HD HYUNDAI ROBOTICS

WARNING

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

HD HYUNDAI ROBOTICS

Hyundai Robot

Hi5aLW230628FMEN2

Hi5a Controller Function Manual

Laser welding function

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1 Overview

1. Overview

The laser welding function provided by Hyundai Robotics is for carrying out non-contact laser welding through interoperation with the laser controller of BlackBird. The laser welding system includes not only a robot controller and robot, but also a scanner, controller and an oscillator related to laser. This document describes the setting, the writing of the robot language, and the collection of data, which all should be performed all by the robot controller to perform laser welding. Welding functions are actually performed by the laser controller, and the robot controller is responsible for the motion program and robot position and posture values and for sending trigger signals to perform welding and for commanding to perform welding.

Figure 1 Laser welding system

2

System setting

2.1. Tool parameter setting

The setting of the additional axis to be performed basically for the execution of application is not necessary for laser welding. The laser scanner to be attached to the robot will be mounted to the end of the R1 axis by using a dedicated jig, and the tool coordinates should be inputted, as shown in the figure below, by taking into consideration the position (z-axis) where the laser enters the welding panel. Depending on the scanner mounting direction, the Y-axis rotation component may be included. The tool data depends on the specification of the scanner. The user may also use the 'Axis origin and tool length optimization' function to input the tool data more accurately. In this process, the end of the tool coordinate is used as an intersection point where the guide beam and the laser focus meet, and then a specific fixed point needs to be taught at more than four postures.

『[F2]: System』 → 『3: Robot parameter』 → 『1: Tool data』

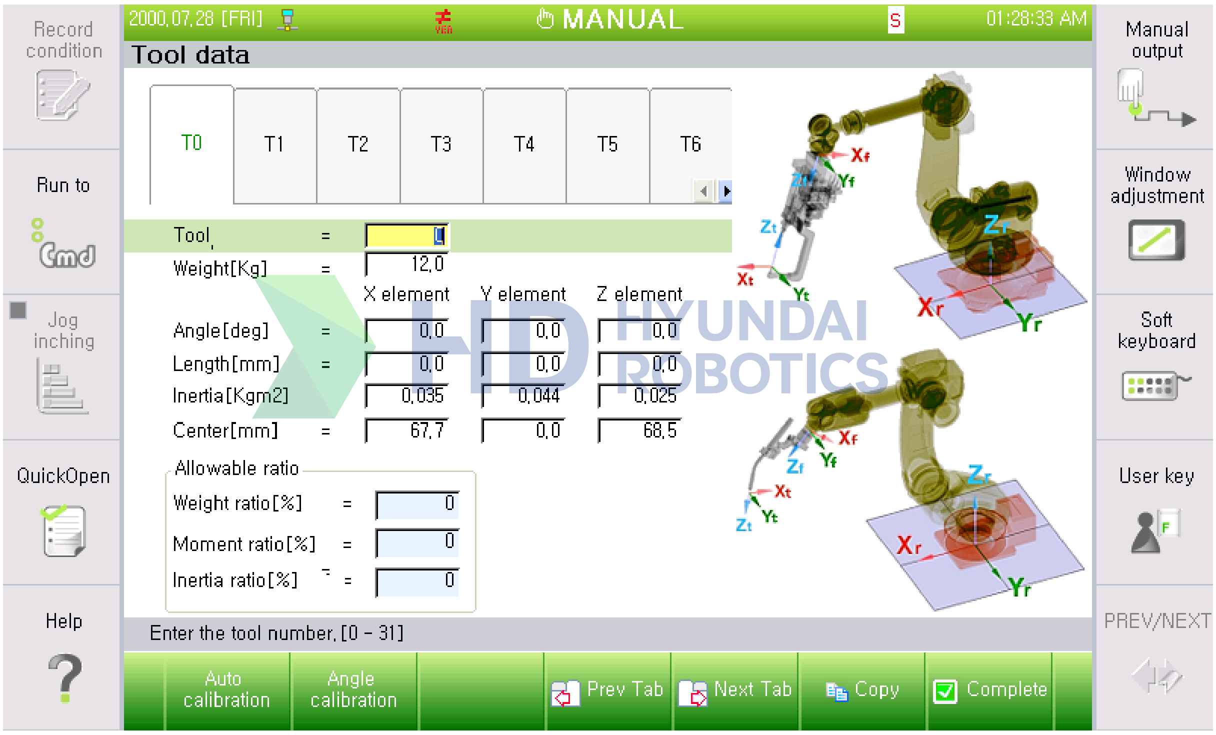

Figure 2 Additional axis parameter setting screen

2.2. Laser welding environment setting

Laser welding can be started by setting the 'BlackBird laser welding' screen. On this screen, it is required to set server information and trigger signal address to generate the recording file that will be provided to the BlackBird controller

『[F2]: System』 → 『4: Application parameter』 → 『27: BlackBird laser welding』

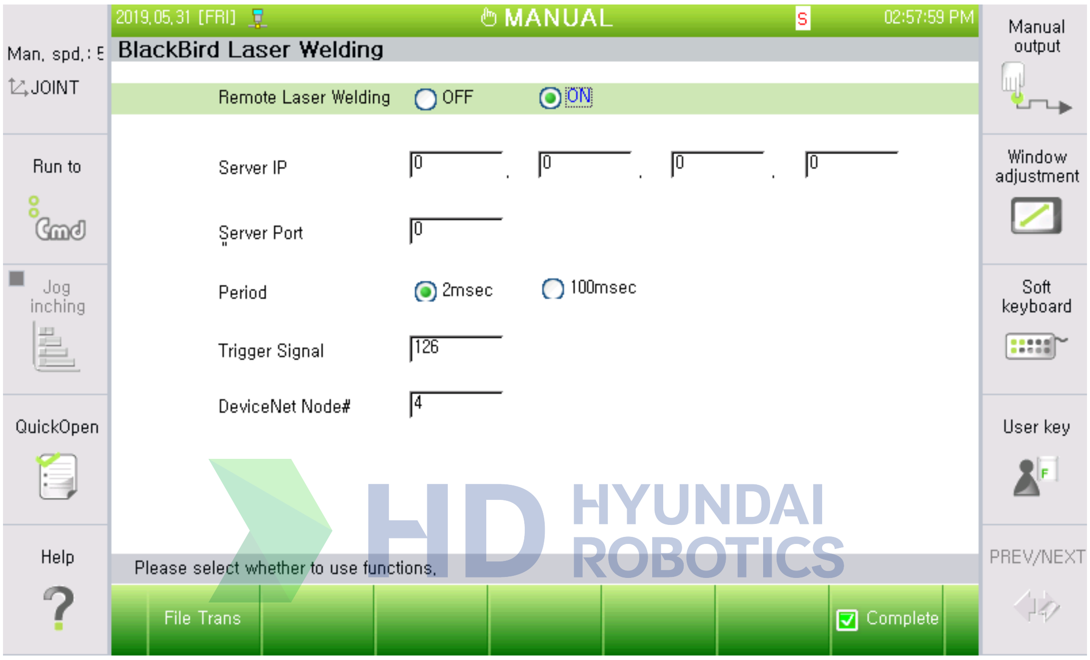

Figure 3 Laser welding setting

(1) Use of laser welding

The user must set the 'Use of laser welding' to the 'ON' mode before performing laser welding. In this state, the following inputs will be valid.

(2) Server IP

The server defined in this function refers to a PC that receives and stores the data defined as [Time - Robot position - Trigger signal] via UDP communication to generate the recording file required by the BlackBird controller. There are many methods to store the recording file, but the method in this setting is to store the data received as a recording file through UDP communication. In addition, a Windows-based PC that runs the BlackBird controller will be assumed as the server, which will be the easiest work.

(3) Server port #

This is for inputting the server port number for the socket communication together with the server IP. Currently, in the server program, the number is fixed to "20000" to make it unnecessary to input the port number.

(4) Sending cycle

The cycle of sending the data from the robot controller (client) to the server can be selected between 2msec and 100msec. Currently, 2msec is used for the recording file, while 100msec can be used for the monitoring. (Currently not used)

(5) Trigger signal (Welding section)

When the laser welding is performed, the laser controller determines the welding time by arbitrarily grouping welding points. If the signal is included in the DeviceNet data definition, it will be inputted as "FN6.5". (Input ".6.5") In addition, it is possible to increase the sending cycle by using separate hard wiring. In this case, it is required to input ‘123’ as a DO address for digital out.

(6) DeviceNet node#

The node number is to check the slave node number to improve the DeviceNet communication. In '2.3 DeviceNet setting', it is required to input the node number that is confirmed after node search is performed.

(7) Move file button

Pressing the relevant button after inserting the USB memory card, the user can move up to five recording files stored in the controller to the memory card. As the function is to move the files, they will not remain in the controller once moved.

2.3. DeviceNet setting

DeviceNet is used to send and receive data between the robot controller and the laser controller. The basic communication cycle provided by Hi5a controller is 20msec. In order to improve the quality of laser welding, the speed of the relevant node has been enhanced to 10msec. The number of the node for which the speed can be enhanced will be read from the value inputted in 2.2 (6) DeviceNet node #. The user must input the node number first and then press the 'Search node' to update the scan list and then select 'Apply' and 'Complete'. Users can refer to the manual related to the DeviceNet function for the contents for the setting.

『[F2]: System』 → 『2: Control parameter』 → 『2: Input and output signals setting』 → 『12: Built-in DeviceNet master information and setting』

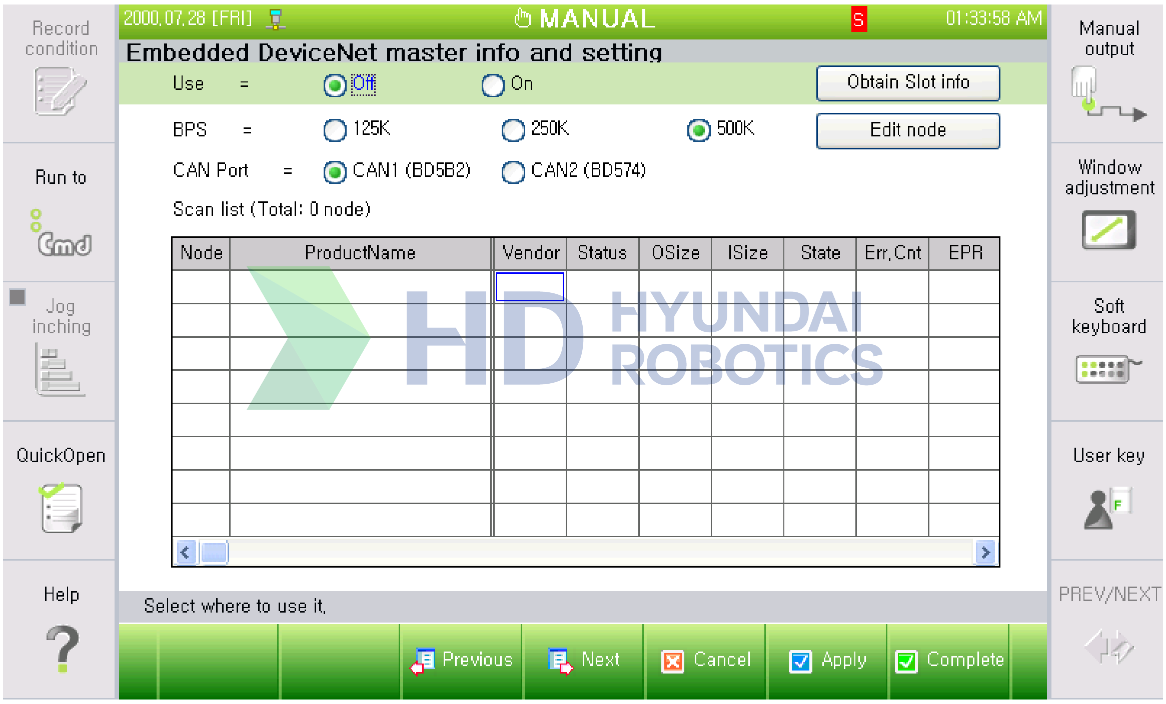

Figure 4 DeviceNet setting

(1) Whether to use
This should be set to 'On' for DeviceNet communication with the BlackBird laser controller

(2) Communication speed
500Kbps should be selected to secure the communication speed of 10msec.

(3) CAN port
CAN2 should be selected when using DeviceNet by adding the DB574 board.

(4) Scan list
When Search node is performed after the above settings are completed, the laser controller will be searched as a DeviceNet slave node. The node information includes the product name, sizes of sent and received data (bytes), communication speed (msec), etc. The node number can be set in the DeviceNet slave (the BlackBird laser controller), and the relevant node number will be scanned and shown in the robot controller.

(5) Definition of sent data

Type	Address	Name
1 Byte	FNx.Y1	Selection Program
	FNx.Y2	Deselection Program
	FNx.Y3	Start Program
	FNx.Y4	Stop Program
	FNx.Y5	**OTF-Trigger**
	FNx.Y6	Ignore Scanner Temp
	FNx.Y7	Reset Interlock by extern
	FNx.Y8	Not Used
3 Byte	FNx.YB2 ~ FNx.YB4	Not Used
1 Byte	FNx.YB5	Program number
2 Byte	FNx.YB6 ~ FNx.YB7	Robot Position X
2 Byte	FNx.YB8 ~ FNx.YB9	Not Used
2 Byte	FNx.YB10 ~ FNx.YB11	Robot Position Y
2 Byte	FNx.YB12 ~ FNx.YB13	Not Used
2 Byte	FNx.YB14 ~ FNx.YB15	Robot Position Z
2 Byte	FNx.YB16 ~ FNx.YB17	Not Used
2 Byte	FNx.YB18 ~ FNx.YB19	Robot Position RZ
2 Byte	FNx.YB20 ~ FNx.YB21	Robot Position RY
2 Byte	FNx.YB22 ~ FNx.YB23	Robot Position RX

(6) Definition of sent data

Type	Address	Name
1 Word	FNx.X1	Interlock Closed
	FNx.X2	Mode Auto
	FNx.X3	Request Scanner Position
	FNx.X4	Program Selected
	FNx.X5	Program Started
	FNx.X6	Program Finished
	FNx.X7	Program Stopped
	FNx.X8	Scanner Temp OK
	FNx.X9	Pilot Laser
	FNx.X10	OTF Sequence Ready
	FNx.X11	Step Finished
	FNx.X12	Program Mode OTF

2.4. Definition of digital signals

The robot controller is wired to a laser oscillator through digital signals and a digital signal. This complies with the overall configuration specification of the BlackBird laser controller system and may be changed to LAN communication or duplicated.

(1) Use of DIO signals
There is no TP related settings for DIO signal input / output, but the wiring for 580, 581 boards and PnP type signals are needed.

(2) Definition of DIO signals

Address	Dout	Din
121	EXT_ACTIVATION	PROG_COMPLETED
122	RESET	FAULT_LASER
123	LASER_ON	LASER_READY
124	REQUEST_LASER	PROG_ACTIVE
125	AIR CURTAIN (ROBOT -> AIR BOX)	MONITORING
126	OTF-Trigger (ROBOT -> SCU)	LASER_IS_ON
127	TORNADO BLADE 1 (ROBOT -> AIR BOX)	EXT_ACTIVATION_ACTIVE
128	TORNADO BLADE 2 (ROBOT -> AIR BOX)	LASER_ASSIGNED
129	PROGRAM_NO: BIT0	AIR CURTAIN (AIR BOX -> ROBOT)
130	PROGRAM_NO: BIT1	TORNADO BLADE 1 (AIR BOX -> ROBOT)
131	PROGRAM_NO: BIT2	TORNADO BLADE 2 (AIR BOX -> ROBOT)
132	PROGRAM_NO: BIT4	
133	PROGRAM_NO: BIT5	
134	PROGRAM_NO: BIT6	
135	PROGRAM_NO: BIT7	
136		
137	LASER INTERLOCK	
138	LASER INTERLOCK	
139	SUC INTERLOCK	
140	SUC INTERLOCK	
141	SUC INTERLOCK	
142	SUC INTERLOCK	

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3

Writing robot languages, and work scenarios

3.1. Command

■ UDPsnd ON

Sets whether to send data while a program is played back. The command needs to be inserted in a way to ensure that it will be turned on before the welding start point is reached in ready posture and will be turned off after the welding is completed.

```
UDPsnd   ON/OFF
```

	Contents
ON	Sends data from the robot controller to the server.
OFF	Stops sending data from the robot controller to the server

```
S1    MOVE P,S=60%,A=3,T=1
      DELAY 0.5
      UDPsnd ON
S2    MOVE L,S=100mm/s,A=3,T=1
      FN6.Y5=0
S3    MOVE L,S=100mm/s,A=3,T=1
      TRIGGOUT FN6.Y5=1,OT=0
S4    MOVE L,S=100mm/s,A=3,T=1
S5    MOVE L,S=100mm/s,A=3,T=1
S6    MOVE L,S=100mm/s,A=3,T=1
S7    MOVE L,S=100mm/s,A=3,T=1
S8    MOVE L,S=100mm/s,A=3,T=1
S9    MOVE L,S=100mm/s,A=3,T=1
      FN6.Y5=0
S10   MOVE L,S=100mm/s,A=3,T=1
      FN6.Y5=1
S11   MOVE L,S=100mm/s,A=3,T=1
      DELAY 0.5
      UDPsnd OFF
S12   MOVE P,S=60%,A=3,T=1
      END
```

[Command usage example]

3.2. Work scenario

Laser welding can be performed in two modes. The first mode is STATIC mode, in which the laser is emitted while the robot is stationary. The mode can be used only when the welding points are within the scanner emission range. Therefore, it is not actually used well for the panel welding for cars. The second mode is the OTF (On-The-Fly) mode, in which the welding of the pre-stored welding points are to be carried out while the robot moves. The mode is mainly used for the BlackBird laser welder. In the OTF mode, there is a recording file in which welding points are grouped into an arbitrary group, and the start and end of the group are stored as a trigger signals. While the welding is carried out, the trigger signal of the recording file will be compared with the actually inputted trigger signals in order to determine the welding point and position. For OTF mode welding, it is required to make the laser controller move the robot over the welding points one by one so that the laser controller can store the welding points. Since the robot position value is sent via DeviceNet communication, no special operation for storing is needed. In the next step, it is required to execute a motion program for the robot to move in the real welding work. In this process, the robot will not move over all the welding points that have been taught, but will move in continuous motion approximately within the laser scanner emission range. Note that this motion program should include the trigger signal to display the welding section and the command (UDPsnd) to send data. When the welding program is performed actually, the status of the laser welder will be checked, and the JOB program will be executed again in continuous motion approximately within the previously written welding points. Whether the robot motions and trigger signals created when the recording file is written are matching with those created when the actual welding is performed is a critical factor in improving the quality of welding. The following figure shows a scenario for a work on a new work panel that should be performed by the robot controller and laser controller.

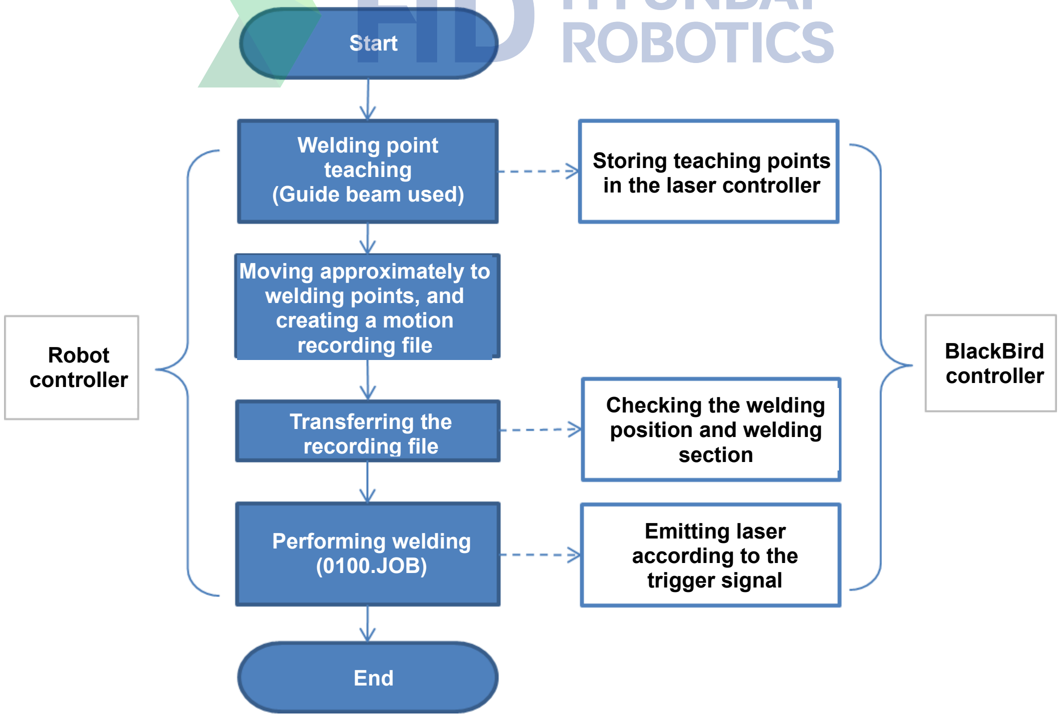

Figure 5 Work scenario

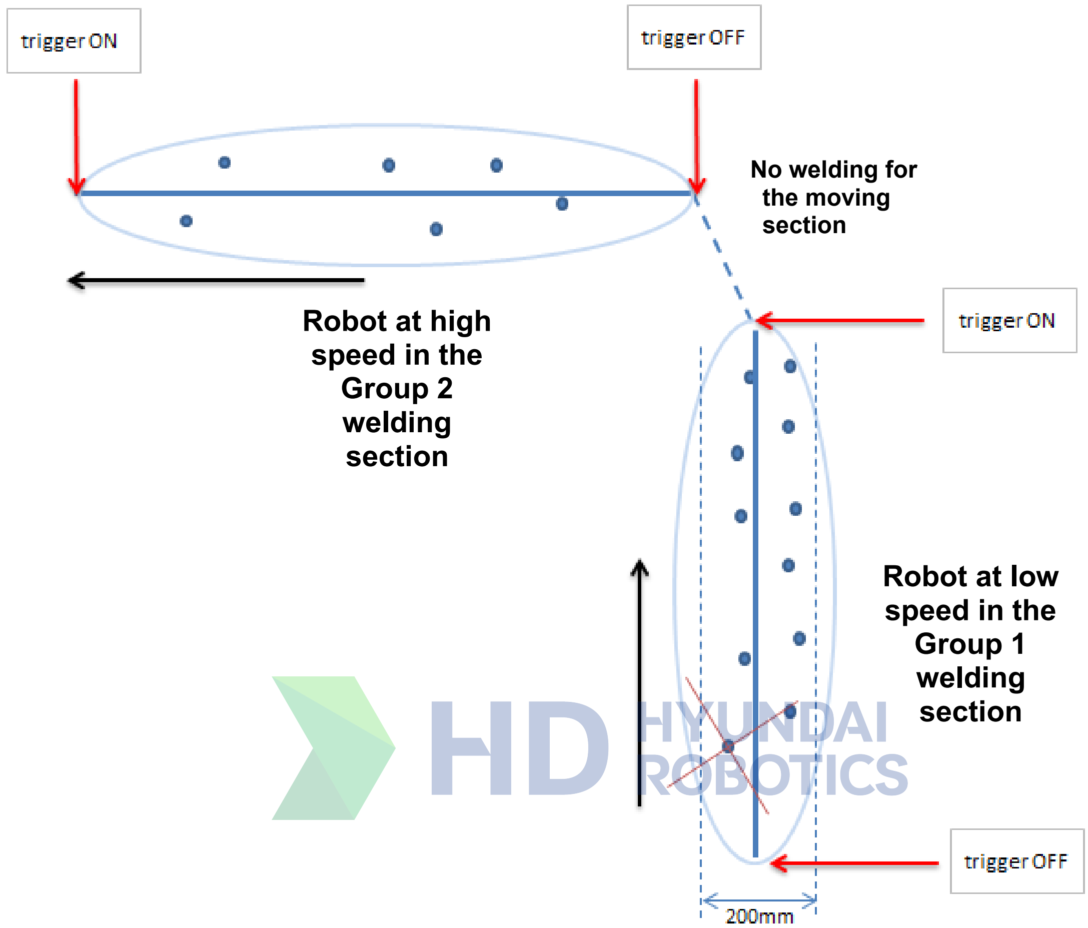

Figure 6 Welding points and robot moving path

- Teaching of welding point is carried out based on the intersection point of the cross-shaped guide beam.
- The working area of the laser scanner is 220X220X140mm.
- The welding motion speed is 100 ~ 200mm / sec but it is getting faster to shorten the work time
- Movement will take place in linear motion in the welding section, while joint motion is also possible in the section where no welding work is carried out.
- The welding group can be arbitrarily set by the user and distinguished using the trigger signal.
- Since the trigger signal is basically in the active LOW mode, the welding will be performed only in the OFF section.

(The signal for the welding section should be set to 'Off' when writing the motion program)

- The recording file must be both started and ended with the trigger signal On to ensure that the recording file can be loaded normally.

3.3. Recording file creation

As shown in the work scenario above, before performing actual welding, the laser welding controller should have a file that store the time information and the trigger signals for the welding motion path and welding section. This file is called the "recording file", which should be created and provided by the robot controller. The robot controller provides this file creation function in two ways, and the user can select one of them according to the site environment.

```
Time;X;Y;Z;RX;RY;RZ;Scan
0.000000;938.855;198.218;861.881;23.542;-1.386;153.193;True
0.001981;938.855;198.218;861.881;23.542;-1.386;153.193;True
0.003981;938.855;198.218;861.881;23.542;-1.386;153.193;True
0.006007;938.855;198.218;861.881;23.542;-1.386;153.193;True
0.007992;938.855;198.218;861.881;23.542;-1.386;153.193;True
0.009995;938.855;198.218;861.881;23.542;-1.386;153.193;True
0.011996;938.855;198.218;861.881;23.542;-1.386;153.193;True
0.013994;938.855;198.218;861.881;23.542;-1.386;153.193;True
0.016018;938.855;198.218;861.881;23.542;-1.386;153.193;True
0.018032;938.855;198.218;861.881;23.542;-1.386;153.193;True
```

Figure 7 Contents stored in the recording file

(1) Sending via UDP

After having completed the settings for sending via UDP in '2.2 Laser welding environment setting', if the user executes the JOB program for motion, the file contents will be sent to the server computer every cycle. After the motion is finished, the recording file will be stored in the server computer.

- Communication method: UDP communication through the LAN cable
- Server computer: BlackBird laser controller or another computer (Windows OS)
- Server communication program: A program written or tested already will be provided (by Hyundai Robotics)

(2) Moving via USB

If the user executes the JOB program for motion after setting the 'Use of laser welding' to the On mode in '2.2 Laser welding setting', a recording file will be created inside the controller. Up to 5 files can be stored, and oldest files will be deleted in order. If the user presses the 'Move File' button to provide files to the laser controller, the files stored in the controller's main board will be collectively moved to the USB storage device

- File name: BlackBirdTimeMinuteSecond.arf (ex. BlackBird093325.arf)
- Maximum count of the stored files: 5
- Storage position: M/B (Can be checked in File Management)

3.4. JOB program writting

In order to execute the work scenario, the user should write the JOB programs, in addition to carrying out the setting for laser welding. However, since the basic contents are already written, the user just needs to refer to them and modify only the parts that need to be changed for a specific work (especially the signal address and the teaching parts). Program configuration is largely divided into OTF and STATIC modes. Each JOB program has its own purpose and is configured in a way that the programs can be called starting with main() to perform the entire welding work. The configuration may be changed for improving the performance and processing errors.

(1) OTF welding mode
The following JOB program numbers are the ones currently written. The user can add or modify programs. However, when it comes to the new work panel, the user only needs to modify the teaching part about WeldingMot(). The relevant program is used not only for storing recording files but also for driving the robot for the actual welding motion. Therefore, if the program is executed separately first to store the recording file, it can also be called when the welding is performed by executing the 0100.JOB file.

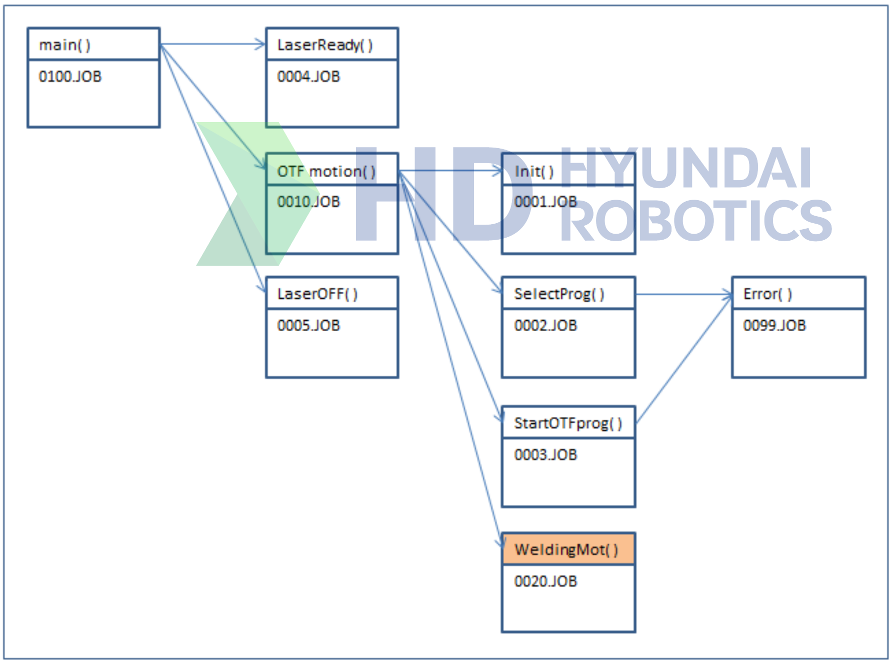

Figure 8 Overview of JOB program in OTF mode

(2) STATIC welding mode
For the STATIC mode, the three programs marked in the following figure will be added. The user only needs to modify the robot position in the file.

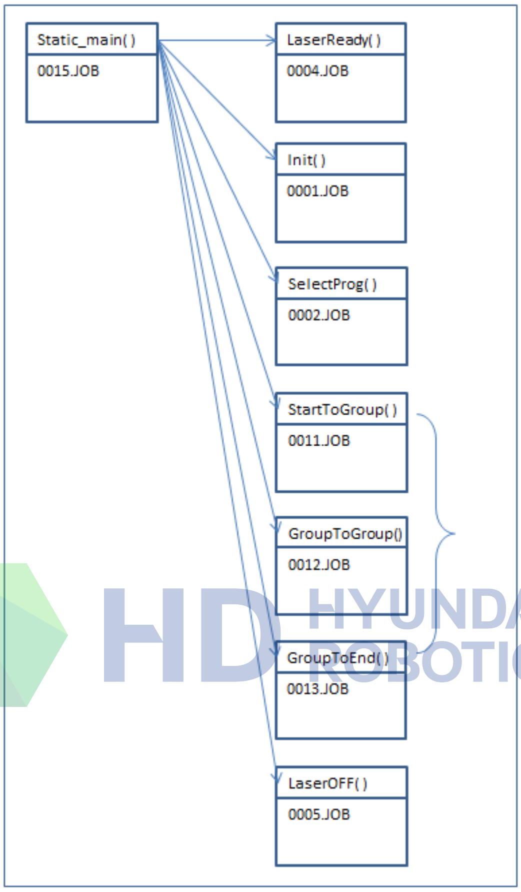

Figure 9 Overview of JOB program in STATIC OTF mode

GRC: 477, Bundangsuseo-ro, Bundang-gu, Seongnam-si, Gyeonggi-do
Daegu: 50 Technosunhwan-ro 3-gil, Yuga-eup, Dalseong-gun, Daegu-si
Ulsan: Room 201-5, Automotive and Shipbuilding Engineering Hall, Maegoksaneop-ro 21, Buk-gu, Ulsan-si
Middle Region: Song-gok-gil 161, Yeomchi-eup, Asan-si, Chungcheongnam-do
Gwangju: Room 101, Building B, Pyeongdongsandan-ro 170-3, Gwangsan-gu, Gwangju-si
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