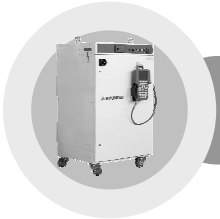
WARNING

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

Hyundai Robot

Hi4aLV071001FMEN3



Hi4a Controller Function Manual

LVS Tracking

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

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1 Overview

1. Overview

1.1. Preliminary Remarks

This function is optional that is not included in a standard components, so you need a License key for this function.

1.2. Laser Vision Sensor

Laser vision sensor is composed of head unit and control unit.

The head unit is composed of laser diode to make a laser strip and CCD camera and optical filter to read the laser strip.

Air injector for cooling is basically provided. Purchasing a plate to use a cooling water is optional.

Contorl unit is composed of image processing part, communication processing part with robot, and weld line configuration processing part by connecting to PC.

The operating principle is to measure the plane positions(up/down, left/right) generated by a laser strip. For this, a scanning angle of laser strip and a reading angle with CCD camera are installed differently.

1.3. Interface of Sensor & Robot

The flow chart of data processing in the laser sensor and robot is as follows.

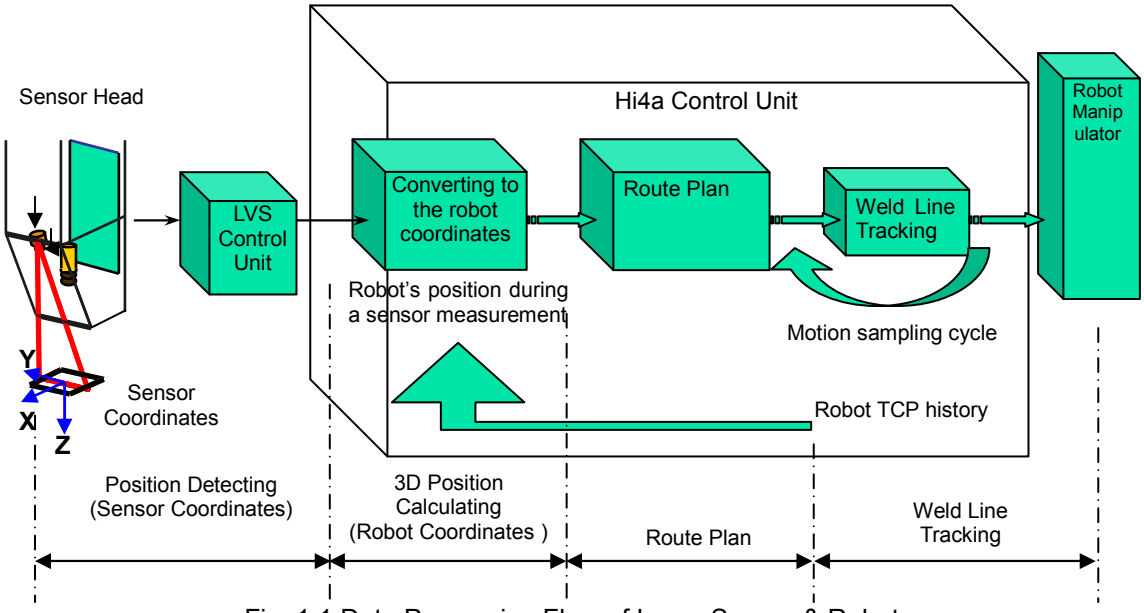


Fig. 1.1 Data Processing Flow of Laser Sensor & Robot

Attach a sensor head to a welding torch or the tip of robot, and communicate with sensor control unit and robot in a serial(RS232C).

To start a tracking or searching function, robot sends the configuration number registered by a user to a sensor control unit. And then the unit processes a configuration of laser strip input to CCD camera and sends a position of weld line(camera coordinates system), angle, and GAP or volume to the robot.

Robot controller is well aware of the position and posture of sensor attached to the torch, so you may obtain the position of spatial weld line by converting the received value of camera coordinates to the one of robot coordinates.

2
Function of Robot

2.1. Tracking Function

2.1.1. Starting Point Detection

There are three selectable modes for detecting a tracking start point as shown in the figure.

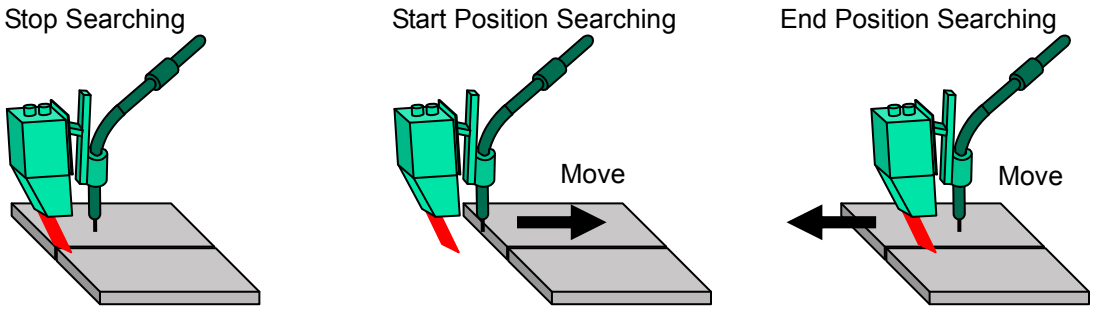


Fig. 2.1 Detecting Modes of Tracking Start Point

- Stop Searching
  A mode detecting a weld line position to detect a start point with a robot unmoved.

- Start Position Searching during a movement
  A mode detecting the first detected weld line position as a start position while robot moves toward the weld line.

- End Position Searching during a movement
  A mode dectecting the ending position of weld line as a start position while robot moves to a direction which has no weld line.

*) The above detected position may be saved in variables.

Caution) The moving search function does not support a circular arc section. Thus, if a starting section of tracking is set to be a circular arc interpolation, you cannot use the moving search function. To use this function, teach a certain distance to be linear from a start point although a circular arc interpolation is needed in the tacking start secion.

2.1.2. Vertical Point Detection

This function is to process an ending part of weld line, during tracking, with a vertical point. You may extend the vertical point and specify the detecting section with the input of extended distance. You may also save the detected position in variables.

2.1.3. Offset Specifying in Start or End Position

You can start a welding from a certain distance of detected weld line by specifying an offset distance toward a weld line from the detected tracking start position or end position.

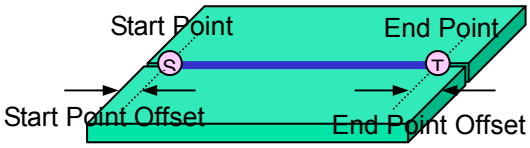


Fig. 2.2 Offset Specifying in Start or End Position

2.1.4. Posture Tracking Function

Robot can track a posture(Pitch & Yaw) along the detected weld line. Although the robot also can track a Roll with the input of sensor on welding subject's distortion, you need to determine whether to apply it after testing because the detecting value of Roll can be infirm depending on sensor makers.

Besides you can select whether to allow a posture calibration in a start point. You also may select whether to calibrate a posture based on the point where a sensor is located, or based on the point where a torch is located during a tracking. Since a usual position of sensor is located as Look Ahead as a torch , you need to calibrate the posture based on the position of sensor. It is recommended to increase a tracking restriction value for the better posture tracking.

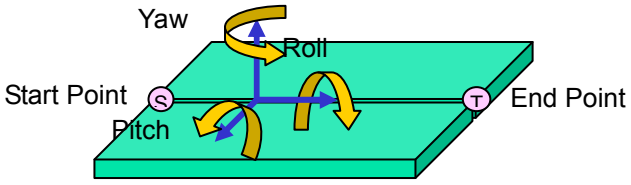


Fig. 2.3 Posture Tracking Function

2.1.5. Monitoring Function of Maximum Locus Deviation

This function is to monitor a deviation from the teaching locus. It can be specified as a distance and angle value respectively. If a tracking volume is larger than the value set by a user while a robot tracks along a weld line, it is considered to be an error and the robot stops.

2.1.6. Ignoring Function of Tack Welding

Since a weld line cannot be detected around a tack welding region(tack) for fixing a working piece, you can ignore a section where the weld line cannot be detected by specifying a maximum allowable distance of tack welding. If it exceeds this value, it is considered as an error and the robot stops.

2.2. Searching Function

This function is to detect only a position of weld line that is identical with the set weld line without using a tracking function. There are three selectable modes for users like the tracking start point detecting function.

- Stop Searching
  A mode detecting a weld line position to detect a start point with a robot unmoved.

- Start Position Searching during a movement
  A mode detecting the first detected weld line position as a start position while robot moves toward the weld line.

- End Position Searching during a movement

  A mode dectecting the ending position of weld line as a start position while robot moves to a direction which has no weld line.

*) The above detected position may be saved in variables.

Caution)
The moving search function does not support a circular arc section. This function can be used only for the step recorded as a linear interpolation.

3
Setting

3.1. Overview

Installing method for a laser vision sensor is described in this chapter. First, communication setting part, sensor head installation, sensor coordinates calibration, and tracking conditions are explained here.

3.2. Communication Setting

3.2.1. Overview

Control unit of laser vision sensor and a robot controller communicate in a serial(RS232C), so the connecting method of communication cable and the serial communication setting of controller are first described here.

3.2.2. Communication Cable

- Communication Cable of Robot & Sensor

① In the use of Main Board CNSIO

CNSIO(9 pins):Port 1		Sensor (9 pins)
pin 2(TxD)	———	pin 2(RxD)
pin 3(RxD)	———	pin 3(TxD)
pin 5(GND)	———	pin 5(GND)

② In the use of Main Board OPSIO1 (JP2=Open, JP3=Short)

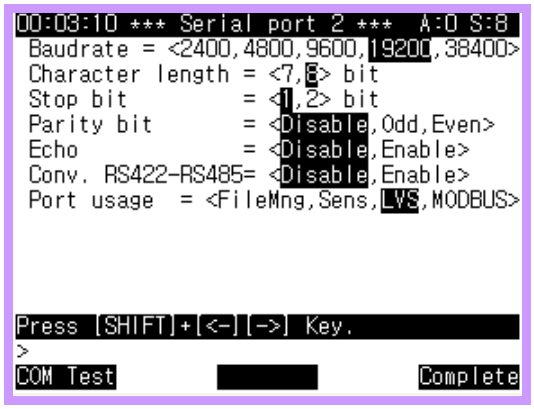
OPSIO1(14 pins): Port 2		Sensor (9 pins)
pin 5(TxD)	———	pin 2(RxD)
pin 1(RxD)	———	pin 3(TxD)
pin 4(GND)	———	pin 5(GND)

- Communication Cable of Sensor & PC

Sensor's serial		PC (9 pins)
pin 2(RxD)	———	pin 2(RxD)
pin 3(TxD)	———	pin 3(TxD)
pin 5(GND)	———	pin 5(GND)

3.2.3. Serial Port Setting

(1) Select 『[PF2]: System』 → 『2: Controller Parameter』 → 『2: Serial Port』 →→ 『3: Serial Port #1(CNSIO)』 or 『4: Serial Port #2(OPSIO)』 in a manual mode, and the following screen will be displayed.



Note 1)
For MTR(Meta Company) System : set up as "19200, 8, 1, Disable, Disable"

Note 2)
If serial port 1 and 2 are all selected as LVS, the port 1 will be operated first.

3.3. Installing a Sensor Head

There are two ways to attach a sensor head to a robot as shown in the figure.

Attaching to a Torch

Attaching to the tip of axis R1

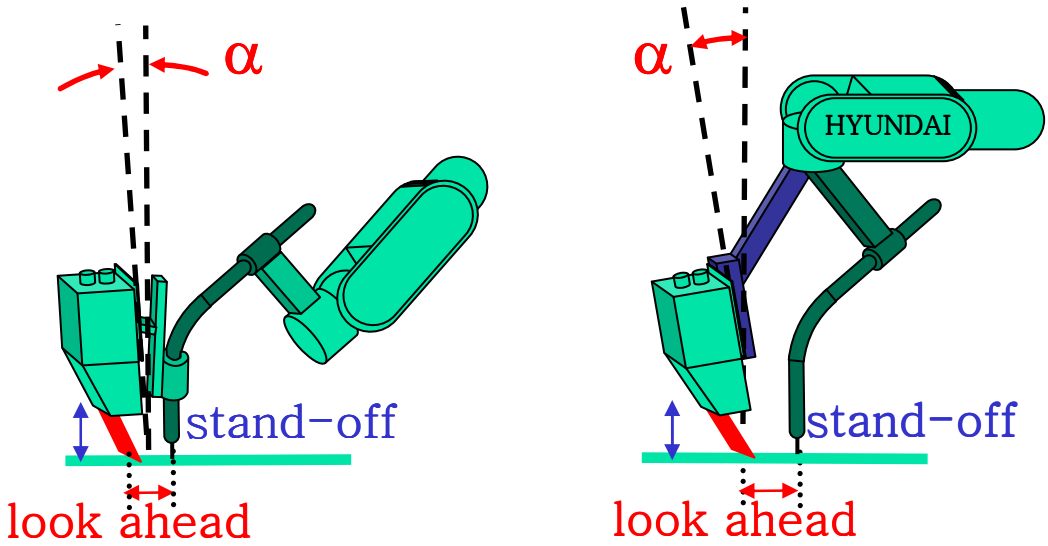


Fig. 3.1 Installing a Sensor Head

In the installation, be sure to maintain a usual look ahead in 40~60[mm], and place a stand-off within a detectable range depending on the kind of sensor head, and then maintain the above within the controllable range of 0~20◦. If possible, it is recommended to have a structure controlling the above 3 factors.

3.3.1. Attaching to the tip of Axis R1

As the figure in the right, the coordinates system of sensor is set up based on the tip of axis R1 in the method of attaching to the tip of axis R1. Thus this method can be used regardless of torch distortion. Accordingly, even if a torch is distorted or replaced with a new one, it is not necessary to reset the coordinates system of sensor.

3.3.2. Attaching to a Torch

As the figure in the left, in the method of attaching to a torch, the coordinates system of sensor is distorted together with the distortion of torch, and the coordinates system of sensor is automatically calibrated with the calibration of torch by a tool automatic calibration function. It is because the sensor coordinates system is set up based on the tip of torch. This method takes the advantage of simple installation of sensor head.

3.4. Sensor Coordinates Calibration

For a seam tracking function by LVS, the sensor-attached position should be correctly set up in a robot because the measurement result of sensor should be converted to a robot coordinates value. This is a sensor coordinates calibration. This function supports the following 3 methods.

3.4.1. Using a Sensor Head Box

This method is applied when using a sensor head by attaching it to a torch. It is used when you know the distance relations between the position of sensor coordinates system and the sensor head box. In other words, this method is to set up a distance by using a received data offset applied value in LVS conditions after the setting of coordinates in a sensor head box when the sensor coordinates system is set up in the sensor head box or the distance of origin in sensor coordinates system from box is acquainted. This is the simplest method among the 3 of setting modes, but its accuracy could be low because the origin position should be adjusted optionally in the real coordinates system of sensor.

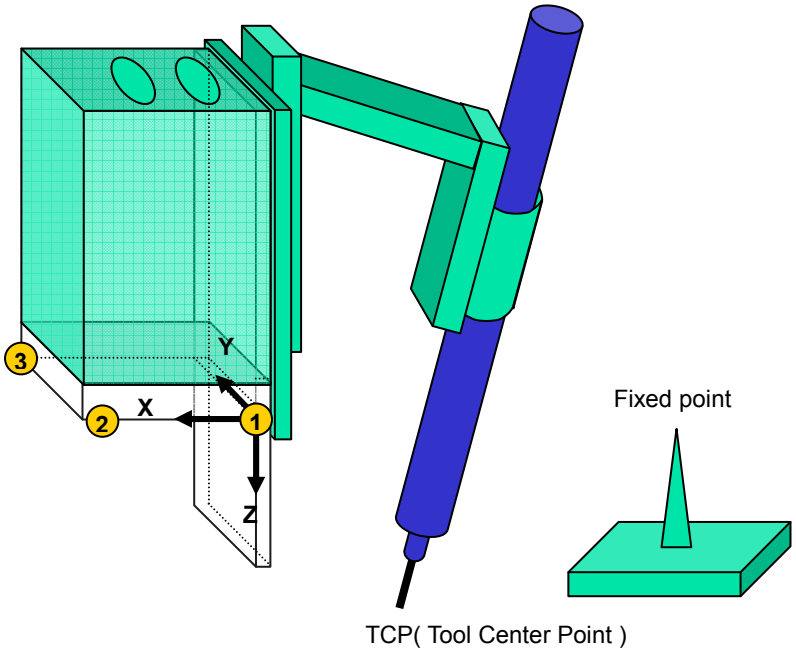


Fig. 3.2 Using Sensor Head Box

Step 1: TCP of robot
Step 2: Origin of sensor(□)
Step 3: Direction of Axis X of sensor(②)
Step 4: A point on XY Plane of sensor(③)

- How to write a operation program

  ① To execute this function, tool calibration should be completed in advance.

  ② First, install a fixed point with a pointed pin in a position where robot is movable as shown in the above figure.

  ③ Select a random program, and match TCP of robot with the fixed point, and then record a step 1.

  ④ Move the robot to match with the fixed point of coordinates origin(①) in a sensor head box, and record a step 2. In the same way, record a point(②) on axis X of sensor in box and a point(③) on XY plane as step 3 and step 4 respectively.

3.4.2. Direct Setting of Sensor Coordinates System

This method is also applied when using a sensor head by attaching it to a torch. It can be used without information on a position of sensor coordinates system. For this method, relatively much more setting working is required because a sensor coordinates system should be directly set up by using a sensor-measuring value with a sensor data monitoring function of robot(refer to monitoring function). However, it is effective to eliminate error-causing factors because the coordinates value of sensor is directly used here.

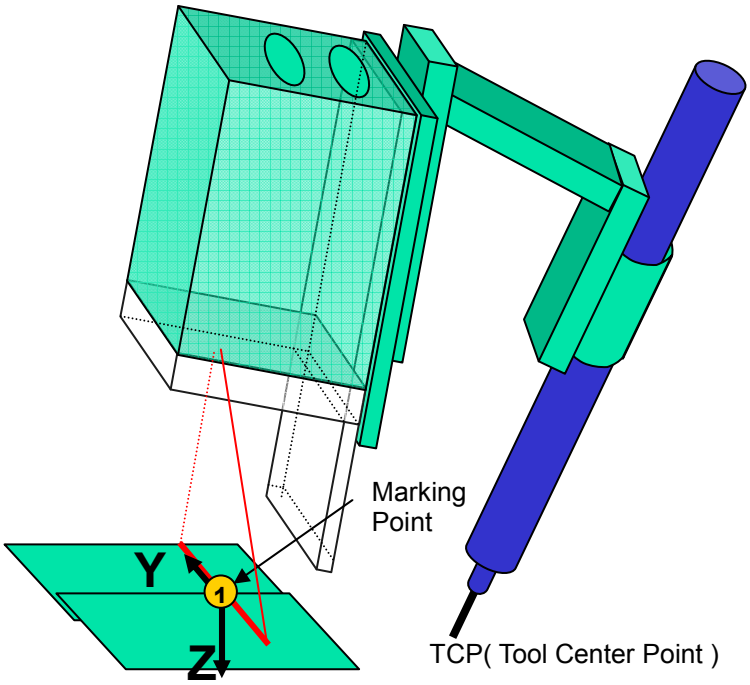


Fig 3.3 Direct Setting of Sensor Coordinates System

Step 1: TCP
Step 2: Origin of sensor coordinates
Step 3: Direction of axis Z of sensor coordinates
Step 4: A point on YZ plane of sensor coordinates

- How to write operation program

  ① To execute this function, tool calibration should be completed in advance.

  ② Exectue a laser sensor data monitoring function with R250 to set up a Joint configuration as 『[PF2]: EditCond』 , and set a [Applied offset : <Disable>, Averaging number of pre. = [30], Allowed value vs average = [0(Disable)].

  ③ Adjust a posture so that a laser belt remains in a certain position when moving up and down with a coordinates system set up to be perpendicular.

  ④ Mark a straight line on the laser belt with a pen to set up a standard point(①).

  ⑤ Move the robot perpendicularly, without changing a posture, to match TCP with the standard point, and exit from monitoring , and then record a step 1.

  ⑥ Execute a monitoring function again with R250.

  ⑦ Move the robot without changing a posture to match the position where a measuring value is X=0, Y=0, Z=0 with the standard point(①), and exit from a monitoring, and then record a step 3.

  ⑧ In the same way as above, move the robot to the position where a measuring value of sensor is X=0, Y=0 and only Z value is + with the standard point(①), and record a step 3.

  ⑨ In the same way as above, move to the position where a measuring value of Y is + and Z value is also + for sensor , and record a step 4.

3.4.3. Specifying Tool Number With Sensor Coordinate System

This method is applied when using a sensor head by attaching it to the tip of axis R1. Although its installation is rather complicated, it is a recommended method because it is the most effective in terms of accuracy improvement and management.

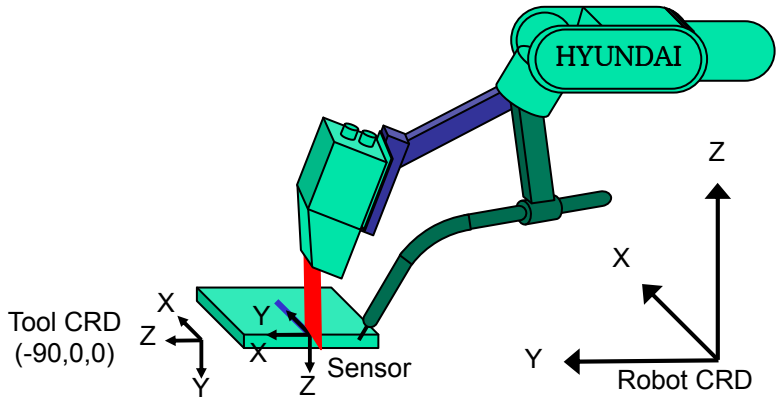


Fig. 3.4 Specifying Tool Number With Sensor Coordinate System

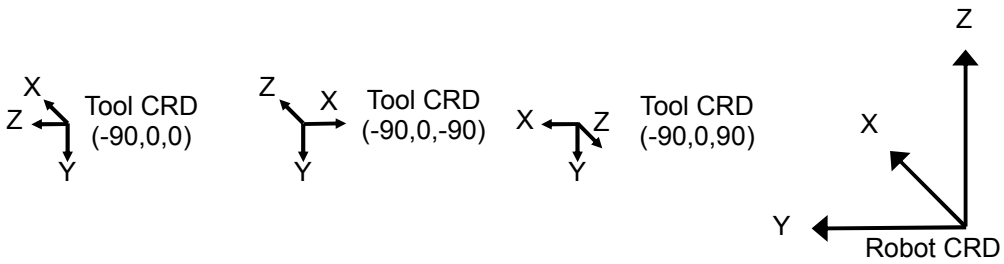


Fig. 3.5 Example of Change to Angles of Tool Coordinates

- How to register the sensor coordinates with tool numbers

  ① To execute this function, tool calibration should be completed in advance.

  ② Prepare a weld line as shown in the above figure, and draw a straight line parallel to the direction of X(or direction of Y) of robot. In other words, set a robot coordinates to be perpendicular to find a parallel line, operating the robot to the left/right(or forward/backward).

  ③ Operate a sensor data monitoring function by pressing a R250[SET].

  ④ Adjust a posture so that a laser strip is placed on the above straight line when moving the robot to the left/right and up/down in a perpendicular coordinates, and that Y value of sensor data monitoring maintains 0 when moving up/down.

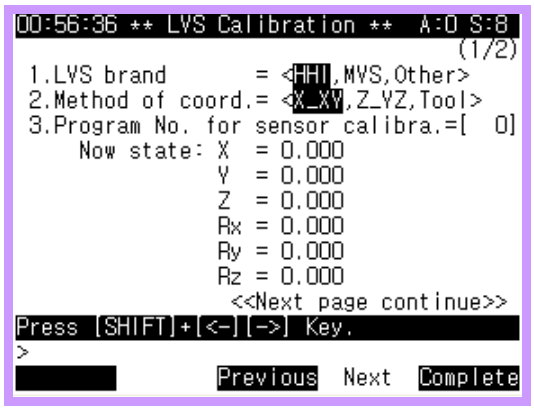
  ⑤ After the exit from monitoring function, select a random program, and place TCP of robot in an edge of above straight line, and the record a step. Here, the posture should be not chaged.

  ⑥ Press [QUICKOPEN] key to change the recorded step posture to the angle of tool coordinates. Here, axis Y of sensor coordinate system becomes an axis X of tool coordinate system, and axis Z of sensor coordinate system becomes an axis Y of tool coordinate system. Refer to the example figure for changing to angles of tool coordinate system as shown above.

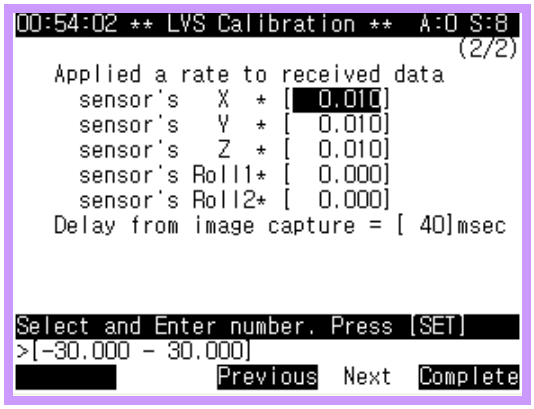
  ⑦ Execute the sensor data monitoring function again,and place it until the detected value in the above straight line is (0,0,0), and then execute an automatic calibration of tool constant. 『[PF2]: System』 → 『3: Machine parameter』 → 『1: Tool Data』 → 『[PF1]: AutoSETg』

3.4.4. Executing a Calibration

(1) Select 『[PF2]: System』→『6: Automatic Constant Setting』→『5: Laser sensor coordi. calibration』 in a manual mode.



(2) Set up a coordinates specification as X_XY or Z_YZ, the item #3 changes to "3. Program No. for sensor calibra. =[0]". Select 『[PF4]: Next 』.



3.4.5. Item Descriptions

- LVS Brand = <HHI,MVS,Other>
  Select a brand of laser vision sensor.

- Method of coord. = <X_XY, Z_ZY,Tool>

  ① X_XY :
  Select it when using a point on XY plane and the X direction of sensor in writing a program for calibration.

  ② Z_ZY :
  Select it when using a point on ZY plane and the Z direction of sensor in writing a program for calibration.

  ③ Tool :
  Select it when specifying a coordinate system of sensor as tool numbers.

- Assigned tool number for sensor / Program No. for sensor calibra.
  Input a tool number set for a sensor coordinate system or a program number written for calibration.

- Now state
  When the calibration function is executed, the position of sensor coordinate system is marked. This value will be saved in a control constand file, and later you can check the current set status when entering this set menu.

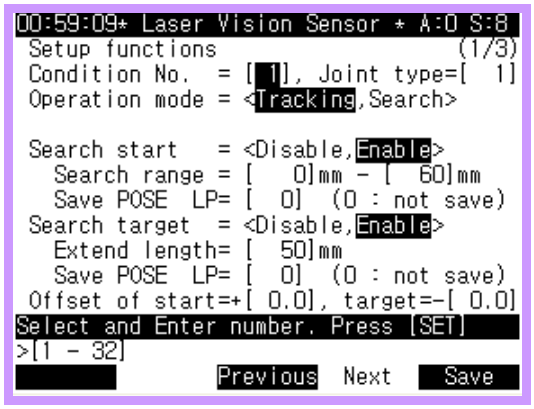
- Applying Magnifications to received data
  A random magnification could be applied to a received data. This value is automatically set when selecting LVS brand, and general users cannot change it.
  In the use of MVS products, the magnification is fixed as 0.01, and for the HHI products, it is fixed as 0.1. However, in the use of Roll tracking, if you intend to ignore one of the two joing angles, set the magnification to be 0.

- Delay from image capture = [0~999]msec
  Set the time from the image capture in a sensor until it is sent to a robot. In the use of MVS products, this value is 60msec.

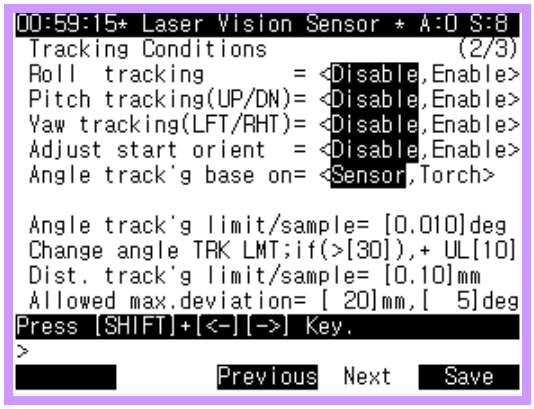
3.5. Sensor Interface Conditions

3.5.1. Operation

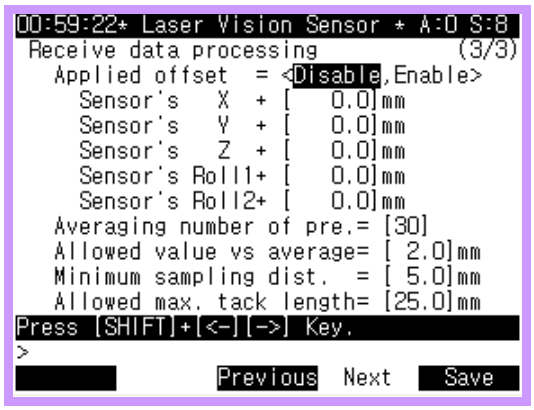
(1) Instruction for laser vision sensor is {LVSON LVS#=Condition No.}. Place a cursor on the instruction and press [QuickOpen]key. The following screen will be displayed.



(2) Press 『[PF3]: Next 』.



(3) Select『[PF3]: Next 』.



3.5.2. Item Descriptions

- Condition No. = [1~32]
  It is an interface conditions number and there are 32 numbers.

- Joint type = [0~255]
  It is a number of configuration to sense, and the configuration can be added/edited/ deleted with a configuration setting program of sensor. In case of MTR(MVS company), numbers 1~99 are supported.

- Operation mode = <Tracking,Search>
  It is an operating mode of sensor, and a weld line tracking function or searching function can be used.

  ① Tracking
  All items of conditions are applied, including a start point detection, and an end point detection.

  ② Search
  This function is to search only the start point without using the tracking function.
  If the left/right value of searching section for the start point in the items for function setting, robot receives the measurement result of sensor as much as " the number of cumulative average of previous value" in the state of stop without moving, and stor the average result in " position save LP".
  When the left/right values of searching section are not identical each other, convert a measuring value of sensor to robot coordinate system and calculate a distance with the previously calculated if the value is within the range of allowable changes compared to average value. And then, save the positions lager than the minimum distance of sampling. If there is a change in the existence of weld line, linearize the saved values to calculate the position of start point, and then save it in "Save POSE LP".

- Search start = <Disable,Enable>
  This value select whether to detect a start point or not.

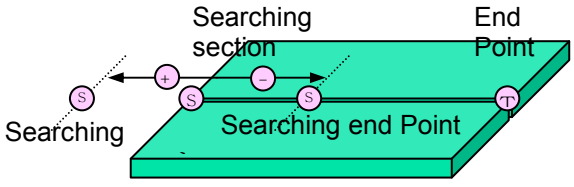


Fig. 3.6 Start Point Detection

  ① Search range = [-999~999]mm ~ [-999~999]mm
  It specifies a start point and end point of searching. The first value determines a start point of searching, and the second value determines an end point of searching. Searching section is determined with the two steps(n,n+1) next to the LVSON instruction, and – value averages the distance value from n step to n-1 step, and + value averages an extended distance from n step to the opposite direction of n+1 step.
  However, if the two values are same, it is a stop searching condition, and it searches a position of Joint if an operating mode is in tracking, in the position specified with this value, and if an operating mode is in searching, in the current position.

  ② Save POSE LP =[0~100] (0:not save)

After the completion of detection, the detected position is saved in a local pose variable specified here. However, if this value is 0, it is not saved, and if it fails to be detected, it stops because of an error. But, if this value is not 0, it does not stop due to an error despite its failure to be detected. You may check whether it is detected or not, making reference to the set LP values here. In case of tracking mode without detection, the instruction next to LVSON is executed. Here, if the next instruction is a step, it stops due to an error for safety. Refer to the operation programming to be explained later for more details.

- Search target = <Disable,Enable>
  Select whether to detect a vertical point or not.

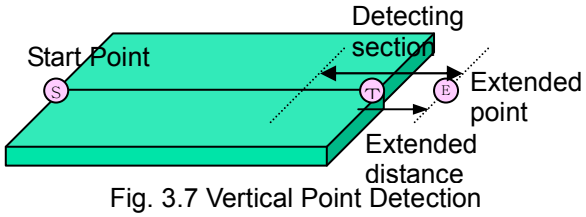


Fig. 3.7 Vertical Point Detection

① Extend length = [0~999]mm
Extend more than the recorded target point for vertical point detection as much as the the set value. Vertical point detecting section is twice the set value here, namely the section from –value to + value. For example, if this value is 100, its vertical point is detected from 100mm ahead of the recorded target point to the 100mm spot through the recorded target point if there is no weld line. And for the other sections , errors occur if there is no weld line.

② Save POSE LP =[0~100] (0: not save)
After the completion of detection, the detected position is saved in the local pose variable specified here. However, if this value is 0, it is not saved.
Even if a robot moves to the extended point and a vertical point is not detected, it will not be processed as an error. So ,you need to refer to the
saved variable values to check if the vertical point is detected or not. In other words, after the setting of unused value for the variable to save a vertical point before LVSON instruction, if there is a change when reading this value right after LVSOF instruction, it is considered to be detected, and if no change, it is considered a failure to detect.

- Offset of start =+[0.0~10.0], Target=-[0.0~10.0]
  Offset can be specified at the detected start point and end point as shown in the below figure.

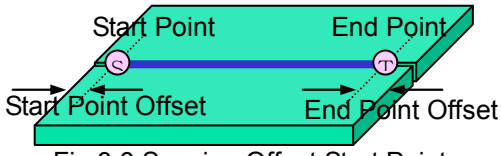


Fig 3.8 Sensing Offset Start Point

- Roll Tracking(LF/RG) = <Disable,Enable>
  It is to select whether to use a tracking for the left/right Rolling of workpiece. The accuracy of tracking is determined according to the measurement accuracy of sensor because Roll tracking is based on the angle of welding line surface. Apply the angle value detected from usual sensor only in a special case because Roll tracking has a vibration due to a high fluctuation of detected angle values.

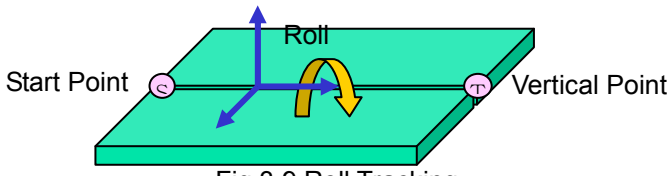


Fig 3.9 Roll Tracking

- Pitch tracking(UP/DN) = <Disable,Enable>
  Select whether to use up/down angle tracking for the moving direction.

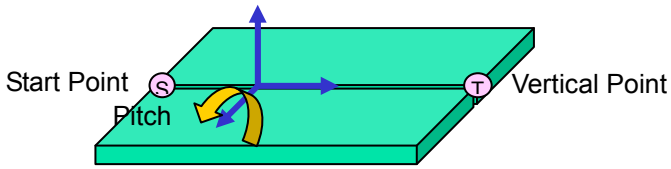


Fig 3.10 Pitch Tracking

- Yaw Tracking(LFT/RHT) = <Disable,Enable>
  Select whether to use a left/right angle tracking for the moving direction.

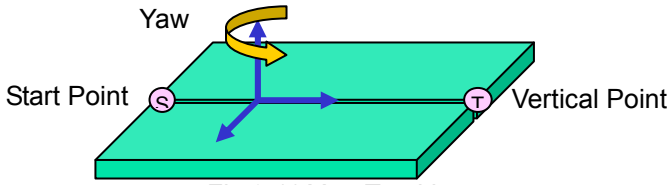


Fig 3.11 Yaw Tracking

- Adjust start orient = <Disable,Enable>
  If 'valid' is selected for a start point detection, it selects whether to calibrate a posture when approaching to the start point after the detection of start point. If selecting 'valid' for the start point posture calibration, robot moves to the start point, calibrating its posture according to the type of weld line.

- Angle track'g base on = <sensor,torch>
  If selecting 'valid' for the posture(Roll/Pitch/Yaw) tracking, select a standard point for the posture calibration. In other words, if selecting a sensor, the posture will be calibrated based on a sensing position by the current sensor, and if selecting a torch, the posture will be calibrated based on a linear position linearized to 4 positions of forward/backward from the current position. Usually, it is recommended to select a sensor.

- Angle track'g limit/sample = [0.000~0.500]deg
  Restrict a maximum tracking value per sample in the angle tracking. If this value is too high, angle change will be too much during tracking, and it too low, the tracking range will be limited. So it is important to take an appropriate value, and 0.01~0.02 is desirable value.

- Change angle TRK LMT;if(>[1~99]),+ UL[1~99]
  Set the conditions to increase the angle tracking restriction/sample value as mentioned above. In other words, if the trackings calculated from configuration of weld line is larger than 'if (>[numer]), it will increase in multiple of angle trackings, and be able to restrict the increase with maximum value. Usually 'if =(>[30]) and + UL =[10] are desirable values.

- Dist. track'g limit/sample = [0.00~5.00]mm

Restrcit a maximum tracking value per sample in the position tracking. If this value it too high, position changes will be too much, and if too low, position tracking angle will be limited. So it is important to take an appropriate value, and usually 0.1~0.2 is desirable value.

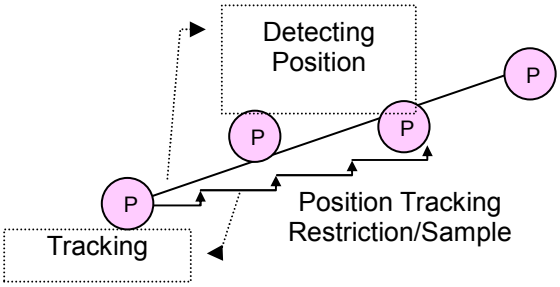


Fig 3.12 Position Tracking Restriction/Sample

- Allowed max.deviation = [20]mm,[5]deg
  Designate the maximum value that can be calibrated through sensing. Generally, it is not a good idea to setup to follow too many values. Generally, it is recommended to setup 20mm for distance tracking and 5 degrees for angle tracking.

- Receive data processing

  ① Applied offset : <Disable,Enable>
  This function is to add a certain amount of offset to the detected value of sensor. For example, if you intend to track in a little higher than the detected value of sensor, you need to input – for Z value, and if you intend to shift to a little bit left of the detected position to weld, you need to input – for Y value.

  ② Averaging number of pre. = [1~30]
  It is used to discriminate truth of received data based on a average value of received data. It is because an incorrect position could be detected by spatter when detecting a weld line in tracking. Usually if the weld line is almost a straight line, it is desirable to set this value to be 30(Max.), and if a change of weld line is great, it can be set to be 5.

  ③ Allowed value vs average = [0(Disable)~99.9]mm
  Set an allowable Changes to discriminate the truth in comparison between the average value as the number of cumultavie average in the above item and the received value. If setting this to be 0, unconditionally a valid value will be processed. If this value is too low, it might not follow the actual change of weld line, and if too high, other abnormal values might be processed as a useful value. So, usually about 2~5mm is a desirable value here.

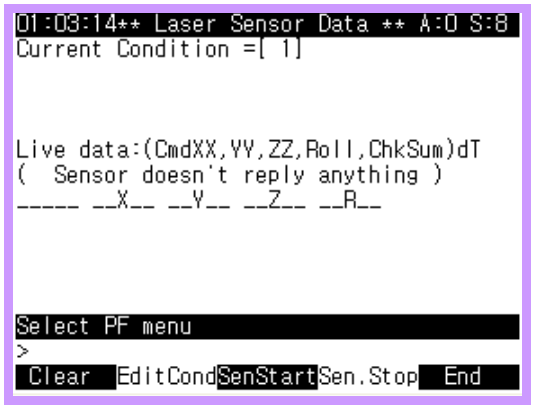
  ④ Minimum sampling dist. = [0.0~25.5]mm
  For tracking, the detecting position in a sensor is saved and linearized to plan a moving course in order to move a robot. Here, this function is to set a saving section for position save. If this value is too low, robot has many small changes, and if too high, no change in the section can be perceived. Thus, usually about 2~5mm is a desirable value.

  ⑤ Allowed max. tack length = [0(Disable)~99.9]mm
  When a tack welding has been completed for a weld line, tack welding section possibly could not detect or could be in excess of allowable changes compared to average value. Thus, although a weld line is not detected, specify the maximum length that is not processed to be an error as the value here.

3.6. Sensor Data Monitoring Function

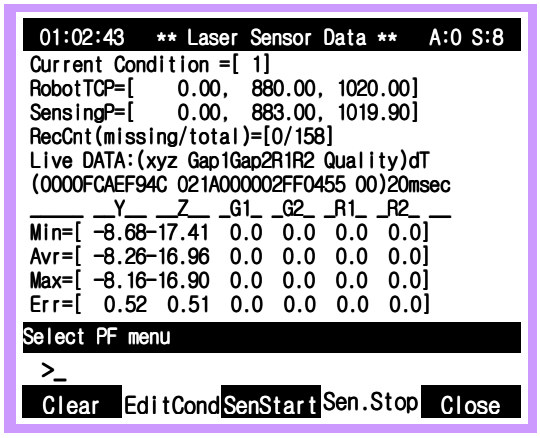
3.6.1. Operation

(1) Input R250[SET], and the following sensor data display screen will be displayed.



If entering this monitoring function during the execution of program, details(contents) is displayed but PF menu is not displayed for safety, and also the corresponding function will not be executed.

(2) The above status is an example when a sensor does not send a data. When pressing 『[PF3]: SenStart』 key and a sensor sends the data, the following screen is displayed.



- 『[PF1]: Clear』 : Initialize a maximum, minimum, error, and RecCnt values.
- 『[PF2]: EditCond』 : Edit the currently selected LVS conditions.
- 『[PF3]: SenStart』 /[SET] : Begin a communication with laser vision sensor.
- 『[PF4]: Sen.Stop』 /[R..] : Stop the communication with laser vision sensor.
- 『[PF5]: Close』 : Exit from a monitoring function.

3.6.2. Contents Descriptions

- Current Condition = [1~32] : Display the currently selected LVS condition numbers.
- RobotTCP : Display the position of robot TCP.
- SensingP :
  Disply the value converting a position detecting result of sensor to robot coordinates value.
- RecCnt(missing/total)=[missing count/total count]
  Display the frequency of total detection sent from a sensor and the frefquency of detection failures or excessive allowable changes compared to average value.
- Live data : Display the received value from the sensor.
- Min : Minimum : Display a minimum value among the received values from the sensor.
- Avr : Average
  Display the received values from sensor on the average as the set number as the number of accumulated average for LVS condition.
- Max : Maximum : Display a maximum value among the received values from the sensor.
- Err : Error(Maximum-Minimum) :
  Display the difference between the above maximum and minimum values.

4

Operation Programming

4.1. Searching Function Programming

For this searching function, 'searching' should be set for an operation mode among function setting of LVS condition. This has 3 types of operation depending on the setting of the first and second value in a start point searching section as shown in the below figures.

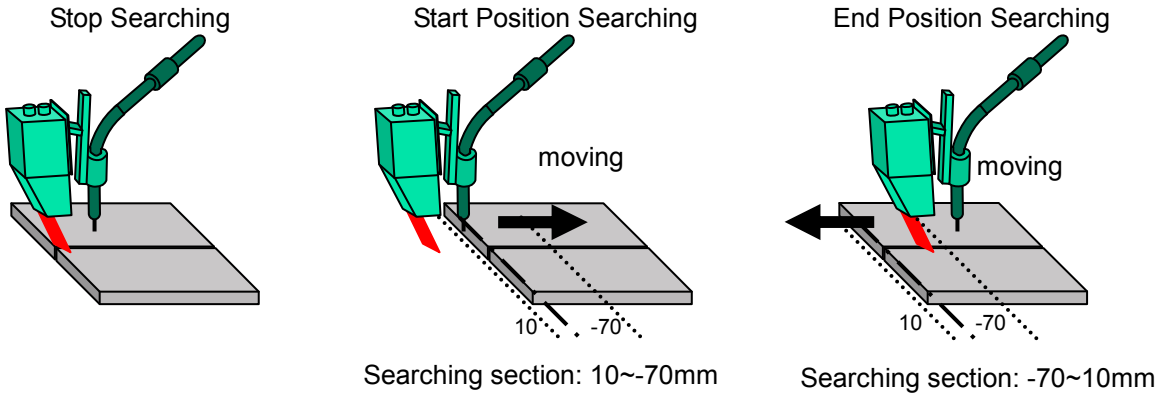


Fig 4.1 Searching Function

- Stop Searching
  When the first and second values are identical with each other in a start point searching section of function setting, the position of specified weld line is detected without moving a robot. Note) If an operation mode is in searching and the above two values are identical, the stop searching will operate in the current position without the movement of robot.

  However, if the operation mode is in tracking, the stop searching function will operate after moving to a specified position even though the above two values are identical.

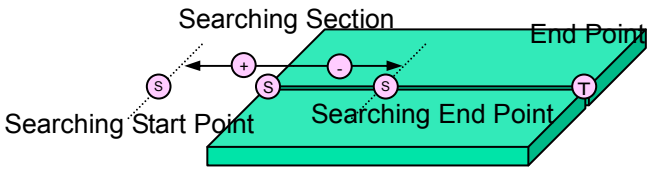


Fig 4.2 stop searching

- Start Position Searching in Movement
  When the first value of the start point searching section is higher than the second one in the function setting, this function searches a starting position of weld line while moving to a calculating position for the second value from a position for the first value. If the weld line is detected at a detection start point, an error for the adjustment of searching section is displayed.

- End Position Searching in Movement
  When the first value of the start point searching section is lower than the second one in the function setting, this function searhes an end position of weld line while moving to a calculating position for the second value from a position for the first value. If the weld line is not detected at a detection start point, an error for the adjustment of searching section is displayed.

If a position save value of start point detection in the function setting items of sensor interface conditions is not 0, the above detected position will be saved in a specified LP. In this case, although a detection fails, it does not stop as an error. Thus, set the unused value for the position saving LP before the execution of LVSON instruction to check if the position is detected or not. And then execute the LVSON instruction to check if the value saved in LP is the previously set value or the detected value. If the detection fails, you can program it to change the detecting position.

Caution 1) Moving search function does not support circular arc trace. You can only use the moving search function for the steps that are recorded in linear interpolation.

- Programming of Stop Searching Example 1

```
      LP1.Z=-9999                    ‘ Set the unused value for LP value
                                       to save in the below LVSON
S1    MOVE L,S=20%,A=0,T=0           ‘ Detecting position for stop searching
      LVSON LVS#=1                   ‘ if saving the detection result of start
                                       point in LP1
      IF LP1.Z=-9999 THEN
         PRINT #0,                   “ cannot detect a weld line in the section”
         STOP                        ‘ stop if errors occur.
       END                           ‘ to execute from the beginning if restarting
                                       after a stop
      ENDIF
 S2   MOVE L,LP1,S=10%,A=0,T=0       ‘ an instruction to move to the detected
 ~~   ~~~~~~~~~~~~~~~~~~~~~~~~        start point
```

- Programming of Stop Searching Example 2

```
      LP1.Z=-9999                    ‘ Set the unused value for LP value to save
                                       in the below LVSON
     V1% = 1                         ‘ to count the frequency of detection failure
     LR1=(0,0,0,0,0,0)R              ‘ a variable to SHIFT if it is not detected
S1   MOVE L,LR1,S=20%,A=0,T=0        ‘ Detecting position for stop searching
      LVSON LVS#=1                   ‘ if saving the detection result of start point
                                       in LP1
      IF LP1.Z=-9999 THEN            ‘ a method to check if it is detected
         V1% = V1%+1
      IF  V1%>5 THEN
         PRINT #0,                   “ cannot detect a weld line in the section”
         STOP                        ‘ stop if it exceeds the repeating times
         END                         ‘ to execute from the beginning if restarting
                                       after a stop
     ENDIF
     V2%=V1%/2                       ‘ A constant calculation
     LR1.Y=(-1)^V1%*V2%*10           ’ move 10,-10,20,-20,….mm to retry
     GOTO S1
      ENDIF
 S2   MOVE L,LP1,S=10%,A=0,T=0       ‘ an instruction to move to the detected start
                                       point
~~    ~~~~~~~~~~~~~~~~~~~~~~
```

This program will shift in the axis Y direction by 10mm(2), -10mm(3), 20mm(4), -20mm(5) to retry when it fails to detect the start point.

- Programming of moving search Example

```
        LP1.Z=-9999                     ‘ Set the unused value for LP value to save
                                          in the below LVSON
S1      MOVE L,S=20%,A=0,T=0            ‘ Prior step for a moving search
        LVSON LVS#=1                    ‘ If saving the detection result of start point
                                          in LP1

        IF LP1.Z=-9999 THEN
            PRINT #0,                   “ cannot detect a weld line”
            STOP                        ‘ stop if the detection fails.
            END                         ‘ to execute from the beginning if restarting
                                          after a stop

        ENDIF
        GOTO S4                         ‘ to skip the reference steps after a normal
                                          detection
S2      MOVE L,S=10%,A=0,T=0            ‘ standard step for start point detection
S3      MOVE L,S=10%,A=0,T=0            ‘ standard step for start point detection
S4      MOVE L,LP1,S=10%,A=0,T=0        ‘ an instruction to move to the detected start
~~      ~~~~~~~~~~~~~~~~~~~~~~~~          point
```

4.2. Tracking Function Programming

In a general operation programming, just follow the below instructions.

(1) For tracking, be sure to record a {LVSON(Cmd.No=465)}instruction one step before the start point. It is because Hi4 tracking function could include a start point searching.

(2) It is recommended to place LVSOF in advance of ARCOF because it could be stopped by a wirestick in ARCOF.

(3) Unlike the searching mode, in the tracking mode, the functions after LVSON instruction are to process an error. Thus it will execute only when the start point cannot be searched.

Note 1) Take note that the instructions between steps after the LVSON instruction will not execute because the steps are first processed after the start point is detected by LVSON instruction.

In the below example of programming, the step 2 is a start point and the step 3 is an end point.

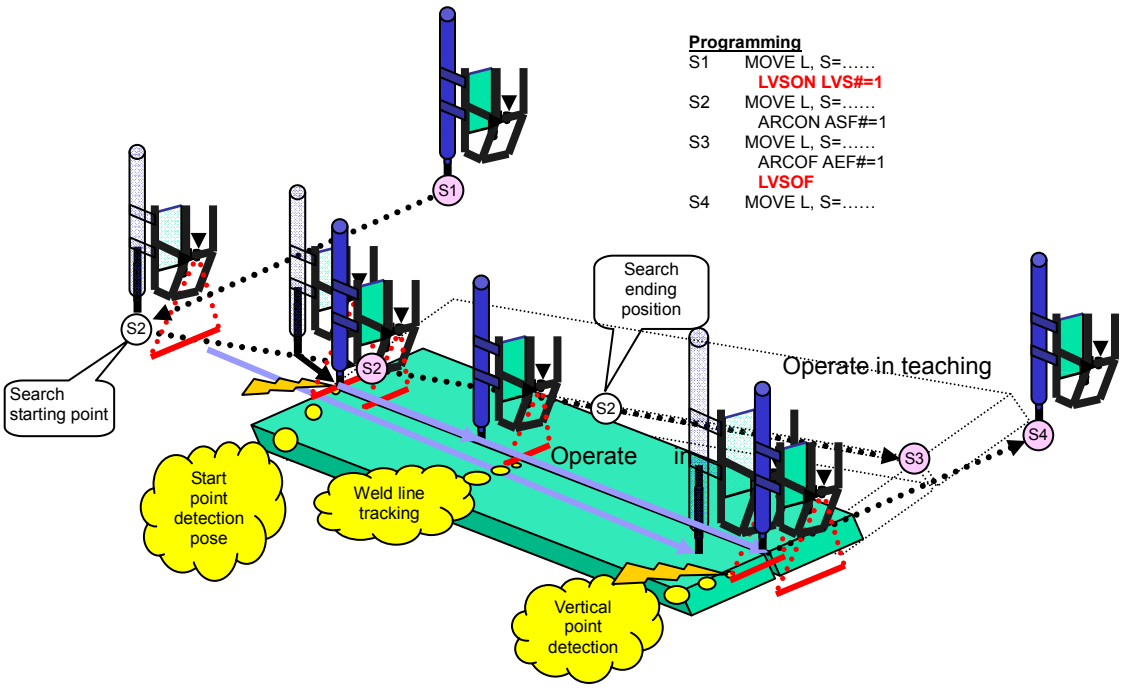


Fig 4.3 Example of Tracking Programming

The above example is about a tracking programming including a start position search in movement.

- Programming Example 1

```
S1   MOVE L,S=30%,A=0,T=0
       LVSON LVS#=1                    ‘ If the start detection position save is 0
S2   MOVE L,S=30%,A=0,T=0              ‘ welding start point
       ARCON ASF#=1
S3   MOVE L,S=10mm/sec,A=0,T=0         ‘ welding end point
       ARCOF AEF#=1
~~   ~~~~~~~~~~~~~~~~~~~~~~
```

If the start detection position save is 0 and the start point is not detected, it stops as an error.

- Programming Example 2

```
S1     MOVE L,S=30%,A=0,T=0
       LVSON LVS#=1                    ‘ If saving the detection result of start point
                                         in LP1
       PRINT #0,                       “ cannot detect a start point”
       STOP                            ‘ if exceeding the repeating times, it stops
                                         as an error.
       END                             ‘ to execute from the beginning if restarting
                                         after a stop
S2   MOVE L,S=30%,A=0,T=0              ‘ welding start point
       ARCON ASF#=1
S3   MOVE L,S=10mm/sec,A=0,T=0         ‘ welding end point
       ARCOF AEF#=1
~~     ~~~~~~~~~~~~~~~~~~~~~~
```

- Example of Start Position SHIFT Programming

```
       V1% = 1                         ‘ to count the frequency of detection failure
S1     MOVE L,LR1,S=20%,A=0,T=0        ‘ detecting position for stop searching
       LR1=(0,0,0,0,0,0)R              ‘ a variable to SHIFT if it fails to detect
10     LVSON LVS#=1                    ‘ If saving the detection result of start point
                                         in LP1
       V1% = V1%+1
       IF V1%>5 THEN
          PRINT #0,                    “ cannot detect a weld line in the section”
          STOP                         ‘ it stops as an error if exceeding
                                         the repeating times
          END                          ‘ to execute from the beginning if restarting
                                         after a stop
       ENDIF
       V2%=V1%/2                       ‘ a constant calculation
       LR1.Y=(-1)^V1%*V2%*10           ‘ move by 10,-10,20,-20,….mm to retry
       GOTO 10
S2     MOVE L,LR1,S=30%,A=0,T=0        ‘ welding start point
       ARCON ASF#=1
S3     MOVE L,LR1,S=10mm/sec,A=0,T=0       ‘ welding end point
       ARCOF AEF#=1
~~     ~~~~~~~~~~~~~~~~~~~~~~
```

This program will shift the welding start point and welding end point to the axis Y direction by 10mm(2), -10mm(3), 20mm(4), -20mm(5) to re-try if it fails to detect a start point.

5
Operation

5.1. Step Forward/Backward

Backward step cannot be used after LVSON instruction is executed. If pressing the backward step, 'no support' message will be displayed. If you intend to move to the previous position of step, select the step and use a forward step.

5.1.1. Tracking Section

In a tracking section, it is possible to move and stop in a step forward, and again move in the step forward.

5.1.2. Start Point Searching Section or Start Point Moving section

When searching a start point in a step forward or pressing the step forward again after a stop in the traveling section to the searched start point, it moves to the start position for start point searching and re-start the start point searching.

5.2. Automatic Operation

5.2.1. Tracking Section

If you stop and re-start while traveling a tracking section in an automatic operation, you may perform a normal tracking. And if it is a section for arc welding, it moves as much as overlap distance along the previously sensed locus to start a welding. It is called "Bead Overlap" function.

5.2.2. Start Point Searching Section or Start Point Moving Section

Like the step forward, when you stop and re-start during an operation in this section, you need to move to the start position for start point searching and start the start point searching from the beginning.

6 Descriptons of Error

Code	E1290 Don't detect the start point.
Cause	There is no starting point when detecting the starting point with laser vision sensor.
Action	Correct the detection range or record point.

Code	E1291 No responding of LVS.
Cause	Laser vision sensor connected to serial does not receive data.
Action	1. Check the use setting of serial port. 2. Inspect the laser vision sensor. 3. Inspect the communication cable.

Code	E1292 Do modify search start length.
Cause	It occurs when the search conditions are identical in the search starting point during the detection of starting point with laser vision sensor. Namely, in case of outward access, when there is a starting point shape in the search starting point. Or, in case of inward access, when there is no starting point shape in the search starting point.
Action	Change the searching distance or starting point.

Code	E1293 Error detect at Laser sensor.
Cause	Laser vision sensor received error. Refer to the logging screen for more details.
Action	Refer to the sensor error number in the screen and sensor manual to take necessary actions. 1 : PC setting communication error – communication with PC failure 2 : sensor camera error – no video in sensor head 3 : sensor link error – no sensor head communication - camera cable error? 4 : no sensor conncetion – no video or communication. Is sensor installed? 5 : sensor operating temperature error – too hot or too cold 6 : sensor power error – sensor head power is out of 24v supply range. Camera cable abnormal? 7 : Laser disable – Inspect the Laser enable key and laser warning lamp. 8 :No sensor calibration – Sensor calibration data error. Try other sensor head. 9 : Out of shape range - No strip in the image 10 : No shape is seen for analysis. There is Ddata itself, but analysis failure only in a searching mode. 11 : Unavaible in this connection.. 12 : No shape is set. Is the shape number correct? 13 :No shape of image for tracking. 14 : [Esc] key is pressed in tool program while robot is communicating with sensor. 15 : Memory error in sensor control unit, format again and load the backup data. 16 : Failure in reading system data 17 : Reading shape from FLASH memory error damage? 18 : Reading shape from FLASH memory error damage? 19 : Analog circuit error(POST) 20 : Video collecting hardware error 21 : Timer hardware error 22 : FLASH memory damage – replacement needed. 23 : Insufficient Data FLASH memory

	24 : There is a damaged sector in FLASH memory.. warning 25 : error log error 26 :power omission in I/O of SAPEII board 27 : ESTOP operation – inspect ESTOP link or conncetion. 28 : Existing within the temperature limit of 5 degree
Code	E1294 Cannot read LVS CONDITIONS.
Cause	It is not possible to read the laser sensor condition file(ROBOT.LVS).
Action	Position the cursor to LVSON instruction , press [QuickOpen] key to make a file. Or otherwise, back up all files , and initialize the system.
Code	E1298 A seam data doesn't exist with LVS
Cause	There is no detection data of laser sensor for calculating position.
Action	If there is no error in Joint shape, adjust the allowable change in laser sensor conditions, or adjust the detection distance of ending point if it is ending point.
Code	E1299 The Search Start supports only LIN
Cause	It occurs when the kind of step interpolation for tracking or moving searching function is not a straight line interpolation.
Action	Change the kind of interpolation to a straight line interpolation.
Code	E1353 Over allowed max. dist. deviation.
Cause	Aberrant distance from trace(locus) by tracking is in excess of allowable value.
Action	Adjust a teaching position, or adjust the allowable averrant distance.
Code	E1354 Over allowed max. angle deviation.
Cause	Aberrant degree from trace(locus) by tracking is in excess of allowable value.
Action	Adjust a teaching position, or adjust the allowable averrant degree.

HYUNDAI
HEAVY INDUSTRIES CO.,LTD.

- **Head Office**
  Tel. 82-52-202-7901 / Fax. 82-52-202-7900
  1, Jeonha-dong, Dong-gu, Ulsan, Korea

- **A/S Center**
  Tel. 82-52-202-5041 / Fax. 82-52-202-7960

- **Seoul Office**
  Tel.82-2-746-4711 / Fax. 82-2-746-4720
  140-2, Gye-dong, Jongno-gu, Seoul, Korea

- **Ansan Office**
  Tel.82-31-409-4945 / Fax.82-31-409-4946
  1431-2, Sa-dong, Sangnok-gu, Ansan-si, Gyeonggi-do, Korea

- **Cheonan Office**
  Tel.82-41-576-4294 / Fax.82-41-576-4296
  355-15, Daga-dong, Cheonan-si, Chungcheongnam-do, Korea

- **Daegu Office**
  Tel.82-53-746-6232 / Fax.82-53-746-6231
  223-5, Beomeo 2-dong, Suseong-gu, Daegu, Korea

- **Gwangju Office**
  Tel. 82-62-363-5272 / Fax. 82-62-363-5273
  415-2, Nongseong-dong, Seo-gu, Gwangju, Korea

- **본사**
  Tel. 052-202-7901 / Fax. 052-202-7900
  울산광역시 동구 전하동 1번지

- **A/S 센터**
  Tel. 82-52-202-5041 / Fax. 82-52-202-7960

- **서울 사무소**
  Tel. 02-746-4711 / Fax. 02-746-4720
  서울특별시 종로구 계동 140-2번지

- **안산 사무소**
  Tel. 031-409-4959 / Fax. 031-409-4946
  경기도 안산시 상록구 사동 1431-2번지

- **천안 사무소**
  Tel. 041-576-4294 / Fax. 041-576-4296
  충남 천안시 다가동 355-15번지

- **대구 사무소**
  Tel. 053-746-6232 / Fax. 053-746-6231
  대구광역시 수성구 범어2동 223-5번지

- **광주 사무소**
  Tel. 062-363-5272 / Fax. 062-363-5273
  광주광역시 서구 농성동 415-2번지