MOTOMAN-UP400RD Options Instructions for Zeroing Function Supplement: UP400RD / UP400RD II Alternate Zeroing Procedure

Rev. 2, Released 2017-05-08

1 Summary

1.1 Purpose of Document

Due to system design, some installed UP400RD (DX100) and UP400RD II (DX200) robots cannot reach factory zero posture on all axes simultaneously (Figure 1). However, the zeroing function can still be used on these manipulators per standard zeroing procedures with alternate postures, or the Alternate Zeroing Procedure detailed in this document. This document is intended to be supplementary to "MOTOMAN-UP400RD OPTIONS INSTRUCTIONS FOR ZEROING FUNCTION", YAI part number: 180163-1CD.

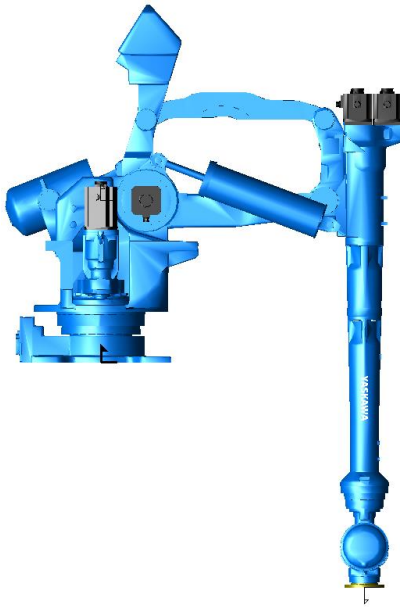


Figure 1: UP400RD / UP400RD II Factory Zeroing Posture

1.2 Target Machines

North American Honda-spec shelf-mount 400 kg payload manipulators, identified by EGA and indicated by tags on the robot and on the controller:

- DX100: UP400RD: YR-UP400RD-B1E (high inertia, D-NET, zeroing)
- DX200: UP400RD II: YR-UP400RD-J10 (high inertia, [zeroing])

1.3 Target Audience

Robot recovery/maintenance technician.

1.4 Precautions

- Refer to standard "MOTOMAN-UP400RD OPTIONS INSTRUCTIONS FOR ZEROING FUNCTION", 180163-1CD, to ensure applicable safety precautions are met. Failure to do so may result in unintentional or unexpected manipulator motion, or operation error, which could result in serious injury or death.
- **Do not resume automatic playback before verifying jobs in teach mode, after zeroing recovery is complete.**
- To ensure best zeroing accuracy, the load on the manipulator axis being zeroed should be as close to that during factory zeroing, or to that of the zeroing position the production jobs were taught to.
- During zeroing, the manipulator will move minutely around the zero position. Ensure sufficient clearance around robot and avoid pinch hazard around active axis.

1.5 Supplement Information

- A supplementary Excel spreadsheet to aid your calculations is available through your plant Maintenance Coordinator and on the EGA robot data directory, \\Egafiler01\Robot_Data\Data\01.Robot System Manuals\02.Motoman\09.Alternate zero for UP400RD: "UP400RD_UP400RD II_Alternate Zeroing_Calc Sheet_Rev-1.xlsx"

Contents

2 Zeroing Procedure by Axis

2.1 S-axis

2.1.1 S-axis Standard Zeroing Procedure and Alternate Postures

- Simultaneous zero positioning of other axes **(L, U, R, B, T) is not required** (see Figure 2)
- Refer to 180163-1CD, section "1.2.2.3 Zeroing Procedure for S-Axis"

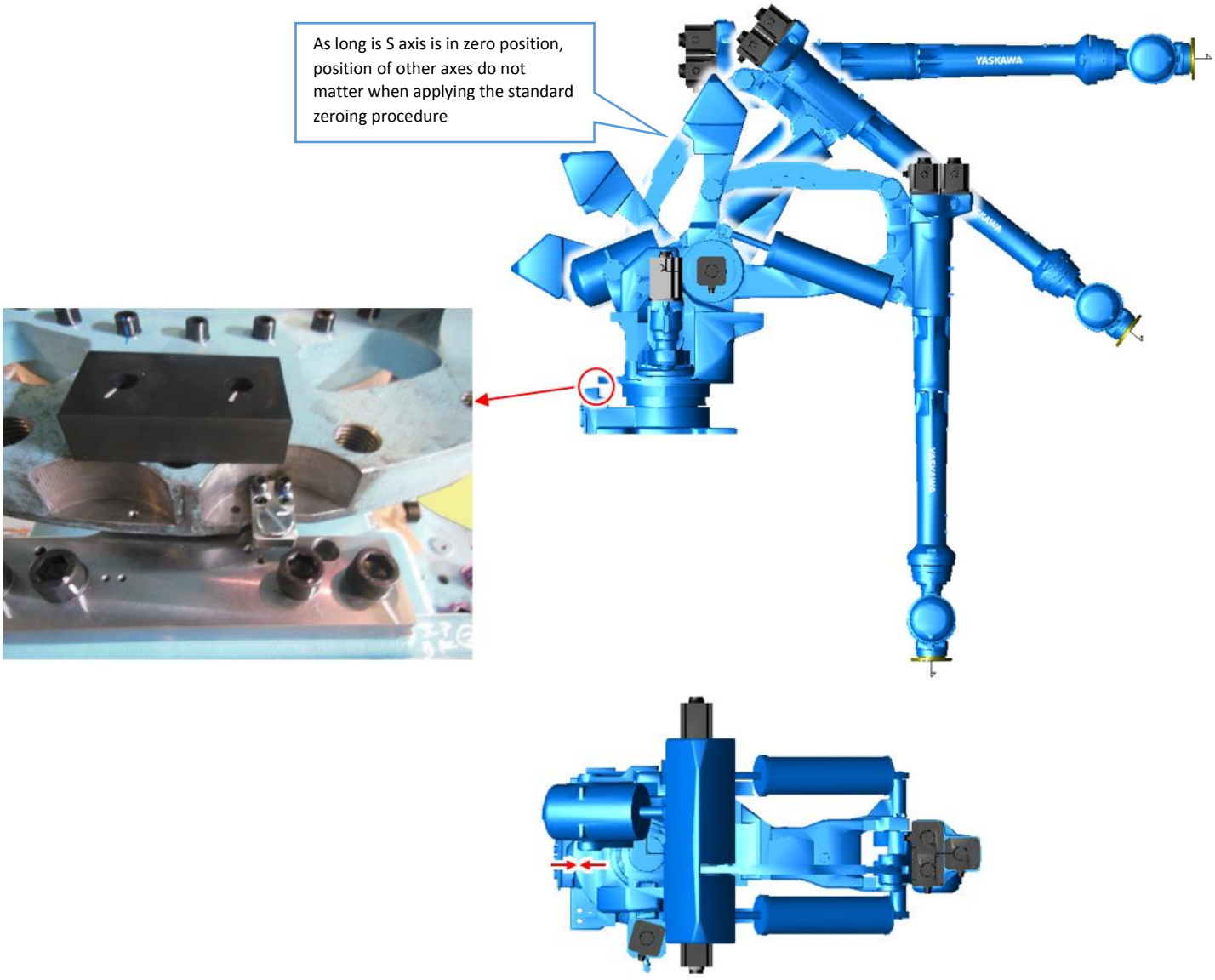


Figure 2: S-axis Zeroing Bracket Location and Alternate Zeroing Postures

2.2 L-axis

2.2.1 L-axis Standard Zeroing Procedure and Alternate Postures

- Simultaneous zero positioning of other axes **(S, U, R, B, T) is not required** (see Figure 3)
- Load variation on axis due to alternate posture and tool load may affect zeroing accuracy
- Refer to 180163-1CD, section "1.2.2.4 Zeroing Procedure for L-Axis"

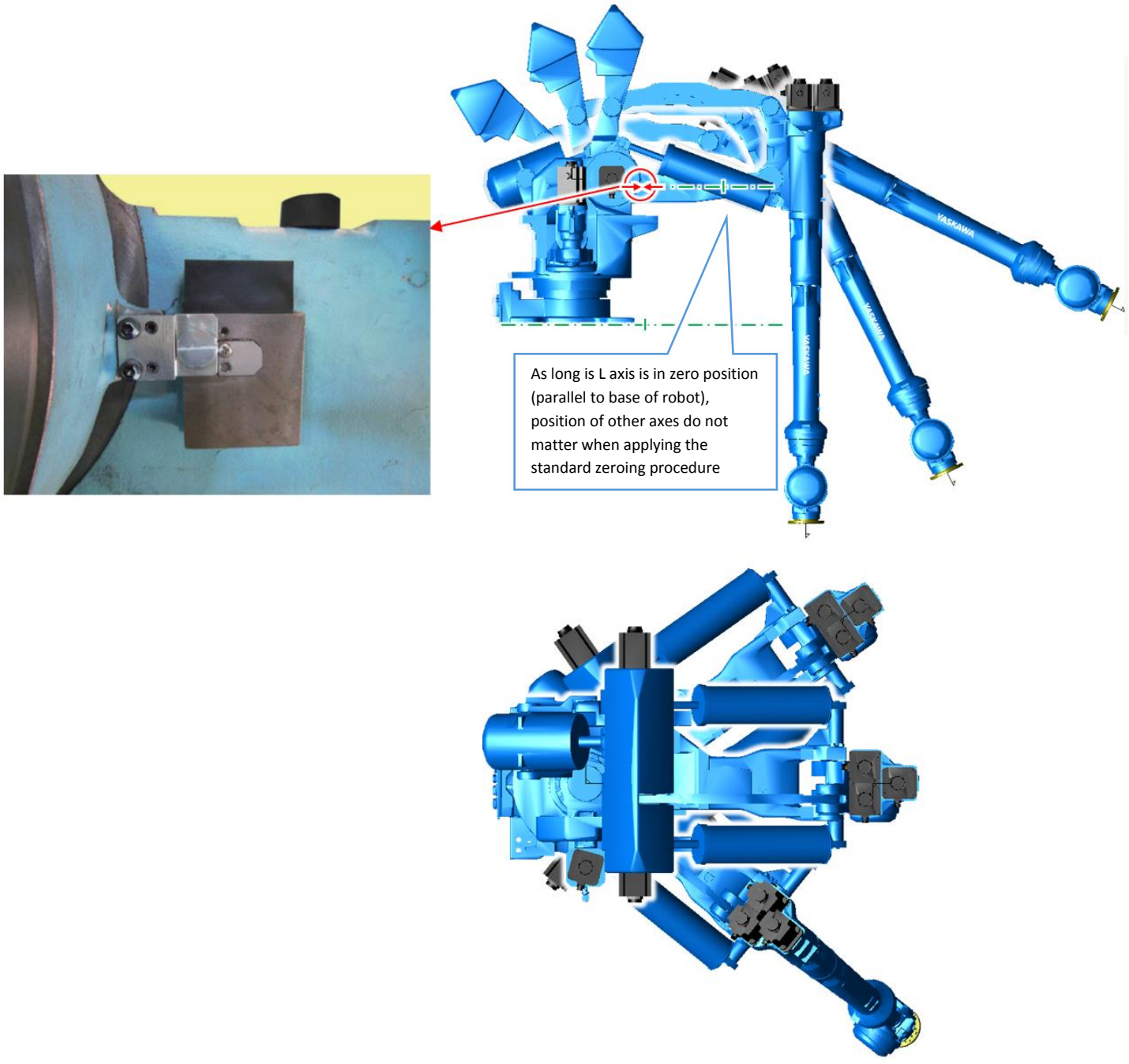


Figure 3: L-axis Zeroing Bracket Location and Alternate Zeroing Postures

2.3 U-axis

2.3.1 U-axis Standard Zeroing Procedure and Zero-L-axis Alternate Postures

- Simultaneous zero positioning of **L axis is required** (Figure 4)
- Simultaneous zero positioning of all other axes **(S, R, B, T) is not required**
- Load variation on axis due to alternate posture and tool load may affect zeroing accuracy
- Refer to 180163-1CD, section "1.2.2.5 Zeroing Procedure for U-Axis"

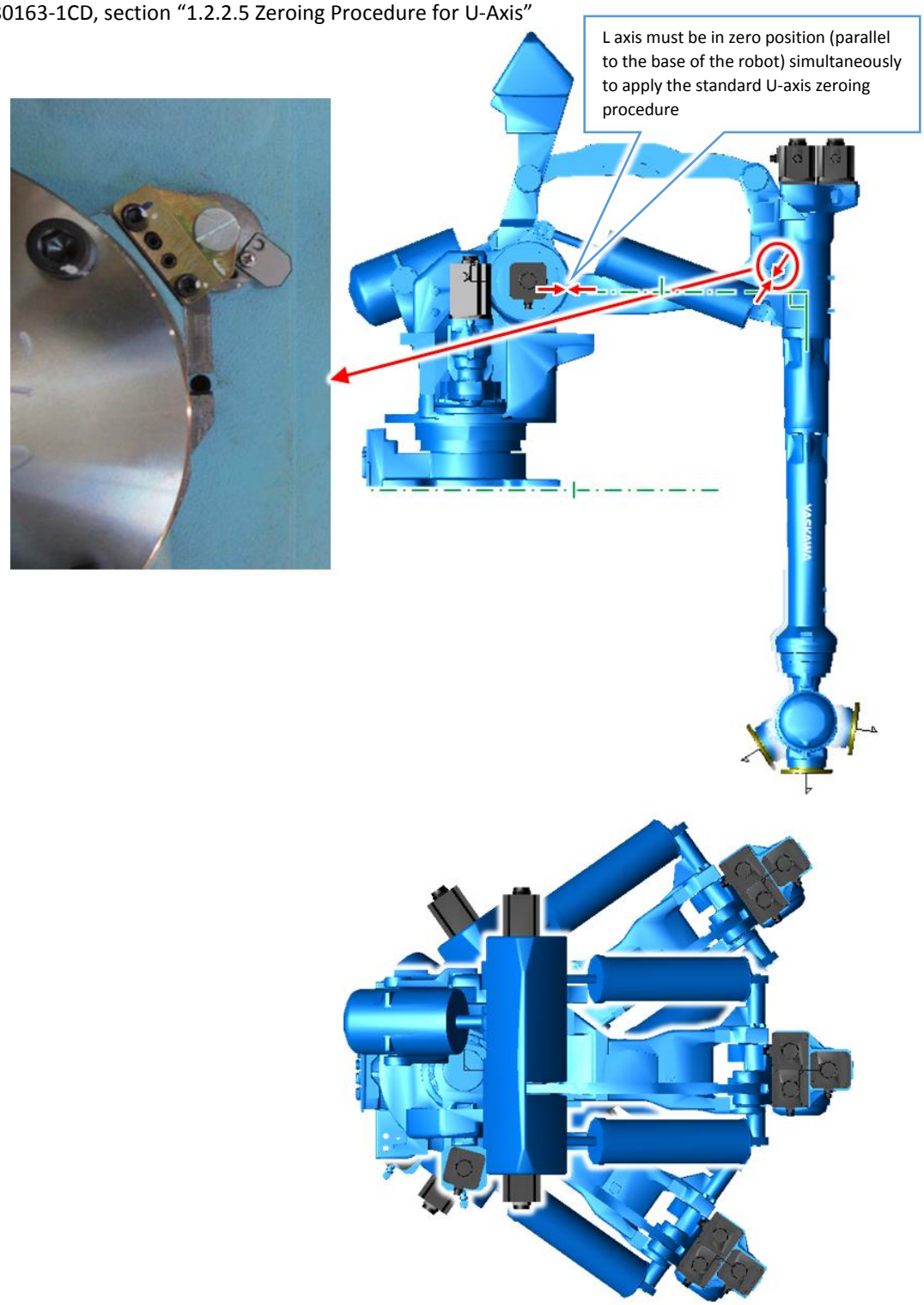


Figure 4: U-axis Zeroing Bracket Location and Zero-L-Axis Alternate Zeroing Postures

2.3.2 U-axis Alternate Zeroing Procedure for Non-Zero-L-Axis Alternate Postures (unabridged)

- Simultaneous zero positioning of **L axis is not required** (see Figure 5)
- Simultaneous zero positioning of all other axes **(S, R, B, T) is not required**
- Load variation on axis due to alternate posture and tool load may affect zeroing accuracy
- Refer to following procedure:

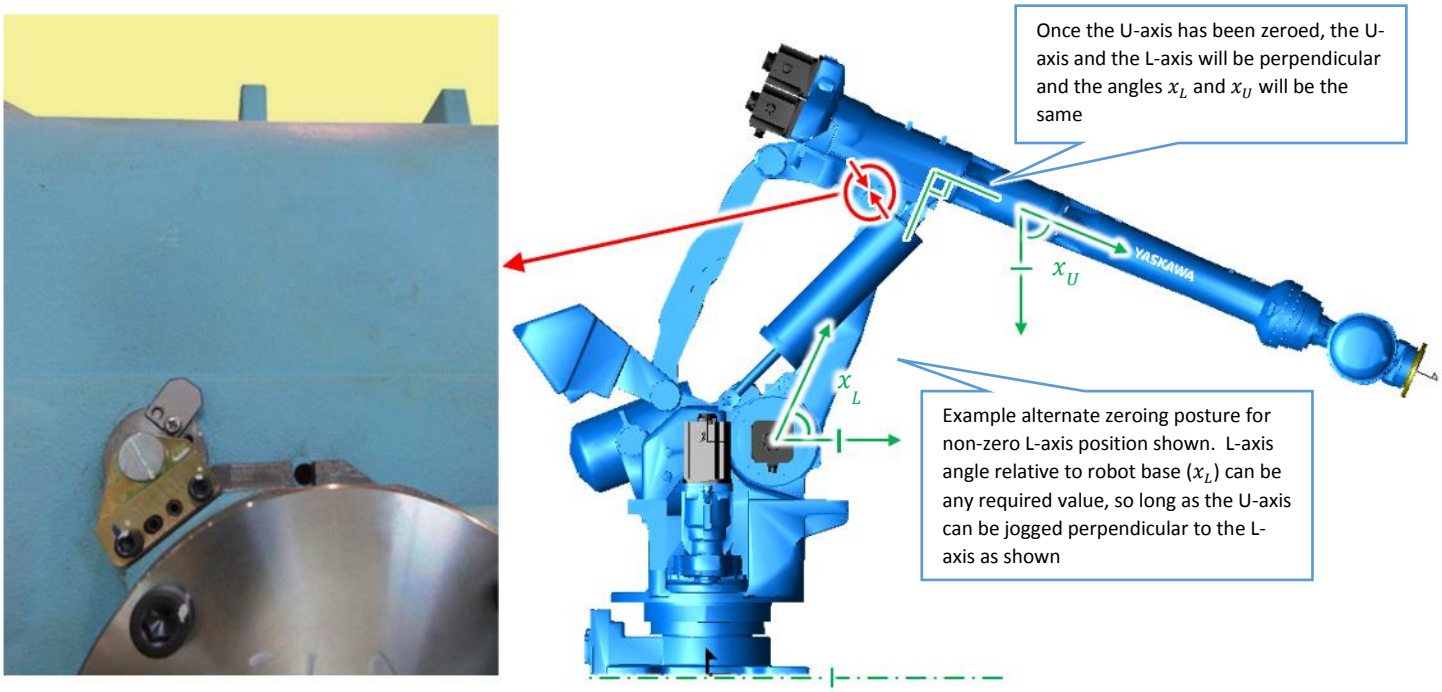
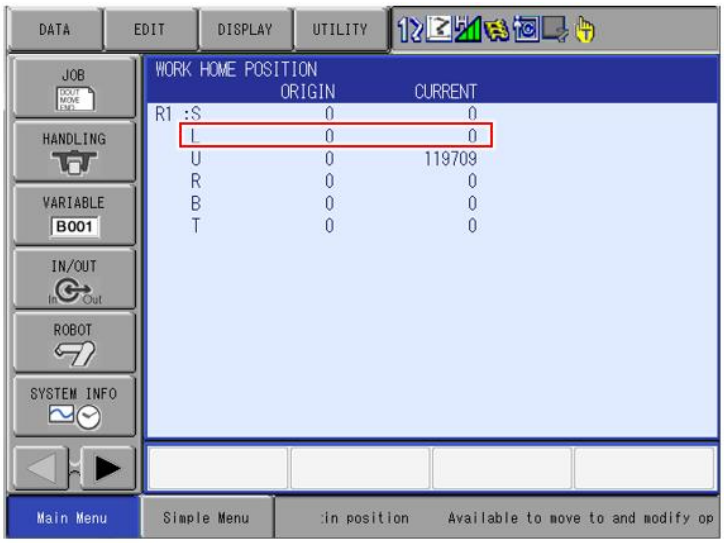
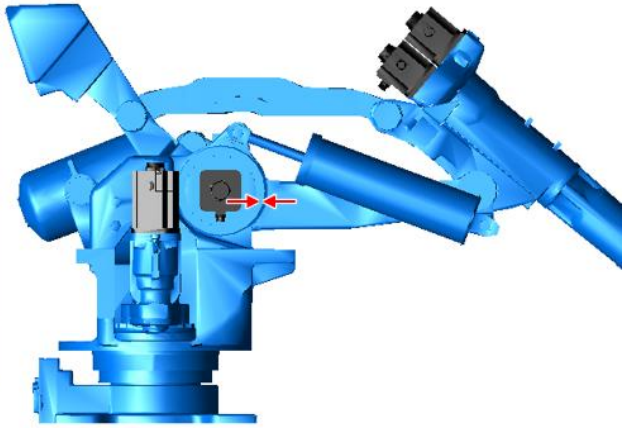


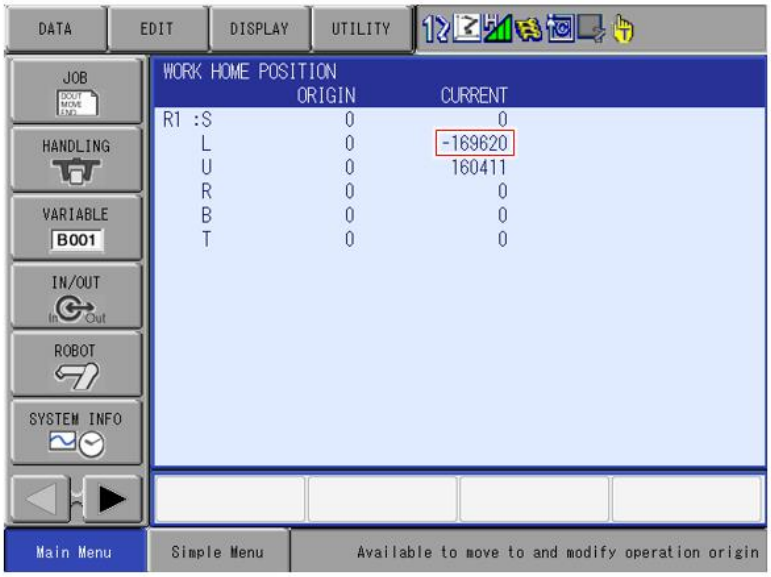
Figure 5: U-axis Zeroing Bracket Location and Non-Zero-L-Axis Alternate Zeroing Posture Example

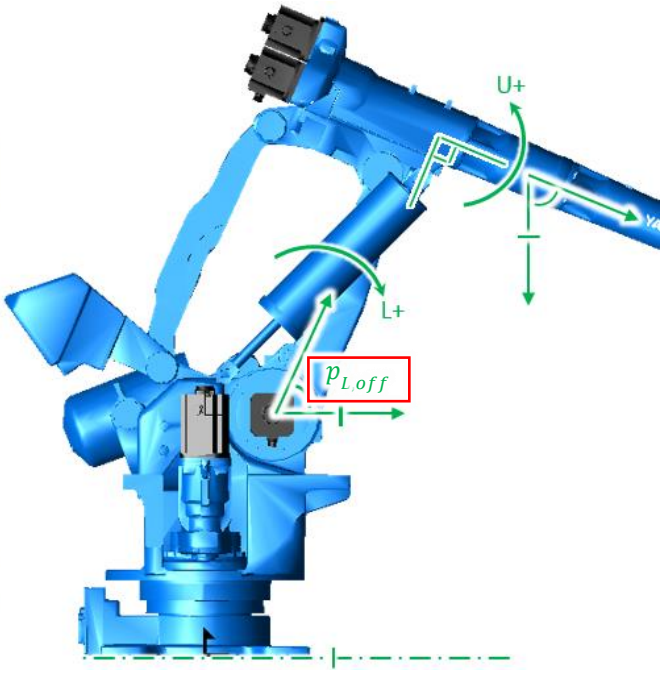
1. Ensure the L-axis is zeroed properly (parallel to the robot base) first per section 2.2.1 L-axis Standard Zeroing Procedure
    a. Verify by checking the L-axis sight marks are lined up when L-axis origin and current pulse counts are zero
    b. Hint: select [Main Menu] -> [Robot] -> [Work Home Position]



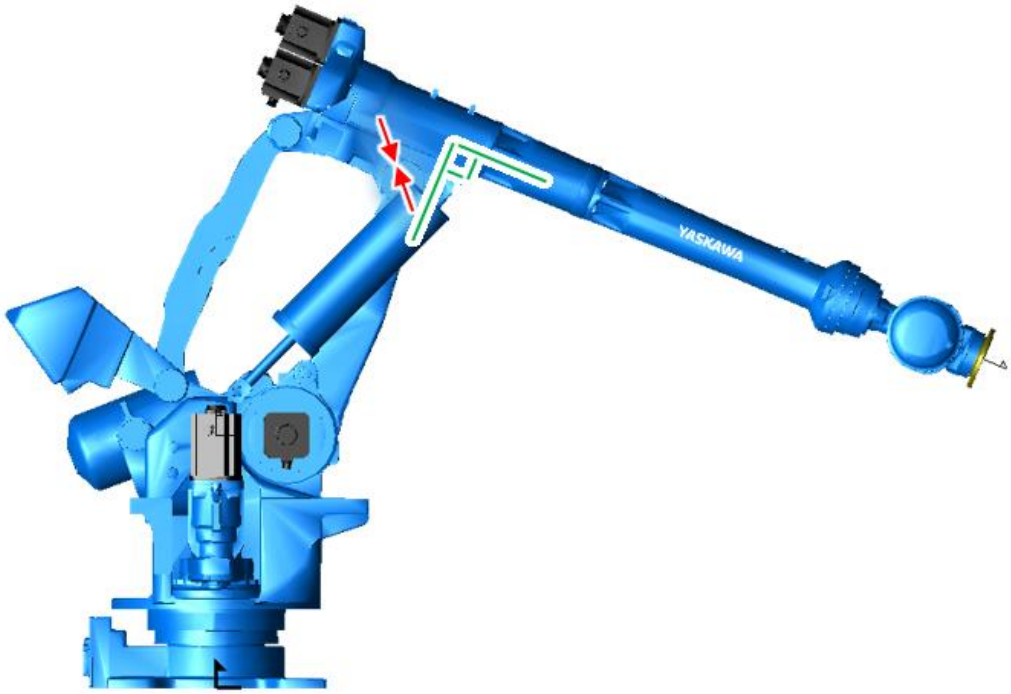


2. Jog the L-axis to clearance position
   a. **Do not move the L-axis from this position until zeroing is complete**
   b. Note this L-axis clearance offset pulse count, $p_{L,off}$
      i. In this example, L-axis clearance offset pulse count, $p_{L,off} = -169620$

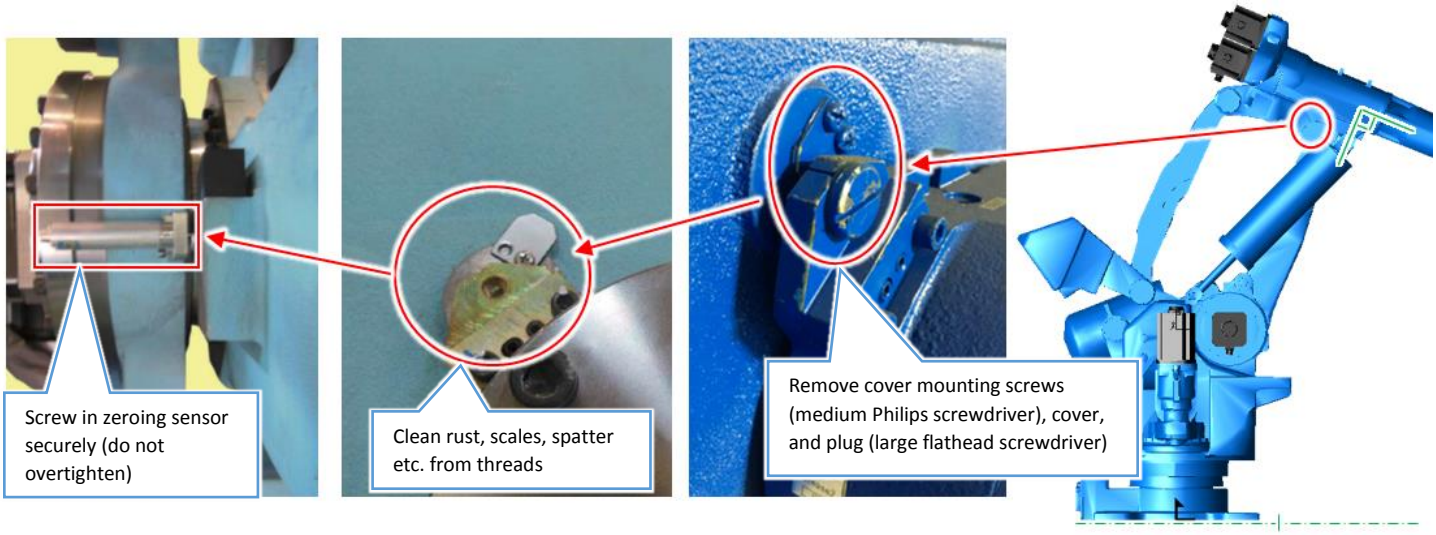




3. Jog the U-axis to zeroing position by lining up the sight marks, so that the U axis and L axes are perpendicular as shown

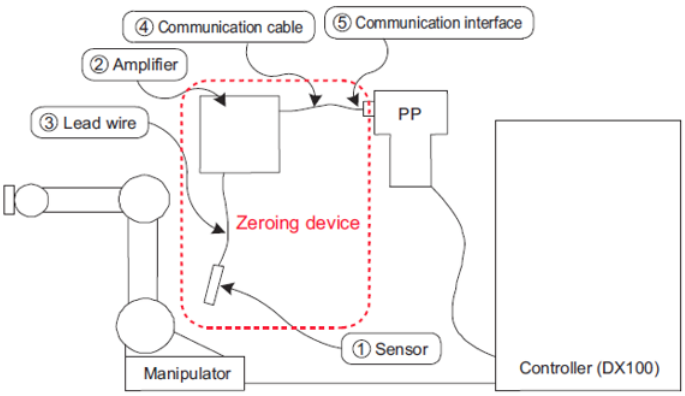


4. Install the zeroing sensor on U-axis zeroing bracket
    a. **Ensure the U-axis sight marks are lined up as precisely as possible by eye to avoid bending the zeroing sensor pin when auto-zeroing**



5. Connect the zeroing kit
    a. Connect sensor to signal amplifier box
    b. Connect communication cable and interface from amplifier box to CF card slot or USB connection (depends on interface of kit in possession) on the programming pendant (PP)
    c. Power ON the signal amplifier box (avoid having the box powered ON for prolonged periods of time before zeroing)
    d. Note: use of USB interface recommended for DX100 & DX200 for improved stability
    e. Kit connection schematic per 180163-1CD:

CF Card Interface Kit



USB Interface Kit

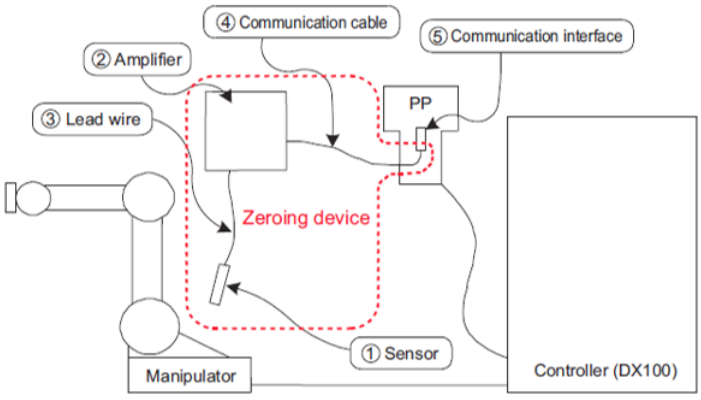


Table 1-1: Components for Zeroing Device Using CF Card Slot

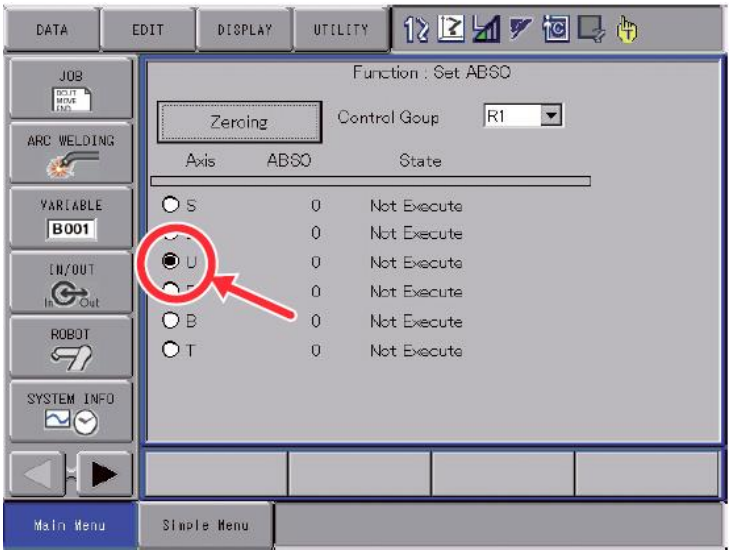
Component	Type	Qty.	Manufacturer
① Sensor	HW0381863-A	1	YASKAWA Electric Corporation
② Amplifier	HW0381864-A	1	YASKAWA Electric Corporation
③ Lead wire	HW0470652-A	1	YASKAWA Electric Corporation
④ Communication cable	C232N-915	1	YASKAWA Electric Corporation
⑤ Communication interface	REX-CF60 ∗	1	YASKAWA Electric Corporation

∗ The communication interface REX-CF60 has been discontinued.

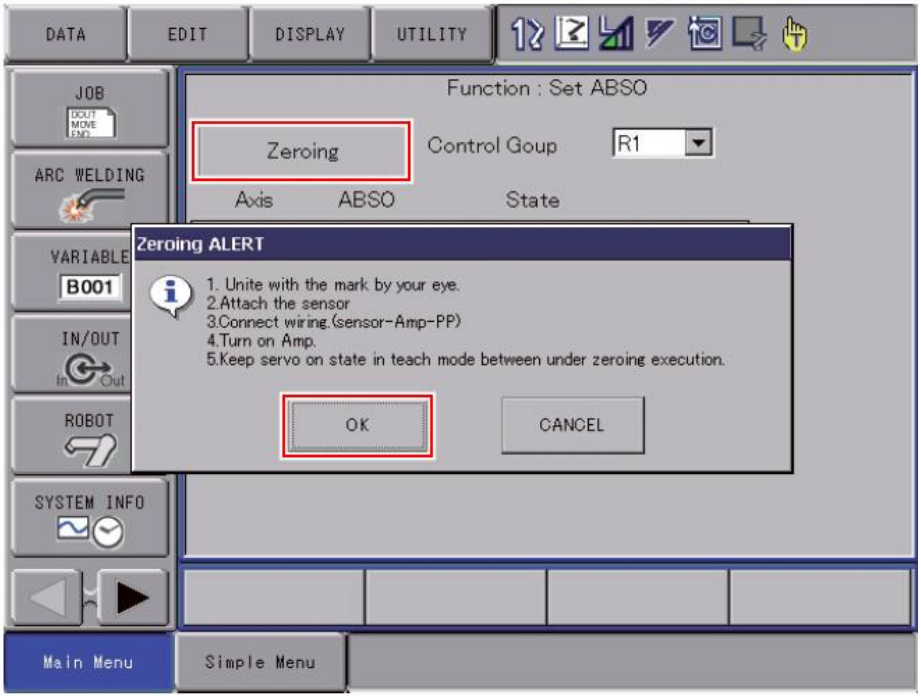
Table 1-2: Components for Zeroing Device Using USB Slot

Component	Type	Qty.	Manufacturer
① Sensor	HW0381863-A	1	YASKAWA Electric Corporation
② Amplifier	HW0381864-A	1	YASKAWA Electric Corporation
③ Lead wire	HW0470652-A	1	YASKAWA Electric Corporation
④ Communication cable	C232N-915	1	YASKAWA Electric Corporation
⑤ Communication interface	REX-USB60F	1	YASKAWA Electric Corporation

6. Run auto-zeroing of U-axis
    a. **Clear safe distance from robot**, as the U-axis will move slightly back and forth around the zero position to find it
    b. Navigate to [Main Menu] -> [Robot] -> [Zeroing]
    c. Select [U]-axis radio button



    d. Turn ON servo power by pressing the [SERVO ON READY] button, and holding in the enabling switch on the PP
    e. Press [Zeroing] button the zeroing function menu
    f. A warning message will appear. Comply to the message and press [OK]



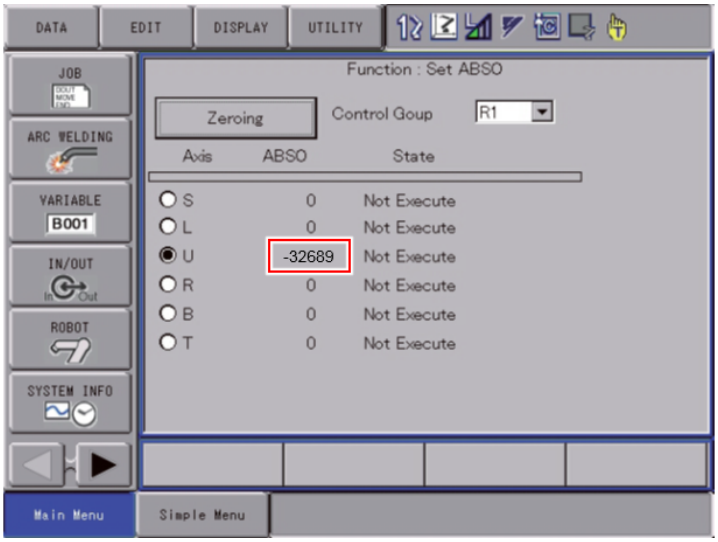
    g. Robot will commence auto-zeroing. Keep servo ON the whole time. If servo power is interrupted, auto-zeroing will have to be re-initiated.
    h. Once zeroing is complete, a confirmation message appears on the PP asking to write the resulting absolute data to the robot.
    i. Select yes to write the resulting U-axis offset absolute data to the robot
        i. If this confirmation is declined, the auto-zeroing data will be lost and auto-zeroing will have to be re-executed

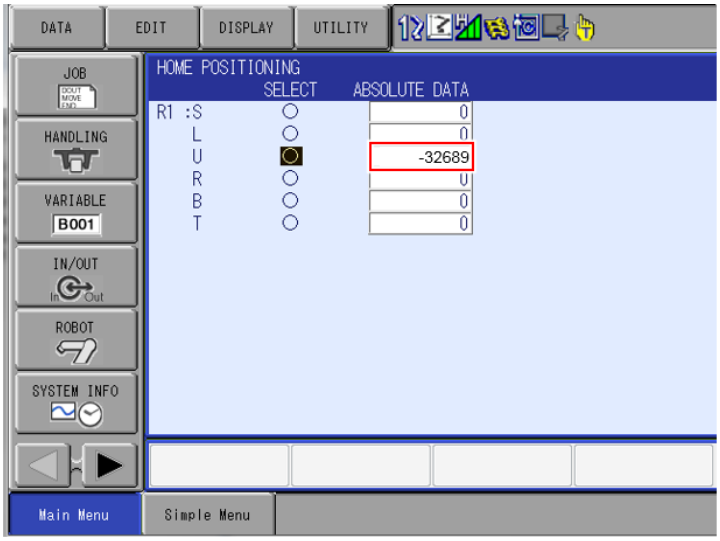
ii. Completion of this step ensures perpendicularity between the U-axis and the L-axis

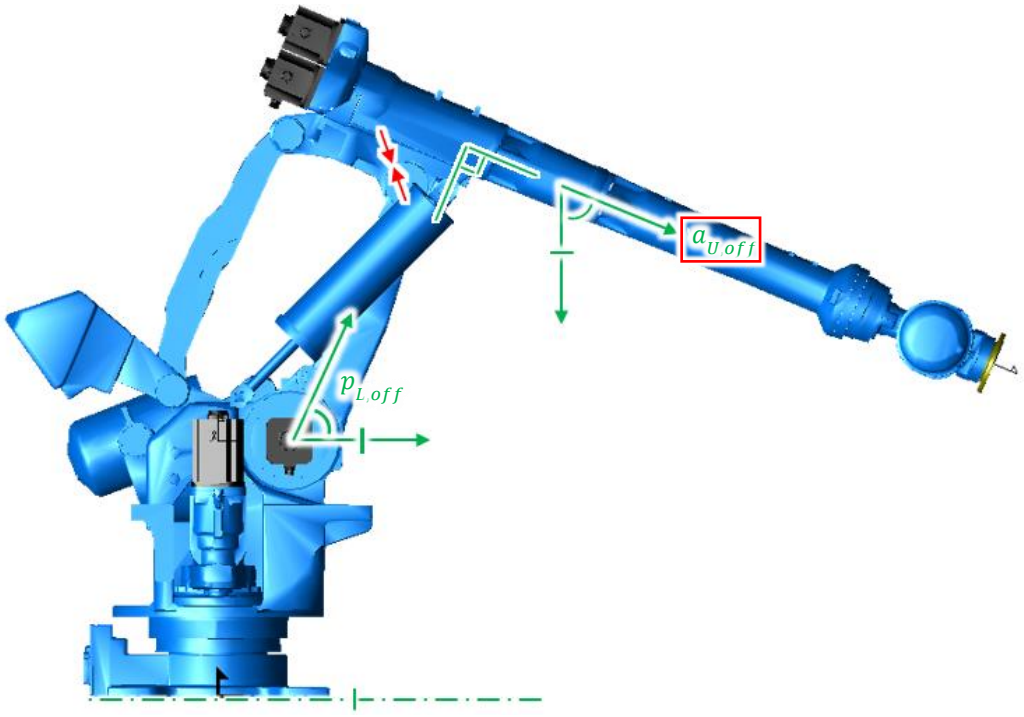
j. Note the resulting U-axis offset absolute data, $a_{U,off}$

i. In this example, the resulting U-axis offset absolute data, $\boldsymbol{a_{U\,off} = -32689}$

1. Hint: the offset U-axis offset absolute data was written to the robot's absolute data in the previous step
2. Verify in [Main Menu] -> [Robot] -> [Home Position] -> [U-axis Absolute Data]







7. Servo power OFF by releasing the PP enabling switch
   a. **DO NOT MOVE THE ROBOT AT THIS STEP –THE CURRENT WRITTEN ABOLUTE DATA OF THE U AXIS IS OFFSET BY THE L AXIS CLEARANCE ANGLE PULSE COUNT**
8. Power OFF the zeroing sensor signal amplifier box, and remove the zeroing sensor and cabling from the manipulator and the PP

9. Calculate the U-axis offset pulse count, $p_{U,off}$, using the L-axis clearance offset pulse count, $p_{L,off}$, obtained in step 2.b above and the following equation:

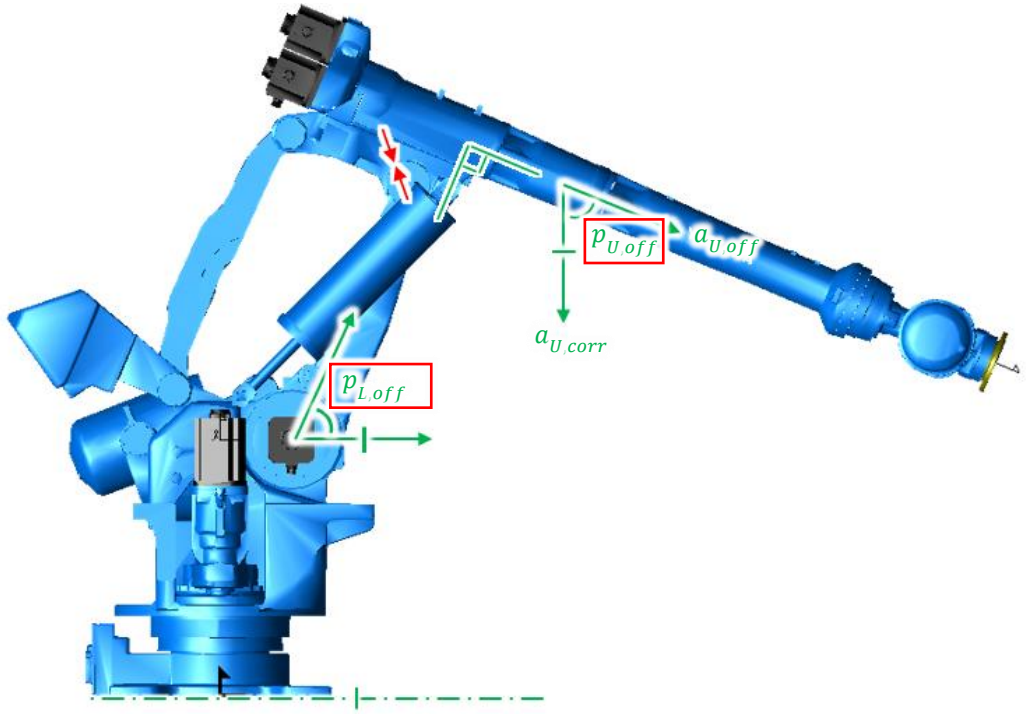
$$[\boldsymbol{L\ axis\ clearance\ offset\ pulse\ count}] \cdot (-0.86607696) = [\boldsymbol{U\ axis\ abso\ data\ offset\ pulse\ count}]$$

Do not round correction factor any further than shown.

It is preferable to use correct whole numbers gear ratio fraction as shown:

$$[\boldsymbol{L\ axis\ clearance\ offset\ pulse\ count}] \cdot (-\mathbf{0.86607696}) = [\boldsymbol{U\ axis\ abso\ data\ offset\ pulse\ count}]$$

$$p_{L,off} \cdot \left(-\frac{\mathbf{20,953}}{\mathbf{24,193}}\right) = p_{U,off}$$



a. In this example, the L-axis clearance offset pulse count, $p_{L,off} = -169620$, obtained in step 2.b.i. Therefore:

$$= -169260 * -0.86607696$$

Do not round correction factor any further than shown

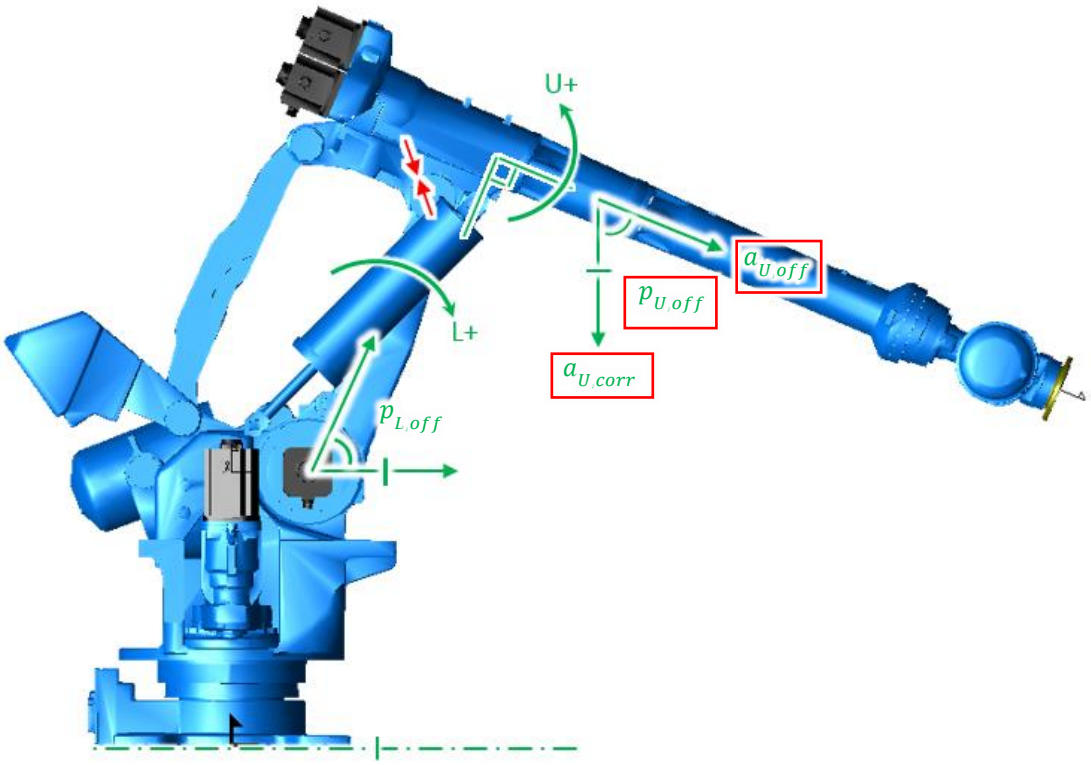
$$= 146903.97 \equiv \mathbf{146904} = [\boldsymbol{U\ axis\ offset\ pulse\ count}] = \boldsymbol{p_{U,off}}$$

Round to the nearest pulse count

10. Add the resulting calculated U-axis offset pulse count, $p_{U,off}$, to the U-axis offset absolute data, $a_{U,off}$, obtained through auto-zeroing in step 6.j.i above, to obtain the U-axis corrected absolute data, $a_{U,corr}$, as shown by the following equation:

$$[\textbf{U axis offset absolute data}] + [\textbf{U axis offset pulse count}] = [\textbf{U axis corrected absolute data}]$$

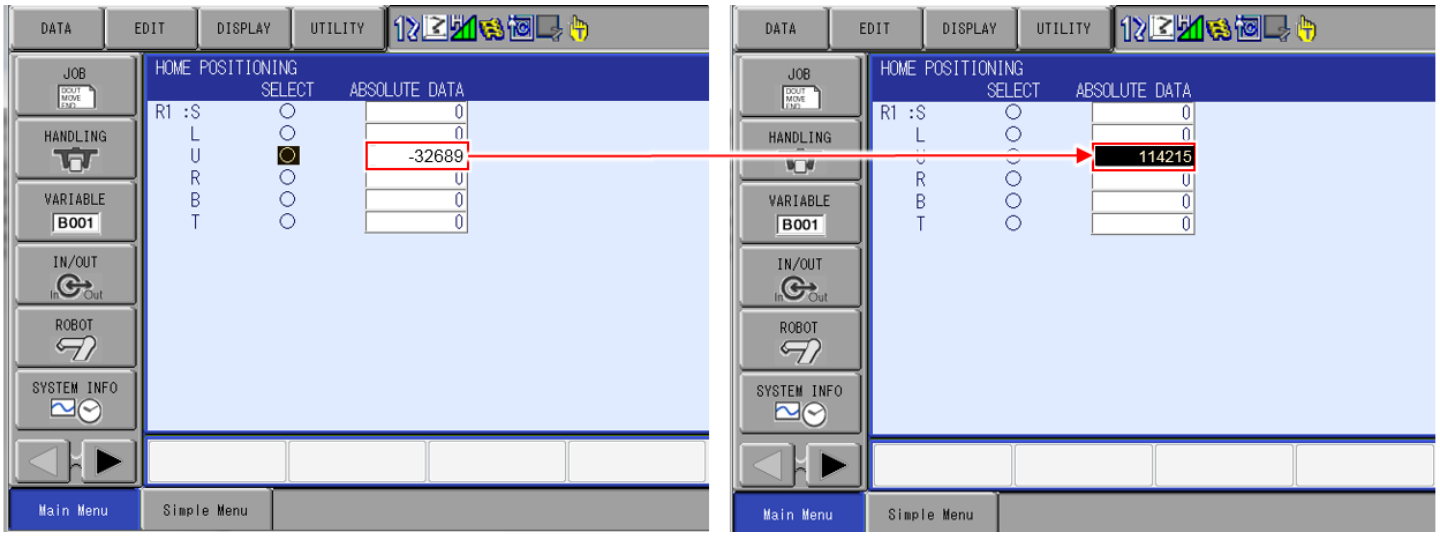
$$\boldsymbol{a_{U,off} + p_{U,off} = a_{U,corr}}$$



a. In this example:
   i. The U-axis offset pulse count, $\boldsymbol{p_{U,off}} = 146904$, from step 9.a
   ii. The U-axis offset absolute data, $\boldsymbol{a_{U,off}} = -32689$, from step 6.j.i
   Therefore:

$$146904 + (-32689) = \mathbf{114215} = \boldsymbol{a_{U,corr}} = [\textbf{U axis corrected absolute data}]$$

11. Type the resulting U axis corrected absolute data into the robot's U-axis absolute data
    a. Navigate to [Main Menu] -> [Robot] -> [Home Position]
    b. Highlight the [U-axis Absolute Data] text box, press [Select] button on the PP, type in the U-axis corrected absolute data, and press [Enter] button on the PP
    c. In this example
        i. The U-axis corrected absolute data, $\boldsymbol{a_{U,corr} = 114215,}$ from step 10.a



12. Perform Functional Safety Board Flash Reset (and Machine Safety Board Flash Reset), as prompted by the PP
    a. Hold [Main Menu] button on PP while performing CPU reset to enter maintenance mode
    b. Enter Safety Mode (password: 5555555555555555)
    c. Navigate to [Main Menu] -> [File] -> [Initialize] -> [Functional Safety Board Flash Reset]
    d. Navigate to [Main Menu] -> [File] -> [Initialize] -> [Machine Safety Board Flash Reset]
13. Verify jobs in teach mode to ensure U-axis absolute data has been set correctly

2.3.3 U-axis Alternate Zeroing Procedure for Non-Zero-L-Axis Postures (abridged)

1. Ensure L-axis is zeroed
2. Jog L-axis to clearance position and jog U-axis to zero position (line up sight marks)
    a. Note L-axis pulse count relative to origin, L-axis clearance offset pulse count, $p_{L,off}$
3. Perform auto-zeroing on U-axis
    a. Note this resulting U-axis offset absolute data, $a_{U,off}$
4. Calculate U-axis offset pulse count, $p_{U,off}$, corresponding to $p_{L,off}$

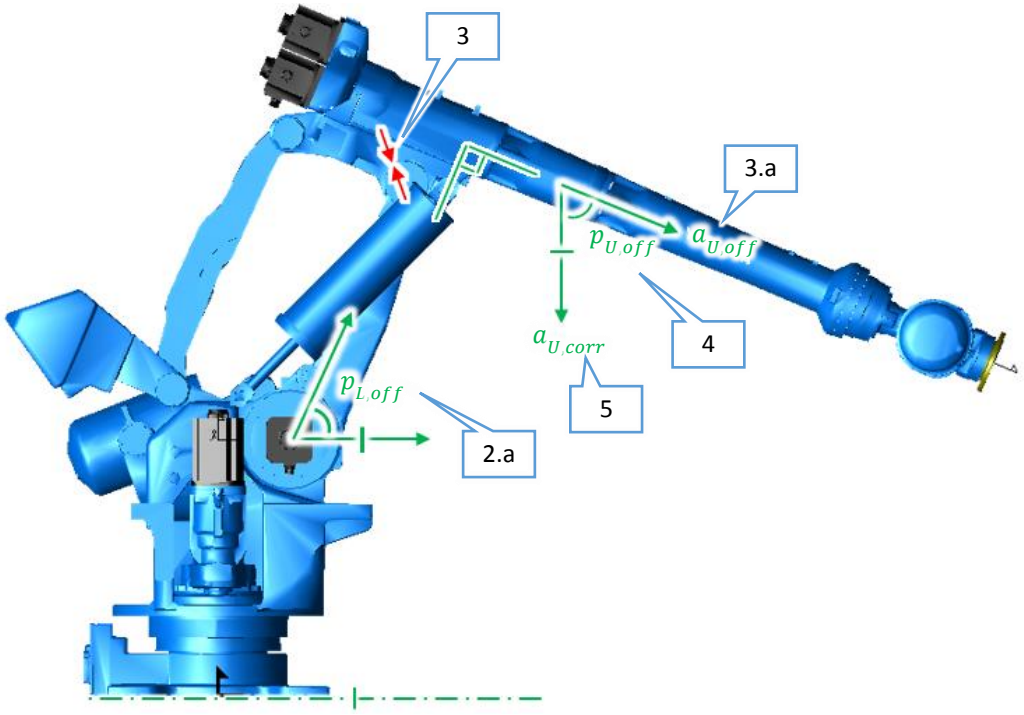
$$\boldsymbol{p_{U,off} = \left(-\frac{20,953}{24,193}\right) \cdot p_{L,off}}$$

$$\boldsymbol{p_{U,off} = (-0.86607696) \cdot p_{L,off}}$$

5. Calculate U-axis corrected absolute data, $a_{U,corr}$

$$\boldsymbol{a_{U,corr} =, a_{U,off} + p_{U,off}}$$

6. Rewrite $a_{U,off}$ with resulting $a_{U,corr}$ into U-axis absolute data manually
7. Verify correct zeroing by running jobs in teach mode



2.4 R, B, T axes

2.4.1 R, B, T axes Standard Zeroing Procedure and Alternate Zeroing Positions

- Simultaneous zero positioning of **R, B, T axes is required**
- Simultaneous zero positioning of all other axes **(S, L, U) is not required**
- Load variation on axes due to alternate posture and tool load may affect zeroing accuracy
- Refer to 180163-1CD, section "1.2.2.6 Zeroing Procedure for R-Axis"
- Refer to 180163-1CD, section "1.2.2.7 Zeroing Procedure for B-Axis"
- Refer to 180163-1CD, section "1.2.2.8 Zeroing Procedure for T-Axis"

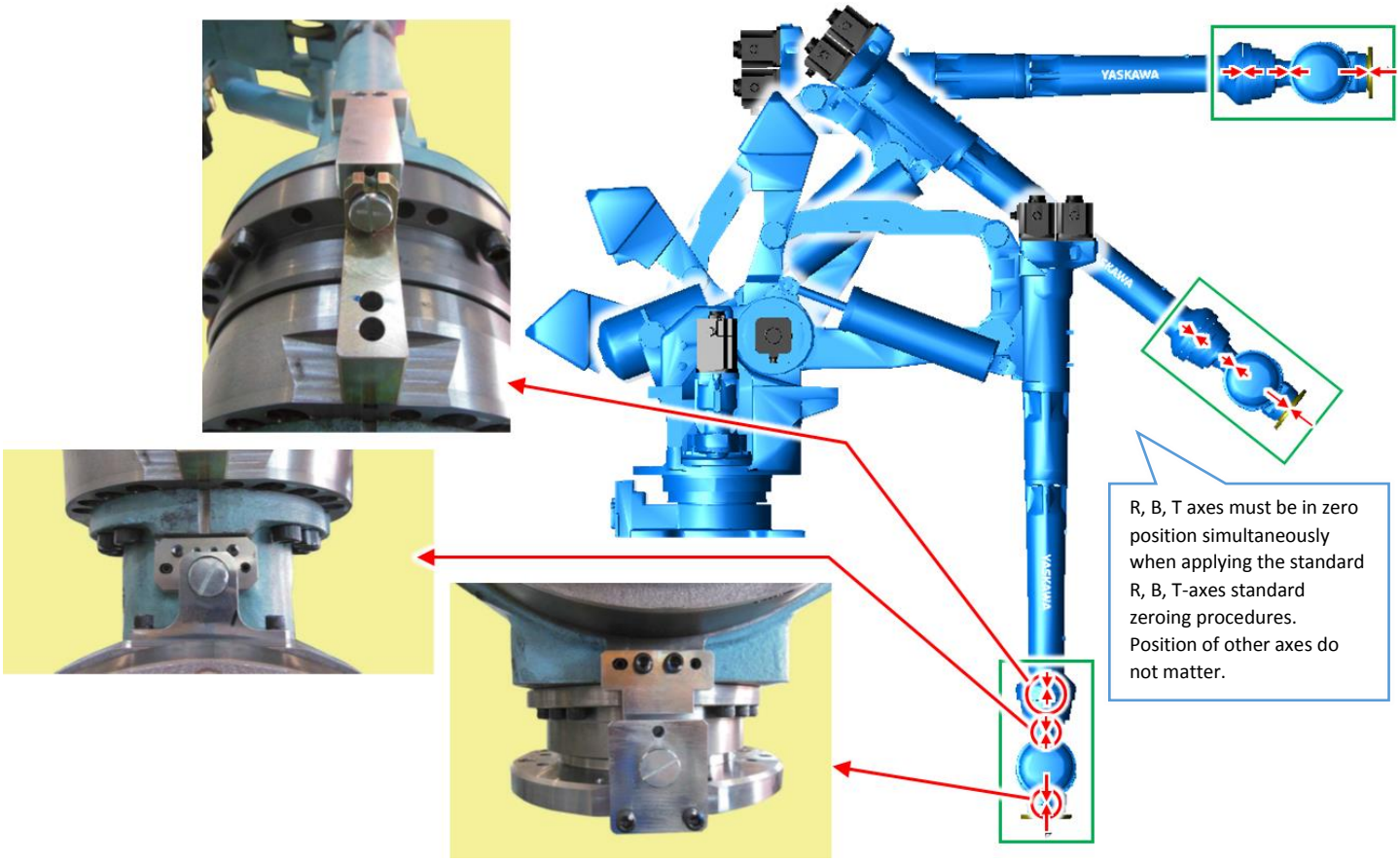
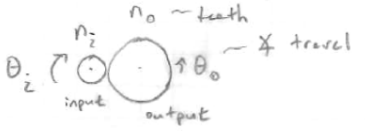


Figure 6: UP400RD / UP400RD II Zeroing Sensor Bracket Locations and Alternate Zeroing Positions

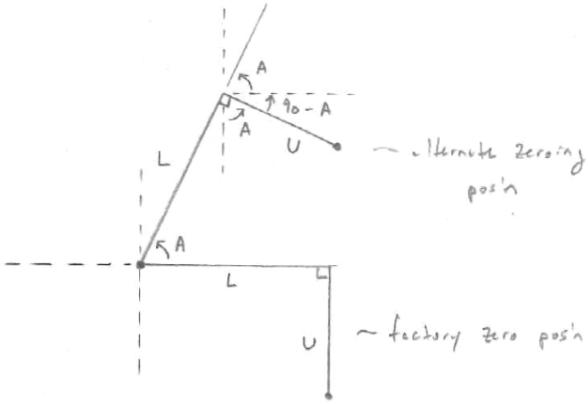
3 Procedure Derivation

- Gear reduc: small input r → large output r



$$\theta_i n_i = n_o \theta_o$$

$$\theta_o = \theta_i \left(\frac{n_i}{n_o}\right)$$



- Relate L & U offset by angle equality

$$\theta_{A_L} = \theta_{i_L}\left(\frac{n_{i_L}}{n_{o_L}}\right)$$

$$\theta_{A_U} = \theta_{i_U}\left(\frac{n_{i_U}}{n_{o_U}}\right)$$

$$\theta_{i_L}\left(\frac{n_{i_L}}{n_{o_L}}\right) = \theta_{i_U}\left(\frac{n_{i_U}}{n_{o_U}}\right)$$

$$\theta_{i_L}\left(\frac{n_{i_L}}{n_{o_L}}\right)\left(\frac{n_{o_U}}{n_{i_U}}\right) = \theta_{i_U}$$

plug →

pulse count

$$\theta_i = P_i \text{ (pulse)} \left(\frac{2\pi \text{ (rad)}}{4096 \text{ (pulse)}}\right)$$

C

$$P_{i_L}\left(\frac{n_{i_L}}{n_{o_L}}\right)\left(\frac{n_{o_U}}{n_{i_U}}\right) = P_{i_U}$$

$$P_{i_U} = P_{i_L}\left(\frac{n_{i_L}}{n_{o_L}}\right)\left(\frac{n_{o_U}}{n_{i_U}}\right)$$

$$P_{i_U} = P_{i_L}\left(\frac{-23}{5583}\right)\left(\frac{2733}{13}\right)$$

$$= P_{i_L}\left(-\frac{20,953}{24,193}\right) = -0.866076964\ P_{i_L}$$

- UP400RD II & UP400RD

	L		U	
num	RCG973	-23	RCG974	13
denom	RCG981	5583	RCG982	2733