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# Robot Accuracy Enhancement Techniques Software Engineering Bulletin

**ROBOT MODEL SUPPORTED**  
All Six Axis Robots

**SOFTWARE REQUIRED**  
All V3.XX and Later Versions

**AUTHORIZED EXTERNAL DISTRIBUTION**  
➔ All Customers

**SOURCE OF INFORMATION:**  FANUC  FRA ➔ SEB - Software Engineering Bulletin

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## 1. OVERVIEW

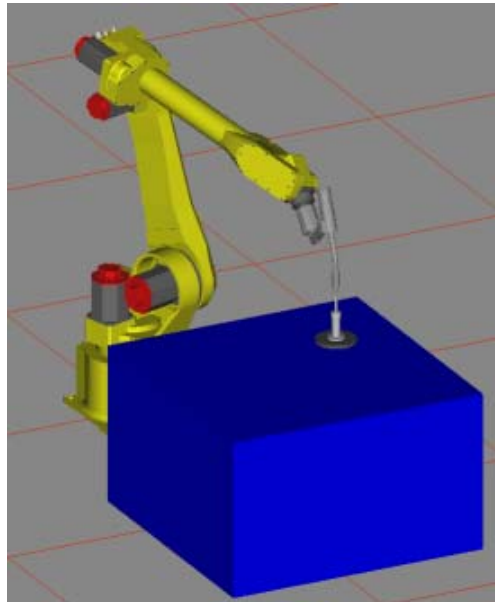
- Robot accuracy is generally dependent on the following items
  - How well the robot was mastered (mastering is also referred to as calibration)
    - J1 mastering error has no effect on accuracy, a taught UFRAME will compensate for this error
    - Similarly, J6 mastering error will be compensated by a taught UTOOL
  - How well the UTOOL was taught
  - How well the UFRAME (if any) was taught
- The taught UTOOL and UFRAMEs are dependent on good robot mastering
- For robot accuracy, the first priority should be to calibrate or at least verify the robot calibration for robot axes 2, 3, 4, and 5

**Information Contained in this Bulletin may be Revised or Updated. To obtain the latest version visit our website For Additional Questions or Technical Support Contact 1-800-47-ROBOT**

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### 2. SETUP

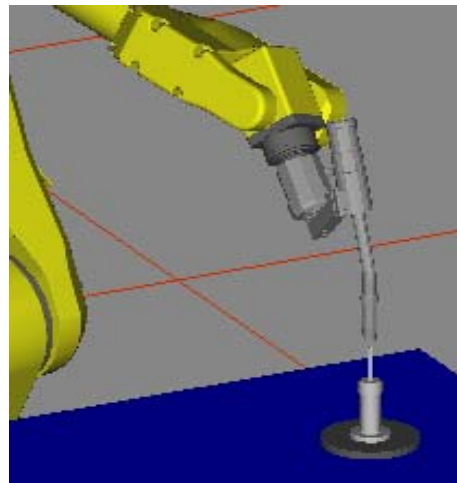
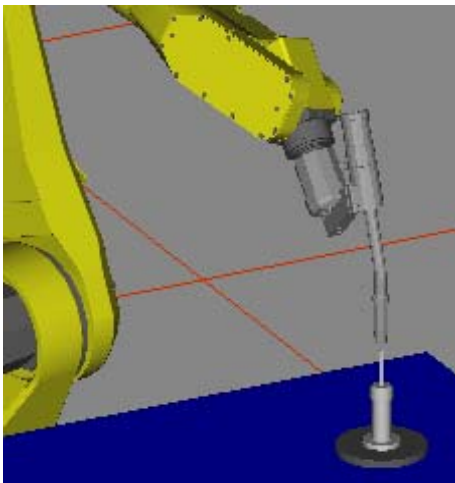
- Create initial TCP (not required, but simplifies J4 calibration)
- Choose a good starting location for reference pointer
  - Such that J1 can be moved 180 degrees from starting position (for J2/J3 calibration)
  - Such that J2 is between 0 and -20 degrees from starting position (for J2/J3 calibration)
  - Such that J3 is within +/- 30 degrees of zero
  - Such that when J4 is zero, you can rotate about World Z +/- 90 degree
- Set the reference pointer such that it is parallel to the World Z axis
- Calibrate J5 then J4
- On robots that can have Front/Back and Up/Down configuration, calibrate J2 and J3



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### 3. CALIBRATE J5

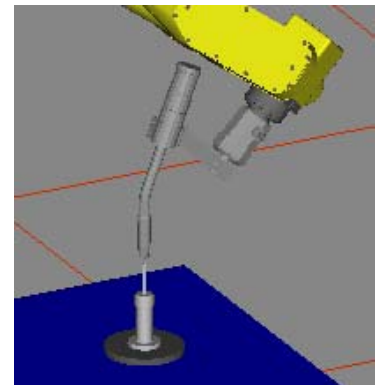
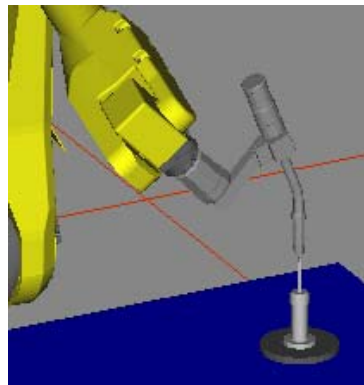
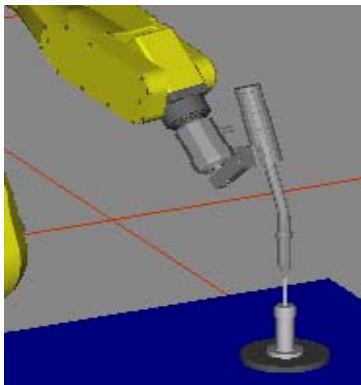
- Create TP program "J5"
- Teach P[1] such that the TCP touches the pointer with J4 and J6 between -180.. 180 degrees (turn numbers all zero)
- Record P[2] at the same location
- Change the configuration of P[2] from F to N or from N to F
- Move to P[2]
- In JOINT jog mode jog ONLY J5 so the TCP is as close as possible to the pointer
- Record P[3]
- Change the representation of P[2] and P[3] to JOINT
- Find the average value for J5 axis between P[2] and P[3]  
Value = (P[2].J5 + P[3].J5) / 2
- With the TCP still touching the pointer, go to [System] Master/Calibrate menu
- Select "4 SINGLE AXIS MASTER"
- Change "MSTR POS" for J5 to the value calculated above
- Change "(SEL)" value for J5 to 1 and press ENTER
- Press F4 "EXEC" softkey
- Wait for the "(SEL)" value of J5 to change from 1 to 0
- Press "[Prev]" hardkey
- Select "6 Calibrate"
- Select "[Edit]" hardkey
- TOUCHUP P[2] and P[1] to current location
- Change the representation of P[1] to Cartesian and change configuration from N to F or F to N
- Move to P[1] and verify the TCP touches the pointer in both configurations



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### 4. CALIBRATE J4

- Create TP program "J4"
- Jog the robot such that J4 joint angle is zero. J3 should be within +/- 30 degrees of zero. The method is more accurate when J3 is closer to zero.
- Rotate J5 & J6 such that the TCP is approximately in the plane formed by J4 and J6 axes and as far away from the wrist as possible while staying away from a singularity. In JOINT jog mode, Jog J1, J2, and J3 so that the TCP touches the pointer and record P[1]
- In WORLD jog mode, rotate about Z axis approximately 90 degrees
- Jogging ONLY WORLD X-Y and JOINT J4, jog so the TCP touches the pointer and Record P[2], and make a note of J2 and J3 angles
- In WORLD jog mode, rotate about Z axis approximately -180 degrees until J2 and J3 angles match that of P[2]
- Jogging ONLY WORLD X-Y and JOINT J4, jog so the TCP touches the pointer and Record P[3]
- Change the representation of P[2] and P[3] to joint
- Find the correction value for J4 by the following formula  
$$\text{Value} = (P[3].J4 - P[2].J4) / 2.0$$
- With the TCP still touching the pointer, go to [System] Master/Calibrate menu
- Select "4 SINGLE AXIS MASTER"
- Change "MSTR POS" for J4 to the value calculated above
- Change "(SEL)" value for J4 to 1 and press ENTER
- Press F4 "EXEC" softkey
- Wait for the "(SEL)" value of J4 to change from 1 to 0
- Press "[Prev]" hardkey
- Select "6 Calibrate"
- In WORLD jog mode, rotate about Z axis by 180 degrees
- Verify that jogging ONLY World X-Y the TCP can touch the pointer and repeat the above steps if necessary



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### 5. CALIBRATE J2 & J3 (ONLY ON SOME ROBOTS)

- Create TP program "J23"
- Teach P[1] such that the TCP touches the pointer
- Record P[2] at the same location
- Change the configuration of P[2] from U to D and T to B
- Move to P[2]
- In JOINT jog mode jog ONLY J2 and J3 so the TCP is as close as possible to the pointer
- Record P[3]
- Change the representation of P[2] and P[3] to JOINT
- Find the average value for J2 and J3 axes between P[2] and P[3]  
$$\text{ValueJ2} = (\text{P}[2].\text{J2} + \text{P}[3].\text{J2}) / 2$$
$$\text{ValueJ3} = (\text{P}[2].\text{J3} + \text{P}[3].\text{J3}) / 2$$
- With the TCP still touching the pointer, go to [System] Master/Calibrate menu
- Select "4 SINGLE AXIS MASTER"
- Change "MSTR POS" for J2 and J3 to the values calculated above
- Change "(SEL)" value for J2 and J3 to 1 and press ENTER
- Press F4 "EXEC" softkey
- Wait for the "(SEL)" values of J2 and J3 to change from 1 to 0
- Press "[Prev]" hardkey
- Select "6 Calibrate"
- Select "[Edit]" hardkey
- TOUCHUP P[2] and P[1] to current location
- Change the representation of P[1] to Cartesian and change configuration from D to U and B to T
- Move to P[1] and verify the TCP touches the pointer in both configurations

