YASKAWA

Job Duplication – Repeatable Robotics Efficiency

SUMMARY:

Describes how to convert programmed points in a job to a relative job in user coordinates. This user coordinate can be retaught, and programmed points will remain in the same location and orientation relative to the user coordinate. This overview is designed for a two-axis 'tilt-rotate' positioner.

ASSUMPTIONS MADE:

- The part is precisely located relative to the planar feature used to create the user frame from cell to cell.
- Each positioner home position is in the same location relative to the robot. For example, if both the robot and positioner home are level to the ground in the original cell, this relationship should be maintained throughout cells.
- User is familiar with Motoman® programming, synchronized motion, positioner/robot calibration.

PART I: INITIAL CELL SETUP, PRE-CONVERSION TO DUPLICATE CELLS

A) VERIFY SYSTEM CALIBRATION

(1) Mount a pointer to the robot tool and create a proper TCP (Tool Control Point).
Refer to "DX200 OPTIONS INSTRUCTIONS" Section 8.3 Tool Data Setting.

> Note: A proper TCP calibration requires precise positioning to an external pointer, which is directly related to the operator robot positioning.

(2) With the newly created tool active, in Cartesian coordinates, rotate about the external pointer using Rx, Ry, Rz keys on the pendant. Verify that the robot TCP remains stationary above the external pointer as the user rotates about the TCP.

> Countermeasure 1: Confirm that all 5 positions used to teach TCP are accurate.
> Countermeasure 2: Robot calibration is critical for a proper TCP. Consider contacting a Yaskawa representative if this is a concern.

(3) Calibrate robot to positioner using the five point procedure documented in "DX200 OPTIONS INSTRUCTIONS FOR INDEPENDENT/COORDINATED CONTROL FUNCTION" Section 2.4 System Setup. See Figure 1 for example calibration positioning.

> Note 1: A proper positioner/robot calibration requires precise positioning to the external pointer, which is controlled by the robot programmer.
> Note 2: In order to minimize the effect of error introduced by teaching the calibration points, store positions that are 90 degrees apart for the secondary axis and 45 degrees apart for the primary axis.
> Countermeasure 1: To evaluate robot/positioner calibration, bring robot pointer to positioner, while in a robot and station job, press 7 to enter coordinated motion, and jog external axis. Robot TCP should track positioner pointer as it moves in space.
> Countermeasure 2: If robot/positioner calibration is unacceptable, evaluate accuracy of the positions used in calibration procedure.
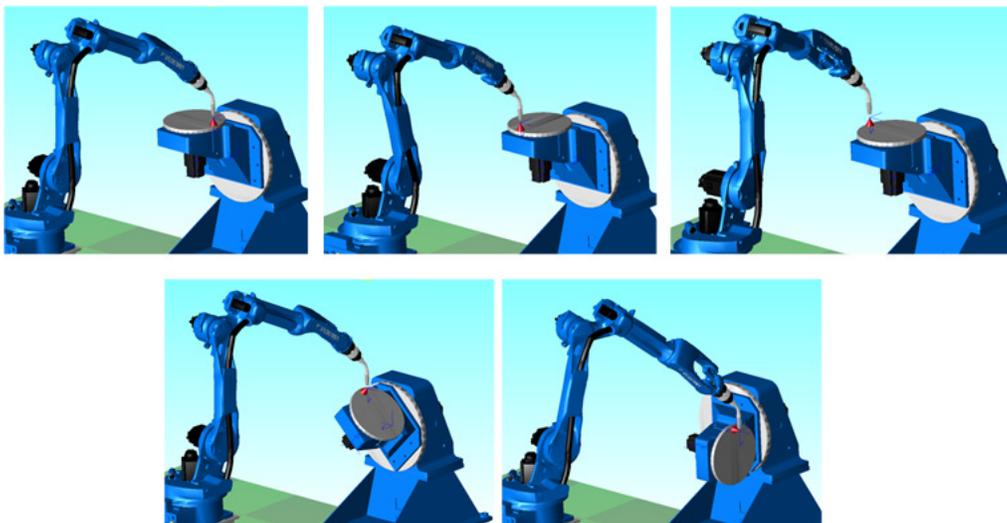> Countermeasure 3: Minimize changes in arm posture during calibration for the most accurate calibration.

Figure 1: Example Robot/Positioner Calibration Positions

B) CREATE USER FRAME

(1) Refer to "DX200 OPTIONS INSTRUCTIONS" Section 8.8 user coordinate setting.

(2) Identify a planar feature on part fixture.

> Note 1: This planar part must be consistently located in both position and orientation to the part fixture from cell to cell.
> Note 2: See Figure 2 for example positions to teach a user frame.

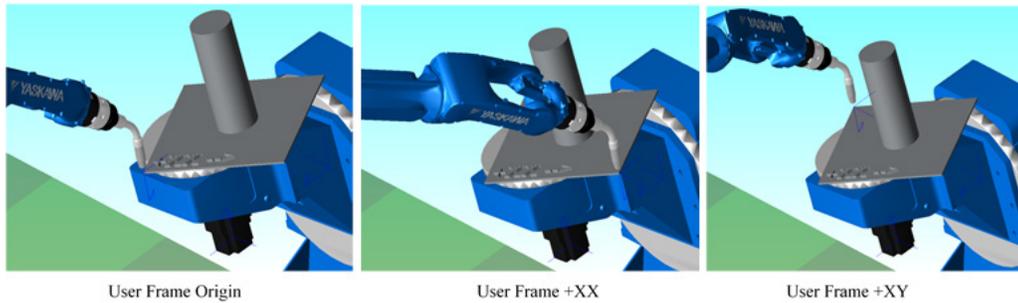User Frame Origin   User Frame +XX   User Frame +XY

Figure 2: User Frame 3 Point Definition

(3) Create a new job with a control group that has both the robot and positioner; this job will only be used to create a dynamic user frame. Capture the origin, +XX and +XY points using SREFP1-3. In this job, use the MFRAME command and the 3 SREFP positions from the planar feature to create a frame. See Figure 3 for job example.

> Note 1: Using SREFP to capture frame locations protects the data from being easily edited.
> Note 2: To set the MTOOL argument of the MFRAME tag, navigate from the Detail Edit screen, select 'MTOOL USER' from 'UNUSED' to 'MTOOL'.
>   Ex. Structure: MFRAME UF#(1) PX000 PX001 PX002 MTOOL
> Note 3: Master Tool Frame (MTF) is the frame which is created during robot/positioner calibration, and its z-axis is the axis of rotation. This instruction creates a dynamic user frame that will be defined relative to the MTF and not Robot Frame.
> Note 4: A user frame can be taught directly in the utility under ROBOT menu and USER frame. Three points: ORG, XX and XY are taught as described above, and the frame is calculated when pressing COMPLETE before exiting the utility. The use of SREFP makes it easier to reference or change these positions for later use, or a sensor can be used to detect these positions and update the frame by executing the MFRAME instruction.

Figure 3: Define Dynamic User Frame Example Job

C) PROGRAM JOB

(1) Convert job to relative job on the user frame just created before programming points. Any positioner locations captured while in a pulse job will not be recorded in angle. Only positioner locations captured in a relative job will be recorded in angle. See Figure 4 for relative job conversion screenshots.
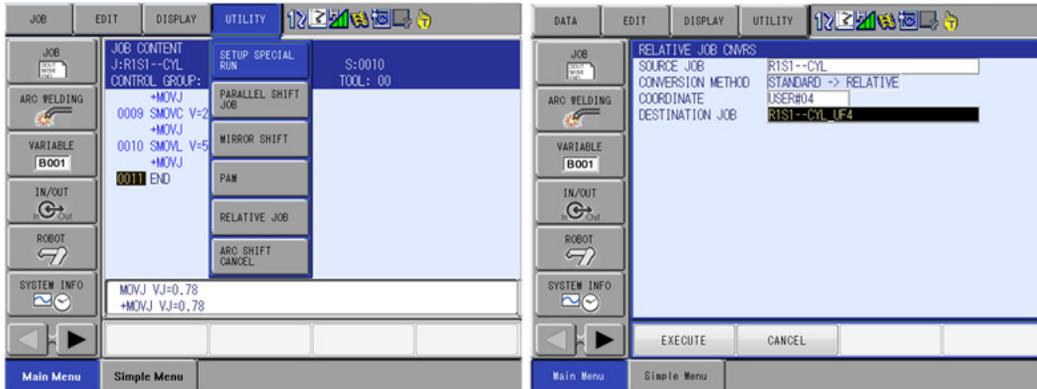

Figure 4: Convert Standard Job to Relative Job

(2) The job is now ready to be saved and loaded into another robot controller.

> Note 1: Be aware that if any motion on P-variables is being used, the relative job conversion will not alter P-variable values.
>
> Note 2: See "DX200 OPTIONS INSTRUCTIONS FOR RELATIVE JOB FUNCTION" for relative job details.
>
> Note 3: If any points were recorded in standard job before being converted to relative job, simply forward to the relevant point and press 'Modify+Enter.' The current external axis position will be overwritten into angle.

PART II: JOB CONVERSION TO DUPLICATE CELLS

A) VERIFY SYSTEM CALIBRATION AS DONE WITH PREVIOUS CELL

- Robot, TCP, robot/positioner calibration.

B) TEACH THE RELEVANT USER FRAME USING THE MFRAME MTF COMMAND AS DONE ON THE ORIGINAL CELL

> Note: Use the same user frame number as was taught in the original cell.

C) CONVERT JOB TO RELATIVE JOB, IN THE USER FRAME THAT WAS JUST CREATED

> Note: Once the relevant user frame is taught on the new controller, the job will shift to its new location. If desired, the job can now be converted from a relative job back to a pulse job.

PART III: CONSIDERATIONS

- This process can only be accurate if all sources of calibration error are minimized.
- This process makes use of MTF (Master Tool Frame) to allow for coordinated motion. If coordinated motion is not needed, create a static user frame.
- Be aware that if a dynamic user frame is used, it is dependent on the robot/positioner calibration. If the positioner calibration is retaught after cell setup all points will move with it. If this is a concern, consider converting the dynamic user frame back into a static frame after job transportation.
- Be aware that any station points stored in a pulse job will be stored in pulses even when converted to relative job. In order to store station locations in pulse, you must convert the job to a relative job before recording station locations.

PART IV: MOTOSIM® VIDEO OF RELATIVE JOB TRANSFER ON 2-AXIS POSITIONER

A) MA2010 ROBOT WITH MH1600-500 TILT/ROTATE POSITIONER:
(motion was developed offline and tested on actual robot in YAI demo lab)
Video: MH1600-500_MA2010

- Robot to positioner calibration
- Creation of SREFP for user frame and MFRAME conversion based on MTF
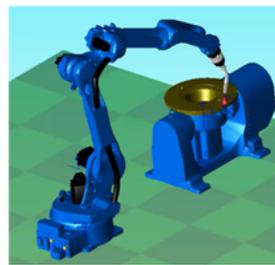- Conversion of R1S1-CYL to relative job based on user frame #2

B) MA2010 ROBOT WITH MOTOPOS D500 TILT/ROTATE POSITIONER:
Video: MotoPos D500_MA2010

- Robot to positioner calibration
- Creation of SREFP for user frame conversion based on MTF
- Import of R1S1-CYL-REL relative job and motion on new cell
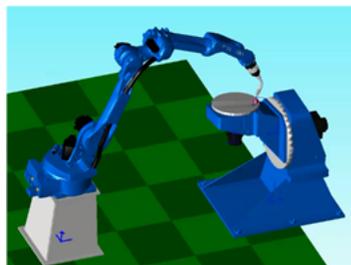
MA2010 with MH1600-500 TR

MA2010 with MotoPos D500