirm the tool change
- Start the tool change monitor function

NOTE: Must enable Tool Change Monitor function in Maintenance Mode to use

Summary

- Ease of use does much more than make programming simpler, it provides more opportunities to automate at a lower cost of ownership
- Utilizing industrial robots in collaborative modes will drastically increase the number of places robots can be used while achieving super human performance
- Regardless of the technology, safety should be the first priority and all robot installations must have a proper Risk Assessment performed