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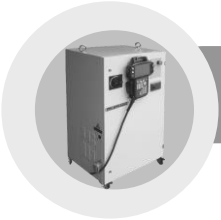
**WARNING**

**INSTALLATION SHOULD ONLY BE PERFORMED BY QUALIFIED INSTALLATION PERSONNEL AND MUST CONFORM TO ALL NATIONAL AND LOCAL CODES**

Hyundai Robot

Hi5OL090601FMEN1



# Hi5 Controller Maintenance Manual

## ROBCAD OLP



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# 1 Introduction

In general, teaching-and-playback type robot teaching is conducted after all steps have been completed, including work cell design, jig and gun production and installation. As a result, in the event that a problem occurs, such as the intervention of a jig in the teaching step, reinstallation must be done by redesigning the jig or the gun, or by changing the location of the robot. This results in wasted man-hours.

When an OLP (Off-Line Programming) approach is used, steps such as robot work plan and simulation, intervention check, cycle time measurement and optimization are performed in advance at the stage of designing the work cell that includes the robot, through a 3D virtual environment on a workstation or PC. This includes a type of teaching that compensates for the downside of the teaching-playback mode that creates the robot work program and moves it to the controller. The S/W used to perform these steps is called a CAR (Computer-Aided Robotics) tool, or a CAPE (Computer-Aided Production Engineering) tool.

Currently, numerous products including ROBCAD, IGRIP and Workspace are used in industrial settings as commercial CAR tools that support various controllers. For these products to execute the OLP process of a specific robot, the OLP package, which is a S/W module, is required. The OLP package performs 3D model simulation as well as robot controller simulation of the appropriate robot, and executes operations such as outputting a correct work program for its application.

## 1.1. Introduction to Hi5 OLP Package


Figure 1.1 The ROBCAD environment and the Hi5 OLP package



The Hi5 OLP package is a software package used to perform offline teaching and simulation of robot spot welding work using the Hi5 controller in ROBCAD. The characteristics of the Hi5 OLP package are defined in [Table 1-1].

Table 1-1 Characteristics of the Hi5 OLP package

| | |
|---|---|
| **Base OLP S/W** | em-Workplace (ROBCAD) v7.1.2 (for PC) of Tecnomatix |
| **Supported controller** | Hi5 controller |
| **Supported Robot Manipulator** | HS165-02, HS200-02 |
| **Main applicable fields** | Spot welding and handling |
| **Motion simulation process** | MOP type and RCS type |

## 1.2. Formation of the Hi5 OLP Package

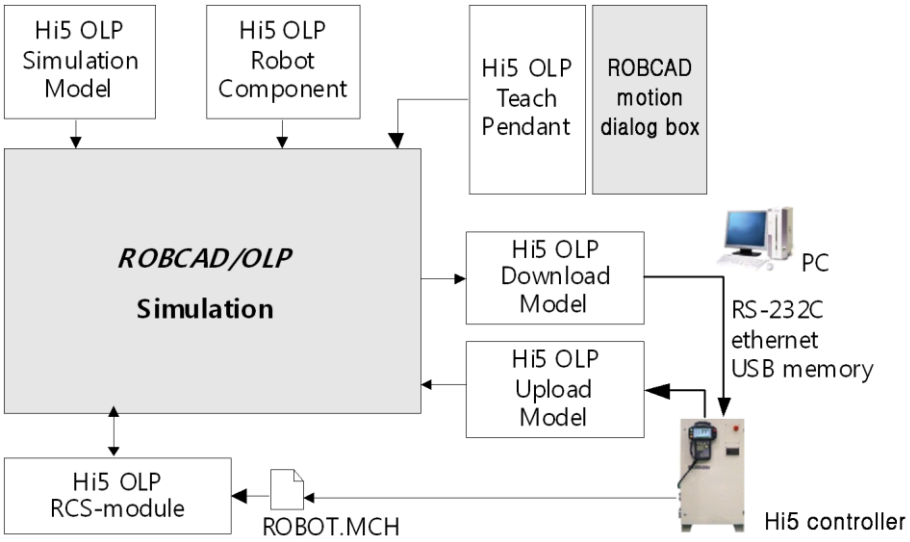


Figure 1.2 Formation of the Hi5 OLP package

The Hi5 OLP package is composed of various components, as shown in [Figure 1.2]. The role of each component is described in [Table 1-2] below.

Table 1-2 Components of the Hi5 OLP package

| Component | Role |
|---|---|
| **Teach Pendant** | Input and edit step parameters and function commands for each location |
| **Simulation Model** | Define and execute the steps and functions of the Hi5 controller, and simulate robot motion through the same method at the time of simulating robot work |
| **Download Model** | Convert robot work that has passed through the simulation, correction and confirmation process into a work program for the Hi5 controller |
| **Upload Model** | Convert a work program existing on the Hi5 controller into a path inside of a ROBCAD work cell |
| **Robot Component** | Call CAD data of a defined shape and the Kinematic data of a robot to inside of the work cell of ROBCAD, and use it for creating and simulating work |
| **RCS-module** | Calculate robot trace when motion operation of the Hi5 controller is simulated |

## 1.3. Preparations

In order to proceed with the teaching of spot welding work using the Hi5 OLP package, the following environment should be established

Table 1-3 Environment for using Hi5 OLP package

| | |
|---|---|
| **ROBCAD** | eM-Workplace (Robcad) for PC Version 7.1.2 or higher<br>Modules required for works including /BASE, /SPOT and /OLP |
| **Hi5 controller** | The newest official version of the software is recommended |
| **Robot Manipulator** | HS165-02, HS200-02 |
| **PC** | Pentium 4 or higher, Windows 2000, XP |
| **HRView** | v2.00 or higher, RS-232C connection cable or Ethernet cable |

To use the Hi5 OLP package, the user should be equipped with the following knowledge in advance.

- Ability to use a spot welding robot
- Ability to perform Off-Line Programming
- Ability to operate the Hi5 controller
- Ability to use ROBCAD/BASE and /SPOT



NOTE **Dot-e file and RCS module**

There are two types of simulations available for the simulation of robot motion executed by ROBCAD: simulation executed by the MOP (Motion Planner) of ROBCAD, and simulation executed by the RCS (Robot Controller Simulation) module of the target robot.
MOP of ROBCAD reads a Dot-e file, which lists the various motion characteristics of the target robot and executes the simulation accordingly.
On the other hand, the RCS module in the controller software of the target robot implements the simulation based on motion-related parts as a robot motion software module that conforms with an RRS (Realistic Robot Simulation) standard interface, so generally it has very high cycle time accuracy in comparison with a Dot-e file.
The Hi5 OLP package is composed of a Dot-e type hhi_hi5 file and an RCS type hhi_hi5_rrs file.

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# 2

# Installation of Work Environments

## 2.1. Installation of Hardware Environment

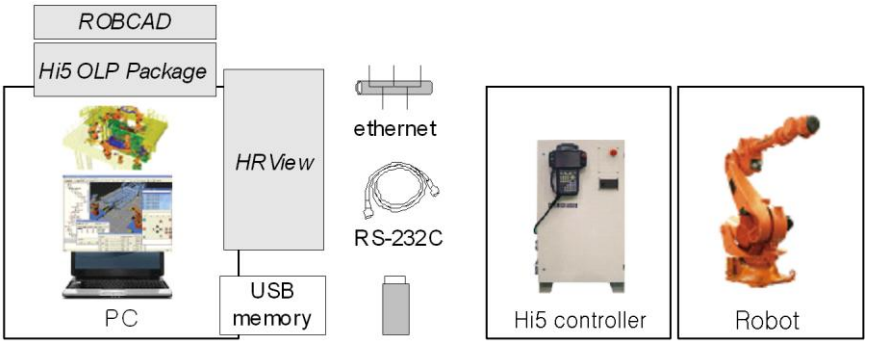



Figure 2.1 Hardware configurations for using the Hi5 OLP package

[Figure 2.1] shows the hardware configurations used for robot teaching with the Hi5 OLP package.

A work program file that is created through a simulation in the desktop PC or notebook PC with ROBCAD installed must be transferred to the Hi5 controller. The work program file can be transferred to the Hi5 controller using USB memory, RS-232C, or Ethernet.

## 2.2. Installation of the Hi5 OLP package

The Hi5 OLP package is not included in ROBCAD package by default, and thus should be installed manually. Install the Hi5 OLP package using the following steps.

[Table 2-1] shows the list of files in the Hi5 OLP package, and the directory where the actual files should be located. Copy the files in the manner specified in [Table 2-1].

Table 2-1 File list and directory

| Directory | File | Description |
|---|---|---|
| $(ROBCAD)/dat/olp/hhi_hi5_rrs/ | hhi_hi5_rrs.apg<br>hhi_hi5_rrs.sim | control files |
| | hhi_hi5_rrs_upload.awk<br>hhi_hi5_rrs_download.awk<br>hhi_hi5_rrs_sim.awk | awk files |
| | hhi_hi5_rrs.copy<br>hhi_hi5_rrs.query<br>hhi_hi5_rrs.lang | other |
| $(ROBCAD)/bin/ | hhi_hi5_rrs_attr | T/P<br>execution file |
| $(ROBCAD)/rrs_bin/hr1.0/ | rrs.ver<br>rcshr01 | RCS module |
| $(ROBCAD)/dat/ | hhi_hi5_rrs.uid<br>hhi_hi5_rrs.scan<br>hhi_hi5_rrs_items_map | T/P<br>user interface |
| | hhi_hi5_rrs.cnf<br>hhi_hi5_rrs.err | other |
| $(ROBCAD)/Libraries/ROBOTS_HYUNDAI<br>/hs165_02.co/<br>The same applied for other robots…… | All files with the following extensions:<br><br>.atr<br>.geo<br>.gm<br>.gmnw<br>.gmapprox<br>.gri<br>.info<br>.m<br>.r<br>.sy<br>.wm | Robot<br>component |
| $(ROBCAD)/Libraries/ROBOTS_HYUNDAI<br>/ hs165_02.co/rrs | All files with the extension .rrs<br>ROBOT.MCH | |

$(ROBCAD) refers to the path name where eM-Workplace is installed. If necessary, create each directory and copy the files in the manner specified.

## 2.3. Registration

Edit the ".robcad" file located in "$(ROBCAD)/dat/".

Insert the following items in the appropriate location

```
################## Controlers & Interpreters #################
…
hhi_hi5                              hhi_hi5_attr
hhi_hi5_OLP_CONT_SUFFIX              JOB
hhi_hi5_OLP_CONTROL_DIR              ../dat/olp/hhi_hi5
hhi_hi5_rrs                          hhi_hi5_rrs_attr
hhi_hi5_rrs_OLP_CONT_SUFFIX          JOB
hhi_hi5_rrs_OLP_CONTROL_DIR          ../dat/olp/hhi_hi5_rrs
…

################## OLP-Controllers #############
…
olpcont33          hhi_hi5
olpcont34          hhi_hi5_rrs
```

Details of the settings for these items are as described in [Table 2-2].

Table 2-2 Details of settings by items of ".robcad" file

| | |
|---|---|
| hhi_hi5<br>hhi_hi5_rrs | Execution file of Teach Pendant<br>(Path based on $ROBCAD/bin) |
| hhi_hi5_OLP_CONT_SUFFIX<br>hhi_hi5_rrs_OLP_CONT_SUFFIX | Extension for uploading and downloading |
| hhi_hi5_OLP_CONTROL_DIR<br>hhi_hi5_rrs_OLP_CONTROL_DIR | Location of controller model |
| olpcont33<br>olpcont34 | Menu item for selecting a controller |

In the menu item <olpcont33> above, the number "33" has been determined according to ROBCAD environment of user. For example, if there are existing <olpcont> up to "30", "31" is the next number that can be used.

NOTE **System-default ".robcad" file and ".robcad" file for specific projects**

As described before, if ".robcad" file (system-default.robcad file) located in "$(ROBCAD)/dat/" is edited, this setting will be equally applied to all ROBCAD users of the system. That is, all ROBCAD users can use the Hi5 OLP package.

If you want to make the setting for a specific project only, you can edit the ".robcad" file after copying it to the directory of the project concerned. You can delete all items except for the item in which the (private .robcad file) value is adjusted.

Edit the "attributes" file located in "$(ROBCAD)/dat/".

Insert the following items in the appropriate location, as shown below. These items are attributes that are used in the Hi5 OLP package in addition to the basic attributes of ROBCAD OLP.

```
# Hi4, Hi5 OLP package (DCM) attributes

HR_TOOL                 i           -1
HR_GUN2_STATE           i           -1
HR_LOC2_TYPE            i           -1
HR_BLOCK_MARK           tBool       -1
HR_FUNC_EXEC            i           -1
HR_GUN_NAME             tString     -1
HR_GUN2_NAME            tString     -1
HR_GUN_NO               i           -1
HR_WELD_CONDITION       i           -1
HR_WELD_SEQ_NO          i           -1
HR_J_DEGS               tString     -1
HR_EXT_J_DEGS           tString     -1
```

## 2.4. License input

The Hi5 OLP package has a protection feature to prevent unauthorized copying. After the package has been installed, it can be used only after the correct license code for the system is entered. Until the license code is input, the Hi5 teach pendant from ROBCAD/OLP will not be executed, and the following message will be displayed in the terminal window.

```
< /usr/home/robcad/jigman/ > robcad
ERROR: /usr/local/robcad/dat/olp/hhi_Hi5/hhi_Hi5.lic could not be opened.
system code(08:00:69:08:a2:a3)
```

In the message above, “08:00:69:08:a2:a3” is a system code identifying the workstation where Hi5 OLP package is installed. (This code will vary according to the system.)
Please supply this system code to the OLP package supplier and request a license code. The supplier will provide a file named hhi_hi5.lic which is appropriate for the system code. The content of this file has the same format as the example below:

```
506242
20100930
```

The first line is a license code, and the second line is the date on which this license will expire (September 30th 2010). (If the date is shown as “0” then the license has an unlimited term and will not expire.) Please note that if you edit the contents of this file, the license will be invalidated.

Copy “hhi_hi5_rrs.lic” to the “$ROBCAD/dat/olp/hhi_hi5_rrs/” directory. The Hi5 teach pendant will now be executed normally. If it does not execute, please check the message in the terminal window again. It may not be executing due to erroneous code delivered from the user to the supplier, or an expired license.

> NOTE **System code**
>
> A system code that has the form of 08:00:69:08:a2:a3 is the MAC address of the Ethernet card. For this reason, a system that lacks an Ethernet card cannot obtain a license.

The installation of the Hi5 OLP package is now complete.

# 3

# Configuration of Work Cell Including Robot

The directory layers that will be mentioned in the description below may vary according to the user's environment settings.

Let's give an example of calling work cell "c01" of project <x_prj>, and placing the HS165-02 robot.

Select <Browse Project Tree> and <x_prj> from 『eMPower - Project』 menu and click [OK]. Select 『Layout』 in the menu window at the top of the screen, click <Load cell> on the 『Layout』 menu displayed at the right side of the screen, and input 'c01' as the name of the work cell.

## 3.1. Calling robot

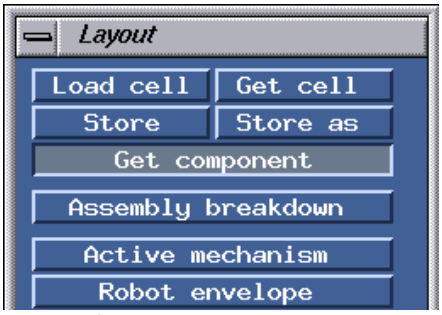



Figure 3.1 Layout menu

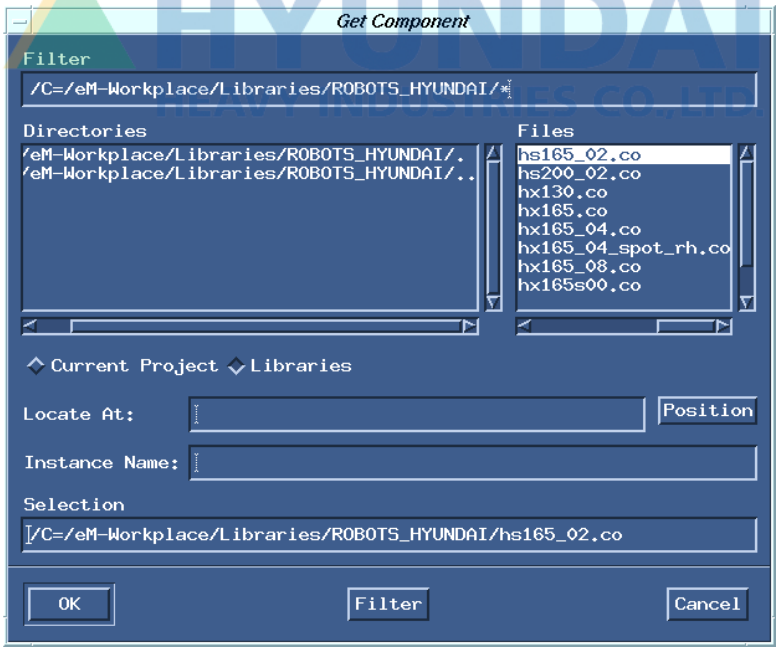



Figure 3.2 Libraries Browser

When you click 『Current library』, a dialog box will be displayed, as shown in [Figure 3.2]. Select ROBOTS_HYUNDAI from the "Directories" list.

Select hs165_02.co, set location, direction and instance name as required, and click [OK]. The robot will appear on the work cell of the graphics window.

## 3.2. Installing a Welding Gun and Selecting a Tool Frame

Select a library again and call an appropriate welding gun component. Then, mount this gun to the robot.

Tools numbered from 0 to 15 can be assigned as step parameters in the Hi5 controller. As an appropriate tool constant should be applied in the ROBCAD simulation according to the tool number parameter of each step, the connection between devices and tool numbers should be assigned in advance.

Therefore, a frame with an appropriate name in an established form should be attached to the tool end of a device with the tool number used. The form is as shown in [Table 3-1].

Table 3-1 Type of frame to be attached on tool end

| Tool number | Frame name |
|---|---|
| **T0** | {Robot instance name}_tcpf0 |
| **T1** | {Robot instance name}_tcpf1 |
| **…** | … |
| **T15** | {Robot instance name}_tcpf15 |



For example, to process a rectangular jog based on Tool No. 0 or a simulation of work program using Tool No. 0, a frame named hs165_02_tcpf0 should be attached to a corresponding tool end.

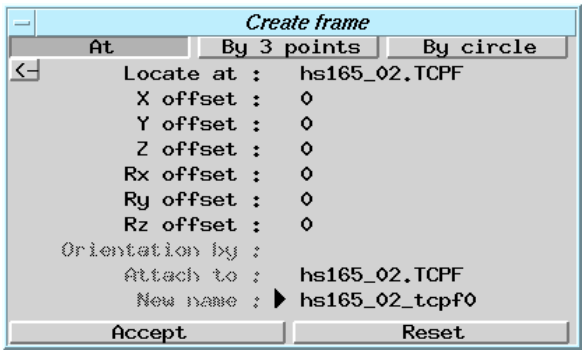



Figure 3.3 Create frame dialog box

When 『Create frame』 is selected from the Layout menu, the Create frame dialog box will be displayed. Assign tool end “entity” for the 『Locate at, Attach to』 item, as shown in [Figure 3.3], then assign the name in established form to “New name” and click [Accept]. If the direction of the created frame is incorrect, the direction can be corrected by <Place Editor> in ROBCAD.

In order to teach to the location of frame created when teaching location from the motion dialog box, click the <Settings> tab in the motion dialog box, click the [Tcpf] button as shown in [Figure 3.4], and enter the name of the created frame in the dialog box displayed, as shown in [Figure 3.5].

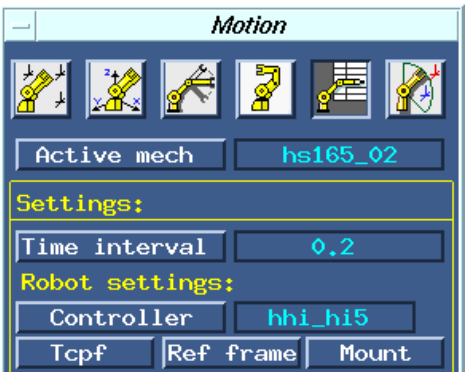



Figure 3.4 Settings tab

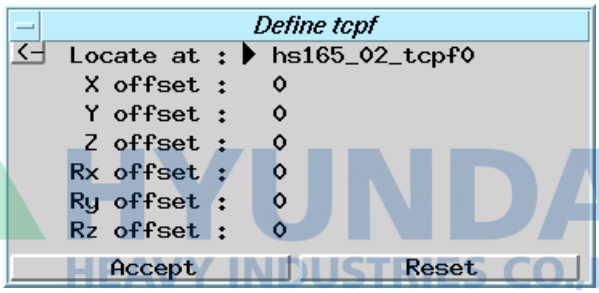



Figure 3.5 Assigning Tcpf

## 3.3. Creating Welding Gun Pose

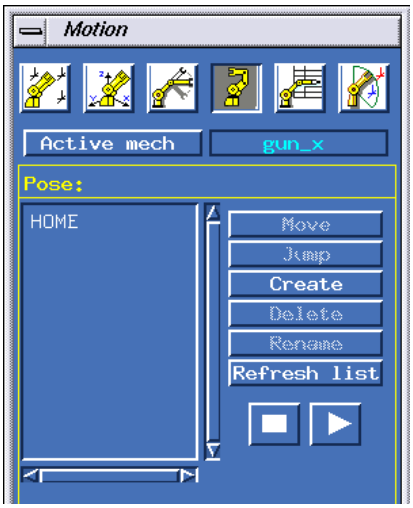



Figure 3.6 Pose tab of Motion dialog box


Figure 3.7 The state of welding gun Pose defined

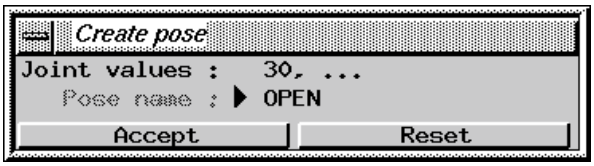



Figure 3.8 Pose create dialog box

Each pressurized and open state of a welding gun should be defined as a separate pose. If a welding gun is a 2-column gun, the state at the time the X1 and X2 signal are given should be defined also.

Open the motion dialog box, click the <Active mech> button and select a welding gun. When the pose tab in the motion dialog box is clicked, the state will become as shown in [Figure 3.6]. Defined poses will be listed in the list box. The example shown in Figure 3.8 is the state of only one pose, which is called HOME.

When the [Create] button is clicked, a dialog box will be displayed as shown in [Figure 3.8]. The user can input poses using this dialog box. The units used are degrees for the X gun and mm for the C gun. The 3 poses described in [Table 3-2] should be created

Table 3-2 Welding gun pose

| The name of pose | Description |
|---|---|
| **CLOSE** | Gun is closed. (Pressurized state) |
| **SEMIOPEN** | Gun is semi-opened.<br>- Apply this for 2-column gun<br>- SEMIOPEN (MX On) |
| **OPEN** | Gun is opened (OPEN) |

When the poses required have been created, the state will become as shown in [Figure 3.7].

## 3.4. Selecting Controller of Hi5 OLP Package

Select the OLP command from the eMPower menu. The OLP items will be displayed in the menu window at the top of the screen.
Select an OLP item from the menu window. The OLP menu will be displayed at the right side of the screen.
When selecting a controller from the OLP menu, a pop-up window will be displayed containing a list of the names of controllers. Select hhi_hi5 to execute the simulation in MOP mode, and select hhi_hi5_rrs to execute the simulation in RCS mode.

## 3.5. Settings Related to the Robot's Manipulator and ".sy" file

The ".sy" file is a text file that contains several settings related to the Robot Manipulator.
The default ".sy" file exists in the "/usr/Robcad/LIBRARIES/ROBOTS_HYUNDAI/hs165_02.co" directory, and its contents are as follows. (Setting values for each additional axis will be listed on the back of the item name.)

```
CLEARENCE -20    -15
EXT_RATIO 1.2    1
```

Table 3-3 Meaning of each item in the ".sy" file

| Item | Meaning |
|---|---|
| **CLEARENCE** | Servo gun clearance coordinates, which is only applied when executing a MOP-type simulation.<br>(Caution: Location value should be recorded rather than clearance width.)<br>A value of -99 means that it is not being used. |
| **EXT_RATIO** | Reduction ratio of the additional axis, which will be applied at the time of uploading/downloading<br>[download] Value of additional axis in ROBCAD * EXT_RATIO = Value of additional axis in work file<br>[upload] Value of additional axis in ROBCAD = Value of additional axis in work file / EXT_RATIO<br>If no value is assigned, 1 will be applied. |

Do not directly modify the default ".sy" file, even if the value needs to be modified. The default ".sy" file will be applied to all work cells of all projects used by calling a corresponding robot, so it should not be modified at the user's discretion.

ROBCAD first finds the ".sy" file with the robot instance name from the work cell directory, and then applies it. If there is no such file, ROBCAD finds the default ".sy" file from the library directory and applies it. By doing this, it copies the default ".sy" file into the work cell as a file with the instance name of the robot being used. The setting that you want can be applied by modifying this copied file

## 3.6. RPBPT.MCH File

The RCS module requires the ROBOT.MCH file (Robot constant file where the robot parameter of the Hi5 controller is saved), which will be used to execute a simulation that is as accurate as the actual motion. Move the ROBOT.MCH file that has been saved in the Hi5 controller into the following directory using HRView or USB.

```
/work cell path/instance name_rrs/
```

For example, this could look like the directory below.

```
C:\work\robcad\x_prj\my_cell.ce\hs165_02_rrs\
```

Create a file with the following contents in the same directory, under the file name ".rrs".

```
Module Name          hr1.0/rcshr01
Module Pathname      hr1.0
Robot Pathname.
Manipulator Type
```

".rrs" file plays the role of notifying ROBCAD of the location of the RCS module and the ROBOT.MCH file.

# 4 Using Teach Pendant

Teach pendant is a dialog box for entering and editing step parameters and function commands on each location. The adjustment of step parameters such as speed, type of interpolation and application of welding and input of functions executing branch, call and I/O can be done in the teach pendant of the Hi5 OLP package.

Select a teach pendant submenu from the OLP menu in order to call teach pendant

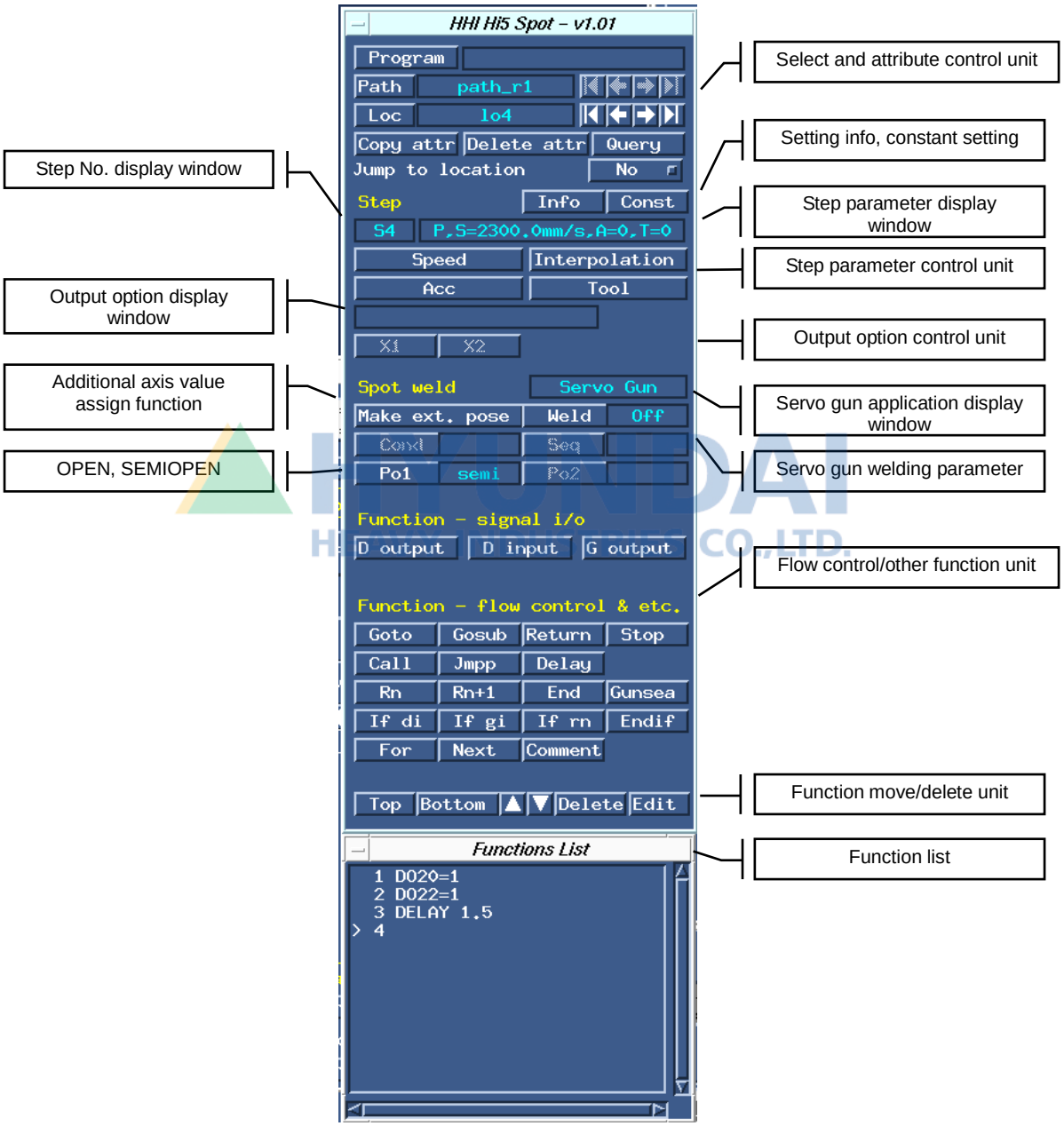



Figure 4.1 Teach pendant of Hi5 OLP package

## 4.1. Select and Attribute Control Unit


Figure 4.2 Select and attribute control unit

The select and attribute control unit selects a program, path or location. A location should be selected first, so that the selected location can be edited. Click the path or location button and select the path or location of the graphics window directly by clicking it with the mouse. You can move forward or backward using the arrow buttons.

If 『Jump to location』 is set to Yes, the movement will be done according to the current selection from the graphics window for moving forward or backward.

<Copy attr> is a function of copying an attribute from one location to various locations. <Delete attr> is a function of deleting an attribute from various locations.
<Query> is a function of showing each state of an attribute setting by step in a different color. When the Query button is clicked in the QUERY dialog box and an attribute is selected for display, the classification of values of the corresponding attribute in different colors will be displayed in the dialog box, and the locations of the graphics window will be displayed in different colors.



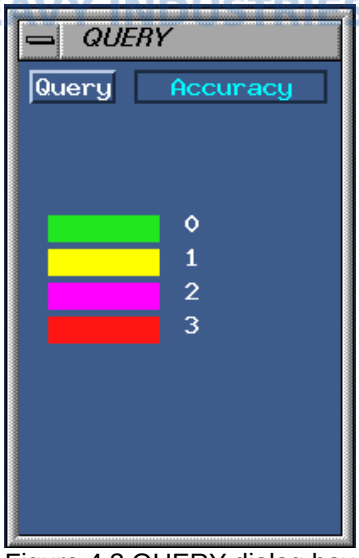



Figure 4.3 QUERY dialog box

## 4.2. Step Number Display Window and Step Parameter Display Window

The Step Number display window displays the Step Number currently selected.

A step number is assigned to each teaching point in the Hi5 controller, but a location with an arbitrary name is equivalent to a teaching point in ROBCAD.

The Hi5 OLP package displays locations by assigning a step number to each location based on where a specific location is placed on path. For example, the 5th location of the path will be treated as step 5.

The step parameter display window display displays the current settings of 4 step parameters, including speed, interpolation, accuracy and tools, in a similar format to actual T/P.

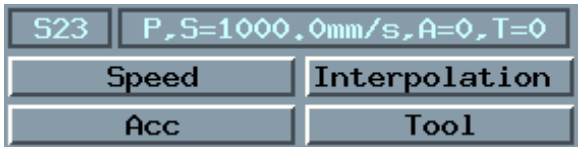



Figure 4.4 Step Number display window, Step parameter display window and control unit

## 4.3. Step Parameter Control Unit



The step parameter control unit is used to control 4 step parameters.

Interpolation, accuracy and tool are selected through the popup menu, and speed is entered through a dialog box, as shown in Figure 4.5. It can be entered in %, mm/s or sec.

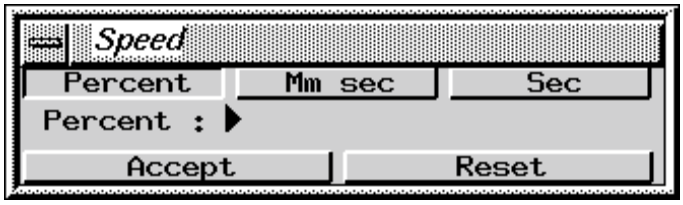



Figure 4.5 Speed parameter dialog box

## 4.4. Constant Setting

When the user clicks the [Const] button of TP while the active mechanism is set, a constant setting dialog box will be displayed, which accepts the input of several attributes to be set for the currently selected robot (Active Mechanism).


Figure 4.6 Constant setting dialog box

<Func exec> sets whether to execute the function existing on each constant when executing a simulation, as in [Table 4-1].

Table 4-1 Available values to be set on Func exec

| Setting value | Description |
|---|---|
| **0** | Execute all functions. (Servo gun operation is excluded, even if it is a function) |
| **1** | Execute all functions. |
| **2** | Execute all functions except WAIT (DI signal wait) function. |

Gun1 and Gun2 set which device should be operated by step parameters G1 and G2 when executing simulation. These can be set in the graphics window by clicking a device directly, and should be set as many times as the number of guns.
Weld cycle time sets welding time in the unit of seconds when a gun is operated in the simulation by G1 and G2.
These settings affect the operation of the simulation, but not the downloaded work program

NOTE **Cautions for constant setting dialog box**

When closing and reopening the constant setting dialog box after making the settings, the setting values will be displayed. However, these settings are not the current setting values of robot, but are the last values input in the dialog box. When opening a constant setting dialog box after closing and reopening the work, no setting values will be displayed. Be careful in this situation, because the settings of items not input will be deleted if you click the Accept button without inputting values, or after inputting some items only. The Accept button should be clicked after filling out all items.
Please refer to the following clause on the info button to see the attribute values set on the currently selected robot.

## 4.5. Constant Setting Information

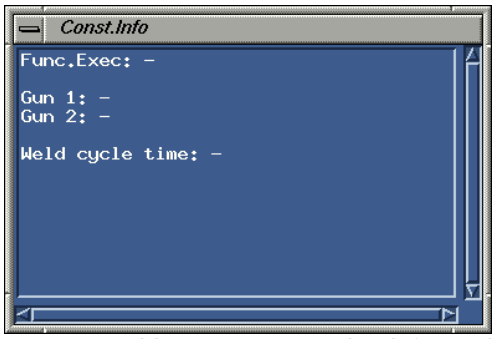



Figure 4.7 Watching constant setting information 1

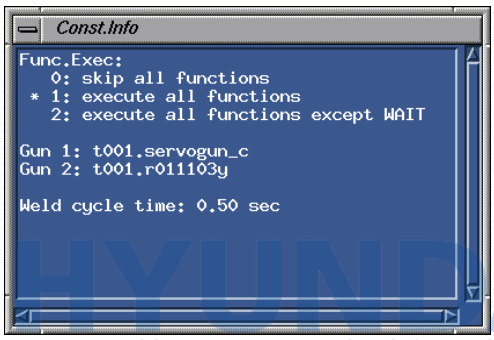



Figure 4.8 Watching constant setting information 2



When the [info] button of T/P is clicked, a window that shows the constant setting values of currently selected robot (Active Mechanism) will appear. (It will disappear if it is clicked again.)

In the event that no setting has been made, setting information will be displayed as shown in [Figure 4.8] after setting is done.

Only the last input values will be displayed in the dialog box that appears when the [Const] button is clicked, so these values might not be correct. Please refer to the setting values by using the [info] button.

## 4.6. Output Option Display Window and Output Option Control Unit

The output option display window can be used when it is set as a pneumatic gun, rather than a servo gun. It shows the output option setting state of the current step in a similar format to the actual T/P. The setting can be modified using the buttons of the output option control unit. Pressing each button toggles the option On or Off


Figure 4.9 Output option display window and control unit

NOTE **Default gun state setting**

If locations are being created for the first time and X1 or X2 has never been assigned in teach pendant, the gun state attribute has not been created. That is, the user has not specified whether the gun is OPEN or SEMIOPEN. In this case, what would happen when performing a simulation or download?

In this situation, the default gun state is applied.
Two basic attributes of DEFAULT_WELD_GUN_STATE and DEFAULT_VIA_GUN_STATE can be granted to the cell. (These attributes are created as soon as 『Weld_locs』 menu of ROBCAD/SPOT is selected.)
DEFAULT_WELD_GUN_STATE is used as the default for welding point locations, while DEFAULT_VIA_GUN_STATE is used as the default for pass point locations.
These attributes can be set by the Attribute Editor in tool box. A value of 2 refers to default SEMIOPEN(X1, X2), while a value of 3 refers to default OPEN (no X1, X2).

If there is no default gun state attribute existing in the cell, non-assigned locations will be set as OPEN.
Of course, once either the X1 or X2 button of teach pendant is used, the default value will be overridden.

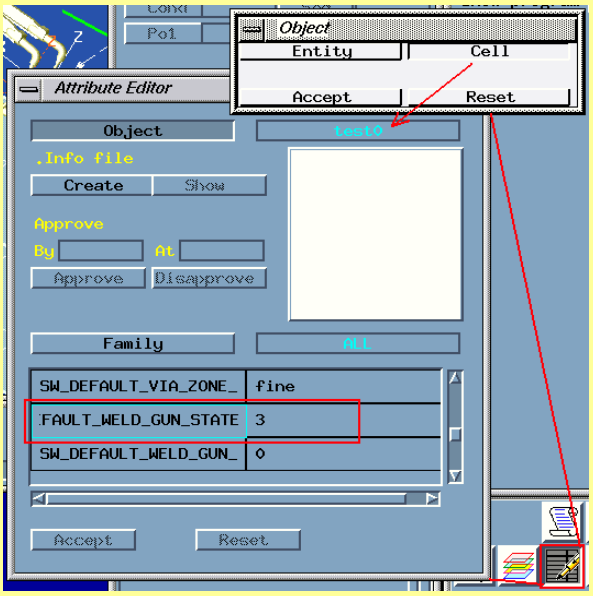



Figure 4.10 Attribute editor dialog box

## 4.7. Signal Input and Output Function Unit

There are 3 buttons, including D output, D input and G output. When a button is clicked, a dialog box will be displayed, as shown in Figure 4.11.

When Accept is clicked, signal input and output function code will be inserted to the current location.

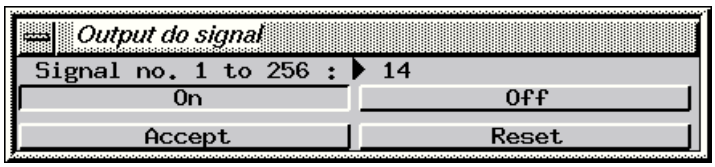



Figure 4.11 Signal input and output function dialog box

## 4.8. Flow Control and Other Function Units

Flow control functions such as GOTO and CVALL and other functions including GUNSEA and annotation can be input.

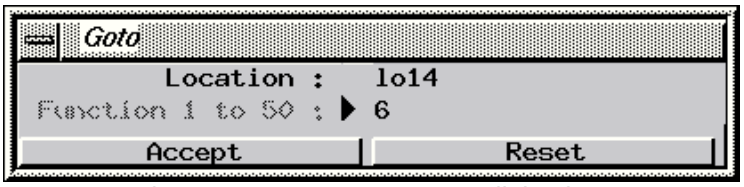



Figure 4.12 GOTO statement dialog box

NOTE **Branch address in ROBCAD**

Step number, function number and label are actually used in Hi5 controller as branch address, just like GOTO. On the other hand, location and function number are used in the ROBCAD simulation as branch address. Therefore, an appropriate conversion must be realized when uploading or downloading.

- Action of download module:
  Converts a location name into an appropriate step number by determining the nth location in a path
  Example: IF DI20=1 THEN lo7 → IF DI20=1 THEN S7
  Assigns an appropriate row number automatically on a corresponding location of the function, and converts the combination of the location name and function number into this row number
  Example: GOTO lo7,3 → GOTO 10

- Action of upload module:
  Converts step number into an appropriate location name by combining path name and number
  Example: IF DI20=1 THEN S7 → IF DI20=1 THEN hs165_005_7
  Converts row number into the combination of the location number and the function number of the corresponding location of the function.
  Example: GOTO 10 → GOTO lo7,3

- Action of simulation module:
  When executing CALL statement or JMPP statement, program number will be recognized in job {program No.} format to attempt branching.
  Example: CALL 2 → Branching to a path named “job2”

## 4.9. Function Move / Delete Unit


Figure 4.13 Function move/delete unit and function list dialog box

The '>' sign will be displayed to the left of one of the commands in the function list dialog box. This is a cursor pointing to the currently selected command, and when a function is entered, it will be inserted between this command and a command on the line above.

The [Top] button and [Bottom] button move the cursor to the first function and the last function in the current step, respectively. The [▲] button and [▼] button move the cursor to the previous function or the next function, respectively. The cursor can be moved with the [Line] button by inputting the function number directly. The [Delete] key deletes the selected function.

## 4.10. Collection of Function Commands

The operations that can be executed in a ROBCAD simulation are limited. Only some of the various HR-BASIC operations used in Hi5 controller are supported.

The list of supported functions is shown in [Table 4-2].

Table 4-2 Function command and the list of corresponding function codes

| Function | | Function command |
|---|---|---|
| **DO signal output (Digital Out)** | | DO?={1-0} |
| **GO signal output (Group Out)** | | GO?={0-255}<br>GO?={&B00000001-&B10000000} |
| **DI signal input (Digital Input)** | | WAIT DI?<br>WAIT DI?,{0-60.0},{loc}<br>WAIT DI?,{0-60.0},{loc},{func.no} |
| **Jump** | | GOTO {loc} [,{func no.}] |
| **Call** | | GOSUB {loc} [,{func no.}] |
| **Return** | | RETURN |
| **Program call** | | CALL {1-999} |
| **Program jump** | | JMPP {1-999} |
| **Robot stop** | | STOP |
| **Work end** | | END |
| **Conditional statement** | **Single IF** | IF DI?={0-1} THEN {loc.} [ELSE {loc.}]<br>IF GI?={0-255} THEN {loc.} [ELSE {loc.}]<br>IF _RN?={0-255} THEN {loc.} [ELSE {loc.}] |
| | **Complex IF** | IF DI?={0-1} THEN<br>{CALL statement} or {JMPP statement} or {DELAY statement} or {STOP statement} or {END statement}<br>ENDIF |
| | | OR, IF GI?={0-255} THEN<br>OR, IF _RN?={0-255} THEN |
| **Iteration statement** | **FOR ~NEXT** | FOR V{1-400}%={0-30000} TO {0-30000}<br>{step or functions}<br>NEXT |
| **Time delay** | | DELAY {1.0-60.0} |
| **Spot welding condition** | | SPOTCND {0-255} |

| Function | Function command |
|---|---|
| **Servo gun search** | GUNSEA {1-2},{1-2},{50-999} |
| **Retrieval register value setting** | _RN?={0-255} |
| **Retrieval register value increase** | _RN?=_RN?+1 |
| **Comment** | ' {comment} |

Unlike HR-BASIC, only CALL statement, JMPP statement, DELAY statement, STOP statement and END statement can be used in a complex IF block.
Only constant variable “V1%~V400%” can be used for an index variable of the FOR statement. Only a constant can be used for initial value and end value.
Another FOR~NEXT can be nested inside a FOR~NEXT, but no more than 4 layers can be nested in this manner

# 5

# Simulation of Work Program


Figure 5.1 Simulation menu

The Simulation Menu is used to execute a simulation of the work program written in ROBCAD for the purpose of checking interference or measuring cycle time.

[Figure 5.1] is the screen that is shown when the [Simulation] button of OLP is clicked. For simulation to be possible, 『Controller』 and 『Program』 must be selected, as in Figure 5.1.

When the [Init simulation] button is clicked, the simulation will be initialized. This means that the simulation will be returned to its initial state, so that it can be processed from the first step.

When the [Run] button is clicked, set program or simulation 1 cycle on path will be executed in the graphics window.

When the [Freeze] button is clicked, the simulation will be paused. When the [Run] button is clicked while the simulation is paused, the simulation will resume from the state in which it was paused. Use the [Init simulation] button if you want to restart the simulation from the first step.

By clicking the [Step] button, you can execute 1 step of the simulation only.

## 5.1. Signal Input and Output

To execute the simulation of signal input and output inside of ROBCAD, signals between various robots or devices should be defined in advance.

The SOP (Sequence of Operation) function of ROBCAD is used for executing the simulation of various robots or devices. Please refer to the ROBCAD manual or help file for details on using SOP.

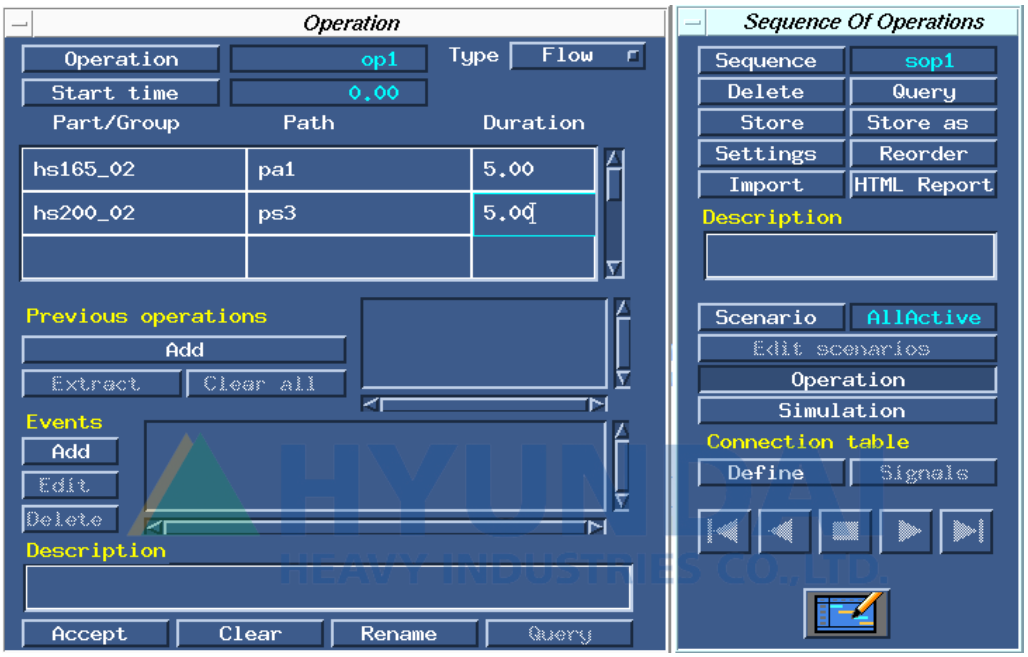



Figure 5.2 Sequence Of Operations menu

Open the SOP dialog box and create a new sequence and a new operation.

In the operation dialog box, select a robot from type list and add the robot and the corresponding path name inside the Procedure Matrix (A table in the middle) by selecting them with the mouse. Creation is completed by clicking Accept, and then clicking Confirm.

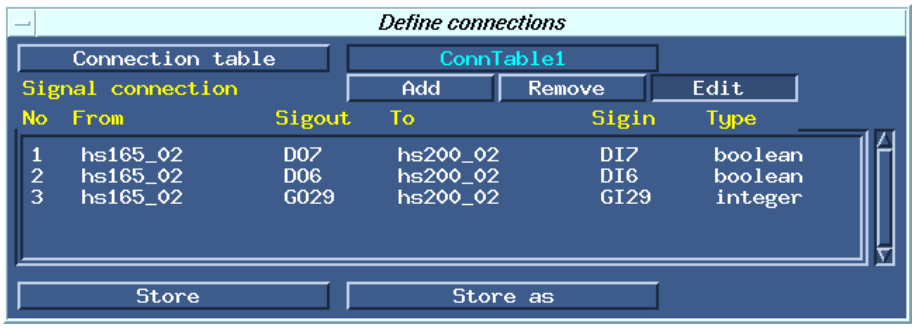



Figure 5.3 Define connections dialog box

Click the [Define] button of the Connection Table row to open the <Define connections> dialog box, then click the [Connection table] button to define a new table. Click the [Add] button continuously to define signal items.

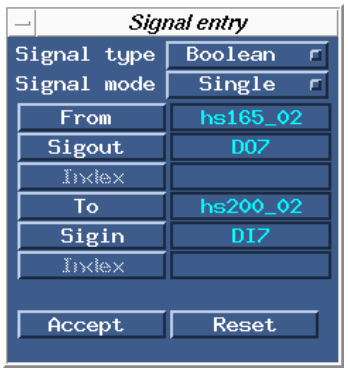



Figure 5.4 Example of defining a signal item

For example, when defining a signal item as shown in [Figure 5.4], DO7 signal of hs165_02 will be connected to DI7 of hs200_02. After the [Accept] button is clicked, the pair of signals defined in the connection table will be added.

The name of a signal should be a pair of DO/DI or a pair of GO/GI. Set Boolean for the signal type of DO/DI and Int for the signal type of GO/GI.

By clicking the [Simulation] button in the <Sequence Of Operations> menu, a dialog box will be displayed as shown in [Figure 5.5], and the simulation of sending and receiving signals can be executed by clicking the Play button.

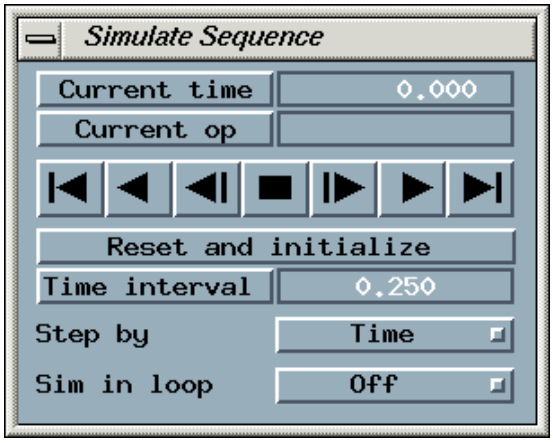



Figure 5.5 Simulate Sequence dialog box

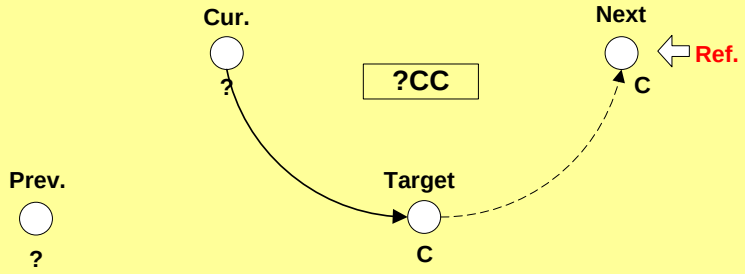
NOTE **Step button and accuracy**

If the step button is used to execute a single step of robot motion, the tool end will not stop precisely at the target location, and will stop at a distance (zone) of accuracy setting. For the tool end to stop precisely at the target location, the accuracy distance (or axis angle) should be set to 0.

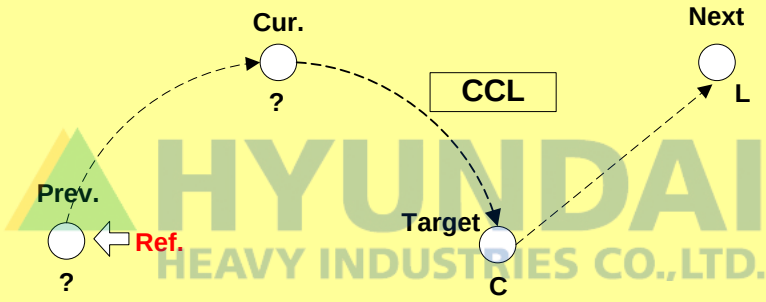
NOTE

## Simulation of circular arc interpolation

Circular arc interpolation of the Hi5 controller and the Hi5 OLP package will be executed using 2 rules.




Rule 1. If the next step of the target is C, use it as a reference point.






Rule 2. If the next step of target is not C, use the previous step as a reference point

※ If step1 is a circular arc interpolation and the robot tool end is located from a far distance, a motion error may occur while describing a very large circle.

※ If the target is the final step, the previous step will be set as a reference point.

## 5.2. RCS Simulation Error

During RCS simulation, an error message may appear. Error messages have the following format:

| |
|---|
| RRS ‘error(Error code) : Error message’ |

[Table 5-1] is a list of errors that can occur during RCS simulation.

Table 5-1 Available setting values for Func exec

| Error code | Error description |
|---|---|
| **-1** | Unsupported RCS service |
| **-48** | A memory problem has occurred when exchanging RCS input and output data with ROBCAD |
| **-51** | Some of the axis angles in the teaching step have gone beyond the range of the soft limit. |
| **-52** | Rectangular coordinates of teaching step have gone out of the motion range of the robot. |
| **-56** | The ROBOT.C01 file was not found, or the robot model name could not be obtained from the ROBOT.C01 file. |
| **-68** | An error from the calculation of motion has occurred while moving on the trace. |
| **-71** | Buffer full, or target point has been reached |
| **-76** | Has gone outside of the range of the soft limit while moving on the trace. |

# 6

# Downloading the Work Program


Figure 6.1 Download menu

The Download menu enables the conversion and saving of the work program written in ROBCAD into a type of text file, which can be read by the Hi5 controller in order to transfer the work program to the Hi5 controller.

[Figure 6.1] shows the [Download] button of OLP being clicked.

## 6.1. Creating the Work Program for Hi5 Controller

Set the file name to be created in <Local name>. The extension of ".JOB" will be automatically attached to the downloaded file. For example, the filename created if <Local name> is set to '0002,' as in Figure 6.2, is "0002.JOB".

If [Path out] is clicked without changing other settings, the list of paths existing on the current work cell will be displayed. Select a path to be downloaded by double-clicking it.

If there is no error on this path, it will be converted into a work file for the Hi5 controller and saved in the cell directory of current project, and its contents will be displayed in the window as shown in [Figure 6.2]. If there is error, the error message will be saved as "{Local name}.err," and its contents will be displayed in the window.

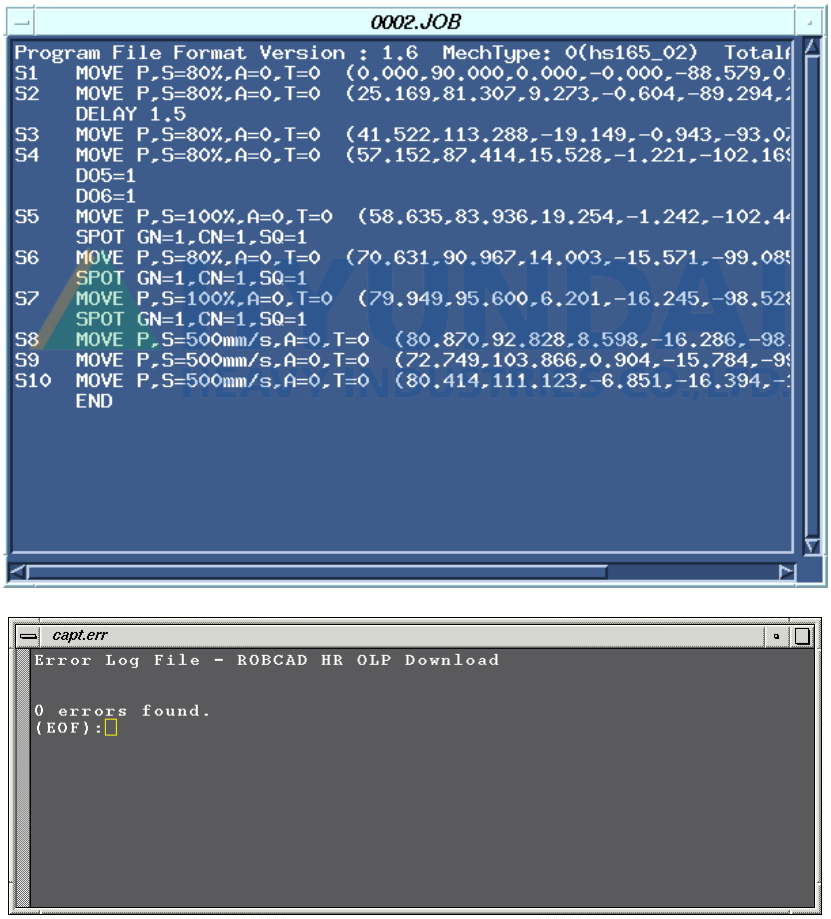



Figure 6.2 Result of downloading as work file for the Hi5 controller

All hidden pose data for each step will be output in the axis angle value.

Transfer the work file to the controller using HRView or USB. (Please refer to the Hi5 controller operating manual for information on how to conduct this process.)

NOTE **Automatic removal of welding point annotation**

ROBCAD/Spot attaches annotation such as 'Weld' or 'GunToState' to each welding point, and output of this annotation can be controlled by changing the value of the variable g_is_remove_spot_comment in front of hhi_hi5_rrs_download.awk.

g_is_remove_spot_comment = 1 → Automatically remove welding point annotations. (Default value)
g_is_remove_spot_comment = 0 → Do not automatically remove welding point annotations.

# 7

# Uploading the Work Program

The work file within the Hi5 controller also can be called to the path in the work cell of ROBCAD. The upload model of the Hi5 OLP package interprets the text file in Hi5 work program format, and uses it to create a path of the ROBCAD work cell.

The upload procedure is processed in the opposite direction of the download procedure.

Be cautious because any command (or grammar) on the work file that is not supported by the Hi5 OLP package is ignored during the simulation inside of ROBCAD.

## 7.1. Creation of Path


Figure 7.1 Upload menu

First, copy the work file of the Hi5 controller to be uploaded into the work cell directory of ROBCAD using HRView or USB. (Please refer to the Hi5 controller operation manual for more information on this process.)

[Figure 7.1] shows the [Upload] button of OLP being clicked. Click <Local name> first and select the work file to be called. Path and locations will be created in the work cell after you click <Program in>.

[Figure 7.2] shows a newly created path being confirmed by opening ROBCAD <Path Editor>.

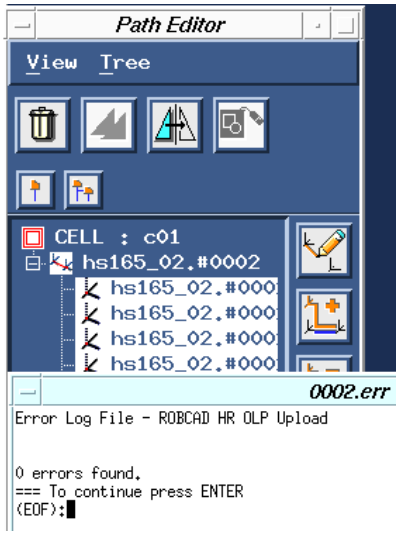



Figure 7.2 ROBCAD Path Editor

The name of the path and each location will be determined according to the following rules.

| | |
|---|---|
| **Path name** | {robot instance name}.#{file name} |
| **Location name** | {robot instance name}.#{file name}_l{step No.} |

For example, if the robot instance name is hs165_02 and the file name is 0002, the name of path will be “hs165_02.#0002” and the name of each location will be “hs165_02.#0002_l1”, “hs165_02.#0002_l2”, etc.

The upload model of Hi5 OLP package creates the step as a local location. From the example above, “hs165_02.#0002_l1” refers to a local location called “0002_l1” which falls under “hs165_02” robot component.

NOTE **Local location and global location**

A local location can be considered as an entity attached to a robot component. That is, if the location of the robot component to which a local location is attached is moved, the local location is also moved. On the other hand, global locations are not attached, and even if the location of a robot instance used for a teach global location is changed, the global location will not be moved.

If a global location is used, the robot position (configuration) will be changed whenever simulation or download is executed, so a difference between simulation and actual robot motion may occur. Therefore, if work is downloaded by using an actual robot controller, it might be better to execute the download after changing the global location to a local location by using the auto teach function of ROBCAD.

NOTE **Changing the name of a local path or local location**

If you change the name of a local location using “rename” in <Path Editor>, an error will occur in the local path. This is considered an error of ROBCAD option.
Names of local path and local locations can be changed by selecting the <Weld_locs> menu from ROBCAD/Spot, and clicking the [Rename] button in the <Locations> menu.

Enter a name of a location in the Location name field (or select a location with the mouse), input a new name in the New name field, and click [Accept] when the Rename dialog box is displayed.

## 7.2. Axis Angle Attribute

Encoder value or axis angle value is not saved when encoder-type step data are uploaded to the location of ROBCAD, and these values are saved after being converted into location/direction values. Therefore, the position of the robot at the time of simulating the uploaded program may differ from the position of the robot in actual movement. (This applies in the event that the location and direction of TCP are the same, but the position of the robot is different.)
To prevent this problem, axis angle of encoder type step data will be saved as a location attribute with the following name when uploading.

- HR_J_DEGS: Axis angle of basic 6-axis (degree)
- HR_EXT_J_DEGS: Axis location or angle of additional axis (mm or degree)

When executing a simulation for a location with an axis angle attribute, the simulation will be done in that axis angle.

Similarly, if downloading, a hidden pose encoder value of step will be created for a location with an axis angle attribute by referring that axis angle.

Be aware that even if location or direction of location is changed using methods such as shift, it will not be reflected to the axis angle attribute.

Click [Delete attr] button of the teach pendant, select “Hr_joint_val” and select locations or path (Deleting attribute of all locations inside of the path) for removing the axis angle attribute.

# 8 Using the Servo Gun

## 8.1. Defining the Servo Gun

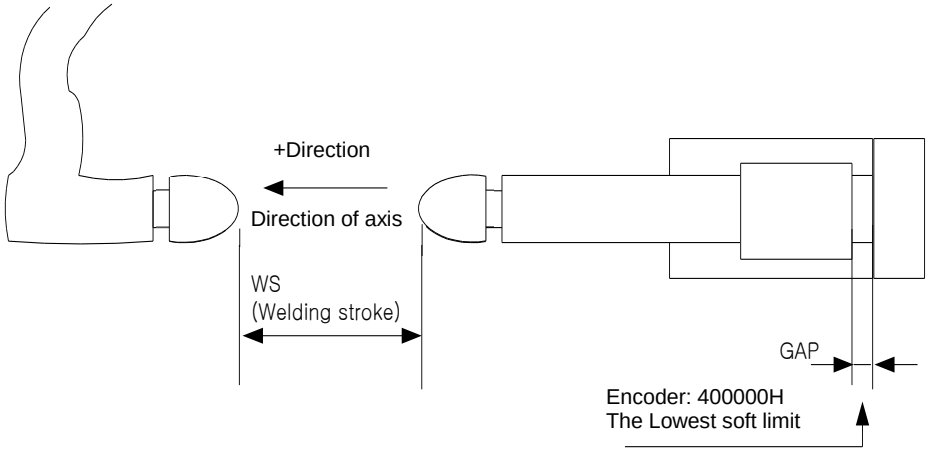



Figure 8.1 Welding stroke and axis constant setting

Axis constant setting (400000H) should be done in our servo gun system, with the position of drive unit reversed to the greatest extent possible, as shown in [Figure 8.1].

Our system has a maximum marginal distance of 10mm to the reverse direction, as shown in Figure 8.2. This value may vary depending on manufacturers.

Therefore, when defining servo gun in ROBCAD, it should be defined according to the rules below.

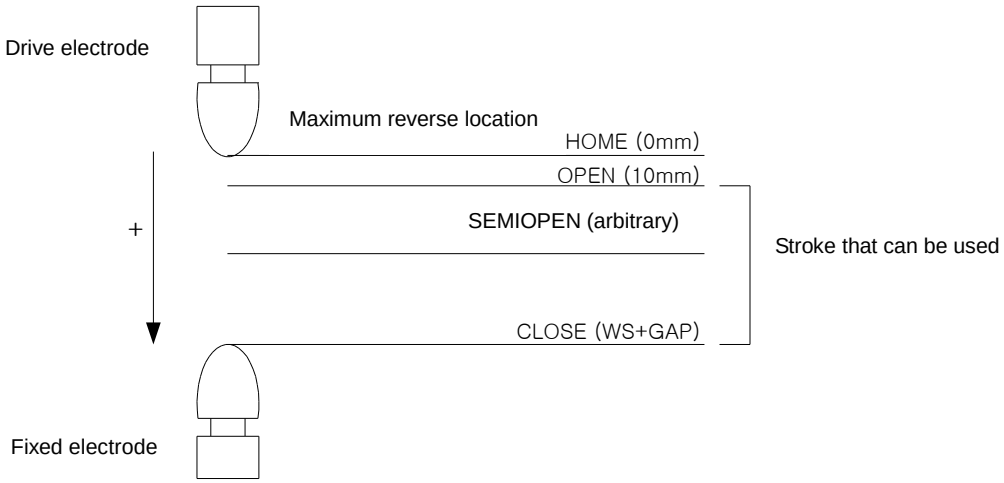



Figure 8.2 Defining locations of servo gun

## 8.2. Registering External Axis

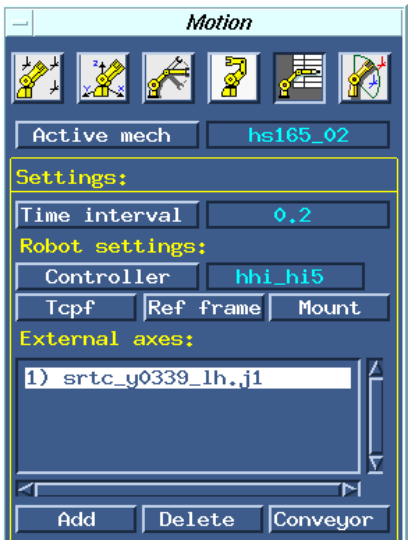



Figure 8.3 Registering servo gun axis as an external axis

To use the servo gun, the servo gun axis should first be registered as an external axis of <Active mechanism>. Click the [Add] button and select servo gun axis mounted as external axis of robot under the <Settings> tab in the motion dialog box, as shown in [Figure 8.3].

Teach pendant determines the external axis number of servo gun and determines whether it is a servo gun or not by comparing the gun name set by the user clicking the [Const] button and the external axis. The sequence of registering the external axis should be the same as the sequence of registering for a gun that is registered from Const.

NOTE **Local location and global location**

The Hi5 controller can control up to 6 external axes. External axes should be registered in the following order.
1) Drive, 2) Servo gun1, 3) Servo gun2, 4) Jig

These axes can be used provided that correct order is used. For example, if there is no drive axis, external 1 axis will be started from servo gun.

## 8.3. Servo Gun Welding Function of Teach Pendant


Figure 8.4 Servo gun welding function of teach pendant

There is a user interface for servo gun welding inside of the teach pendant, as shown in [Figure 8.4]. If servo gun axis is not assigned as an external axis, <Air Gun> (meaning pneumatic gun) will be displayed instead of <Servo Gun>. Buttons related to the servo gun can be used only when servo gun is assigned.

The presence of the welding point and gun number can be selected by clicking the [Weld] button. 3 parameters should be set for servo gun welding, including gun number, welding condition number and welding sequence number. These 3 parameters can be set by using [Weld], [Cond] and [Seq] button of the teach pendant. When [Weld] button is set to Welding Off, [Cond] and [Seq] buttons cannot be used.

Servo gun can be set to be spread to “OPEN” or “SEMIOPEN” location by using [po1] and [po2] button. Of course, this setting is possible on pass points, not welding points. For example, if the current step is a welding point of Gun 2, [po1] can be set to “OPEN” or “SEMIOPEN”, but [po2] button cannot be used.

## 8.4. Assigning an External Axis Value to the Location

Control of the servo gun actually means control of the external axis, so each location should be “Compound”. However “ROBCAD/SPOT” doesn’t create “Compound” locations by classifying cases of servo gun welding separately.
Therefore, a user should assign an external axis value to a normal location created at “ROBCAD/SPOT” by using the [Update] button shown in [Figure 8.5]. ([Remove ext.] button is used for deleting assigned external axis value.)


Figure 8.5 Compound function of Move commands tab in Motion dialog box

It is very difficult for a user to process this work for a large number of locations separately. Therefore, teach pendant of Hi5 OLP package enables this process to be performed automatically.


Figure 8.6 External axis automatic assign function of “servo gun welding” (Make ext. pose)

By clicking the [Make ext. pose] button shown in [Figure 8.6], a dialog box that accepts path or locations will be displayed.

When selecting a welding path, an external axis value will be assigned to all locations of the corresponding path according to the rules below. In addition, external axis values can be assigned exclusively to specific locations by selecting these locations.

- For welding points, an external axis value will be assigned to the welding gun as a pose value, which is defined as “CLOSE”.
- For pass points, the external axis value will be assigned to the welding gun as a pose value, which is defined as “OPEN” or “SEMICLOSE” depending on the “po1”, “po2” setting.

Servo gun axis value of each location is redefined according to the rules above whenever selecting [Make ext. pose] button.

## 8.5. Simulation

Before executing simulation, assign an external axis by using the external axis automatic assign function.

Simulation will be executed in a simplified manner compared to actual servo gun operation. The characteristics of simulation motion that are different from actual operation are as follows.

- 2 parameters, including welding condition number and welding sequence number, do not have any effect on simulation action.

## 8.6. Download and Upload

Before executing a download, assign an external axis with the external axis automatic assign function (external axis automatic assign function).

When executing a download, servo gun welding points will receive spot function as the first function, and gun number, welding condition number and welding sequence number set by teach pendant will be reflected as parameter of spot function.

On the other hand, upload identifies servo gun welding points and parameters as spot function.

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