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WARNING

THE INSTALLATION SHALL BE MADE BY QUALIFIED INSTALLATION PERSONNEL AND SHOULD CONFORM TO ALL NATIONAL AND LOCAL CODES.

Hyundai Robot

Hi5OC120701FMEN1

Hi5 Controller Function Manual

Coordinate System Calibration for OLP

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Contents

List of Figures

1 Overview

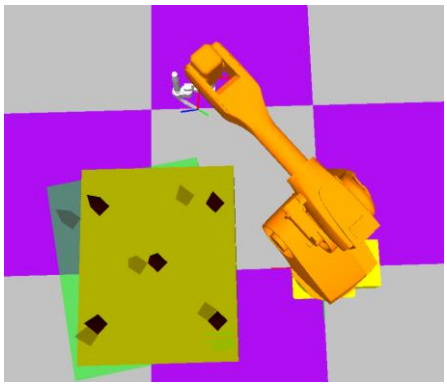
1.1. Overview

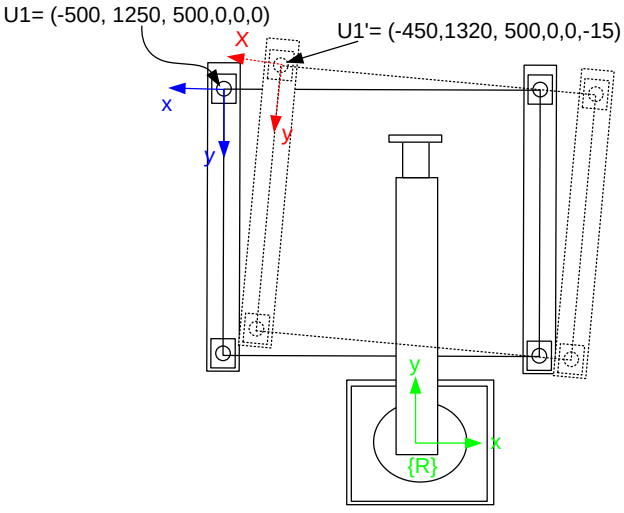
The OLP (Off-line programming) is designed for planning jobs in simulation environments and minimizing additional teaching jobs in the actual working place. Theoretically, the program created in the OLP may be downloaded to substitute real work. However, in real working conditions, various tolerances exist in terms of robot's accuracy, accuracy of the robot's installation positions and installed work piece positions, etc. Those tolerances are the reasons why the OLP applications may not be applied in worksites as they are.

Therefore, it is needed to correct the position calculated in the OLP to fit in the real job position, which is called 'OLP installation tolerance calibration.' The function may correct the OLP installation tolerance by performing the teaching operation to the CAD-based base program created in the OLP and the robot found in the same location, and by creating the formula which converts the difference between the two coordinate systems.

The function's correction method uses the user coordinate system. Users teach the robot program to be converted into the user coordinate system. When the base program created in the OLP and the program created by the user's teaching are put, the conversion value between the two programs is added as the conversion value of the pre-set user coordinate system. As a result, the job position of the program that has been taught to change into the user coordinate system is corrected to match the real workpiece position.

An OLP-based workpiece 1 is located at U1 as shown in the following figure, but if it is positioned at U1' during the actual installation, differentials occur between the two coordinate systems: -50 mm, 70 mm, and 0 mm in the X, Y, and Z directions; 0, 0, and -15 degrees in the Rx, Ry, and Rz directions, respectively. The calibration function compensates for the installation tolerances by computing the U1' instead of the U1.





The Hi5 controller supports the 10 user coordinate systems. So, each workpiece may be compensated for the installation tolerance based on each of the set user coordinate system.

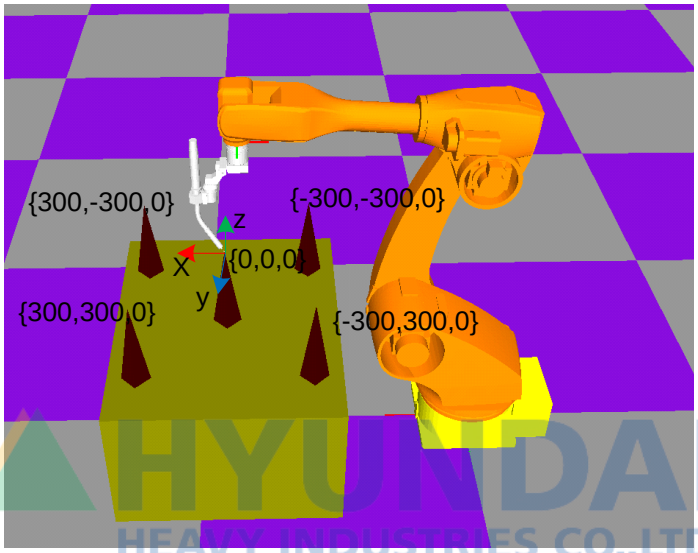
2

Preparation for OLP Program

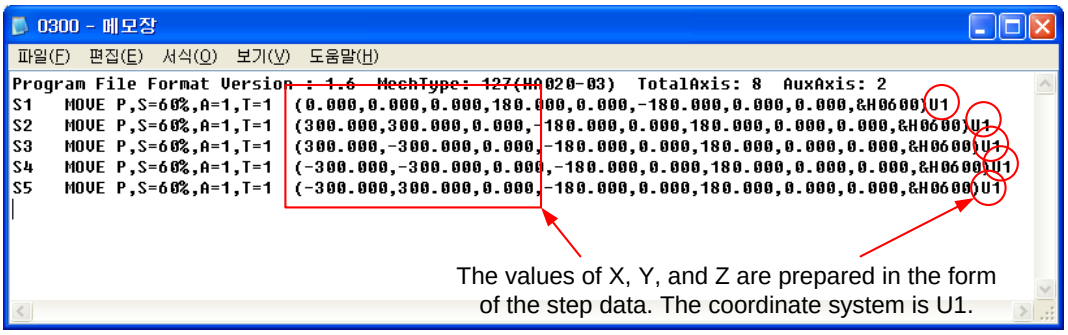
2.1. Preparation for the OLP Benchmark Program (in OLP package)

ARCON is a command of starting the arc welding.
In order for this function to be used, the OLP-based landmark position shall exist and the real workpiece shall also have the landmark positioned in the same location as the OLP-based one.

When there are 5 landmarks as shown in the following figure, write each landmark point on the benchmark record program based on the OLP data.



Write the program in the form of the Hi5 controller program as below with the use of the edit function of the notepad application on the PC. For instance, the following figure shows the preparation for 300.JOB.



1) Prepare the positions of X, Y, and Z in the form of the OLP data.
2) Set appropriate values of the position vectors of Rx, Ry, and Rz in the same way.
3) Select the converted user coordinate system, Un for the record coordinate system.

Notes

- Set the position of the benchmark program as a representative position that includes the area of the job program if possible.

2.2. Preparation for the OLP Job Program

The job program is taught by the OLP-based HRSpace and RobCad. For instance, they create the 500.JOB program prepared in the OLP.

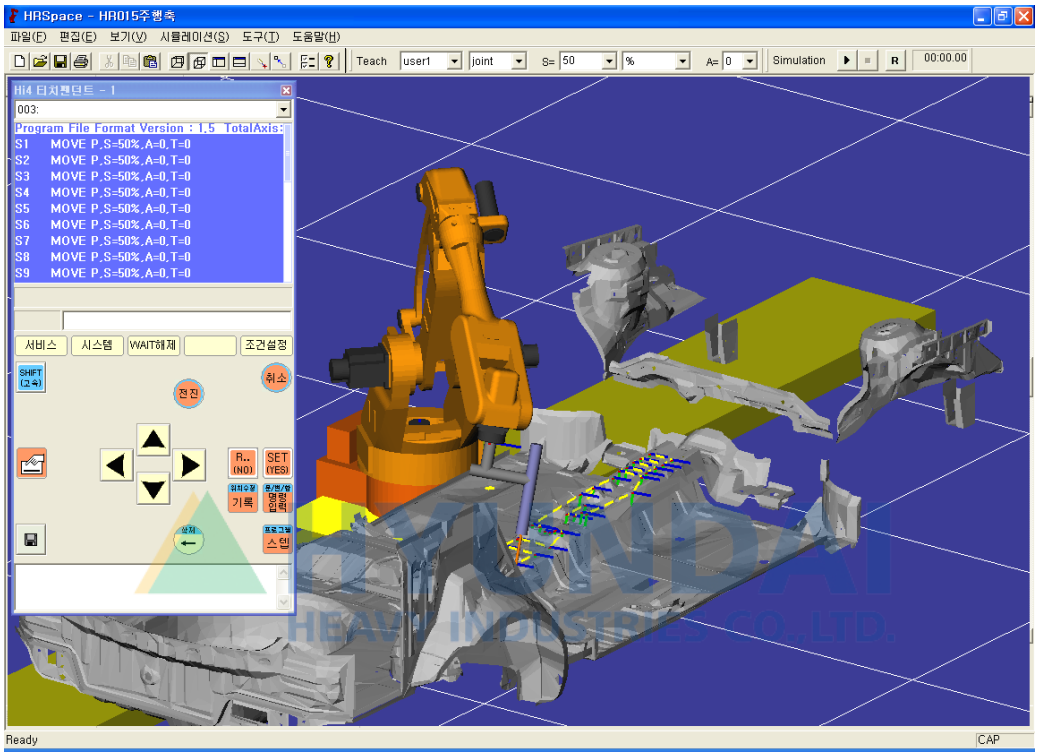


Figure 2.1 Example of preparation for the job program

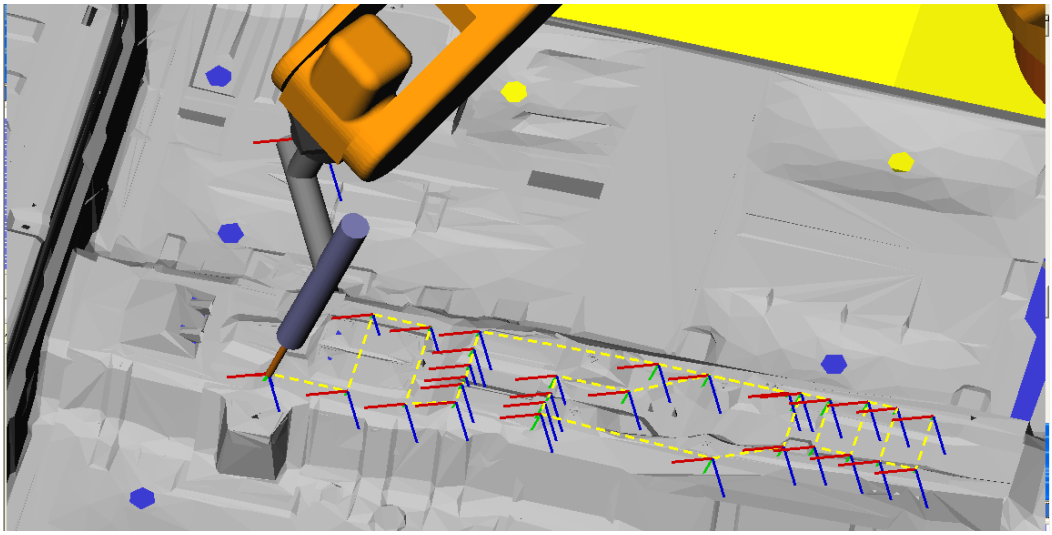


Figure 2.2 Example of the job program

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3 Download of OLP Programs' Controller

3.1. Download of OLP Programs' (benchmark record and job programs) Controller

As a way of copying files into HRView or USB, copy the OLP 'benchmark program' (300.JOB) and 'job program' (500.JOB) onto the controller.

4

Preparation for Benchmark Teaching Program

The preparation for the ‘Benchmark Teaching Program’ is a teaching job of marking the position that is the same as that of the OLP-based ‘Benchmark Program’ onto the real workpiece, which means that the teaching process is performed to the workpiece in the real worksite, not in the OLP’s virtual space

Notes

1) Precisely calculate the tool length with the automatic integer set before preparing the benchmark teaching program.

2) Make the step order of the benchmark teaching program correspond to that of the benchmark program (300.JOB) created in the OLP, and precisely teach the step order to the landmark point on the real workpiece. That is, match the step 1 position of the benchmark program with that of the benchmark teaching program, and continue the teaching job by applying the same step order of the benchmark program (300.JOB) to the rest of landmarks (2~5 step).

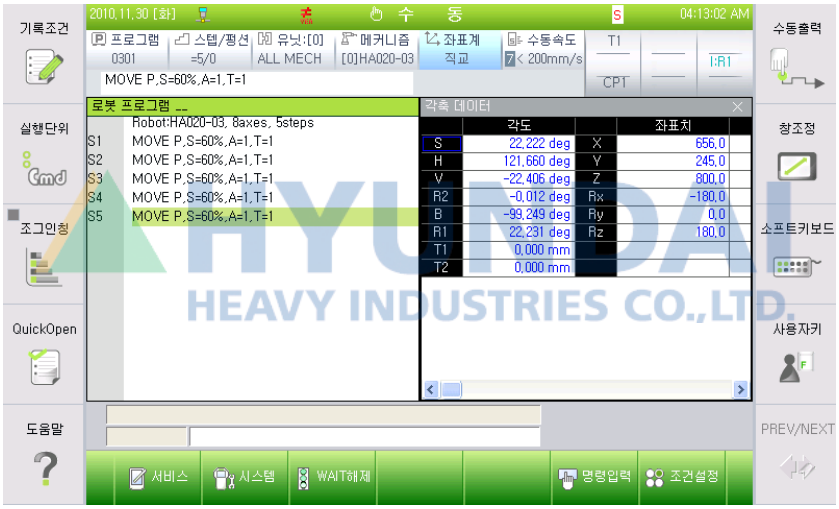


Figure 4.1 Example of preparation for the job program

For instance, create the benchmark teaching program on the 301.JOB program.
Through the above 2 and 3 processes, the OLP-based ‘Benchmark Program’ is on the program 300.JOB; the ‘Benchmark Teaching Program’ is on the 301.JOB program.

5

Coordinate System Conversion of Job Program

Check whether the job program (500.JOB) has been set in the form of the user coordinate system (U_Crd).

If the job program for the calibration has been recorded as the user coordinate system, turn to Chapter 6. If it has not, perform the processes from creating the user coordinate system to converting the job program into the user coordinate system.

5.1. Creation of the User Coordinate System

Create a user coordinate system on the Hi5 controller which position is similar to that of the OLP.

There are two methods of creating the user coordinate system.

1) One method by teaching 3 points

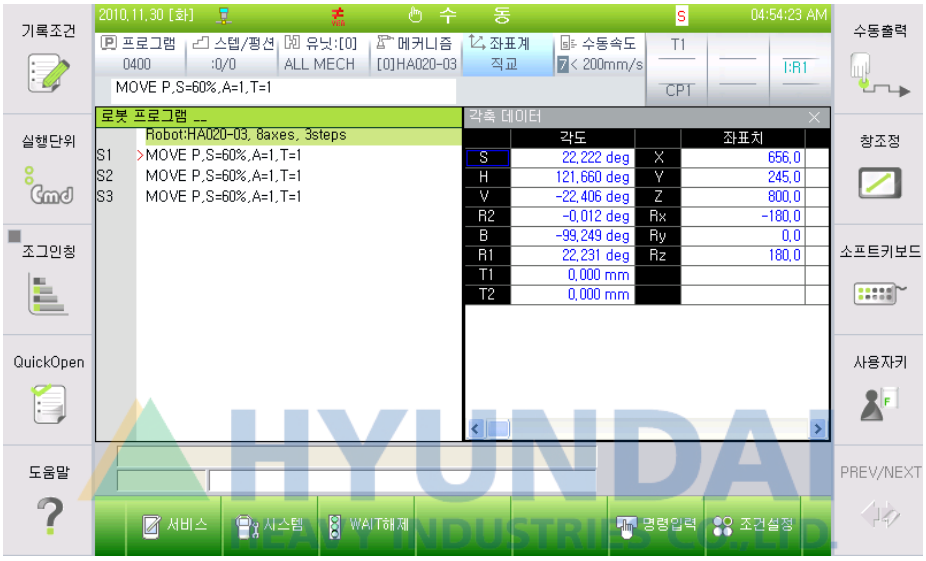


Figure 5.1 Example of the program to set the user coordinate system

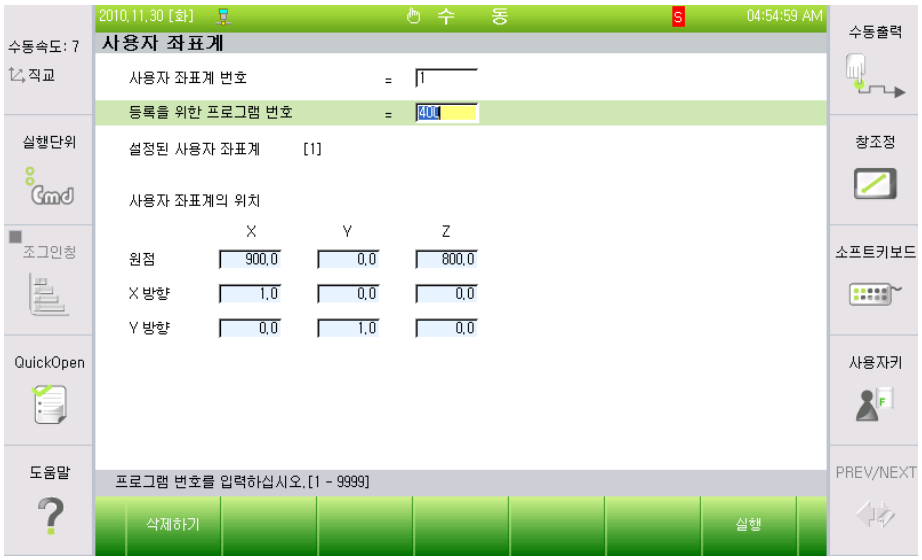


Figure 5.2 Example of the user coordinate system

2) The other method by using the MKUCRD command

Ex) when setting the origin, X-axis (P2) and XY-plane (P3) in the user coordinate system, use the command of MKUCRD 1, P1, P2, and P3.

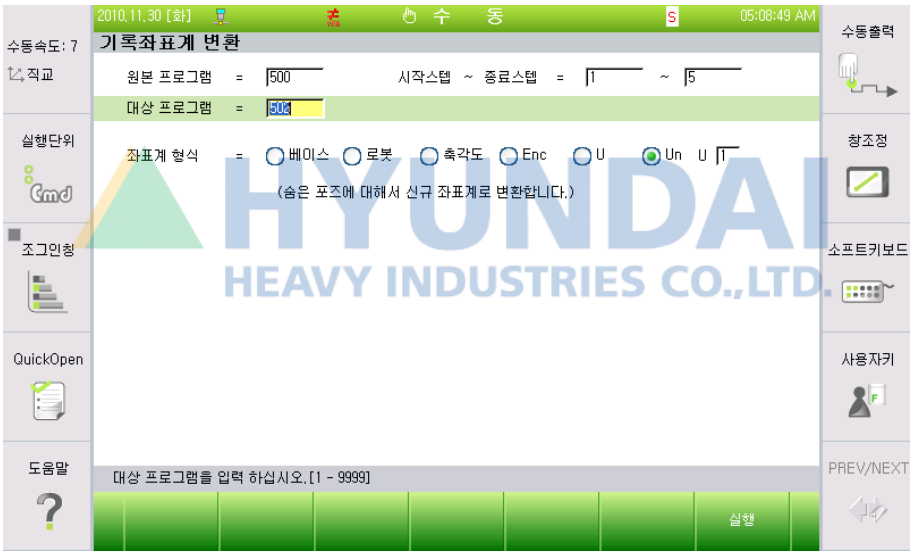
Please, refer to the Hi5 User Manual with respect to the method of creating the user coordinate system in detail.

5.2. A batch Record Coordinate System Conversion Function

The job program (500.JOB) may be recorded in the form of an axial angle, base, or robot coordinate system including the user coordinate system (U_Crd). In this case, they need to be converted into the user coordinate system.

A function is needed to convert the coordinate systems recorded into the existing programs in a lump, called the 'A Batch Record Coordinate System Conversion' function. With the use of the function, they may be easily converted into the user coordinate system.

Proceed with the following procedure: 『Service』 → 『6: Program Conversion』→ 『4: Record Coordinate system』'. For example, in the case when the 500.JOB program is not in the form of the user coordinate system, create the system by copying the program that has been converted into the user coordinate system #1 at # 502 as below. If you press the "Run" button (PF7), # 502 (502.JOB) is created as the user coordinate system #1 (U1).



Each menu means as follows.

(1) Original Program
Put the number of the original program of a job program.

(2) Target Program
Put the number of a program where the program with a converted coordinate system is copied. When the number of the original program is the same as the number of the target program, the existing program is overwritten.

(3) Start Step ~ End Step
Put a range of the step which recorded coordinate system is subject to conversion.

(4) Form of the coordinate System
Select the coordinate system into which the range of the step of the target program is converted. Select the user coordinate system (Un) and the number for the calibration of the OLP coordinate system before the start of running.

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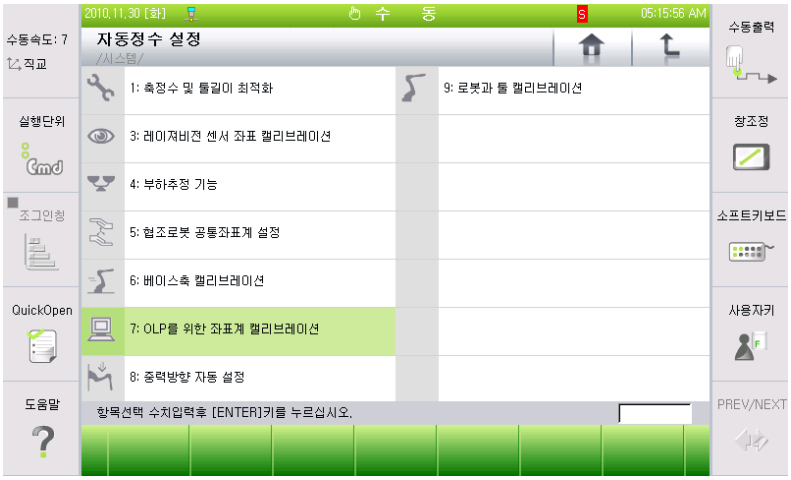
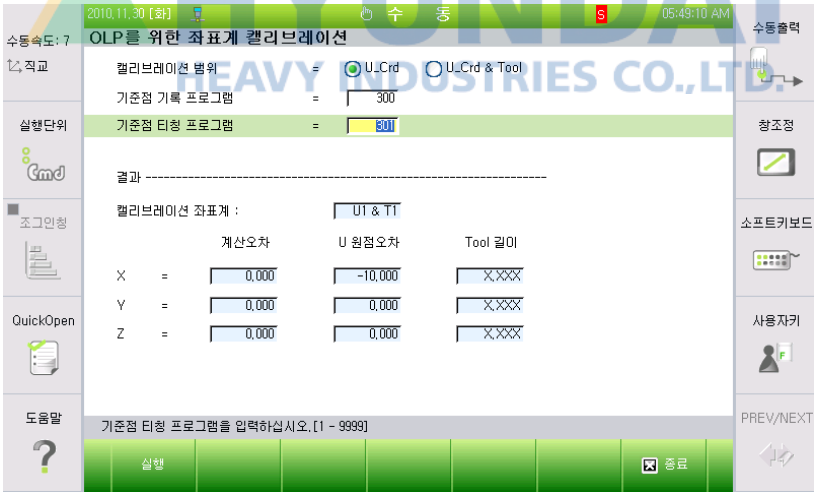
6

Coordinate System Calibration for OLP

After the job program has been converted into the user coordinate system, the calibration of the coordinate system for OLP may work. Select menus as follows: 『[F2]: System』 → 『6: Automatic Integer Settings』 → 『7: Coordinate System Calibration for OLP』.



For instance, the benchmark record program selects the OLP benchmark program #300. The benchmark teaching program selects the program #301 where the same position has been taught.



6.1. Explanation on Menu Items

(1) A Range of Calibration

- **U_Crd**
  Calibrate the user coordinate system alone.

- **U_Crd & Tool**
  Calibrate the user coordinate system and the tool length at the same time. In this case, each step's position vector of the benchmark teaching program shall be taught differently.

(2) Benchmark Record Program
Put the number of the program prepared by the CAD-based data. Select the 'Benchmark Program' created in the OLP.
With respect to the benchmark record program, all steps shall be set in the form of the same user coordinate system (U_Crd).

(3) Benchmark Teaching Program
Put into the workpiece the number of the program that has received the landmark position that is the same as the 'position of the Benchmark Record Program.' All of the base, robot and axial coordinate systems may be used, provided that they are automatically converted into the base coordinate system recorded in the form of the user coordinate system.

(4) Results
Calibration coordinate system U? & T?
Both the U? & T? display the numbers of the calibrated user coordinate system and the tool. If the "Run" key is pressed, the U? is converted into the number of the user coordinate system of the benchmark record program just as the U1, and the T? are changed into the number of the tool of the benchmark teaching program just as the T1.

(5) Calculation Tolerance (X, Y, Z)
The calculation tolerances display the maximum values of each step's position tolerance X, Y, and Z of the benchmark record and the benchmark teaching programs when the result of the U_Crd (or U_Crd & Tool) calibration has been applied.

(6) U Origin Tolerance
The U Origin Tolerance displays the difference between the existing set user coordinate system and the user coordinate system resulting from the calibration. (U origin Tolerance = the position of the newly created user coordinate system – the position of the existing user coordinate system)

(7) Tool Length

The tool length is calculated when the range of the calibration has been selected as the 'U_Crd & Tool.' When the function is chosen, first, the tool length is searched then U_Crd is searched. To find out the tool length, deliver many different teaching position vectors of the tool for each step as shown in the following Figure when you teach the 'Benchmark Teaching Program.'

If the range of the calibration is limited only to the U_Crd, it does not matter that the position vectors of the 'Benchmark Teaching Program' are the same. However, it shall be performed when the data of the tool length are accurate.

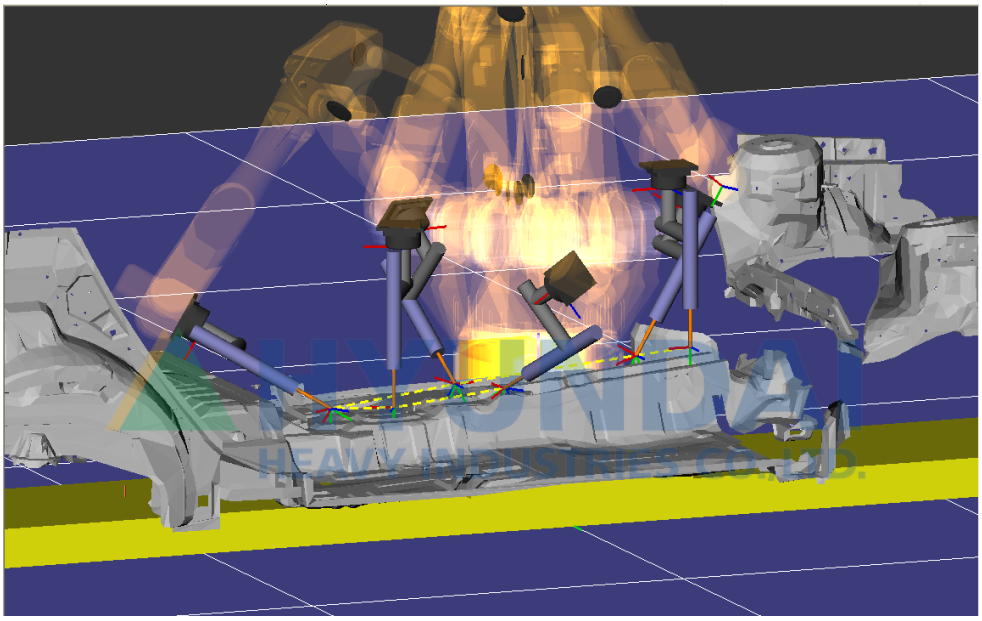
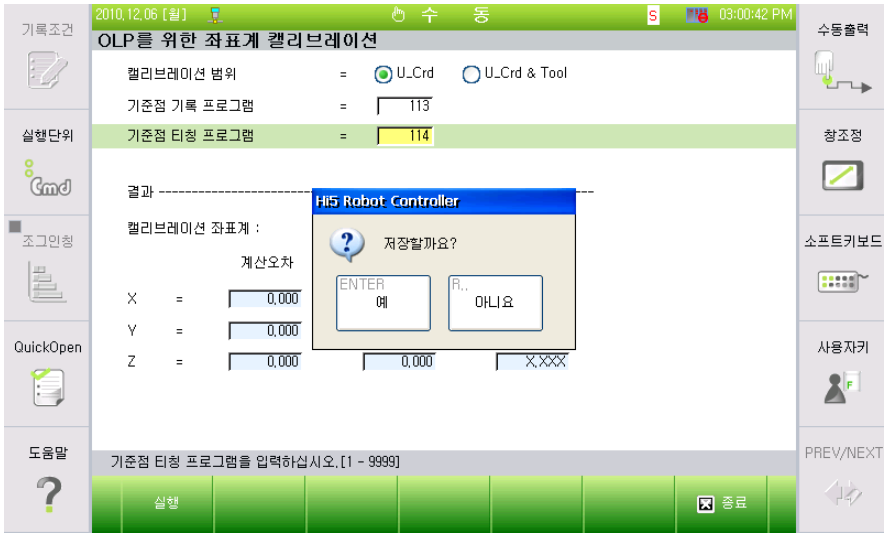
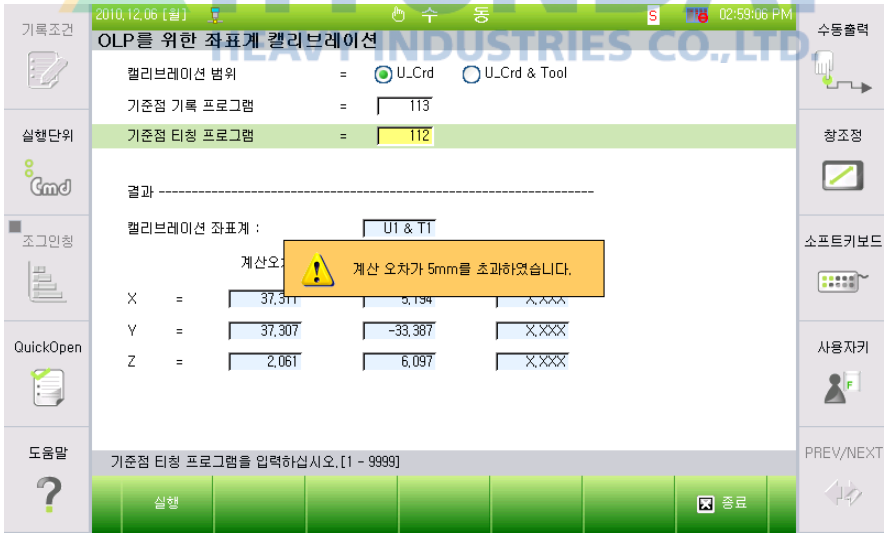


Figure 6.1 Example of instructed position vectors including TOOL parameter

If the 『[F1]: Run』 key is pressed, the calibration result is displayed. And if the “ENTER” key is pressed, the data of the user coordinate system are saved automatically.



When the calculation tolerance is over 5mm, it is judged that the data have some problems. Therefore, when the error is displayed as below, the data are not applied to the user coordinate system



When the following errors also happen, the calculated result is not applied to the user coordinate system.

Error Messages

- **The value may not be found.**
  The value is not converged, or it is an unsolved program. Please check the positions and the position vectors of the record and the teaching programs and correct them.

- **There are steps that move the auxiliary axis.**
  The 'Benchmark Teaching Program' has been prepared with different positions of the auxiliary axis. Please fix the position of the auxiliary axis and perform the teaching process.

- **There are steps that are outside the motion field.**
  The 'Benchmark Teaching Program' has steps that are outside the job field. Please check and correct them.

- **The distance between benchmarks is less than 1cm.**
  The distance between benchmarks is too narrow, less than 1cm. Please keep some distance between the benchmarks for programming.

- **The changes of the teaching program's position vectors are less than 10 degrees.**
  The error occurs when the U_Crd & Tool has been selected as the range of the calibration. In this case, the teaching program's position vectors shall be different. When the changes of all the teaching programs' position vectors are set less than 10 degrees, the error occurs. Please check and correct them.

- **The user coordinate system E1350 has not been set yet.**
  When the 'Benchmark Record Program' selects not the Un but the U as the coordinate system form, the involved user coordinate system shall be selected on the 'Condition Settings.' The error occurs when the user coordinate system is not set.

(Notes)

- When the calculation tolerance is large, please check it out because the preparations for the 'Benchmark Record Program' and 'Benchmark Teaching Program' could be wrong.

- When the U_Crd has been selected as the range of the calibration, the teaching process of the 'Benchmark Teaching Program' shall be performed when the tool length is accurate.

- U Origin Tolerance
  ① When the involved coordinate system is not registered on the controller, the 'U Origin Tolerance' is displayed as the origin tolerance of the base coordinate system.

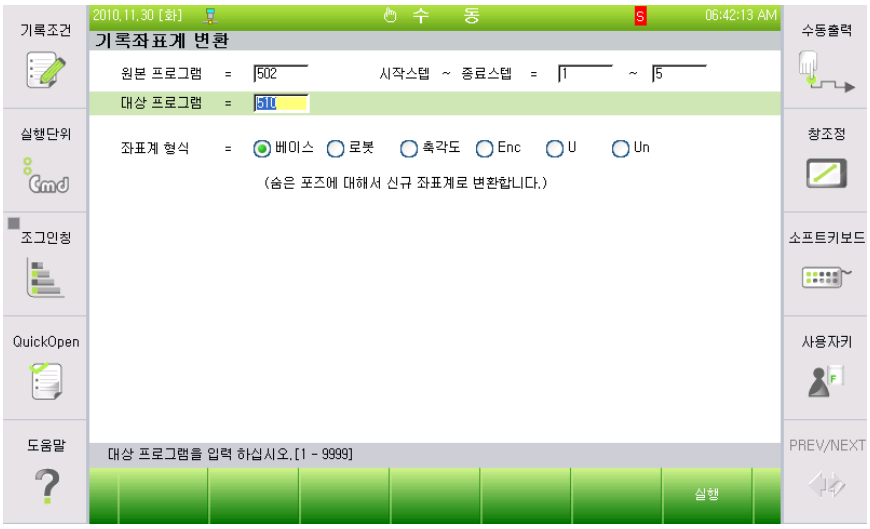
  ② In the above case when the U origin tolerance is {0.597, 0.200, 0}, and the user coordinate system # 1 is not registered, {0.597, 0.200, 0} is registered as a new origin of the user coordinate system.

  ③ If the same result has been induced when {100,100,100} is given to the user coordinate system #1, the user coordinate system #1 gets registered with a new coordinate {100.597, 100.2, 100.0}.

7

Return of Job Program Coordinate System (User To Base)

To return the program (500.JOB), the converted user coordinate system for the calibration to the original (Base) coordinate system, reuse the function of the 'A Batch Record Coordinate System Conversion.'



When the [F7]: Run』 key is pressed, the program #502 is reconverted back into the base coordinate system, the program #510 created.

8 Driving of Job Program

Because the tolerance between the OLP and the installation has been corrected due to the correction of the user coordinate system, select and drive the 510.JOB program on the controller.

(1) Check whether the position of the job program is correct with the use of the step's function of back and forth movements.
(2) The step that interrupts the job may be corrected in the same way as the usual method of correcting the step position.

As a result, it may be checked whether the position that had caused the tolerance before the OLP coordinate system calibration has been corrected.

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