WARNING

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

Hyundai Robot

Hi4aOL071001FMEN3

Hi4a Controller Function Manual

ROBCAD OLP

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1 Overview

1. Overview

Robot teaching of traditional teaching-and-playback type is done after completing all of the design of workcell, the manufacturing of jig & gun and the installation. Therefore, if the problem of the interference by jig on teaching stage is occurred, redesign jig or gun or reinstall it changing the position of robot. It causes consuming more working hours.

At the stage of designing workcell including the robot by workstation or PC, OLP(Off-Line Programming) performs the procedure in advance such as Robot Working Plan, Simulation, Interference Check, Cycle Time Measuring & Optimization etc through three dimensional(3D) cyber environment. And as moving it to the controller by creating Robot Working Program, this is the Teaching type which makes up for the weakness of Teaching-Playback type. For S/W used by the performance of these procedure, it is named as CAR(Computer-Aided Robotics) Tool or CAPE(Computer-Aided Production Engineering) Tool.

As the commercial CAR Tool supporting current various controller, the products such as ROBCAD, IGRIP, and Workspace etc. is used in the industrial field. OLP package which is S/W module is needed in order that these products perform OLP procedure of certain robot. OLP package performs actions such as simulating robot controller not to mention 3D model of related robot and outputting working program fitting in Use Type.

1.1. Introduction of Hi4a OLP Package

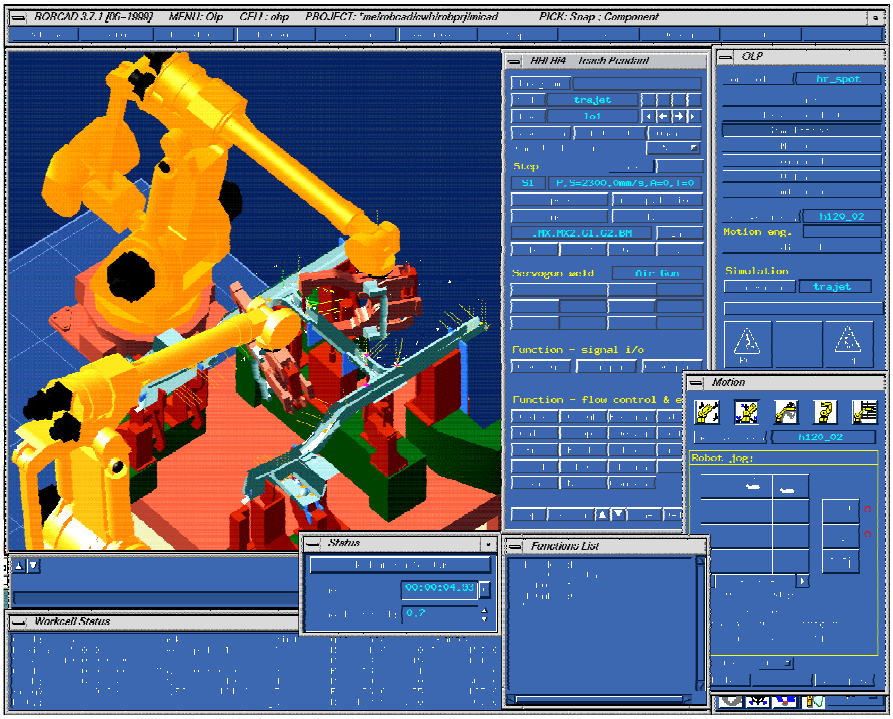


Figure 1.1 ROBCAD Environment & Use of *Hi4a OLP Package*

This is the set of software performing simulation and off-line Teaching of robot spot welding working using Hi4a controller at ROBCAD. *Hi4a OLP Package* has the characteristic which is the same as Table 1-1.

Table 1-1 Characteristic of *Hi4a OLP Package*

Infra OLP S/W	Tecnomatix em-Power (ROBCAD) v7.1.2 (For PC)
Support Controller	Hi4a Controller
Support Robot Body	HD165-00, HR006, HR010L01, HR015, HR030L01, HR050-01, HR120, HR120S02, HR130-02, HR150, HR150S02, HR165-02, HX130-02, HX165-02/04, HX165S00, HX200-00, HX200L00, HX200S00, HX300-02
Main Application Field	Spot Welding & Handling
Motion Simulation Process	RCS Module

1.2. Configuration of Hi4a OLP Package

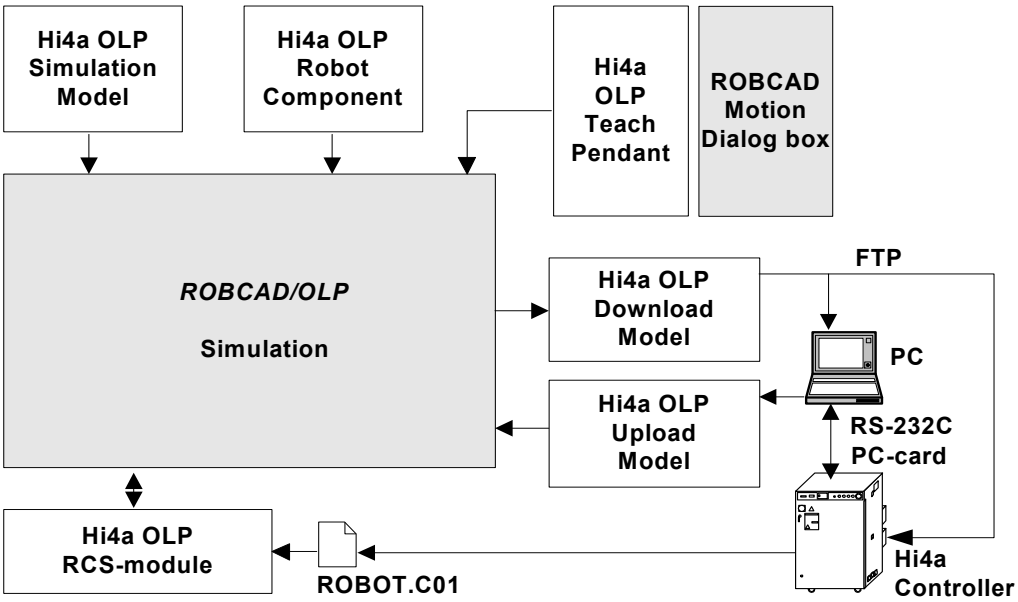


Figure 1.2 Configuration of *Hi4a OLP Package*

Hi4a OLP Package is composed by the same various components as Figure 1-2. The role of each component are the same as below,

Table 1-2 Components of *Hi4a OLP Package*

Component	Role
Teaching Pendant	In/output of step parameter & function command language about each location.
Simulation Model	Simulate the robot motion by the same type as step of Hi4a controller, function analysis and performance when simulating robot working.
Download Model	Convert the robot working passing adjustment and confirmation by simulation as working program type for Hi4a Controller.
Upload Model	Convert the working program existed in Hi4a Controller as the path in workcell of ROBCAD.
Robot Component	Use them for operation creation and simulation by importing CAD data defining the shape of robot and kinematics and the workcell of ROBCAD.
RCS-module	Calculate the robot trajectory when simulating motion movement of Hi4a Controller.

1.3. Preparation

To perform Teaching for spot welding working using *Hi4a OLP Package*, the environment should be the same as below,

Table 1-3 Environment to use *Hi4a OLP Package*

ROBCAD	eM-Workplace (Robcad) for PC (Over Version 7.1.2) Necessary modules for operation including /BASE, /SPOT, /OLP.
Hi4a Controller	Over main ROM v10.0 When connecting workstation by FTP ➔ LAN card is necessary, & over mv10.07-07
Robot Body	See Table 1-1 Support Robot Body
PC	Over Pentium 4, Windows 2000, XP
HRView	Over v1.28, RS-232C connection cable (SRAM card compatible with Hi4a controller)

To use *Hi4a OLP Package*, the knowledge is necessary as below,

- Understanding about spot welding robot use
- Understanding about Off-Line Programming
- Control Method of Hi4a Controller
- Use Method of ROBCAD/BASE & /SPOT

2

Installation of Working Environment

2.1. Hardware Environment Installation

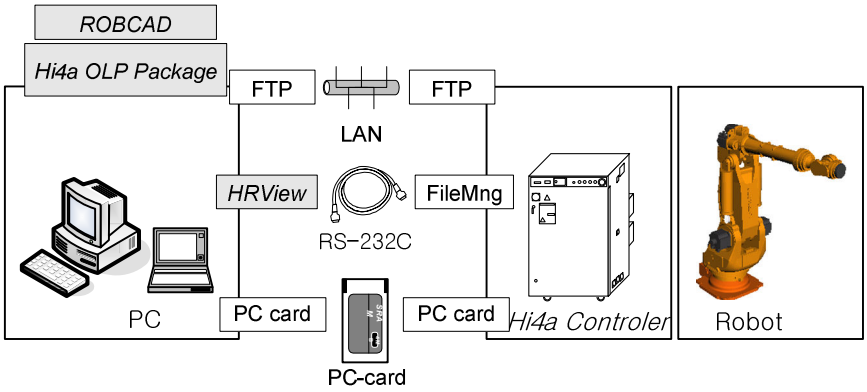


Figure 2.1 Hardware Configuration of *Hi4a OLP Package* Use

Figure 2-1 shows Hardware configuration used for Robot Teaching using *Hi4a OLP Package.* It moves The work program created through the simulation run on a desktop or laptop PC with ROBCAD installed, is transferred to Hi4a controller. Current Hi4a Controller supports PC-card of PCMCIA type and two media of RS-232C. (Over mv10.07-07, FTP is supplied.)

If you use RS-232C, a laptop or desktop should be installed in the field and it can connect the controller by RS-232C.

If you use PC-card, a laptop or desktop should have PCMCIA socket.

If the controller and the PC are directly connected with Ethernet, you can directly use the FTP command from the FTP client program and command prompt to transfer the work program to Hi4a controller.

2.2. Installation of Hi4a OLP Package

Hi4a OLP Package is not included in ROBCAD Package basically and it should be installed by manual. Please follow the procedure as below,

First of all, log in as super user account.
Table 2-1 shows the directory of list of file composing Hi4a OLP Package and its position. Copy the files and make it same as Table 2-1.

Table 2-1 File List & Directory

Directory	File	Note
$(ROBCAD)/dat/olp/hhi_hi4_rrs/	hhi_hi4_rrs.apg hhi_hi4_rrs.sim	control files
	hhi_hi4_rrs _upload.awk hhi_hi4_rrs _download.awk hhi_hi4_rrs _sim.awk	awk files
	hhi_hi4_rrs.copy hhi_hi4_rrs.query hhi_hi4_rrs.lang	etc.
$(ROBCAD)/bin/	hhi_hi4_rrs_attr	T/P Run file
$(ROBCAD)/rrs_bin/hr1.0/	rrs.ver rcshr01	RCS Module
$(ROBCAD)/dat/	hhi_hi4_rrs.uid hhi_hi4_rrs.scan hhi_hi4_rrs _items_map	T/P user interface
	hhi_hi4_rrs.cnf hhi_hi4_rrs.err	etc.
$(ROBCAD)/Libraries/ROBOTS_HYUNDAI/hx165_04.co/ The same as other robots …	.atr .geo .gm .gmnw .gmapprox .gri .info .m .r .sy .wm	robot component

- $(ROBCAD) refers to the directly where eM-Workplace is installed.
- If necessary, create each directory and install them.

2.3. Registration

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

Insert below bold characters' items in proper position.

```
################ Controllers ################
hhi_Hi4a                          hhi_hi4_attr_rrs
hhi_hi4_OLP_CONT_SUFFIX     Hi4a
hhi_hi4_OLP_CONTROL_DIR     /usr/local/robcad/dat/olp/hhi_hi4_rrs

################ OLP-Controllers : Popup
olpcont47                         hhi_hi4_rrs
```

The details set by these items are the same as Table 2-2.

Table 2-2 Setting details of .robcad file items

hhi_hi4_rrs	Teaching Pendant Run File (Path of $ROBCAD/bin Standard)
hhi_hi4_OLP_CONT_SUFFIX	Extension when doing up/download
hhi_hi4_OLP_CONTROL_DIR	Position of controller model
olpcont47	Menu items when selecting controller

The number-47 at menu item olpcont47 is decided by the user's ROBCAD environment.
For example, if olpcont is existed up to 40, you can use 41.

NOTE **system-default .robcad file and.robcad file for specific project**

As is explained above, editing .robcad file (system-default .robcad file) located in /usr/local/robcad/dat/, this settings are applied equally to all ROBCAD users of system. Therefore, all ROBCAD users can use Hi4a OLP Package.

If you want to configure the setting for a specific project, copy the .robcad file to the directory of the project and edit the file. You can delete all other items except the edited item of (private .robcad file).

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

Please insert below items in proper position. This is additionally used attributes in Hi4a OLP Package except basic attribute of ROBCAD OLP.

```
# Hi4a 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

Hi4a OLP Package has counterfeiting prevention. After installing, you can use it by inputting license code which fits to the system. If you don't input license, you can run Hi4a Teach Pendant in ROBCAD/OLP and the message appears on terminal window as below,

```
< /usr/home/robcad/jigman/ > robcad
ERROR: /usr/local/robcad/dat/olp/hhi_hi4/hhi_hi4.lic could not be opened.
system code(08:00:69:08:a2:a3)
```

"08:00:69:08:a2:a3" outputted on the message is the system code of workstation installing *Hi4a OLP Package.* (This code is different from system.)

Inform this system code to OLP Package supplier and request license code. The supplier will make the file naming hhi_hi4.lic which fits to system code. Details of this file are the same type as below example.

```
506242
20050930
```

The first line is license code and the second line is the date closing this license (2005-SEP-30). (If the date is 0, it means license is unlimited as long as not closing.) When you change the details of file, you should be careful because the license is invalid.

Copy hhi_hi4_rrs.lic file on $ROBCAD/dat/olp/hhi_hi4_rrs/ directory. From now on, Hi4a will be RUN normally. If not, check the message on terminal window. It might be a case that is wrong transferring code between user and supplier or is closing of license.

NOTE **System Code**

The system code of 08:00:69:08:a2:a3 type is MAC address of Ethernet card. Therefore, you can not get the license from the system that Ethernet card is not mounted.

Now the installation of *Hi4a OLP Package* is completed. Log out at super user account.

3

Configuration of Workcell Including Robot

- Directory layer to be mentioned as below can be different from the environment settings of the user.
  For example, call c01 workcell of x_prj project and arrange HR120 robot.
  After selecting <Browse Project Tree> on Robcad – Project menu, select x_prj. After selecting Layout on menu window of the upper screen, press load cell on layout menu which appears the right side of screen and select c01 workcell.

3.1. Importing Robot

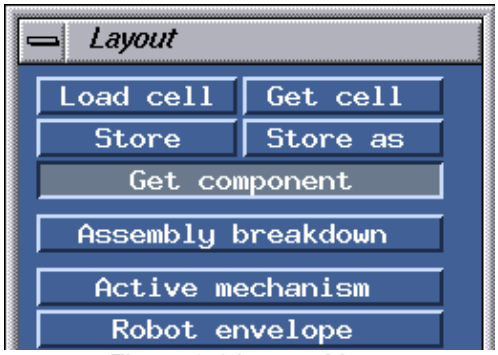


Figure 3.1 Layout Menu

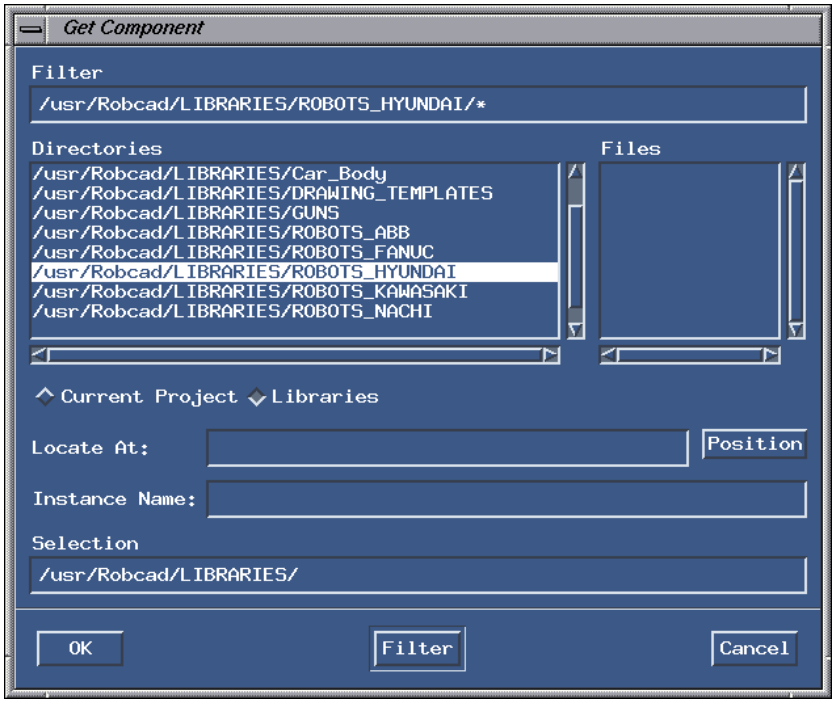


Figure 3.2 Libraries Browser

Pressing current library, you can view the dialog box which is the same as Figure 3-2. And select ROBOTS_HYUNDAI on directories list box. The same as Figure 3-1, current library will be set up as ROBOTS_ HYUNDAI.

Now, press Get component, select hr120, set up the position, direction and instant name if necessary, and then press Accept. Robot on workcell of graphics window will appear.

3.2. Installation of Welding GUN & Selection of Tool Frame

Select library again and import proper welding GUN component. And mount GUN on the robot.

As step parameter, Hi4a controller can designate tool number of 0 to 15. In simulation, you should apply the fitting tool constant according to tool number parameter of each step. Because of that, you should designate it in advance that a certain device corresponds to the certain tool number. Therefore, at the end of the toll of device of used tool number, the frame of name to fit decided type should be attached. See Table 3-1 for the type.

Table 3-1 Type of frame to attach at the end of tool

Tool No.	Frame Name
T0	{robot Instant Name}_tcpf0
T1	{robot Instant Name }_tcpf1
…	…
T15	{robot Instant Name }_tcpf15

For example, to apply cross jog of number 0 tool standard as robot instant name is hr120 or to simulate the working program using number 0 tool, the frame naming hr120_tcpf0 should be attached at the end of related tool.

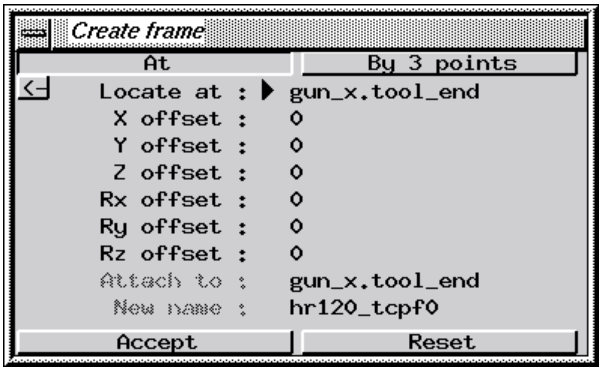


Figure 3.3 Create frame dialog box

On layout menu, press Create frame and then Create frame appears. The same as Figure 3-3, designate tool-end entity on Locate at & Attach to items and designate the name of type decided on new name and then press Accept. If the direction of created frame is wrong, you can change the direction as Place Editor of ROBCAD.

When teaching the location on motion dialog box, press settings tap of motion dialog box which is the same as Figure 3-4 to teaching it to the position of created frame, and then input the created frame name on the dialog box shown as Figure 3-5,

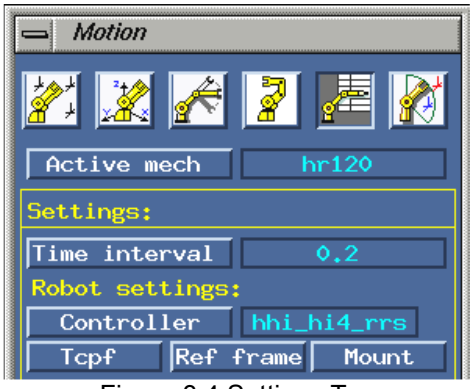


Figure 3.4 Settings Tap

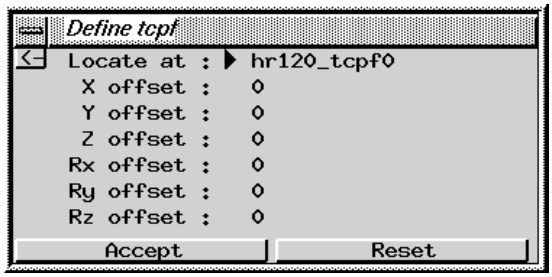


Figure 3.5 Tcpf Designation

3.3. Creation of Welding Gun Pose

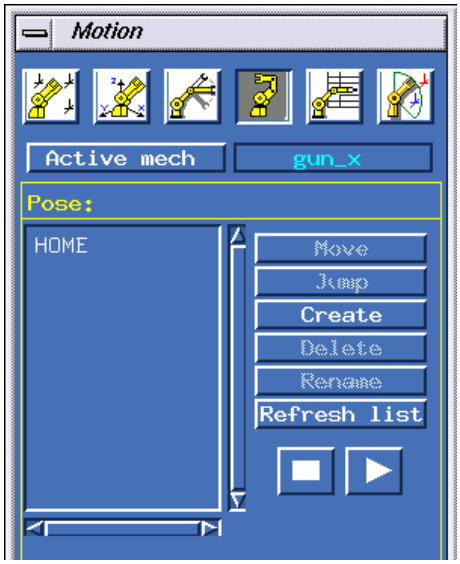


Figure 3.6 Pose Tap of Motion Dialog Box

Figure 3.7 The state defining welding GUN Pose

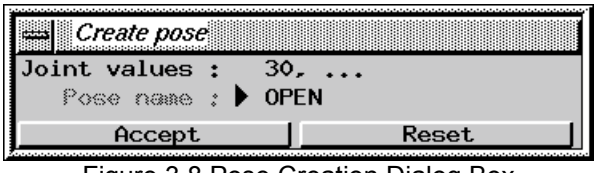


Figure 3.8 Pose Creation Dialog Box

Welding GUN should define the each pressure and open state as pose. If the welding GUN is two layers' GUN, you should define the state that applies MX signal.

Open Motion dialog box and click active mech button and then select welding GUN.
Clicking pose tap of motion dialog box, it turns out the state which is the same Figure 3-6. Defined poses are arranged in the list box and at the example of figure, this is the state that single pose which is HOME is defined. If you click create button, the dialog box the same as Figure 3-8 and you should input poses here. For unit, it is degree in case of general X and it is mm in case of C GUN. Three pose of Table 3-2 should be created.

Table 3-2 Welding GUN Pose

Pose Name	Explanation
CLOSE	The state GUN is closed (Pressure State)
SEMIOPEN	The state GUN is opened narrowly - Two layers' GUN applied only. - Small Open (MX On)
OPEN	The state GUN is opened widely (Great Open)

When completing necessary pose creation, it turns out the state the same as Figure 3-7.

3.4. Controller Selection of Hi4a OLP Package

Select OLP command on Robcad menu. OLP item will appear at the menu window of upper part.

Select OLP items of menu window, OLP menu at the right side of screen will appear.
On OLP menu, select controller and pop-up window listing the name of selecting controller will appear.
And then select hhi_hi4_rrs between items.

3.5. Settings related to Robot Body & .sy File

- .sy file is the text file containing few settings related to robot body.
- /usr/ Robcad/ LIBRARIES/ ROBOTS_HYUNDAI/ hr120.co directory has default .sy file and its details are as below,

```
ZERO_POSITION   0.0   90.0   0.0   0.0   0.0   0.0
OFFSETS   4194304   4194304   4194304   4194304   4194304   4194304
FACTORS   -200524.0238   183835.4184   -183835.4184
              -150849.3469   -154630.359   94786.06326
INTERFERENCE   -1   0.0125   -0.017351947   0.015350877

ROBOT_TYPE_FIELDS   21d4   0001   0000

EXT_ZERO_POSITION
EXT_OFFSETS
EXT_FACTORS
EXT_TYPES

CLEARENCE
```

- The meaning of each item is the same as Table 3-3.

Table 3-3 Meaning of each item of .sy file

Item	Meaning
ZERO_POSITION	Standard Axis Coordinate
OFFSETS	Axis Constant
FACTORS	(Bit Constant)-1
INTERFERENCE	Interference factor between axes (V-H, B-R2, R1-R2, R1-B)
ROBOT_TYPE_FIELDS	Robot Type
EXT_ZERO_POSITION	Standard Axis Coordinate of additional axis
EXT_OFFSETS	Axis Constant of additional axis
EXT_FACTORS	(Bit Constant)-1 of additional axis
EXT_TYPES	Tyoe of additional axis. It is sliding axis if you designate it as prism, and it is rotation axis if you designate it as rot.

Values are arranged by dividing the spaces more than 1 unit. If the values of 6 units are arranged, each of them is the order of S, H, V, R2, B, R1 axes. FACTORS and EXT_FACTORS are arranged by two lines per three axes of a line. Bit values are all decimal.

NOTE **How to calculate EXT_FACTORS (Bit Constant of additional axis–1)**

※ Bit Constant = (movement amount per a cycle of motor) / (bit resolution per a cycle of motor)

Bit resolution per a cycle of motor of Hi4a controller is fixed as 8192[bit/rev].
■ Example of rotation axis
In case of the rotation axis directly connected to gear ratio 100:1,
100 × 8192 / (2π) = 130379.7294 bit/rad
■ Example of right coaxial
In case of the right coaxial composed by pinion of diameter 100mm and rack,
8192 / (100π) = 26.07594588 bit/mm

In case of standard axis angle, interference factor between axes, and robot type, it has a few chance to change, however, the value of other items will be diversified by installation type of robot. If you need to adjust the value, you should not adjust .sy file directly. Because default .sy file is applied to all workcell of all used project by importing related robot, you should not adjust it optionally.

ROBCAD searches .sy file first having robot instant name on workcell directory and then applies it. If there is no such file, you should apply it searching default .sy file at library directory. Therefore, it makes a copy on workcell as the file of instant name of the robot used for workcell. And then you can apply wanted settings by adjusting the copy.

For example,

```
< 2 sgi0 /usr/home/robcad/jigman/x_prj/c01.ce >
cp   /usr/Robcad/LIBRARIES/ROBOTS_HYUNDAI/.sy   hr120. sy   ↵
< 3 sgi0 /usr/home/robcad/jigman/x_prj/c01.ce >vi   hr120.sy   ↵(Or change to Notepad)
```

In case additional axis is used for robot, the value should be arranged the same number of as each additional axis number in four items related to additional axis. If the number is wrong, error is occurred when downloading.

Next, this is the example of .sy file for the robot (therefore, 3879070(dec) is set on the axis constant of S axis) installed by applying two sliding axes, adjusting constant of S axis as -90.

```
ZERO_POSITION   0.0   90.0   0.0   0.0   0.0   0.0
OFFSETS   3879070   4194304   4194304   4194304   4194304   4194304
FACTORS   -200524.0238   183835.4184   -183835.4184
              -150849.3469   -154630.359   94786.06326
INTERFERENCE   -1   0.0125   -0.017351947   0.015350877

ROBOT_TYPE_FIELDS   21d4   0001   0000

EXT_ZERO_POSITION   0.0   0.0
EXT_OFFSETS   4194304   4194304
EXT_FACTORS   -154630.359   94786.06326
EXT_TYPES   prism   prism
```

3.6. ROBOT.C01 File

To perform the accurate simulation the same as the actual, RCS module needs ROBOT.C01 file (mechanical constant that robot parameter of Hi4a controller is saved.) actually to be used. Please move ROBOT.C01 file saved in Hi4a controller to below directory using HRView, PC card, or FTP.

```
/workcell path/instance name_rrs/
```

For example, the directory is the same as below,

```
/usr/home/robcad/jigman/x_prj/c01.ce/hr120_rrs/
```

At the same directory, create the file the same as below as the name of .rrs.

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

.rrs file plays a role that it notifies the location of RCS module and ROBOT.C01 file to ROBCAD.

4

Use of Teach Pendant

Teach Pendant is the dialog box to perform the input & editing of step parameter and function command language about each location. Teach Pendant of Hi4a OLP Package is possible to input functions performing step parameter adjustment, branch or call and I/O of speed, interpolation type, and welding treatment used in actual Hi4a controller.
For calling Teach Pendant, select Teaching Pendant additional menu of OLP menu.

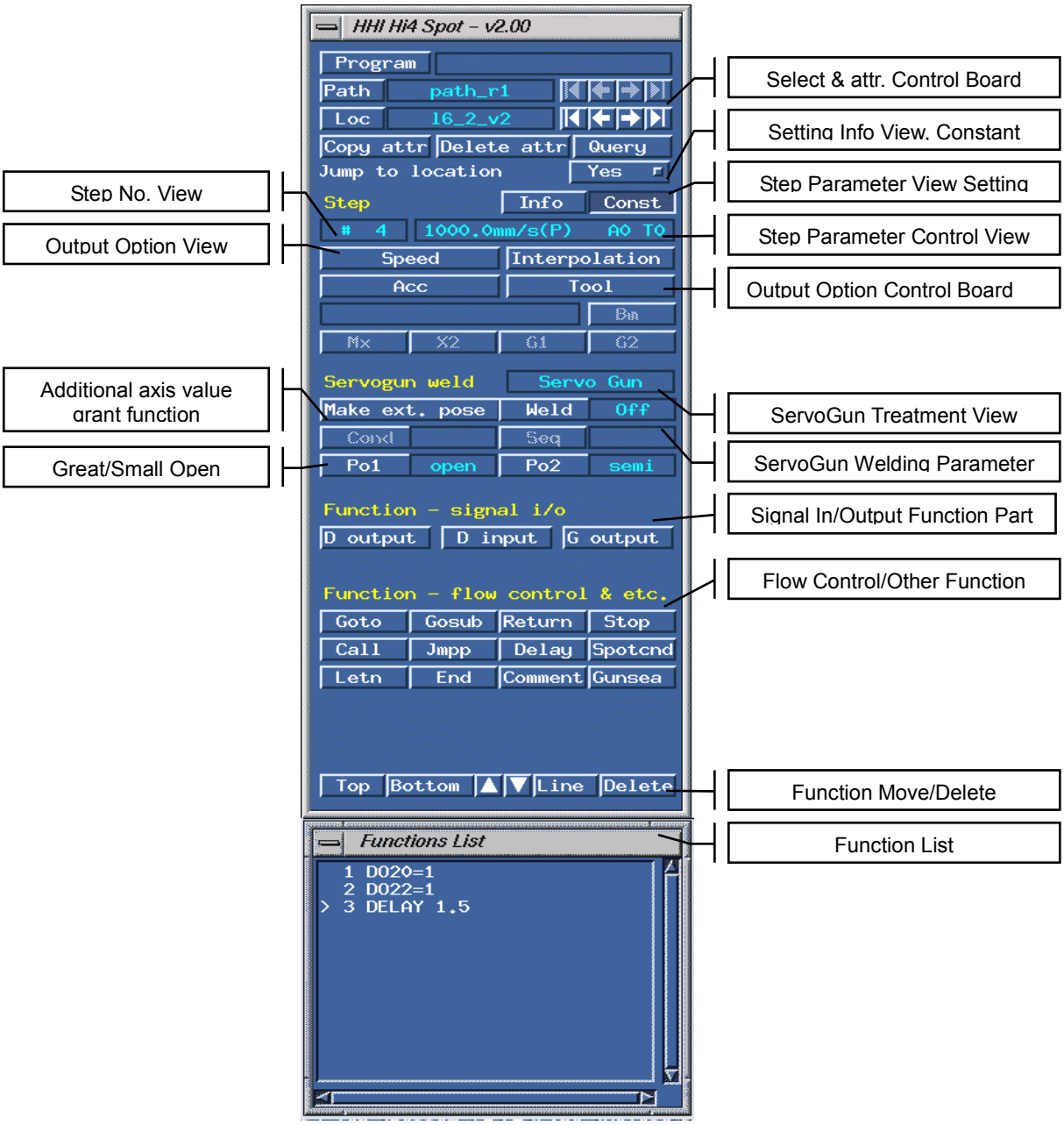


Figure 4.1 Teach Pendant of Hi4a OLP Package

4.1. Select & Attribute Control Board

Figure 4.2 Select & Attribute Control Board

Select program, path or location. After selecting location first, you can edit selected location. After pressing location button, select wanted path of graphics window or location directly with clicking mouse. Or, you can move it forward or backward using arrow button.

If Jump to location is set as Yes, the current selection in graphics window is moved to follow it when moving forward or backward.

Copy attr is the function which copies the attribute of wanted type of single location to multiple locations. Delete attr is the function which deletes attribute of wanted type about multiple locations.

Query is the function which shows the state of attribute setting per step as distinguishable color. In Query dialog box, press Query button, select wanted attribute, and then each value of corresponding attribute appears in dialog box as distinguishable color and locations of graphics window are distinguished by color and marked.

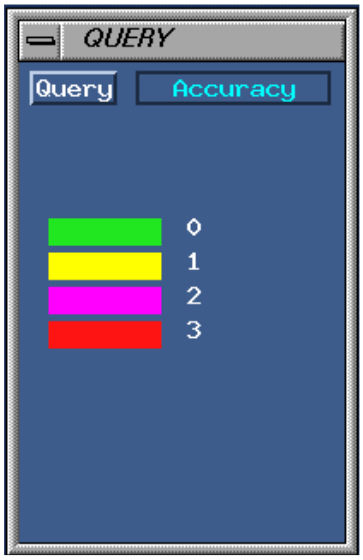


Figure 4.3 QUERY Dialog Box

4.2. Step No. View Window & Step Parameter View Window

This marks current selected number of step. In Hi4a controller, step number is marked on each Teaching point, however, the location named optionally is corresponded on Teaching point. Hi4a OLP Package decides step number corresponded to certain location is located in which order of path and shows it. For example, if it is the fifth location of path, it is treated as step 5.

Step parameter view window shows current setting value of four-unit step parameters of speed, interpolation, accuracy, and tool as the type similar to actual T/P.

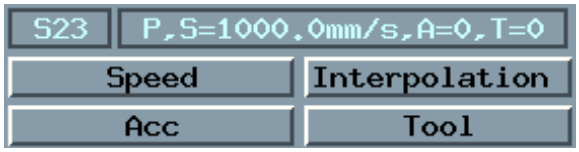


Figure 4.4 Step No. View Window, Step Parameter & Control Board

4.3. Control Board of Step Parameter

Step parameter control board is used for adjusting 4-unit step parameter.
You can select Interpolation, accuracy, and tool through pop-up menu, and input speed through the dialog box as below. You can input it as %, mm/sec or sec unit.

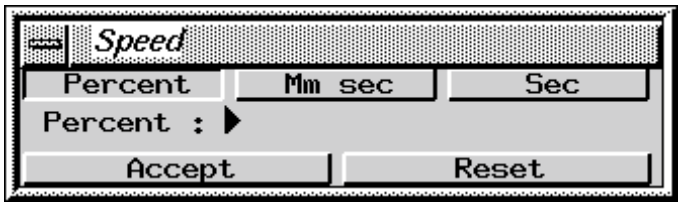


Figure 4.5 Speed Parameter Dialog Box

4.4. Constant Setting

In the state of setting Active Mechanism, press Const button of T/P, and then constant setting dialog box appears for inputting few attributes to set on current selected Active Mechanism.

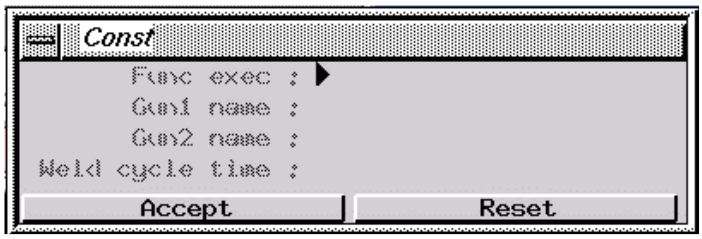


Figure 4.6 Constant Setting Dialog Box

Func exec sets up as Table 4-1 that decides to perform the function existed in each step when performing simulation.

Table 4-1 Setting value available on Func exec

Setting Value	Explanation
0	Not perform all functions. (ServoGun motion is a function but it is exceptional.)
1	Perform all functions.
2	Perform all functions except WAIT (DI Signal Waiting) Function.

Gun1 and Gun2 set up for which device should be operated by step parameter G1 and G2 when performing simulation. You can set it up by clicking the device at graphics window and you should set up as many as the number of Gun.

Weld cycle time sets up the welding time when GUN motion is performed by G1 and G2 in simulation by sec. unit.

All of these settings affect simulation motion only and don't affect working program to be downloaded.

NOTE **Caution of constant setting dialog box**

After setting up constant setting dialog box, set values appears as itself after closing it and opening it again. However, it is not showing current set value on robot but it is only showing the last input value on dialog box. If you open constant setting dialog box after closing operation and opening it again, there is nothing to appear. In this case, if you press Accept button not inputting or inputting some items, settings of items not inputted are deleted. Please be careful of it. Therefore, you should fill out all items and then press Accept button.
For viewing set attribute values on selected robot, see details of next clause about info button.

4.5. Information View of Constant Setting

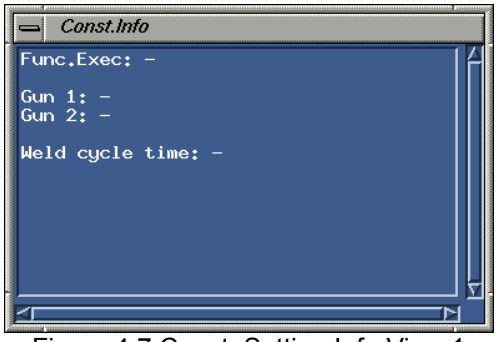


Figure 4.7 Const. Setting Info View 1

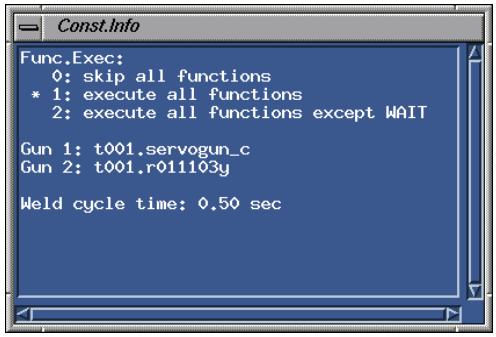


Figure 4.8 Constant Setting Info View 2

If you press the info button of T/P, the widow which shows const. setting values of currently selected robot (Active Mechanism) appear. (If you press it once more, it disappears.)

Figure 4-7 shows the state that the setting is undone. After completing the setting, the info the same as Figure 4-8 appears.

The dialog box appeared by pressing Const. button shows the final inputted values only on the dialog box, therefore, it might be not accurate. See the setting value using info button.

4.6. Output Option View Window & Output Option Control Board

Output option view window shows the output option setting state of current step as the type similar to actual T/P. You can change the setting using the buttons of output option control board. If you press each button, it is toggled as On & Off.

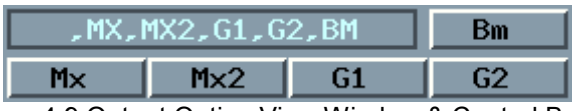


Figure 4.9 Output Option View Window & Control Board

NOTE **Default Gun State Setting**

If locations are created initially, and MX or MX2 are not designated even once in TeachPendant, it means Gun state attribute is not created yet. That is, the user doesn't designate whether Gun is OPEN or SEMIOPEN. Now, what will be happened to simulation or download?

In this case, default Gun state is applied.
In Cell, you can grant two basic attribute of DEFAULT_WELD_GUN_STATE & DEFAULT_VIA_GUN_STATE. (These attributes are created the moment you select Weld_locs menu of ROBCAD/SPOT.)
DEFAULT_WELD_GUN_STATE is used for default of welding point location and DEFAULT_VIA_GUN_STATE is used for default of passing point location separately.
For these attributes, you can set it up as Attribute Editor of tool box. If the value is 2, it means default SEMIOPEN(MX), and if 3, it means default OPEN(no MX).

If there is no default Gun state attribute in Cell, undesignated locations become just open. Of course, once you use MX & MX2 buttons of TeachPendant, the location is not related to default.

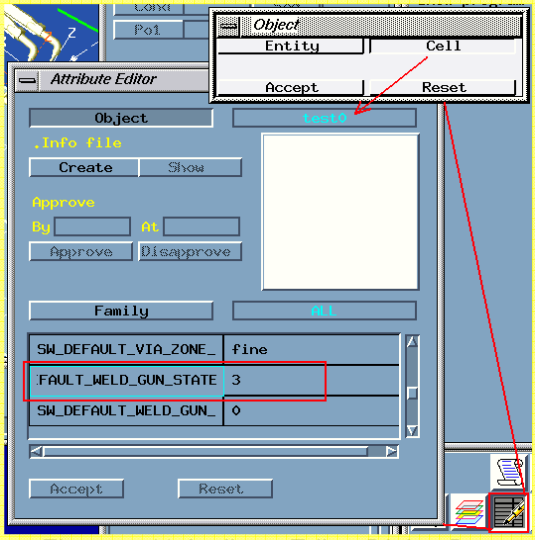


Figure 4.10 Attribute Editor Dialog Box

4.7. Signal In/Output Function Part

There are three buttons; D output, D input, & G output. If you press the button, the dialog box appears as below,
If you press Accept, signal in/output function code is inserted on the current position.

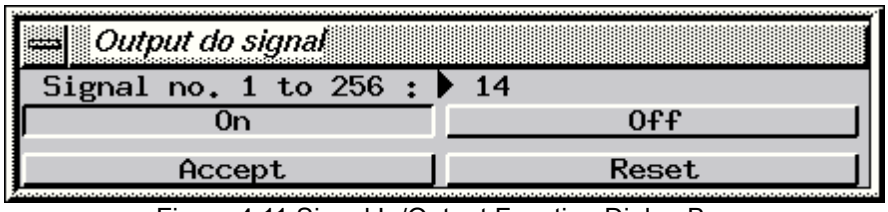


Figure 4.11 Signal In/Output Function Dialog Box

4.8. Flow Control & Other Function Part

You can input the function for flow control such as GOTO & CALL and other functions such as SPOTCND & LETN.

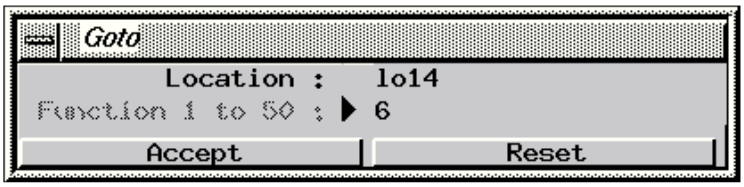


Figure 4.12 GOTO Sentence Dialog Box

NOTE **Branch Address at ROBCAD**

In actual Hi4a controller, use Step No., Function No. or Label as the branch address the same as GOTO. On the other hand, in ROBCAD simulation, use location and Function No. only as branch address. Therefore, proper change is done when uploading and downloading.

■ Operation of download module:
Location name judges location's order of path and change it as proper Step No.
ex: IF DI20=1 THEN lo7 → IF DI20=1 THEN S7
The combination of location name and function number changes it this Line No. after marking proper Line No. automatically on corresponding function position.
ex: GOTO lo7,3 → GOTO 10

■ Operation of upload module:
Step No. changes it as proper location name by combining path name and No.
ex: IF DI20=1 THEN S7 → IF DI20=1 THEN hr120_005_7
Line No. changes it as the combination of Location No. and Function No. of corresponding function position.
ex: GOTO 10 → GOTO lo7,3

■ Operation of simulation module:
The program number tries to branch off being recognized as job{Program No.} when performing CALL sentence or JMPP sentence.
ex: CALL 2 → Branch off as the path which is called as "job2"

4.9. Function Moving/Deleting Part

Figure 4.13 Function Moving/Deleting Part & Function List Dialog Box

In function list dialog box, '>' sign is marked on the left side of the one between command language. This is a cursor indicating currently selected command language and when you input function, it is inserted in command language and the interval of just upper line command language.

Top button & Bottom button move each cursor to the first & last functions of current step. ▲button & ▼ button move each cursor to front & back functions. Line button can move the cursor by inputting function numbers directly. Delete key deletes selected functions by cursor.

4.10. Function Command Language Set

In simulation of ROBCAD, the motion is limited. Some of various motions of HR-BASIC used by Hi4a controller are supported.
The list of supported function is the same as below,

Table 4-2 Function Command Language & Corresponding Function Code List

Function		Function Command Language
DO (Digital Output)		DO?={1-0}
GO (Group Output)		GO?={0-255} GO?={&B00000001-&B10000000}
DI (Digital Input)		WAIT DI? WAIT DI?,{0-60.0},{loc} 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
Working finished		END
Conditional statement	**Simple Sentence IF**	IF DI?={0-1} THEN {loc.} [ELSE {loc.}] IF GI?={0-255} THEN {loc.} [ELSE {loc.}] IF _RN?={0-255} THEN {loc.} [ELSE {loc.}]

	Complex Sentence IF	IF DI?={0-1} THEN
		{CALL Call} or {JMPP Call} or {DELAY Call} or {STOP Call}or {END Call}
		ENDIF

		or, IF GI?={0-255} THEN or, IF _RN?={0-255} THEN
Looping statement	**FOR ~NEXT**	FOR V{1-400}%={0-30000} TO {0-30000} {Step or functions } NEXT
Time delay		DELAY {1.0-60.0}
Spot welding condition		SPOTCND {0-255}
ServoGun Search		GUNSEA {1-2},{1-2},{50-999}
Recovery Register Value Setting		_RN?={0-255}
Recovery Register Value Increase		_RN?=_RN?+1
Comment		' {comment}

- **In complex sentence IF block, you can use CALL sentence, JMPP sentence, DELAY sentence, STOP sentence, and END sentence only which is differ from HR-BASIC.**

- **For index variable of FOR sentence, you can use integer variable V1%~V400% only. And for initial & closing values, you can use constant only. You can input different FOR~NEXT in FOR~NEXT, however, nesting over 4 layers is impossible.**

5

Simulation of Working Program

Figure 5.1 Simulation menu

This is the function to perform the simulation on the purpose of interference check or cycle time about written working program in ROBCAD.

When you press simulation button of OLP, Figure 5-1 appears. To make the simulation possible, the controller and program should be selected as the figure. The simulation is initialized by pressing Init simulation button. Therefore, it is stayed in the initial state to process it from No. 1 Step.

Pressing Run button, the simulation 1 cycle about the set program or path is performed in graphics window.

Pressing Freeze button, the simulation is halted for a while. Pressing Run button, the simulation is continued in the same state. If you want to the simulation for it from the first step again, use Init simulation button.

Step button is the function to perform the simulation of one step only whenever pressing it.

5.1. Signal In/Output

To perform the simulation of signal in/output in ROBCAD, the signal definition between multiple robots and devices should be decided in advance.

To perform the simulation for multiple robots and devices, use SOP(Sequence of Operation) function of ROBCAD. For more details of SOP, see ROBCAD Manual or Help.

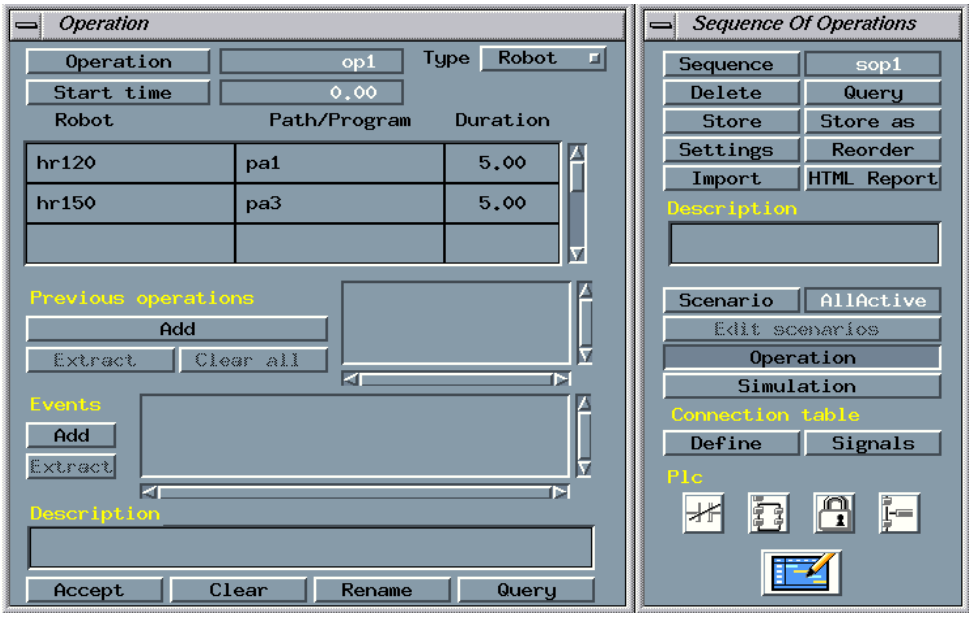


Figure 5.2 Sequence of Operations Menu

Open SOP dialog box and then create new sequence and operation.
When operation dialog box is opened, select robot in type list, select the robot in Matrix(The table in the middle) and its corresponding path name, and then input it. Pressing Accept and Confirm, operation creation is closed.

Figure 5.3 Define connections Dialog Box

In SOP dialog box, pressing Define button of connection table line, it makes Define connections' dialog box open, and define new table by pressing Connection table button. And then, define the signal items by pressing Add button.

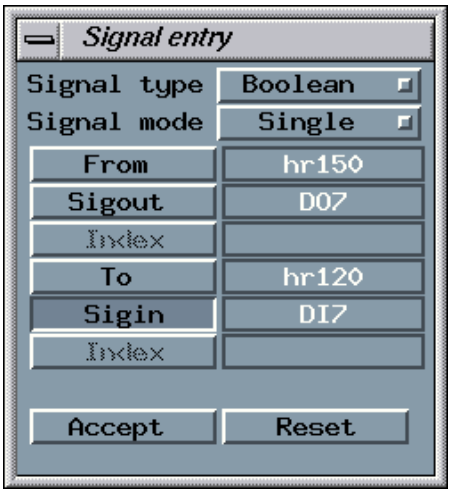


Figure 5.4 Example of Signal Item Definition

For example, if you define it as Figure 5-4, DO7 signal of hr120 is connected to DI7 of hr150. Pressing Accept button, a couple of the defined signal at connection table is added.
Signal name should be a couple of DO/DI or GO/GI. Use Boolean for the signal type of DO/DI and Int for the signal type of GO/GI.

Now, pressing simulation button on Sequence of Operations menu, the dialog the same as Figure 5-5 appears and you can perform the simulation sending & receiving signals by pressing the play button.

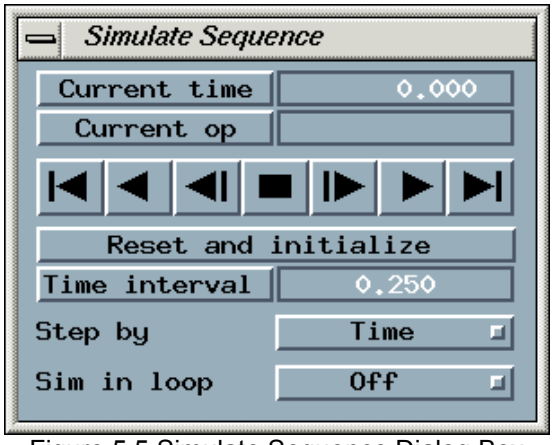


Figure 5.5 Simulate Sequence Dialog Box

NOTE **Step Button & Accuracy**

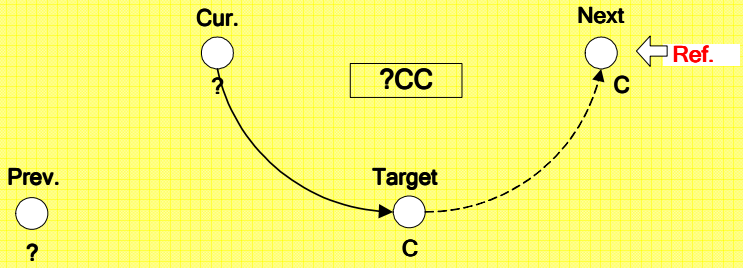
In case of performing the robot motion of a step by step button, the tool end is not stopped in the target location accurately, but it is stopped as far as the zone of accuracy setting. To stop it at the target location accurately, apply 0 for accuracy distance (or axis angle.)

NOTE **Dot-e file & RCS Module**

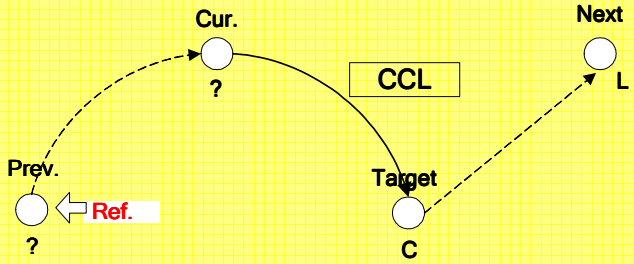
There are two ways for the simulation of the robot motion performed by ROBCAD; performed by self motion planner of ROBCAD and RCS(Robot Controller Simulation) module of the object robot. It performs the simulation followed by reading Dot-e file listing various motion characteristics of the object robot.
On the other hand, as RCS module is robot motion software module following RRS(Realistic Robot Simulation) Standard Interface, generally its cycle time accuracy is much higher than Dot-e file because of implementing it based on motion related part in object controller software.
Hi4a OLP Package performs the simulation using RCS module for Hi4a controller.

NOTE **Arc interpolation simulation**

Arc interpolation operation between actual Hi4a controller and Hi4a OLP Package is executed under 2 principles.



Principle 1. When the next target step is C, use this as the reference point



Principle 2. When the next target step is not C, use the prior step as the reference point

※ If Step 1 is arc interpolation and the current location of the tool end is far off, the robot can generate an error while trying to create a large arc.
※ When the target is the last step, prior step becomes the reference point.

5.2. RCS Simulation Error

On simulation by RCS, error message can be outputted in ROBCAD as below.

RRS ‘error(Error Code) : Error Message’

Table 5-1 shows the list of error occurred by the simulation by RCS.

Table 5-1 Value to set up at Func exec

Error Code	Error Explanation
-1	RCS Service is not supported
-48	Memory problem is occurred when exchanging RCS in/output data with ROBCAD
-51	Some of axis angle of the teaching step are out of softlimit range.
-52	Rectangular coordinates of the teaching step are out of motion range of robot.
-56	ROBOT.C01 file is not founded or robot model name info is not obtained in ROBOT.C01 file.
-68	While doing the trajectory movement, motion calculation error is occurred.
-71	Target point buffer full is occurred.
-76	While doing the trajectory movement, it is out of softlimit range.

6

Downloading Working Program

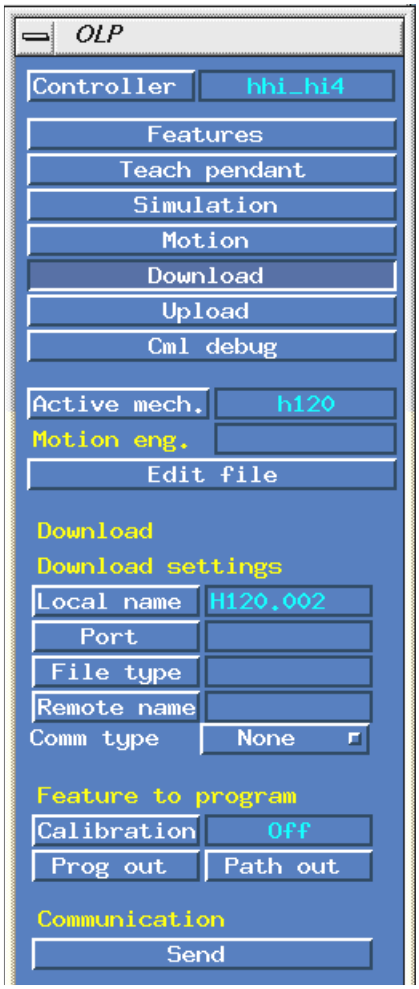


Figure 6.1 Download Menu

This is the function to convert and save it as a text file which is readable by Hi4a controller in order to transfer the working program written in ROBCAD to Hi4a controller.

Figure 6.1 shows when pressing download button of OLP.

6.1. Creating working program for Hi4a controller

Above all, set up the file name to create for local name. The extension called. Hi4a is attached automatically for the downloaded file. For example, the created file name is HR120.002.Hi4a in case local name is set up as HR120.002 as below figure,

Leaving other setting, press path out and then the list of the existing path on current workcell appears. Select the path to download by double-clicking.

If there is no error on the path, the path is converted as working file for Hi4a controller and it is saved in cell directory of current project and then the details appear as below Figure 6-2. If error is existed, the error message is saved in {Local name}.err and the details appear on window.

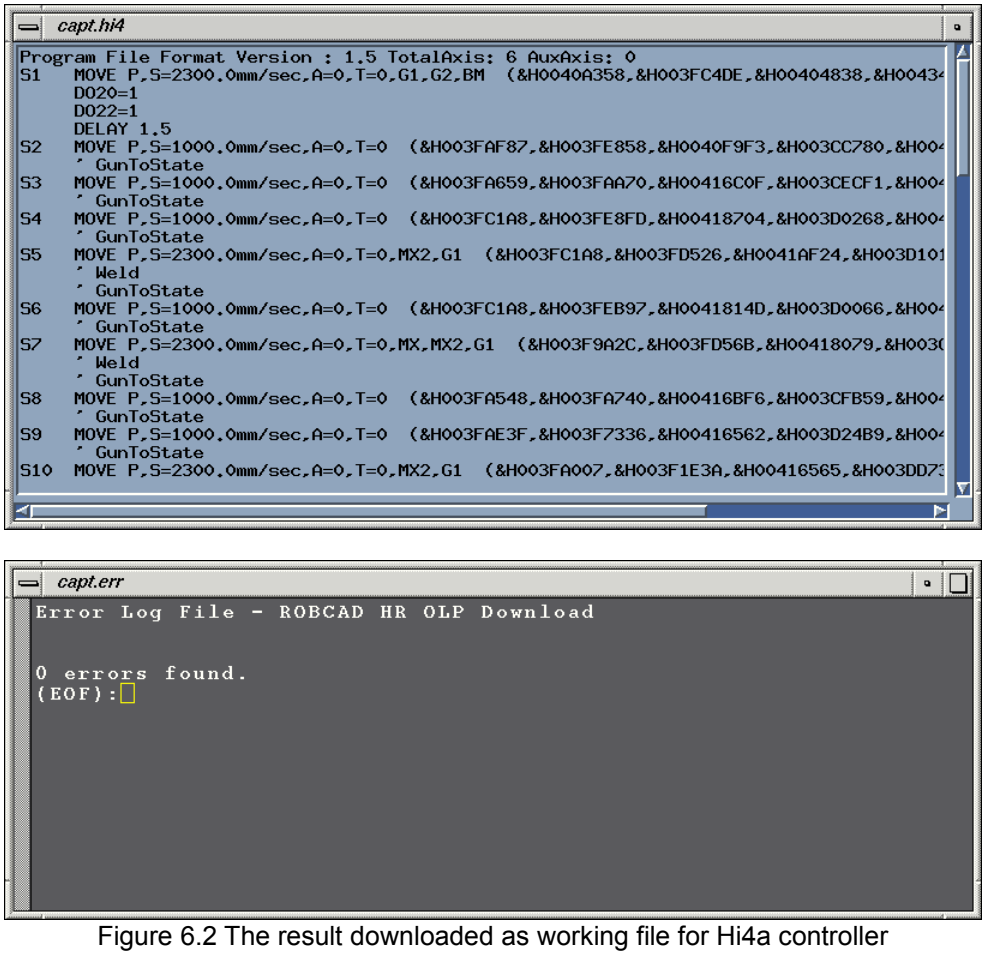


Figure 6.2 The result downloaded as working file for Hi4a controller

The output of all hidden position date of each step is in encoded value.

Now change the file created in terminal or console window as proper name of the working file for Hi4a.

For example,

```
C:\work\robcad\jigman\x_prj\my_cell.ce > dir/w↵
HR120.002.err      HR120.002.hrc   HR120.sy

C:\work\robcad\jigman\x_prj\my_cell.ce > rename   HR120.002.hrc   HR120.002↵
```

Perform the file name change as above,

The file name receivable by Hi4a controller is composed by the body name registered as below example and operation number of 3 digits. All of them should be capital letters.

HR120S-2.340 HR150S-2.999 HR015-03.003 HR006-03.810	(O)
HR130-2.125 HR165-2.009 HX130-01.020 HX165-01.035	(O)
hr120s-2.002 Hr120.002 HR120S.000 HX130.1000 HX130_02.012	(X)

NOTE **Welding spot comment auto removal function**

ROBCAD/Spot leaves a comment such as 'Weld, 'GunToState etc. for each welding point and by adjusting the g_is_remove_spot_comment parameter of the front part of hhi_hi4_rrs_download.awk, you can adjust whether to leave the output of this comment

g_is_remove_spot_comment = 1; → Automatically remove welding spot comment (Default)
g_is_remove_spot_comment = 0; → Do not automatically remove welding spot comment

6.2. Loading working program of PC as Hi4a controller

If working file is moved to PC, you can load it to controller. For perform it, there are three ways of using PC-Card, RS-232C and FTP.

- Using PC-Card

  This is copying a file at PC Card. After inserting this card in PC-card socket of Hi4a controller, use the [Service] – [File Manager] – [Copy] function of controller and then copy the working file as memory from PC-card.

- Using RS-232C

  Run HRView in PC and do setting for controller and communication available. After selecting the working file at the list box of PC side directory, transfer the file to controller. For further information about HRView use, see 『HRView Function Manual』

- Using FTP

  When the PC is connected to Hi4a controller through Ethernet, you can use the FTP command from the command prompt or use the commercial FTP client to transfer the work file from the controller side to the PC. You must use ASCII mode.

```
C:\robcad\jigman\x_prj\my_cell.ce> ftp 10.8.5.43↵   (IP address of Hi4a controller)
connected to 10.8.5.43.
220 FTP server ready.
Name (10.8.5.43:robcad): robot↵
331 Password required.
Password: hi2001↵
230 User robot accepted.
Remote system type is UNIX.
ftp> asc↵
200 TYPE is now : Ascii
ftp> put HR120.002↵       (Current directory of workstation → Hi4a Controller)
local: HR120.002 remote: HR120.002
200 PORT command successful
150 Opening data connection for receiving files
226 Receiving OK.
811 bytes sent in 0.02 seconds (44.54 Kbytes/s)
ftp> _
```

7

Downloading Working program

In Hi4a controller, you can import the working file to the path in the workcell of ROBCAD. The upload model of Hi4a OLP Package translates the text file of Hi4a working program type and then makes it as the path of ROBCAD workcell.
The upload procedure is processed as reverse direction of download procedure.

- **Between the working files of Hi4a controller, the command language(or grammar), *Hi4a OLP Package* is not supplied, is ignored when performing simulation in ROBCAD and you should be careful of it.**

7.1. Loading Working program of Hi4a controller to PC

Move the working file of controller to PC. For perform it, there are three ways of using PC-Card, RS-232C and FTP.

- **Using PC-Card**
  After inserting the PC-card in PC-card socket of Hi4a controller, copy the working file from memory to PC-card using the [Service] – [File Manager] – [Copy] function of controller. And move PC-card to PC and then copy the working file to hard disk drive.

- **Using RS-232C**
  Run HRView in PC and do setting for controller and communication available. After selecting the working file at the list box of control side directory, transfer the file to PC. For further information about HRView use, see 『HRView Function Manual』

- **Using FTP**
  You can use the FTP command from the command prompt or use the commercial FTP client to transmit the work file from the controller side to the PC. You must use ASCII mode.

```
C:₩workWrobcadWx_prjWc01.ce > ftp 10.8.5.43↵  (IP address of Hi4a controller)
connected to 10.8.5.43.
220 FTP server ready.
Name (10.8.5.43:robcad): robot ↵
331 Password required.
Password: hi2001 ↵
230 User robot accepted.
Remote system type is UNIX.
ftp> asc ↵
200 TYPE is now : Ascii
ftp> get HR120.002 ↵              (Hi4a Controller → Current directory of workstation)
local: HR120.002 remote: HR120.002
200 PORT command successful
150 Opening data connection for transfering files
226 transfering OK.
811 bytes sent in 0.02 seconds (44.54 Kbytes/s)
ftp> _
```

※ For further information about FTP, see 『Hi4a Controller Operation Manual』

Use in the command prompt or windows explorer, you should make the extension as .hrc in order that the upload model of Hi4a OLP Package can read the loaded file. At this time, use a simple name as possible as you can because the file name is reflected on the path name and each location name.

For example,

```
C:\work\robcad\x_prj\c01.ce > dir/w ↵
HR120.002                   HR120.sy
C:\work\robcad\x_prj\c01.ce > copy   HR120.002   p02.hrc
```

In case it is the same as above, perform the file name change.

NOTE **Limiting the file name when uploading**

If the points more than two are included in the file name the same as hr120.002.Hi4a, you cannot upload it in ROBCAD.
After changing the name as above, perform upload, or include only one point by using the name of hr120_002.Hi4a etc.

7.2. Creating the Path

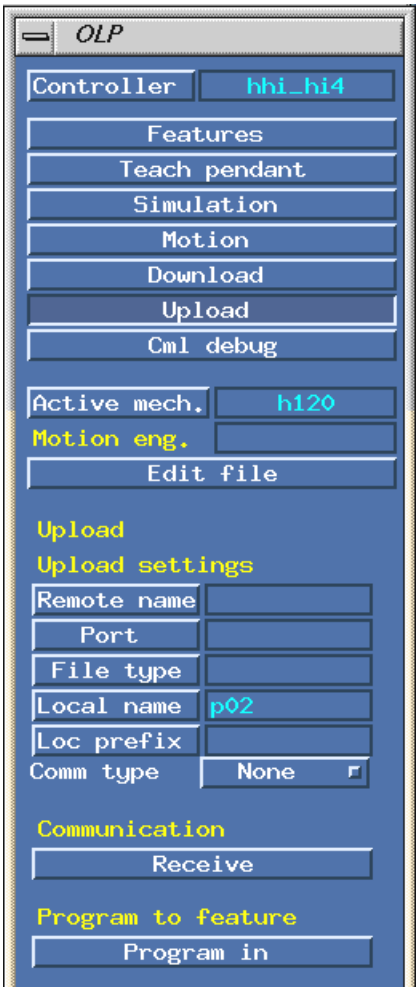


Figure 7.1 Upload Menu

Now import the working program to the workcell of ROBCAD.

Figure 7.1 shows when pressing “upload” button of OLP. Press the “local name” to import first and select the working file. Pressing “program in”, the path and locations in the workcell are created.

Figure 7-2 confirms newly created path by opening ROBCAD PathEditor.

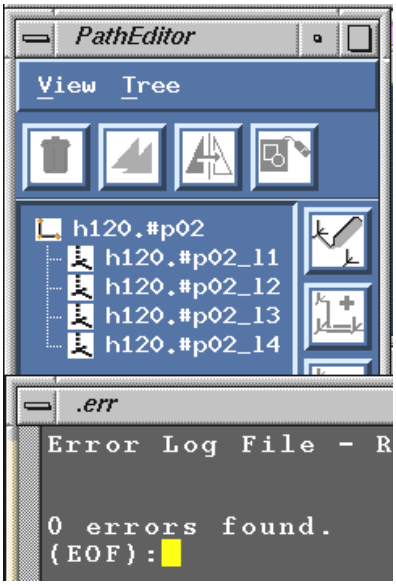


Figure 7.2 ROBCAD PathEditor

The path and each location name are decided by following below rules.

Path name	{Robot instant name}.#{file name}
Location name	{ Robot instant name }.#{ file name }_l{step number}

For example, if robot instant name is hr120 and file name is p02, path name is decided as “hr120.#p02” and location names are decided as each “hr120.#p02_l1”, “hr120.#p02_l2”, …. the same as figure.

Upload model of *Hi4a OLP Package* creates step as local location. In example, “hr120.#p02_l1” means the local location called “p02_l1” which is included in “hr120” robot component.

NOTE **Local & Global Location**

Local location can be regarded as the entity included in robot component. That is, when moving the position of robot component including local location, the local location is also moved. On the other hand, global location is not included in anything. And when the position of robot instant used for doing teaching for global location, the global location is not moved.

Using global location, the difference between simulation and actual robot motion is occurred because robot configuration is changed whenever performing simulation or download. Therefore, you download the operation by the actual robot controller, it is recommended to download it after changing global location to local location using auto teach function of ROBCAD.

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

In local path, error is occurred when changing the names for local locations by the rename function of patheditor. This is regarded as the error of ROBCAD specification. In ROBCAD/Spot, select Weld_locs menu, press rename button on locations menu, and then you can change the names of local path and local location. When rename dialog box appears, input location name at location name (click location with mouse), input the new name at new name, and then press Accept.

7.3. Axis angle attribute

When the step data of encode type is updated to the location of *ROBCAD,* the encoder value or axis angle value is not saved but converted to position/location value to be saved. Therefore it can cause the difference between the robot position from when the uploaded program is simulated and the actual position of the robot operation. (Resolution when the position/direction is aligned but the robot position is different.)

To prevent this problem, the step data of encode type during the upload is saved in the following name of axis angle as location attribute.

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

For location with axis angle attribute, it is simulated according to that axis angle during simulation.

For location with axis angle attribute, it creates the position encoded value of the hidden step by referring to the axis angle during the download.

But, even when you change the location position or direction with shift etc., keep in mind that it is not reflected to the axis angle attribute.

If you want to remove the axis angle attribute, click on the Delete attr button on the teach pendant. Select Hr_joint_val and then select the location or path (Remove attribute of all location within the path).

8

Use of Servo Gun

8.1. Definition of ServoGun

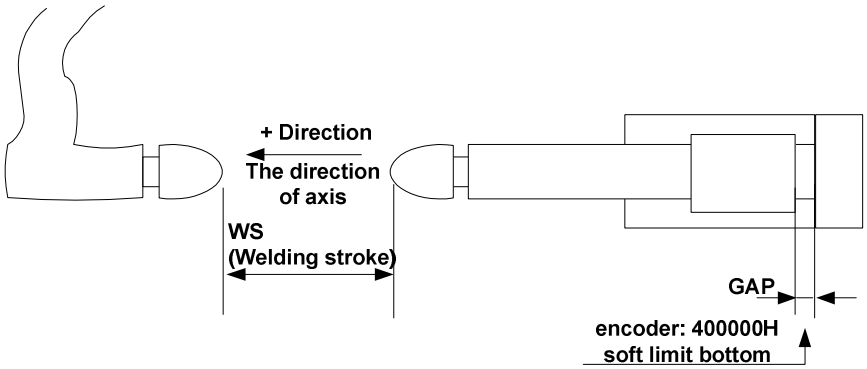


Figure 8.1 Welding Stroke & Axis Constant Setting

Our ServoGun system performs the axis constant setting (400,000H) on the position moving the motion part backward maximum the same as Figure 8-1.

The same as Figure, it has the allowance stroke of maximum 10mm to the backward direction. This value can be different by makers.

Therefore, you should define it followed by below rules when defining ServoGun in ROBCAD.

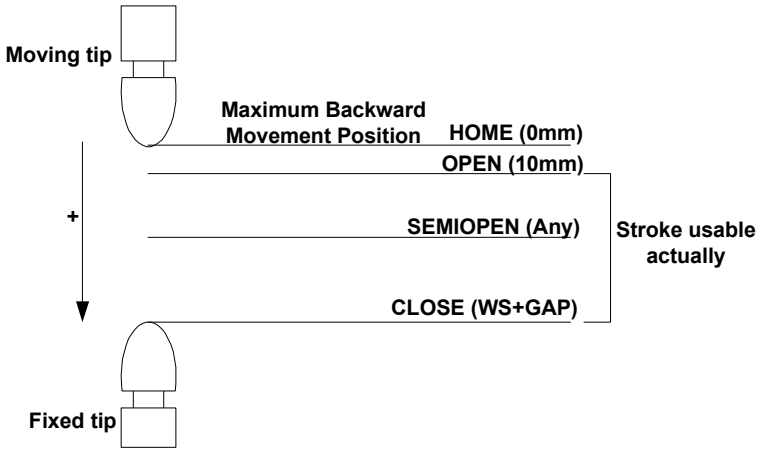


Figure 8.2 Definition of ServoGun Positions

Therefore, external axis registration of .sy file is the same as below,

EXT_ZERO_POSITION	0
EXT_OFFSETS	4194304
EXT_FACTORS	(Bit constant)-1
CLEARENCE	60 * Used for simulation only

8.2. External Axis Registration

Figure 8.3 Registering ServoGun as external axis

To use ServoGun, the axis of ServoGun should be registered firstly as the external axis of active mechanism. In the state of clicking settings tap of motion dialog box as Figure 8-3, click Add button and then select the axis of ServoGun mounted as robot external axis.

TeachPendant figures out ServoGun and the external axis number of ServoGun comparing Gun name set by the user pressing Const. button to the external name. The registration order of external axis should be equal to the order of Gun set in Const.

NOTE **Local & Global Locations**

Hi4a controller can control the external axes up to 6 units. When registering the external axis, you should follow below order.

1) Traverse, 2) ServoGun1, 3) ServoGun2, 4) Jig

You can use some of them. However, you should follow the order. For example,
if there is no traverse axis, the external 1 axis is begun from ServoGun.

8.3. ServoGun Welding Function of TeachPendant

Figure 8.4 ServoGun Welding Function of TeachPendant

In TeachPendant, there is user interface for ServoGun welding the same as Figure 8-4. In case ServoGun axis is not designated as the external axis, Air Gun which means pneumatic is marked instead of ServoGun. Buttons related to ServoGun is available in ServoGun state only.

You can select the welding point treatment of current location and Gun No. by clicking “Weld” button. For ServoGun welding, you should set up three parameters; Gun No., Welding Condition No., & Welding Sequence No. You can set them up by three buttons of “Weld”, “Cond”, & “Seq”. If you set up the “Weld” button as welding OFF, “Cond” & “Seq” buttons become unusable.

With “po1” & “po2” buttons, you can set up the ServoGun to widen as “OPEN” or “SEMIOPEN” positions. Of course, it is only available for passing point not welding point. For example, if current step is the welding point of Gun2, “po1” can be set up as “OPEN” or “SEMIOPEN”, however, “po2” becomes unusable.

8.4. External Axis Value Designation on Location

Each location should be “Compound” because the control of ServoGun is external axis control eventually. However, “ROBCAD/SPOT” do not make “Compound” locations dividing the case ServoGun welding separately.

Therefore, the user should designate the external axis value using the “Update” button of Figure 8-5 on general location created in “ROBCAD/SPOT”. (Use “Remove ext.” button to remove the designated external axis value.)

Figure 8.5 “Compound” Function of “Move Command” tap on “Motion” dialog box

It is hard to apply the operation for every single location. Therefore, TeachPendant of Hi4a OLP Package offers the function performing the operation automatically.

Figure 8.6 External axis auto designation function of “Servogun weld” (Make ext. pose)

Clicking “Make ext. pose” button at Figure 8-6, the dialog box, paths or locations are inputted, appears.

Selecting the welding path, it designates the external axis value the same as below rules about all locations of corresponding paths. Or you can designate the external axis value only by selecting wanted locations.

- In case of the welding point, it is designated by the pose value defined as “CLOSE” on the welding Gun.
- In case of the passing point, it is designated by the pose value defined as “OPEN” or “SEMIOPEN” according to “po1” & “po2” settings.

ServoGun axis value of each location is redefined by above rules whenever selecting “Make ext. pose” button.

8.5. Simulation

Before performing simulation, you should the external axis as auto designation function. Simulation is performed as type which is much more simplified than actual ServoGun. The simulation motion characteristics, different from the real are the same as below,

- Two parameters of welding condition number and welding sequence number do not affect the simulation motion at all.

8.6. Download & Upload

Before performing download, you should the external axis with external axis auto designation function.
Performing download, ServoGun welding points have SPOT function as the first function, and GUN No., Welding Condition No., & Welding Sequence No. set as TeachPendant are reflected as the parameter of SPOT function.
Constantly, upload is SPOT function and it recognizes ServoGun welding point and parameter.

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