HD HYUNDAI ROBOTICS

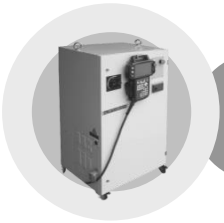
Use this

All installation work must be performed

by a qualified installer

and must comply with applicable laws and regulations.

Hi5aLVS230629FMEN3



Hi5a Controller Function Manual

LVS Welding Line Tracking Function

HD HYUNDAI ROBOTICS

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Printed in Korea – Jun. 2023. 3rd edition.

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1 LVS Function

1.1. About the LVS Welding Line Tracking Function

LVS is the abbreviation of laser vision sensor. The LVS function is used to track the welding line by automatically correcting the position and misalignment errors of the workpiece during welding. The sensors currently supported by Hi5a are the Oxford OSL, Renue, and Riftek RF627 sensors.

The LVS function makes it possible to perform welding along the actual workpiece welding line when the taught trajectory does not match because of the misaligned workpiece, as shown in Figure 1.1. Therefore, the taught job program may be used as is without changing it.

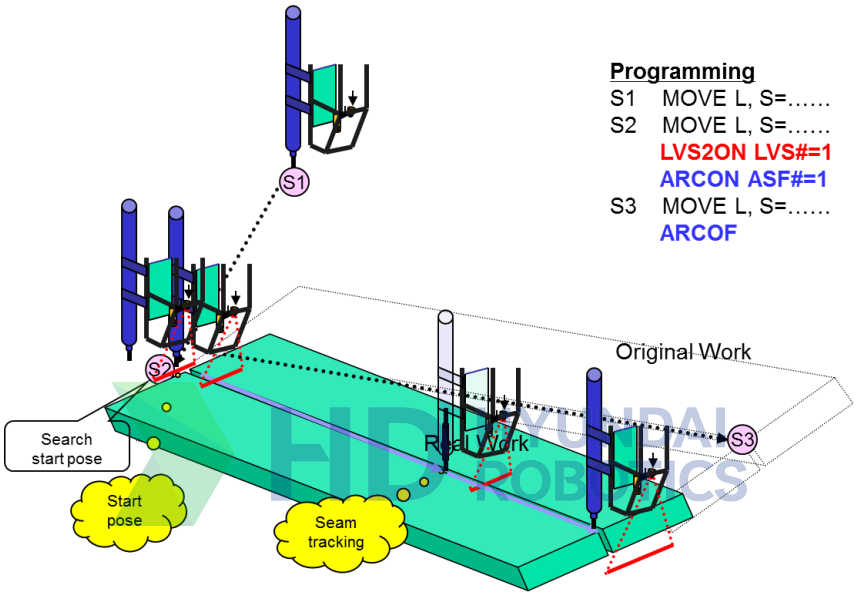


Figure 1.1 Example of the LVS welding line tracking in which the starting point search is used

Figure 1.1 shows an example of the LVS welding line tracking in which the starting point search is used. When the starting point search is performed, movement will occur in the direction of + Tool X to identify an invalid welding line. When an invalid welding line is found, movement to the starting point will automatically occur, saving the correction amount.

* Caution: The LVS2ON command should exist above the ARCON command. The ARCOF command should exist after one or more MOVE statements.

1.2. Understanding the LVS Welding Line Tracking Function and Sensor Installation

The LVS sensor detects the position of the welding line of the seam type set by the user in the condition edit window. The LVS sensor is installed near the torch and transmits the relevant information to the robot controller. Using the information, the robot performs controlling such that the TCP can track the sensed welding line. Therefore, the robot can track the welding line without changing the job program even when the workpiece is misaligned. In other words, this function can be used in both cases when the workpiece is misaligned and when there is an error with the workpiece that needs welding.

1.2.1. Processes of Sensor Installation and LVS Welding Line Tracking

A good understanding of the LVS function can minimize problems in the field. Mount the bracket on the torch to fix the sensor, as shown in the figure. In this process, performance may be degraded if the look ahead is too large. In general, α is 10–20 degrees.

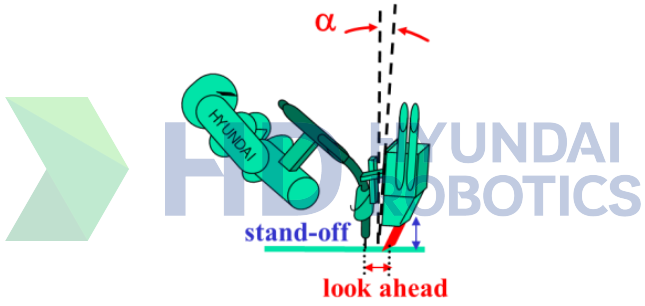


Figure 1.2 LVS sensor installation

If spatter is splashed on the LVS sensor, you can replace the covers that protect the laser receiving and emitting units. The LVS welding line tracking will be progressed by repeating the process of welding line sensing → target point calculation → cue related processing → position and posture error calculation → welding line tracking, as shown in the figure below.

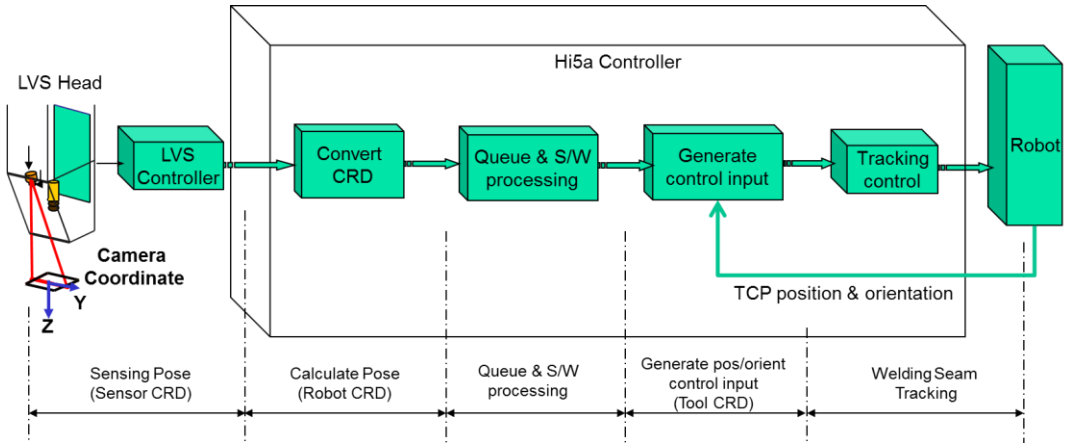


Figure 1.3 Principle of LVS tracking

Queue refers to a memory that stores these sequential target points. Regarding S/W processing, it refers to a variety of processing required for the LVS function, such as starting point search, end point search, spatter prevention, monitoring, stick-out correction, tracking amount limit, arc retry, arc restart, multipass, and seam finding.
The LVS function not only performs position traction but also makes it possible to set an option for automatically correcting the posture (orientation).
In this process, the Yaw, Pitch, and Yaw/Pitch options can be set.

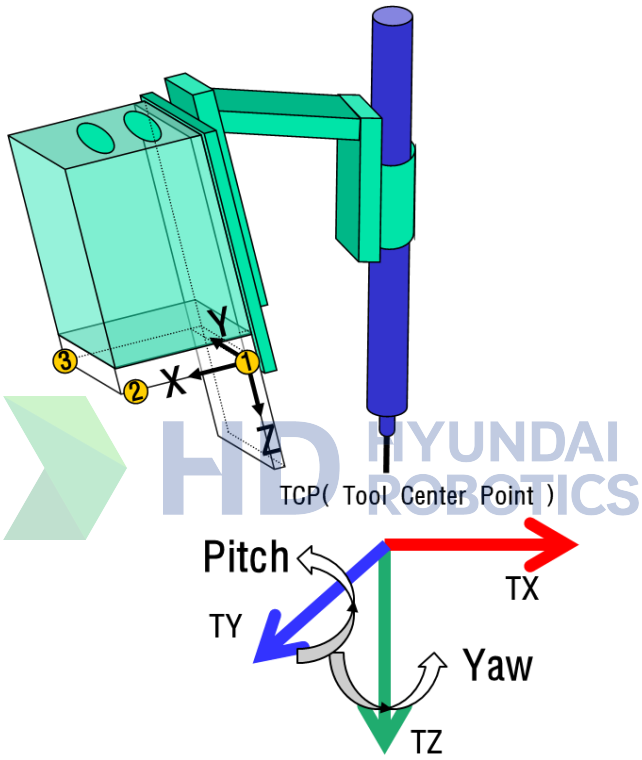


Figure 1.4 Principle of LVS tracking

* Safety precautions As the LVS function generates incremental commands, the robot may move on a path different from the previously taught path. That said, it is important for safety to set and use the traction amount limit function properly. Do not work close to the robot during teaching.

1.2.2. Preparatory Stage for LVS Function Use

A license is required to use the LVS function. You must request and obtain the relevant license from the head office. For using the LVS function, the LVS sensors provided by our company should be used, and the LVS sensors currently supported are as follows.

LVS sensors supported Meta SLS, Oxford OLS50, Riftek RF627, and Renue sensors

The preparatory procedures for using the LVS function by using the robot of our company area are shown below.

1) Sensor communication opening (IP and port settings)
2) Sensor controller settings (seam, laser intensity, shutter, filter [MA, Median, etc.], mismatch, etc.)
3) Sensor-TCP calibration
4) Checking of the manual mode (GUN off) operation after teaching for the welding workpiece
5) Verification of welding quality after operation in auto mode

1.2.2.1. Sensor communication opening (IP and port settings)

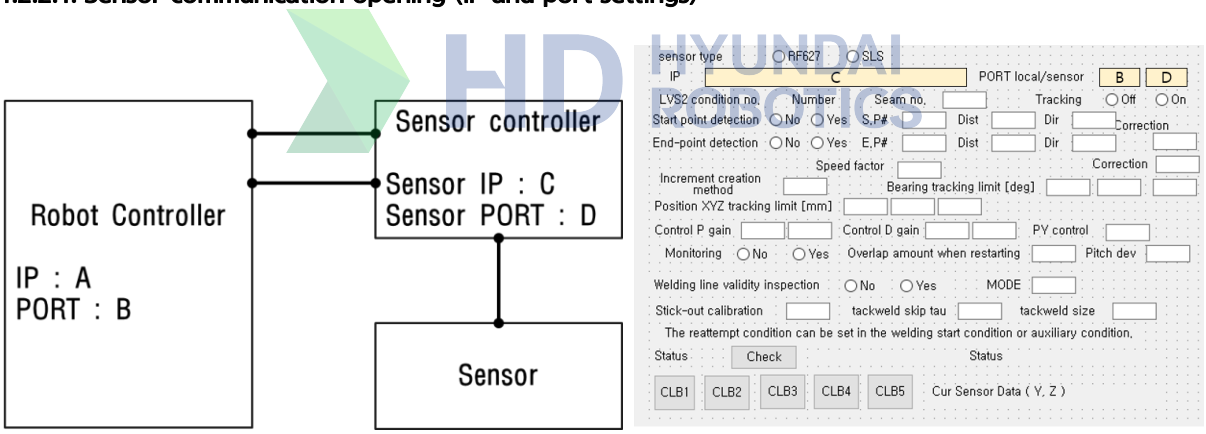


Figure 1.5 Sensor-controller communication opening

Pressing the QuickOpen key in the LVS2ON command makes it possible to enter the condition setting edit screen. Select the sensor type and set the sensor's IP address. Regarding port settings, "local" is for the controller's port, and "sensor" is for the sensor's port.

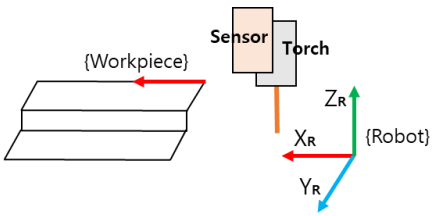
1.2.2.2. Sensor Controller Settings (Seam, Laser Intensity, Shutter, Filter, Mismatch, etc.)

Set not only the seam type corresponding to the seam number but also the laser intensity, shutter, filter, mismatch, etc. in the sensor controller, and save them in the sensor.
The sensor can recognize the seam only when the laser intensity and shutter value are properly set according to the surface condition of the welding workpiece. Set the filter. Using a median filter is recommended to reduce the spatter misrecognition rate. Set the mismatch. Mismatch is for inspecting the characteristics of the relevant seam, such as a gap. LVS sensors are sensitive to welding light and spatter. For the prevention of a large amount of spatter, the welding conditions and peripheral devices, such as airblows, should be used, and a blocking cover should be installed to shield the welding light.
When all of the items are set and stored in the sensor, communication with the sensor will occur according to the conditions corresponding to the seam number in the condition edit window.

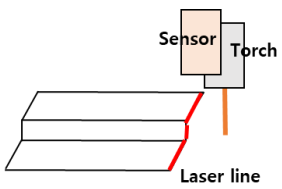
1.2.2.3. Sensor-TCP calibration

Before sensor-TCP calibration is performed, tool calibration and tool angle correction must be performed first.
Set the TCP in a position perpendicular to the calibration specimen. In this process, the calibration specimen should be placed parallel to the X-axis direction of the robot.

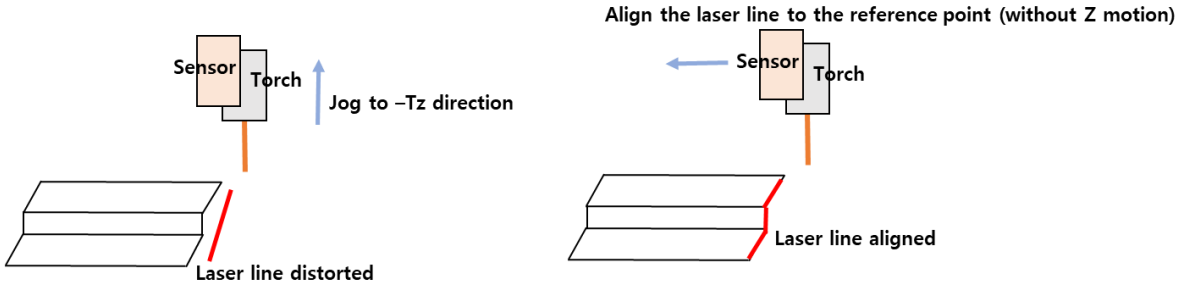
Step 1: Insert the LVSON COND#=1, OPT=TRK command by inputting command input-arc-LVSON.



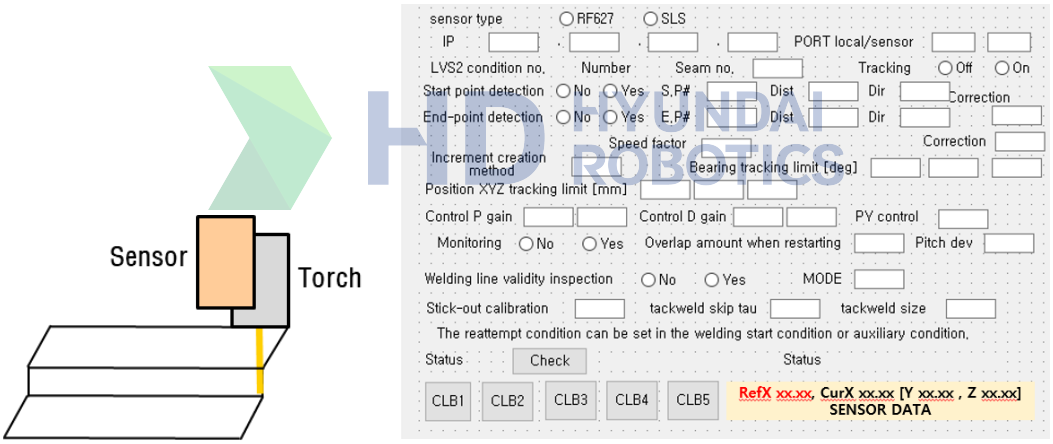
Step 2: Enter the condition edit window by pressing the QuickOpen key in the LVSON command. Pressing the [CLB1] button will turn the laser on and show the sensor data at the bottom part of the condition edit window. If no response or sensor data is coming in, check the communication settings again.



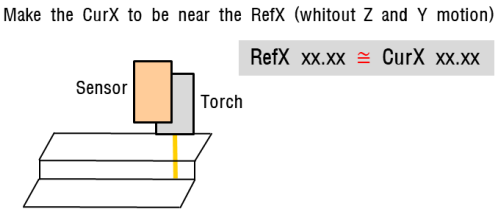
Align the laser with the reference point of the calibration specimen by jogging based on the Cartesian coordinate system.

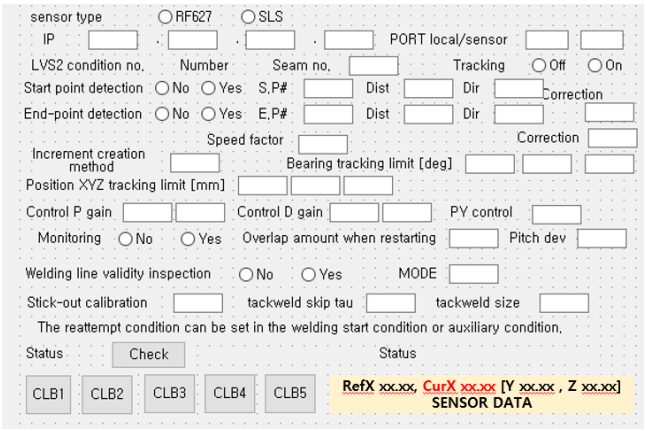


Step 3: Jog in the +Z direction. The laser is deviated from the reference point. In this process, align the laser with the reference point by jogging on the X-Y plane. Then, click the [CLB2] button again.

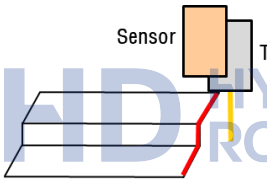


Step 4: Move the TCP to the reference point, and then click [CLB3]. This operation must be performed with precision. Clicking [CLB3] will display the RefX value.





Step 5: Clicking [CLB4] will display the CurX value. Perform Cartesian jogging in the X direction, and click [CLB4]. Clicking [CLB4] will update CurX. Repeat this operation to make CurX close enough to RefX.



Step 6: Perform Cartesian jogging to align the laser with the reference point. In this process, perform jogging to make the Y of [Y xx.xx, Z xx.xx] close to 0.0. After that, clicking the [CLB5] button will complete the calibration process.

*Note: Given a movement occurring to the pose corresponding to S.P# in the condition edit window after calibration, the calibration is considered to have been performed well if the movement is toward the reference point.

1.3. LVS Condition Settings

You can enter the condition edit window by pressing the QuickOpen key in the LVSON command.

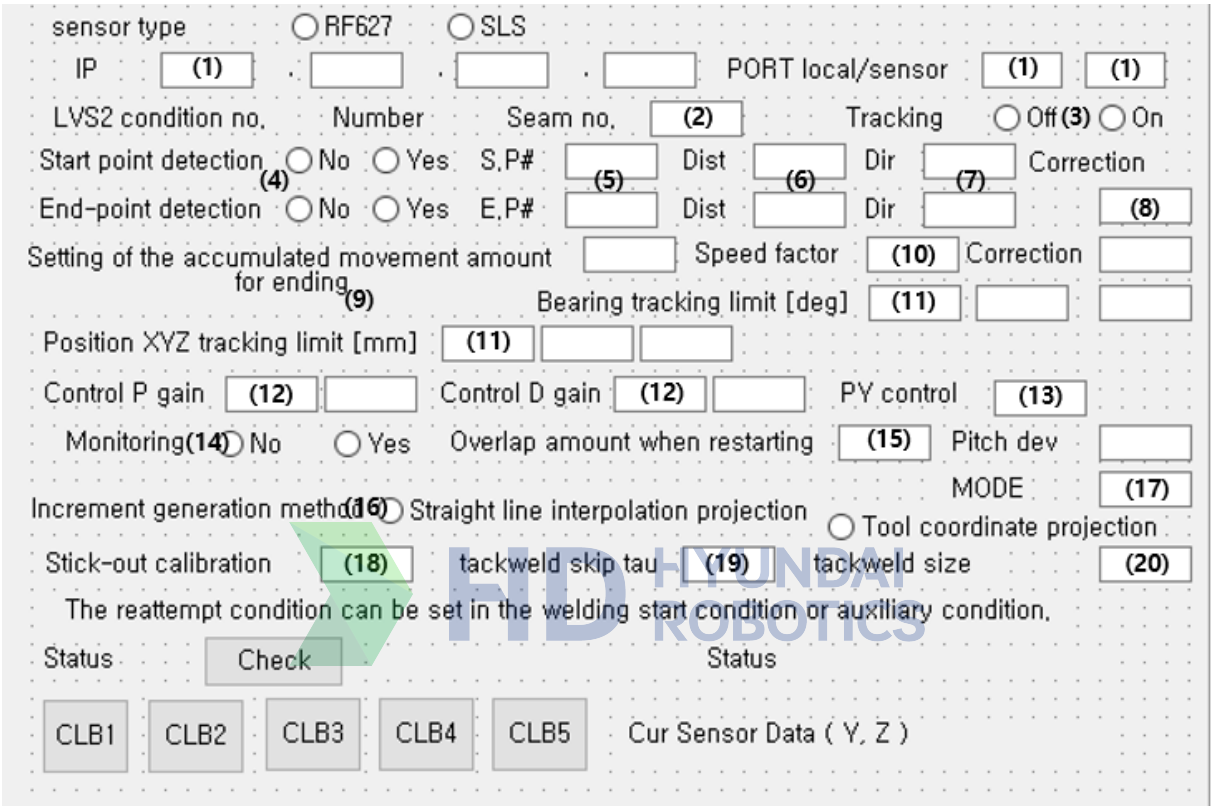


Figure 1.6 LVS condition edit window

(1) IP, PORT
As for IP, set the IP of the sensor or sensor controller.
Regarding the port, “local” is for the port of the controller, and “sensor” is for the port for the sensor.

(2) Seam number
This refers to a seam number registered in the LVS sensor. It gives a command for the LVS sensor to perform sensing with the seam number set in here.

(3) Tracking
It sets tracking as “enable” or “disable.” This tracking off function can be used conveniently when multipass welding is performed.

(4) Detection of the starting point and end point
It sets whether to search for the starting point or end point.
Starting point detection will occur, as shown in the figure below.

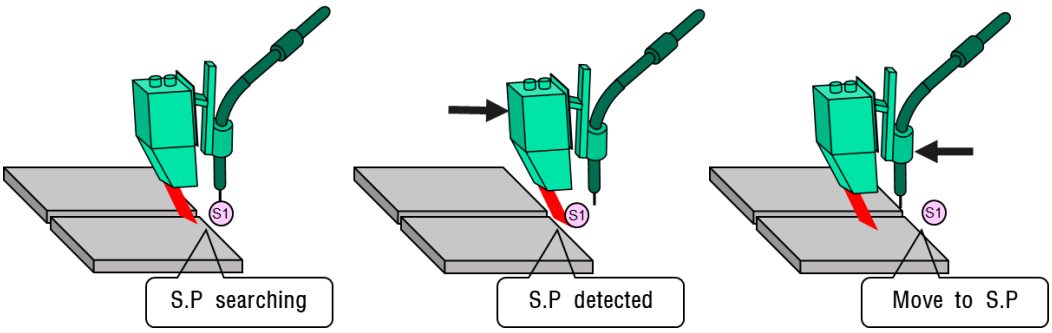


Figure 1.7 Example of enabled LVS starting point search

While starting point detection is enabled, if the LVSON command is executed, the search will start as shown in Figure 1.7.
When the starting point is searched, the robot will move to the starting point and store the information of the welding line that will be tracked afterward.
If starting point detection is disabled, tracking will start after movement occurs from the sensing starting point to the laser progressing direction, as shown in the figure below.

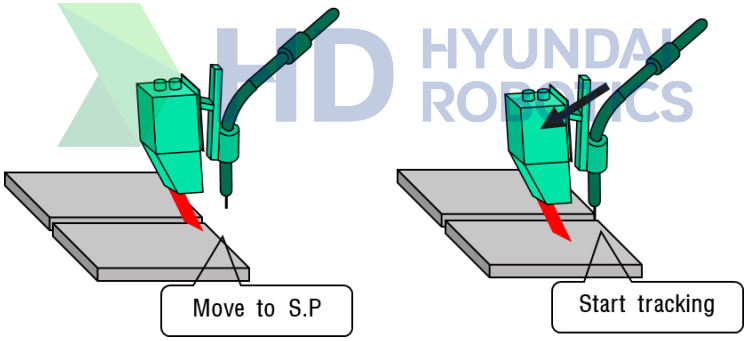


Figure 1.8 Example of disabled LVS starting point search

End point detection will occur, as shown in the figure below. If end point detection is used, it is possible to compensate for the end point error as much as L_{TS}, which is the TCP-laser strip distance.
In end point detection, welding will be performed by extending the end point to the point that the sensor does not determine to be a seam.

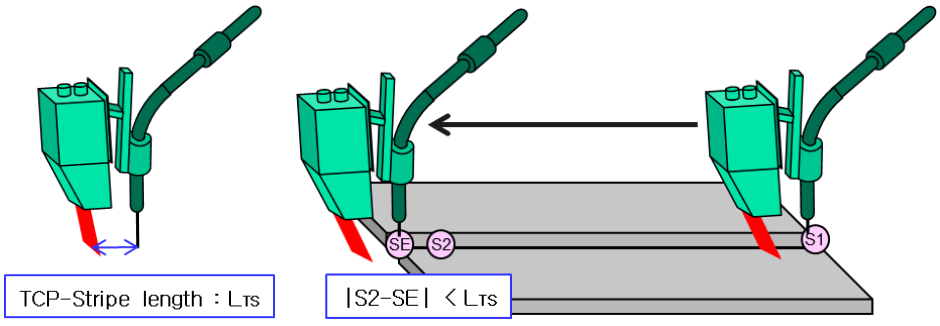


Figure 1.9 Example of LVS end point search

(5) Allocated pose number (S.P#, E.P#)
When the starting point search and end point search are completed, the pose will be recorded in the corresponding pose number.

(6) Search distance (Dist)
It sets the maximum search distance for the starting point search and end point search.

(7) Search direction (Dir)
If it is +1, searching will be performed in the direction of +ToolX, and if it is -1, searching will be performed in the direction of –ToolX.

(8) Correction (Search correction amount)
If there is a position error with the pose when the starting point search and end point search are performed, this function can be used to correct the error.

(9) Setting of the accumulated movement amount for ending
In Mode 4, tracking will end if movement occurred as much as the set distance (mm).

(10) Speed factor
It sets the movement speed to the end point when the end point search is enabled. In Mode 4, this refers to the movement speed in the forward direction.

(11) Position XYZ tracking limit and orientation tracking limit
It sets the error in comparison with the taught program. An error will occur when tracking is performed beyond this limit value.

(12) Control P gain and D gain
It sets a value within the range of 10–30. (In general, all values are used as 15.)

(13) PY control
If it is 0, only the position will be corrected, while orientation control will not be used. If the value is 1, 2, or 3, Pitch, Yaw, and Pitch & Yaw will be tracked along the welding line, respectively. When Mode 4 is to be used, 4 should be used for PY control.

(14) Monitoring
When the monitoring function is activated, tracking data can be collected in the 0001.GDT file.

(15) Overlap amount when restarting
It designates the overlap distance when restarting.

(16) Incremental generation method
It uses linear interpolation projection.

(17) MODE
This refers to the version of the LVS function. Mode 1 is for normal tracking, 3 for stationary tracking, and 4 for tracking without a MOVE statement.

(18) Stick-out correction
It can be used to adjust the wire stick-out length.

(19) Tack welding detection sensitivity
It sets the tack welding detection sensitivity. In general, values ranging from 0.7 to 0.1 are used.

(20) Tack welding length
It sets the tack welding length. For this distance, tracking will be ignored, and interpolation will proceed.

(21) The retry condition can be set in welding start condition – auxiliary condition.

(22) Crater treatment can be set in the crater backward distance item in the welding end condition.

(23) Pressing the [Check] button after the execution of the LVSON command will show the current status.

1.4. LVS Command

The basic form of the LVSON command is as follows.

LVSON COND#=1, OPT=TRK

In addition, the command is also available in various forms, as shown below.

OPT	Example of usage	Usage
TRK	LVSON COND#=1,OPT=TRK	General tracking (MODE1) Stationary tracking (MODE3) It is tracking that will operate without a MOVE statement. (MODE4)
TRK,Side=2.0,Updown=-2.3	LVSON COND#=1,OPT=TRK,Side=2.0,Updown=-2.3	Modes 1, 3, and 4 are all supported. Tracking by shifting in the left-right and up-down directions
SEAMF	LVSON COND#=1,OPT=SEAMF	Touch sensing by using LVS The current point beamed at by the laser will be converted into a pose and then stored.
FMINZ	LVSON COND#=1,OPT=FMINZ	When a cylinder is scanned, its vertex will be found, converted into a pose, and then stored.
EPS	LVSON COND#=1,OPT=EPS	The end point will be searched with priority, scanned and found, and then converted into a pose and stored.
TRK_TRJSAVE	LVSON COND#=1, OPT=TRK_TRJSAVE,S=100,RN=V1%,TCRDSFT=0,10,0	Multipass tracking function using LVS

1.5. Job Program Teaching Using the LVS Function

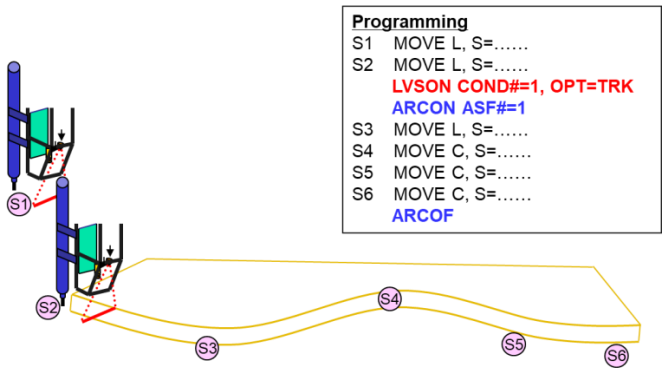
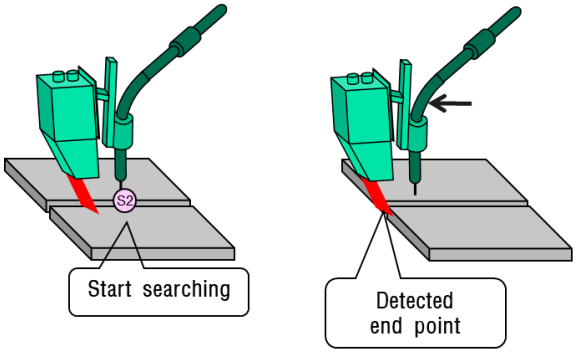


Figure 1.10 Job program teaching using the LVS function

The LVSON command should always be recorded above the ARCON command, as shown above. The reason is to start the welding with the starting point after the starting point search is completed.
When teaching is performed for the welding lines for multiple steps, and then the ARCOF command is encountered, the LVS tracking function will end. In this process, if the end point search option is used, welding will be performed while movement to the end point is taking place. Then, the arc end condition will be executed. Caution must be observed in the case of end point search. The end point can be corrected as much as the gap between the laser strip and TCP in the taught trajectory (Figure 1.8).
In addition, if the seam continues to be recognized near the end point, there is a risk of welding being performed for what is not a welding line.
An easy solution for the problem above is to use an EPS option that is LVSON COND#=1, OPT=EPS.
If the function is used in this way, the end point can be detected and stored in the pose variable. In this process, the search distance and number of the pose variable can be set in dist and E.P# in QuickOpen.



Programming
S1 MOVE L, S=……
S2 MOVE L, S=……
LVS2ON COND#=1, OPT=EPS

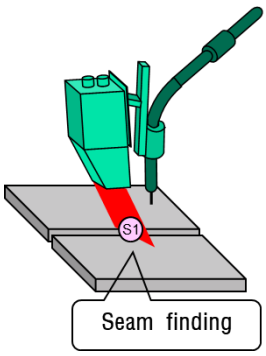
OPT=EPS option makes the robot search the end point and save the end point to the pose variable with assigned pose number (E.P#).
EPS is an abbreviation of End Point Search.

The OPT=EPS methodology mentioned above plays the same role as wire touch sensing. In this method, the end point pose is calculated in advance and is then used to designate the specific pose, such as MOVE L, P11, S=50 mm/min, A=3, and T=1 to perform teaching.

If the OPT=SEAMF method is used, the sensed point can be stored in the pose variable.

Programming Example 1

Robot programming for storing the sensing pose by using the seam finding function



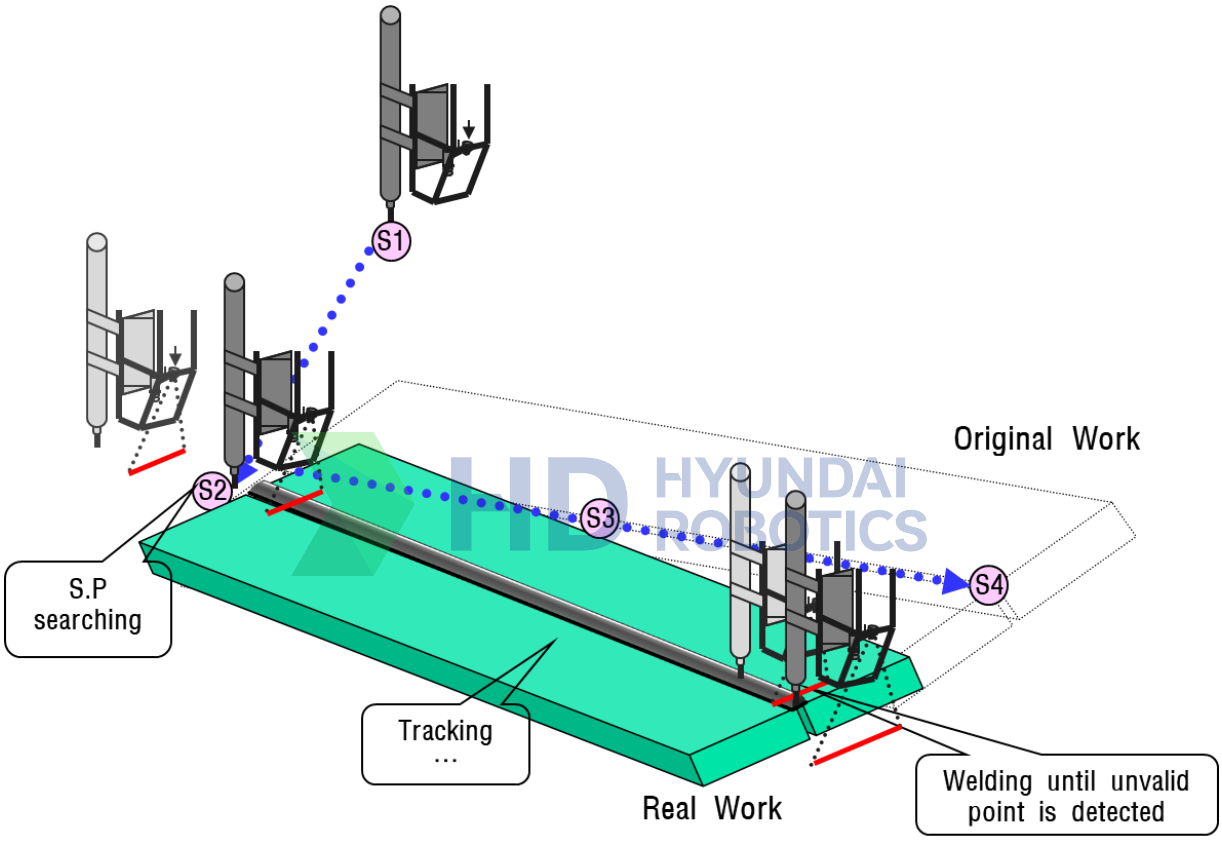
Programming
S1 MOVE L, S=……
LVS2ON COND#=1, OPT=SEAMF

OPT=SEAMF option makes the robot search the sensing point and save the point to the pose variable with assigned pose number, S.P#.

```
S1 MOVE L, S=20%, A=0, T=0        'Move to the position to carry out Seam Finding.
   DELAY 0.2                      '0.2 sec delay
   LVS2ON LVS#=1, OPT=SEAMF       'Perform Seam Finding (Sensing pose is to be stored in
S.P#).
END
```

Programming Example 2

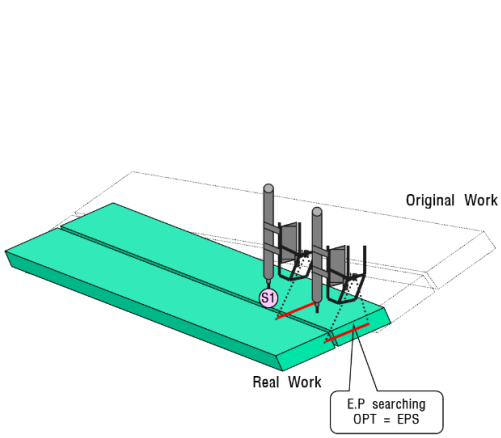
Robot programming using the starting point search and end point search
In the LVS condition edit window, set both the starting point search and end point search as “enable,” and then input the search distance.



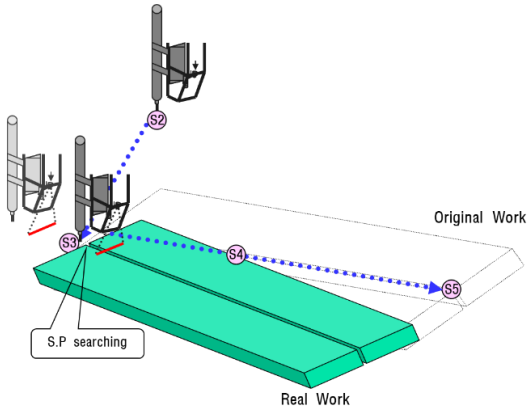

```
S1 MOVE L, S=20%, A=0, T=0
S2 MOVE L, S=20%, A=0, T=0      'Move to the starting point search position.
   DELAY 0.3
   LVSON COND#=1, OPT=TRK    'After the starting point search, move to the starting point, and
then start tracking.
   ARCON ASF#=1
S3 MOVE L, S=80cm/min, A=3, T=0   'Welding trajectory point 1
S4 MOVE L, S=80cm/min, A=3, T=0   'Welding trajectory point 2
   ARCOF                         'Move to the sensed end point, and then perform welding.
   END
```

Programming Example 3

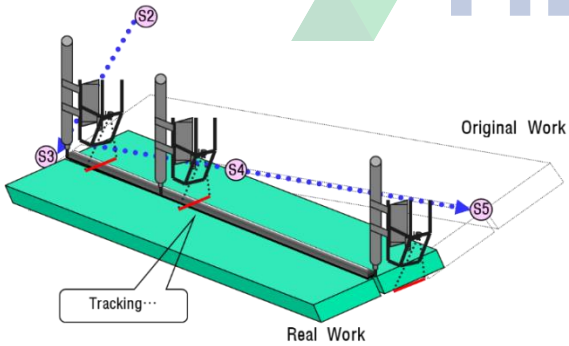
Robot programming using the starting point priority search and end point priority search
In the LVS condition edit window, set the starting point search as “enable,” set the end point search as “disable,” and then input the search distance.



Work progress 1 (Store the pose after the end point priority search.)



Work progress 2 (Search the starting point.)

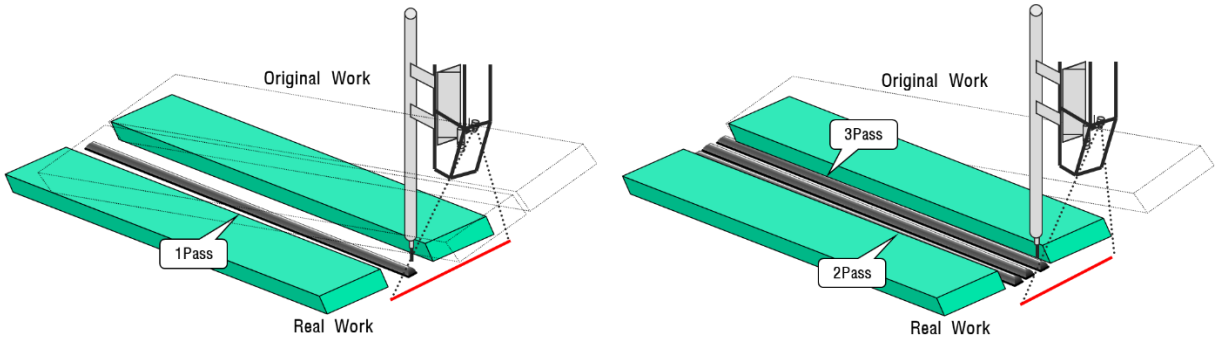


Work progress 3 (Perform welding up to the end point, and then end the welding.)’

```
S1 MOVE L, S=80cm/min, A=3, T=0   ‘Near the area where welding ends, near S4
   DELAY 0.3
   LVS2ON COND#=1, OPT=EPS      ‘After the end point search, set E.P#=100 in the LVS condition, and store it in P100.
S2 MOVE L, S=20%, A=0, T=0
S3 MOVE L, S=20%, A=0, T=0        ‘Move to the starting point search position.
   LVS2ON COND#=1, OPT=TRK      ‘After the starting point search, move to the starting point, and then start tracking.
   ARCON ASF#=1
S4 MOVE L, S=80cm/min, A=3, T=0   ‘Welding trajectory point 1
S5 MOVE L, P100, S=80cm/min, A=3, T=0   ‘Welding trajectory point 2
   ARCOF
   END
```

Programming Example 4

Robot programming using the LVS multipass function
Only for 1pass welding, the tracking should be enabled, while tracking should be disabled for use.




```
MOVE L, …                                   'move to SP search position
DELAY 0.3
LVSON COND#=1, OPT=TRK_TRJSAVE,S=10,RN=V100%,TCRDSFT=0,10,0
'1PASS, tracking with tracking to 'VALID' and multipass trj will be saved in P[10]~ P1[0+V100%]
ARCON ASF#=1
MOVE L, …..                                 '1PASS welding
ARCOF
MOVE P10,…                                  'Move to 2PASS multipass start position
DELAY 0.3
LVSON COND#=1, OPT=TRK_TRJSAVE,S=1000,RN=V101%,TCRDSFT=0,-20,0
'2PASS, and save 3PASS with tracking to 'INVALID', multipass trj will be saved in P[1000]~
P1[1000+V101%]
ARCON ASF#=1
FOR V50%=10 TO 10+V100% STEP 1
MOVE L,P[V50%], …                           '2PASS welding
NEXT
ARCOF
MOVE P10,…                                  'Move to 3PASS multipass start position
ARCON ASF#=1
FOR V50%=1000 TO 1000+V101% STEP 1          '3PASS welding
MOVE L,P[V50%], …
NEXT
ARCOF
```

1.6. LVS Function Troubleshooting

If a problem occurs, first enter the QuickOpen window of the LVSON command, and then click the [Check] button.
If tracking is not performing properly at the welding site, the following reasons can be considered.

(1) Excessive spatter or welding light
Design the casing well such that the sensor can be less sensitive to welding light and spatter.
Use airblow.
Check whether the seam is recognized by the sensor controller during welding.

(2) See whether the seam position that is inputted into the sensor is different from the desired seam position.
In this case, set the seam in the sensor controller, store the seam in the sensor, and then carry out testing.

(3) See whether the sensor does not detect the seam.
Check if seam registration and seam number setting have been properly performed.
Check the real-time sensing screen during welding.
Adjust the values such as mismatch, gap, angle, and laser intensity.

(4) Communication errors
Inspect the sensor and sensor controller, robot controller's IP, port, and cables.

(5) Problem with control gain
P gain 15, 15 / D gain 15, 15 is the basic value.

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