WARNING

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

Hyundai Robot

Hi4aCS071001FMEN3

Hi4a Controller Function Manual

Conveyor Synchronization

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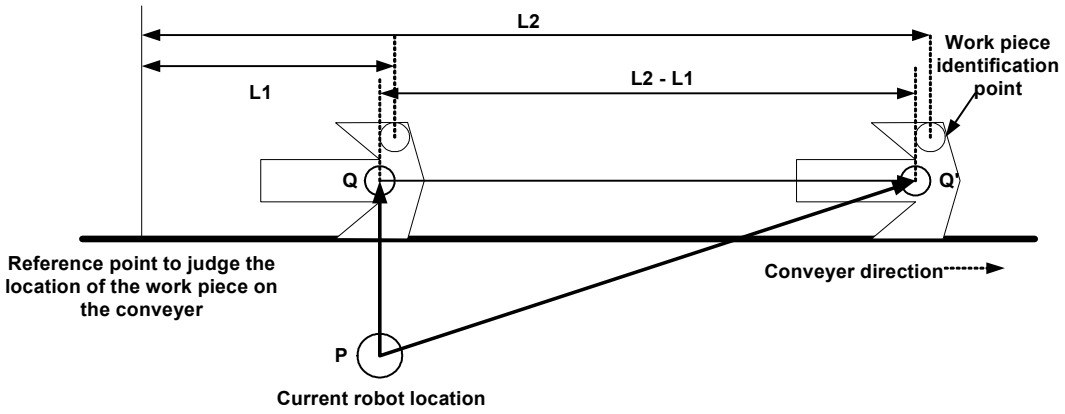
Contents

1 Overview

Conveyor synchronization is the process of the robot following the moving work piece mounted on the conveyor. The robot maintains the relative position and position between the work piece and the tool by synchronizing with the conveyor speed to execute a specific operation to the moving work piece.

1.1. Conveyor synchronization logic



Conveyor synchronized playback, the robot calculates the movement of the work piece from the reference position and plays by an additional of that distance.

In the above figure, assume that the conveyor is stopped for teaching and that the robot is taught to move from position P to position Q of the work piece.

When the conveyor is moving and the work piece has moved to the position off by 「L2 - L1」 from taught position Q, the robot shifts the recorded position of Q to Q' by moving the distance by 「L2 - L1」.

1.2. Position of work piece on conveyor

A work piece detection sensor is installed at the point where the work piece flows in to the conveyor and this point becomes the reference point to judge the position of the work piece.

The controller identifies the point where the work piece passes the reference point as the 0 position in relative position to the conveyor. As the work piece flows along the conveyor, the controller calculates the relative position of the work piece according to the conveyor pulse signal and synchronizes the robot to the conveyor.

1.3. Teaching the work piece and position of work piece during playback

The teaching process must be executed when the work piece passed the reference point for position identification and this is when you need a command to record the teaching position.

On the other hand, the position of the work piece during playback is the relative position on the conveyor at an arbitrary time.

1.4. Meaning of teaching and playback in conveyor synchronization

The meaning of teaching in the point of conveyor synchronization function is defined as the recording operation of robot position, position, speed etc., for the specific object coordinate (virtual coordinate definite by the work object). In other words, it is the process of recording the work position, position, speed etc. of the robot to the work piece irrelevant of the work piece position (or conveyor speed) on the conveyor when the person sitting on the conveyor Executes playback.

On the other hand, playback is maintaining the relative position, position, speed etc. of the work piece from the robot known from teaching, irrelevant from position of the work piece on the moving conveyor.

2

System Composition and Connection

2.1. System composition

- **Limit switch or optical switch for work piece detection (Pulse count start signal)**
  This device notifies the controller that the work piece entered a specific position on the conveyor.

  When the limit switch starts operating, the controller starts counting the number of pulse coming from the pulse generator and executes the conveyor synchronization playback. Therefore, the position where the limit switch is, becomes the reference point to identify the position of the work piece on the conveyor.

  For automotive paint line, you will have to use a wide internal pressure limit switch or a general limit switch with Barrier Relay (or Zener Barrier).

- **Deceleration device**
  The deceleration device detects the conveyor movement from the motor axis or chain of the conveyor and decelerates the conveyor to the RPM regulated by the control device and rotates the pulse generator.

- **Pulse generator**
  A pulse generator which generates the applicable pulse to the conveyor movement (rotation) is connected to the motor part of the conveyor. And the pulse generated from the conveyor connected to the robot controller is entered to the robot controller.

  Robot controller counts the pulse as the work piece passes the limit switch and calculates the current position of the work piece.

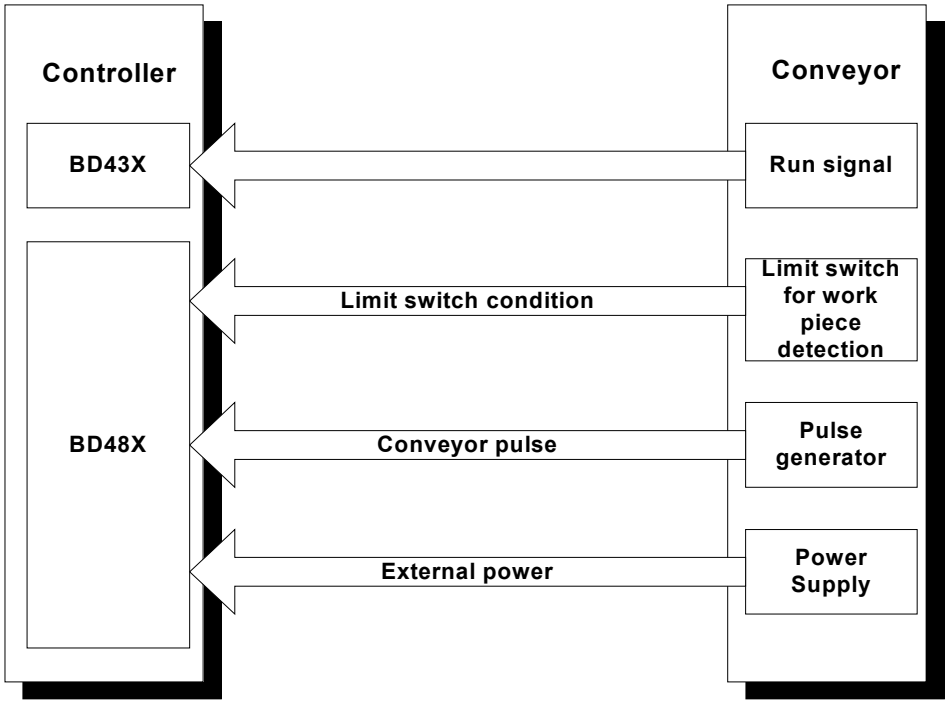
- **Conveyor running signal**
  For conveyor synchronization playback in normal operating mode, the signal must be entered. This notifies the controller that the conveyor is in operation, and generally, a support contact point for the magnet switch is used to supply the power to the motor in conveyor.

  The run signal is allocated to the input signal currently not in use among the general input signal (DI signal).

2.2. System connection

The connection of various devices and controller to compose the conveyor system is as follows. Conveyor pulse, limit switch status and conveyor system power are connected.

The conveyor system can be in RS422 or RS232 type.



■ **Controller terminal connection**

The conveyor run signal is connected to the CNIN connector of I/O board within the robot controller. The limit switch operation signal, pulse signal and conveyor system power are connected to the option (BD48X) board CNCP1 or CNCP2 connector.

CNCP1

Terminal name	PIN No.	Description	Input specification
PAI1+,PAI1-	1, 2	Pulse input on RS422 type conveyor A	0 ~ 5V,100KHz or below
PBI1+,PBI1-	3, 4	Pulse input on RS422 type conveyor B	0 ~ 5V,100KHz or below
AI1	5	Pulse input on RS232 type conveyor A	0 ~ -30V,100kHz or below
BI1	6	Pulse input on RS232 type conveyor B	0 ~ -30V,100kHz or below
STA_LS1	7	Limit switch signal input for work piece detection	0 ~ -30V
P+, P-	8, 9	External power	20 ~ 30V

CNCP2

Terminal name	PIN No.	Description	Input specification
PAI2+,PAI2-	1, 2	Pulse input on RS422 type conveyor A	0 ~ 5V,100kHz or below
PBI2+,PBI2-	3, 4	Pulse input on RS422 type conveyor B	0 ~ 5V,100kHz or below
AI2	5	Pulse input on RS232 type conveyor A	0 ~ -30V,100kHz or below
BI2	6	Pulse input on RS232 type conveyor B	0 ~ -30V,100kHz or below
STA_LS2	7	Limit switch signal input for work piece detection	0 ~ -30V
P+, P-	8, 9	External power	20 ~ 30V

■ **Selection of count method**
For the connection method, you can connect using RS422 and RS232. You can set up using the dip switch of option (BD48X) board as follows.

Setting	ON	OFF	Description
Jumper 5 (JP5)	RS422	RS232	Input of channel 1
Jumper 6 (JP6)	RS422	RS232	Input of channel 2

The resolution of the conveyor pulse count is 16 bit and the pulse is counted in 4 multiples. Also you can select whether to use Up Count or Up/Down Count using the following option (BD48X) board jumper.

Jumper No.		JP1	JP2	JP3	JP4
Setting content	Channel 1 conveyor synchronization pulse Up Count	Short	Open	-	-
	Channel 1 conveyor synchronization pulse Up/Down Count	Open	Short	-	-
	Channel 2 conveyor synchronization pulse Up Count	-	-	Short	Open
	Channel 2 conveyor synchronization pulse Up/Down Count	-	-	Open	Short

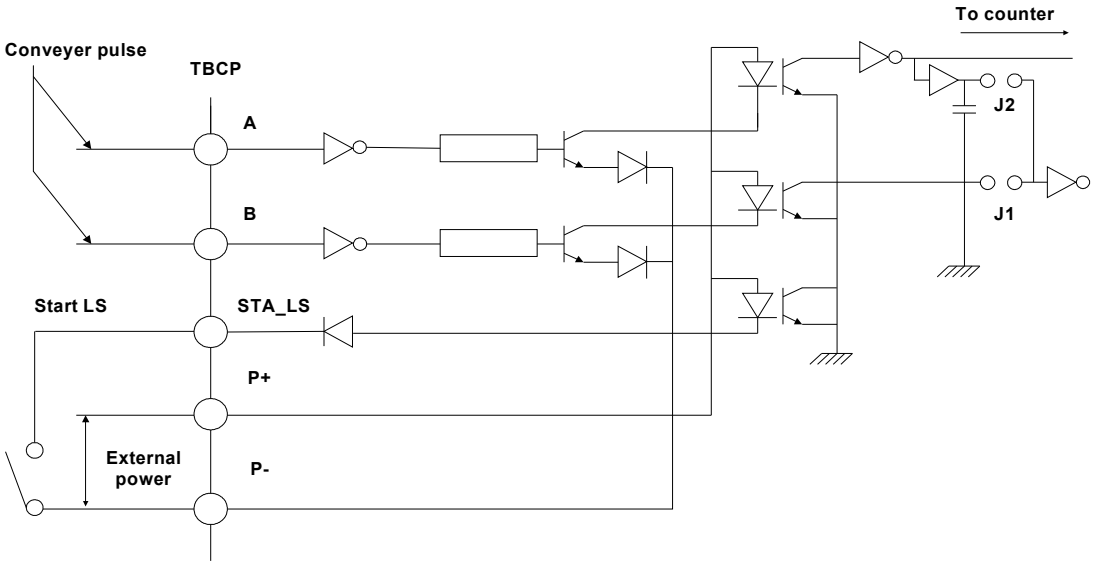
Reference

- After setting the jumper, you must set the 『CNVY Pulse count type=<UP,UP/DOWN>』 from 『[PF2]: System 』 → 『4: Application parameter』 → 『6: Conveyor』 → 『1: First Conveyor parameter setting』 as same as the jumper setting.

- When setting the Up/Down counter, the conveyor pulse data (CP) can have negative value. And if the pulse data (CP) increases in negative value as the conveyor rotates in positive direction, you can switch the pulse line on option (BD48X) board A/B to set the pulse data to increase in positive as the conveyor rotates in positive direction.

■ **Conveyor pulse counter circuit**

Following is the conveyor pulse counter circuit of RS232C type.

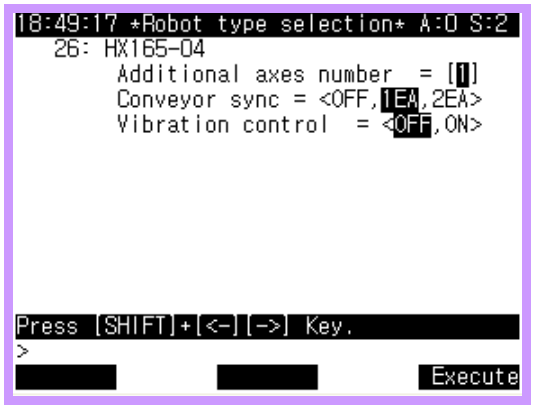


Reference

- Set the input range of the external power within the standard and DC 24V is recommended.
- For the conveyor pulse generator, use the interface within the range of -5 ~ 25V.
- Because the length of connection varies by the different interface of conveyor pulse generator, please consult with our experts.

3
Conveyor Parameter

To apply the conveyor synchronization function, you must set the conveyor synchronization to <1EA> or <2EA> after selecting 『[PF2]: System』 → 『5: Initialize』 → 『2: Robot type selection』.



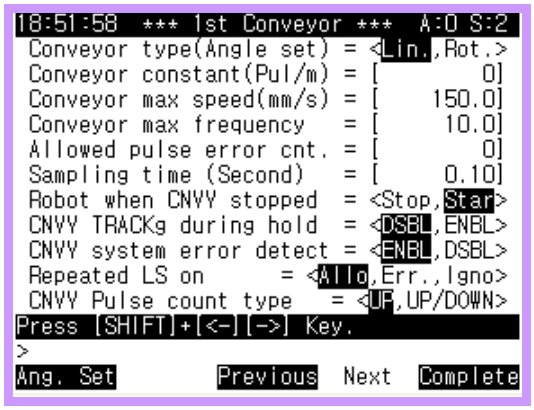
To playback the robot after applying the conveyor synchronization function, the robot controller has to know various details of the information on the conveyor. Enter this information to the controller is called conveyor parameter setting.

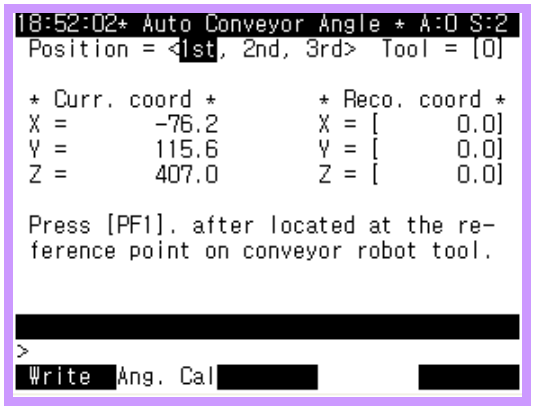
Therefore, the conveyor parameter setting must be done prior to preparing the work program. Also after completing the setting, you should backup the control constant file (ROBOT.C00) to SRAM card.

3.1. Conveyor type (Angle Set)

Select the conveyor type and the position of the conveyor will automatically be set in the 3D space. The procedure for automatically setting this angle is as follows.

(1) If the conveyor type was selected to straight line, press the 『[PF1]: Ang. Set』 key and you will see the following screen.





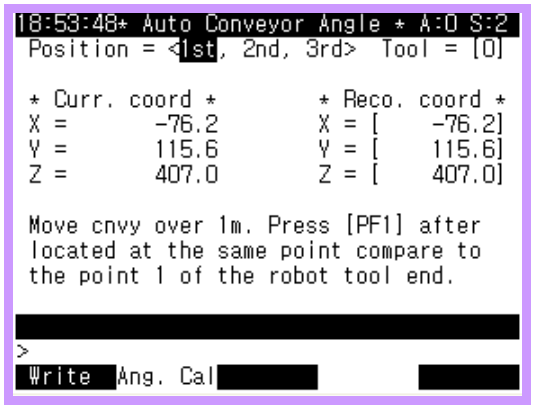
- Position
  To automatically calculate the position of the conveyor in an arbitrary position, the straight line conveyor needs 3 recording points and circular conveyor needs 3 recording points.

- Tool : This shows the tool number at the robot end.

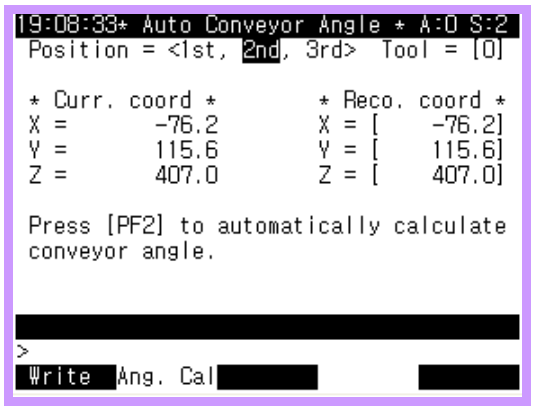
- Curr. Coord : This shows the X, Y and Z coordinates of robot's current position.

- Reco. coord
  If you press the 『[PF1]: Write』 key, the current coordinates are recorded.

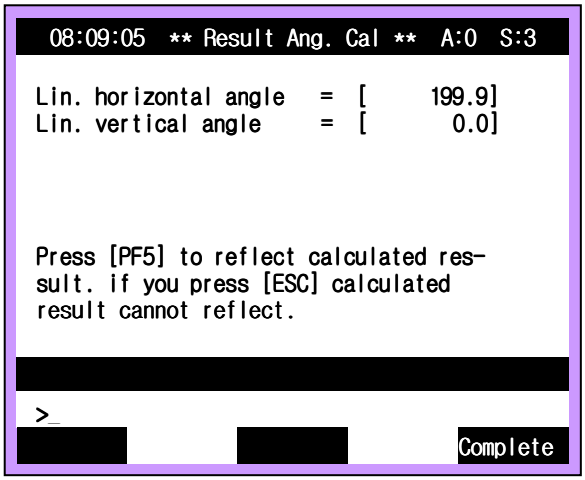
(2) After setting one arbitrary position on the conveyor as the reference point, move the robot tool end to the selected reference point and press the 『[PF1]: Write』 key to see the following screen.



(3) After moving the position to <2nd> using the [SHIFT]+[<-][->] key, move the conveyor more than 1m, locate the robot tool end at the same position as <1st> and press the 『[PF1]: Write』 key to see the following screen.



(4) To calculate the position of the straight line conveyor, you only need 2 recording points. If the conveyor type is circular, move the cursor to the <3rd> position using the [SHIFT]+[<-][->] key and move the conveyor more than 1m to record 1 more point. Press the 『[PF2]: Ang. Cal』 key to see the following screen.

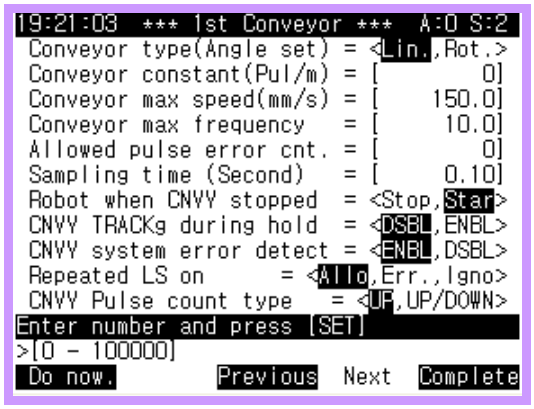


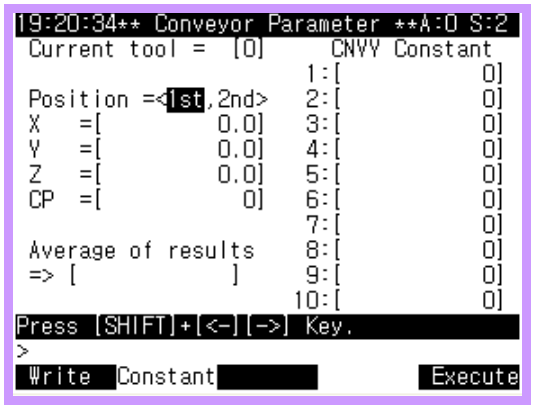
(5) When the conveyor type is circular, the angle and center for circular conveyor are calculated and displayed.

3.2. Conveyor constant (Pul/m)

Conveyor Constant refers to the number of pulse generated from the pulse generator when the conveyor moves 1m, and the robot controller receives the pulse number from the conveyor and uses it to calculate the position of the work piece on the conveyor. The procedure to automatically setup the conveyor constant is as follows.

(1) Press the 『[PF1]: Do now.』 key to see the following screen.





- Current tool : This indicates the number of the tool at robot end.
- Position :To automatically calculate the conveyor constant, you need 2 positions.
- CNVY Constant : You can record up to 10 conveyor constants.
- Average of results
  This is the value shown when you obtain couple of conveyor constants and calculate the average of the obtained conveyor constants.

(2) Locate the cursor on <1st>, move the robot to an arbitrary point (point A) on the conveyor and press the 『[PF1]: Write』 key.

(3) Locate the cursor to <2nd> by using the [SHIFT]+[<-][->] key, move the conveyor about 1 m, locate the conveyor at point A and press the 『[PF1]: Write』 key.

(4) After obtaining the <1st> and <2nd> recorded position, press the 『[PF2]: Constant』 key to calculate the conveyor constant, and save conveyor constant in the wanted number. Repeat this process to calculate couple of conveyor constants, and then press the 『[PF5]: Execute』 key to calculate the average value. The results will be shown in 『Average of results』.

3.3. Conveyor max speed

This is to process the error when the conveyor speed is abnormally high. Considering the speed trend of the conveyors to use, set a maximum permitted speed. The controller will internally calculate the conveyor speed and generate an error when the speed exceeds the permitted speed set for conveyor.

Generally the conveyor pulse has a slight ripple centered on the average value and this makes the conveyor speed to have a slight ripple. Therefore considering this, the permitted speed of the conveyor should be set higher (varies by conveyor operating system and characteristics of pulse generator) than the conveyor speed. For the straight type conveyor, the unit is mm/sec and for circular type, the unit is deg/sec.

3.4. Conveyor max frequency

This sets the top limit for the number of normal pulses per 1 second from the pulse generator. The robot controller calculates the number of pulse per 1 sec based on the number of input pulse during the sampling period, and when this value exceeds the permitted frequency of the conveyor, an error is generated judging that the wrong data was received due to noise etc. Currently the possible input range is 1 ~ 15 KHz.

3.5. Allowed pulse error cnt.

When the conveyor pulse is received abnormally, the robot controller generates an error message saying 『E0019 CNVY pulse count changed a lot』. At this time, to protect the work piece in operation, this sets the robot to continue the operation even though the pulse error is generated.

For example, if an error saying “Allowed pulse error cnt” is detected when the permitted number of times for pulse error is set to 3, the robot controller will generate an appropriate pulse value when there is a pulse error up to 3 times for one work piece but generate an error for the 4th time. Number of times permitted can be set up to 20 and the pulse error information is initialized when the playback for the work piece is completed.

3.6. Sampling time (Second)

The controller calculates conveyor's moving distance from the number of pulse received during the sampling period, and calculates the average conveyor speed received during the sampling period. The reason for calculating the average speed from the conveyor speed during the sampling period is to reduce the vibration of the robot due to oscillation of conveyor speed. Currently the sampling period is fixed to 0.1sec.

Depending on conveyor speed change / Sampling period	Robot vibration	Robot response
Long	Decrease	Slower
Short	Increase	Faster

3.7. Robot when CNVY stopped

This sets the condition to decide the robot operation if the signal is not received for conveyor operation, i.e. if the conveyor stops, in normal mode.

- Stop : Robot stops. In other words, it is same as sending the stop command to the robot.
- Start : Robot operates according to the condition setting/playback mode condition.

3.8. CNVY TRACKg during hold

This decides whether to execute conveyor synchronization when the robot stops temporarily from stop command.

- DSBL : The robot immediately stops without synchronization.
- ENBL
  The robot proceeds by synchronizing to the conveyor speed. But the robot will not follow the conveyor in the following cases.

  ① When [RESET]+[SET] key or [RESET]+[0]+[SET] key is pressed on teach pendant
  ② When RESET command is executed by external signal

Reference

- Consult with our experts if you are going to use ENBL.

3.9. CNVY system error detect

When you cannot set the robot motor ON from the system error for conveyor synchronization, this prevents the system error related to the synchronization process when a system error is generated related to the conveyor synchronization from incomplete system installation or board damage.

Error No.	Synchronization system error type
E0017	Conveyor pulse line trouble
E0018	BD481 interface error
E0019	CNVY pulse count changed a lot
E0021	Conveyor speed is too high

Reference

- Always set this function to <ENBL> during conveyor synchronization playback to check the system.

3.10. Repeated LS on

This sets whether to process the work piece that enters through the limit switch when there is already a work piece in synchronization process.

- **Allo**
  The robot controller can manage up to 10 positions of work pieces. Therefore you can still control the position of the 9 work piece when there is one work piece in synchronization process. When the number of work piece in process becomes 11, the error message (E1035 Works over permitted No. entered.) is generated.

- **Err.**
  When another work piece enters during a synchronization process for one work piece, it generates an error message. (E1035 Works over permitted No. entered.)

- **Igno**
  When another work piece enters during a synchronization process for one work piece, ignore this additional work piece.

3.11. CNVY Pulse count type

This item notifies the robot controller of the jumper status of pulse counter circuit of option (BD48X) board (JP1 and JP2 of channel 1 or JP3 and JP4 of channel 2).

3.12. Lin. horizontal/vertical angle

The robot controller has to know in which direction the conveyor is moving in robot coordinate to synchronize the moving conveyor.

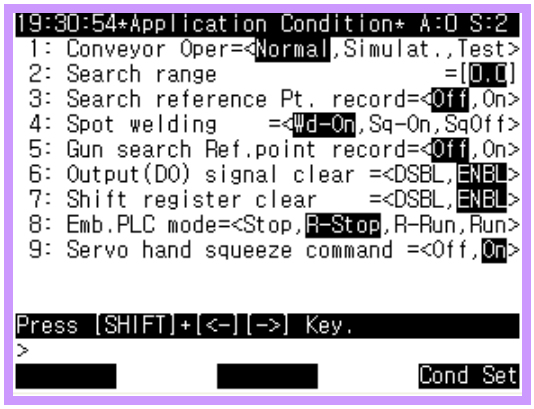
When the conveyor is in an arbitrary direction, it requires a considerable amount of time to accurately calculate the direction the conveyor will move in 3D space. To remove this inconvenient operation, Hi4a controller provides a method of calculating the conveyor position by easy user operation.

The method of automatically calculating the conveyor position is shown in『3.1. Conveyor type (Ang. Set)』. Refer to that section.

4 User Interface

4.1. Conveyor operation type

(1) Conveyor synchronization playback can be done in 3 modes and it can be selected from 『[PF5]: Cond Set』 → 『[PF1]: AppliCnd』.



- Normal
  The robot operates synchronized to the work piece on the operating conveyor.

- Simulat.
  This does not operate the conveyor and the robot operates according to the simulation speed of the conveyor that the user specified. You can check the soft limit and cycle time of the robot,

- Test
  Without operating the conveyor, you can check the robot operation from the conveyor data entered. Test is used to teaching check after teaching is complete. You can check the robot operation when the work piece is stopped on the conveyor because the pulse counter is not cleared when executing program end.

Signal processing during conveyor operation according to operating type

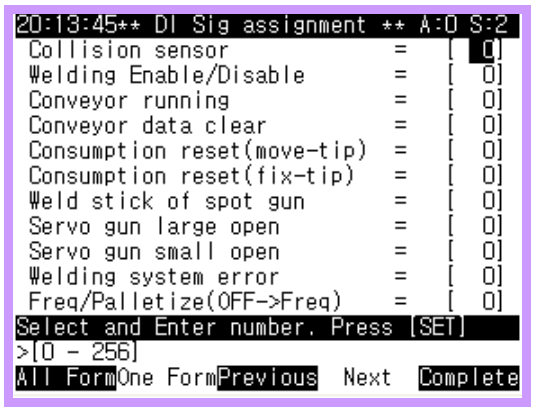
	CNVY Run Signal	
	On	**Off**
Normal	Normal	Stop or execute (set by user)
Simulation, Test	Error	Normal

4.2. Input/Output signal

Allocate a general signal for the input/output signal related to the conveyor synchronization system.

4.2.1. Input signal assigning

(1) Allocate the general signal from 『[PF2]: System』 → 『2: Controller parameter』 → 『1: Setting input &output signal』 → 『7: Input Signal assigning』.

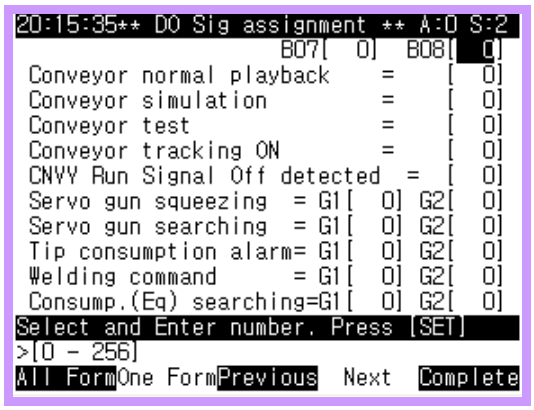


- **Conveyor running**
  For the conveyer synchronization playback zone, this signal must be entered in the Normal mode but not in Test of Simulation mode.

- **Conveyor data clear**
  You can clear the conveyor data with external input signal. When this signal is received when the robot is stopped, the conveyor data (CP, CR, CS) is cleared.

4.2.2. Output signal assigning

(1) Allocate the general signal from 『[PF2]: System』 → 『2: Control parameter』 → 『1: Setting input & output signal』 → 『6: Output signal assigning』.



- **Conveyor normal playback /simulation /test**
  The signal for the conveyor operation type selected in application condition / conveyor operation is sent out.

- **Conveyor tracking ON**
  It outputs ON/OFF status of conveyor synchronization playback. If conveyor synchronization playback ON command is executed, the signal output becomes ON and if the conveyor synchronization playback OFF command is executed, the signal output becomes OFF.

- **CNVY Run Signal OFF detected**
  If the received conveyor run signal is OFF, it notifies externally that it has detected this signal.

4.3. Command

- **CNVYPOS (Reference position record)**
  To teach the work piece on the conveyor, operate the conveyor and stop it once the work piece passes the limit switch, and enter the CR value shown in the conveyor data monitor. This will become the reference point to judge the position of robot following the work piece on the conveyor.

- **CNVSYNC (Conveyor synchronization playback)**
  This command designates the zone to execute the conveyor synchronization for program playback. Robot executes the synchronization after 『CNVSYNC 1』 command and does not execute the conveyor synchronization for the command after 0 or 2.

Parameter	Conveyor synchronization playback	Conveyor data		
		CP	CR	CS
CNVSYNC 1	On	Calculation	Calculation	Calculation
CNVSYNC 0	Off	Calculation	×	×

- **WAITCNVY (Conveyor interlock wait)**
  This is used for setting the robot to standby until the work piece reaches the specificed position from the limit switch (Start LS) for work piece detection.

	WAITCNVY 0	WAITCNVY 1
Conveyor tracking during wait	Off	On

4.4. Conveyor data

4.4.1. Types of conveyor data

There are three types of conveyor data the robot controller manages internally.

- Conveyor pulse counter (CP)
  This is the parameter to manage the received number of pulse from the pulse generator to calculate the movement of the work piece.
  In normal mode for conveyor operating type, the pulse count starts from when the limit switch detects the work piece and in simulation or test mode, the pulse count value is always the same.

- Conveyor register (CR)
  This parameter calculates and keeps the results of the position of the work piece (In other words, the distance from the limit switch point in unit of mm for straight line conveyor and deg for circular conveyor) corresponding to the specific pulse number set in conveyor pulse counter value.

  For the normal mode for conveyor operating type, the distance is calculated and entered from pulse counter value, but for the simulation mode, it is not always the same as the calculated distance from pulse counter value.

  This is because in simulation mode, conveyor pulse counter and conveyor registry are separated, and the registry value becomes the input value or it is calculated by the conveyor speed entered by the user.

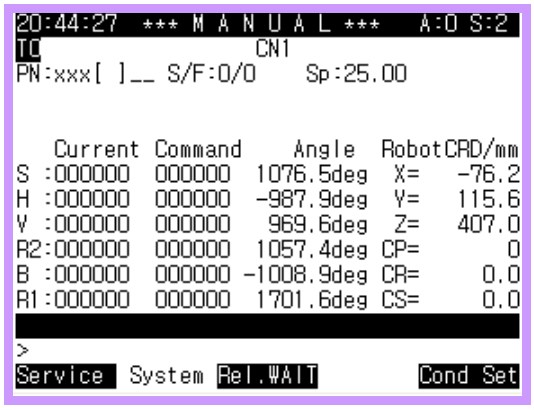
  In test mode, the conveyor registry value is always consistent.

- Conveyor speed (CS)
  This is the conveyor speed calculated from the moved distance of the conveyor for the sampling period in conveyor parameter setting. The unit for straight line conveyor is mm/s, and the unit for circular conveyor is deg/s.

  In normal mode for conveyor operating type, the actual conveyor has a moving speed. But in test mode, it is always 0 and in simulation mode it is the conveyor simulation speed that the user set.

4.4.2. Conveyor data monitoring

When you select 『[PF1]: Service』 → 『1: Monitoring』 → 『4: Conveyor data』, you can check the CP, CR and CS value for the work piece on the conveyor.



4.4.3. Conveyor data increase point and clear point

The conveyor data increase point or change point according to conveyor operating type, is as follows.

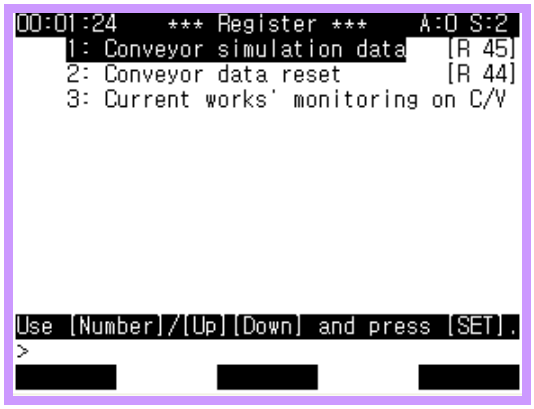
	Normal	Simulation	Test
CP	LS input	Always same	Always same
CR	LS input	1) Execute conveyor synchronization command after setting simulation speed 2) Increases after initializing the simulation registry value	Always same
CS	LS input	1) Simulation speed setting 2) Reads simulation speed when executing step 0	Always 0

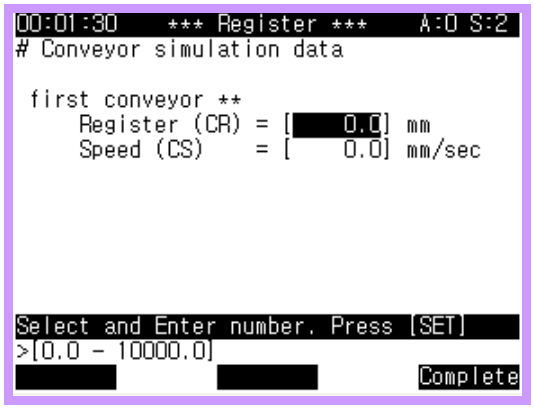
The conveyor data clear point according to conveyor operating type is as follows.

	Normal	Simulation	Test
CP	① Execute program cycle end ② Execute conveyor synchronization reset command(CNVSYNC2) ③ Conveyor data manual reset (when robot is stopped) ④ Conveyor data clear input signal ON (when robot is stopped)	① Execute conveyor synchronization reset command(CNVSYNC2) ② Conveyor data clear input signal ON (when robot is stopped)	① Execute conveyor synchronization reset command(CNVSYNC2) ② Conveyor data manual reset (when robot is stopped) ③ Conveyor data clear input signal ON (when robot is stopped)
CR	Same as above	① Execute program cycle end ② Execute conveyor synchronization reset command(CNVSYNC 2) ③ Conveyor data clear input signal ON (when robot is stopped)	① Execute conveyor synchronization reset command(CNVSYNC 2) ② Conveyor data manual reset (when robot is stopped) ③ Conveyor data clear input signal ON (when robot is stopped)
CS	Same as above	① Execute conveyor synchronization reset command(CNVSYNC 2) ② Conveyor data clear input signal ON (when robot is stopped)	Always 0

4.4.4. Simulation register and speed setting

In simulation mode, the robot is operated by conveyor simulation speed and simulation registry set by the user. The data can be set in 『[PF1]: Service』 → 『2: Register setting』 → 『6: Conveyor data』 → 『1: Conveyor simulation data [R 45]』, and the simulation playback will be done with the entered data.





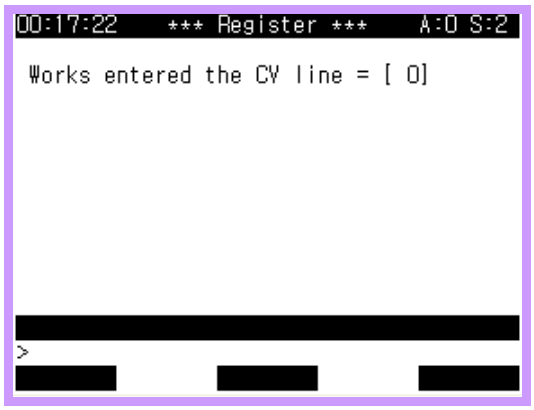
4.4.5. Conveyor data manual reset

This clears the current conveyor data manually. This can be executed from 『[PF1]: Service』 → 『2: Register setting』 → 『6: Conveyor data』 → 『2: Conveyor data reset』 or by R code of 『R44: Conveyor data manual reset』.

The robot must be stopped, and the operating mode must be in normal or test mode, and the conveyor pulse count, registry, speed will all be initialized to default value of '0' after execution.

4.4.6. Current works' monitoring on C/V

You can check how many work pieces have passed the limit switch in 『[PF1]: Service』 → 『2: Register setting』 → 『6: Conveyor data』 → 『3: Current works' monitoring on C/V』.



4.5. R code

- **R44 (Conveyor data clear)**

  This can be used when the robot is stopped and the operating type is not simulation. You can manually clear various data related to the conveyor. In other words, you can clear CP, CR, CS, work piece entry (including multiple work piece entry) information, synchronization playback status etc.

- **R45 (Conveyor register manual input)**

  This can only be used in the manual mode by manually entering the CR value the user wants. CR value is in mm unit for straight line conveyor and deg unit for circular conveyor. This changes the CR value with the entered value, and the CP value is also updated by the conveyor constant. When the limit switch is entered by operating the conveyer when the CR value is manually entered, the CR and CP value increases from the entered values.

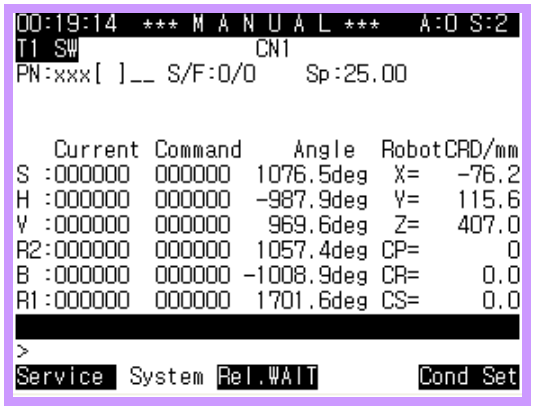
- **R46 (Manual conveyor limit switch on)**

  This can only be used in the manual mode when limit switch is not entered as a signal but manually entered. You can check whether the pulse data is entered and set the conveyor constant when installing the system.

4.6. Other information monitoring

- **Conveyor operating type**

  Each 『CN1』, 『CS1』, 『CT1』 string is displayed in manual or auto mode screen according to the operating type normal /simulation/test.



- **Signal input condition during conveyor operation**

  When the signal is ON during conveyor operation, the string that indicates the operating type is sequentially added to the output.

  Ex) When conveyor operating type is 『Normal』
  Conveyor running: 「 」 → 「C」 → 「CN」 → 「CN1」
  Conveyor stoping: Fixed to 「CN1」

- **Conveyor synchronization playback ON/OFF/RESET condition (CNVSYNC 1/0/2)**

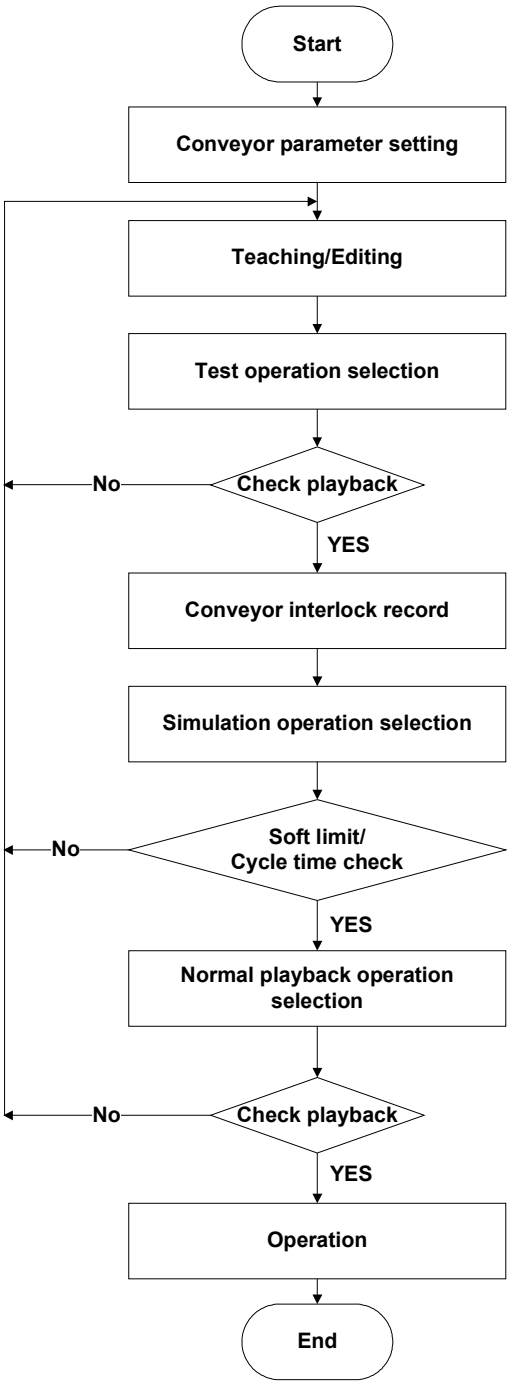
  CNVSYNC 1 means the conveyor synchronization playback is ON and CNVSYNC 0 means the conveyor synchronization playback is OFF. CNVSYNC 2 means the conveyor tracking OFF and at the same time clears the current conveyor data. When synchronization playback is set to ON, the conveyor operating type is highlighted.

  Ex) When conveyor operating type is 『Normal』
  Synchronized playback ON (CNVSYNC 1) : 「CN1」
  Synchronized playback OFF(CNVSYNC 0/2) : 「CN1」

5
Teaching Preparation

5.1. Conveyor synchronization operation procedure

The conveyor synchronization operation is done in the order of conveyor parameter setting, teaching and editing, checking playback and normal playback as shown in the below flowchart.



- **Conveyor parameter setting**
  This is the initial stage required after installing the conveyor system. This must be carefully set because it sets the level of operating position tolerance of all synchronized playback.

- **Teaching and editing**
  When the conveyor parameter setting is complete, the work piece moves on the conveyor to pass the limit switch and enter the work space. Stop the conveyer when the work piece reaches the desired position, and execute the teaching and editing process.

- **Checking playback**
  When the teaching and editing process is complete, you can check the playback operation depending on the operating mode in the order of test, simulation and normal mode. At this time, the playback check process for test and simulation mode is optional. The user should appropriately make the decision according to the system environment.

- **Normal playback**
  When the playback check process is complete and there were not any issues, the conveyor operation is selected to normal mode to execute playback for actually flowing conveyor.

5.2. Limit switch operation point (conveyor reference point) decision

Limit switch operation point is the reference point to judge the position of the work piece on the conveyor. Because the limit switch or optical sensor notifies that the work piece entered the conveyor work zone, it should be set close to the operating zone of the robot so that it can be detected accurately at a stable timing.

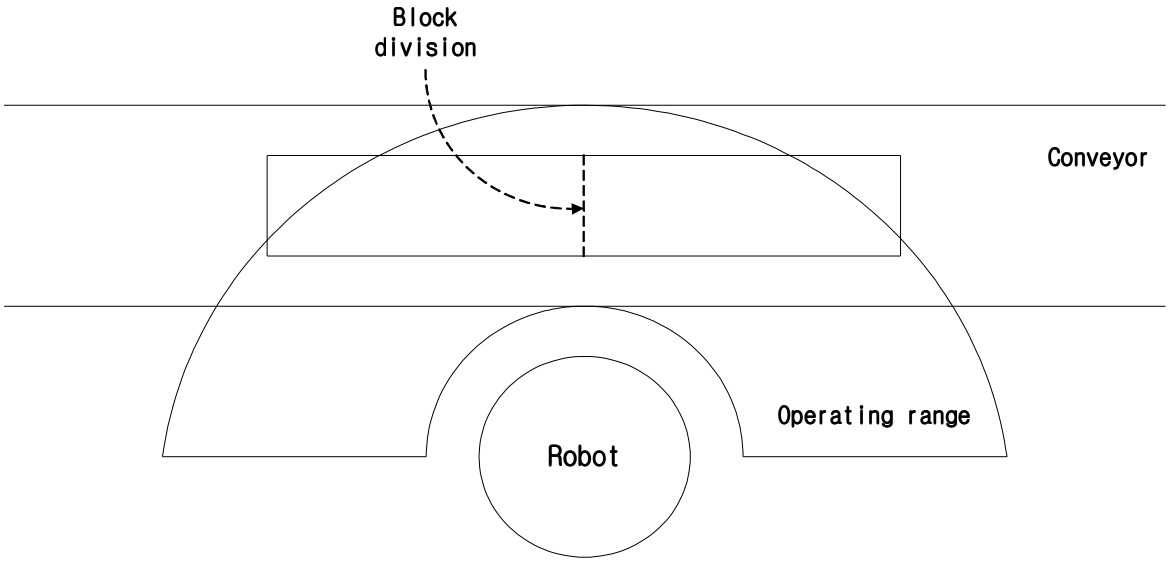
When the position of the limit switch is decided, mark the position on the equipment.

5.3. Conveyor speed decision

This decides the conveyor speed when actually executing the playback. Generally because the conveyor synchronization process involves some speed variation, set the maximum speed of the conveyor. At this time you should check whether an error is generated when exceeding the maximum speed or whether the program can be played back without the robot having to operate outside the operation zone. If not, lower the maximum conveyor speed or edit the program.

5.4. Block division

When the work piece is large compared to the operating range of the robot, you can divide the teaching and prepare several programs and use the method of calling them. This is called the block division method.



As shown above, when the robot is teaching a work piece relatively larger than the operating range of the robot, divide and move the conveyor in blocks to execute teaching. Therefore prior discussion must be done on how many blocks to divide.

6
Teaching

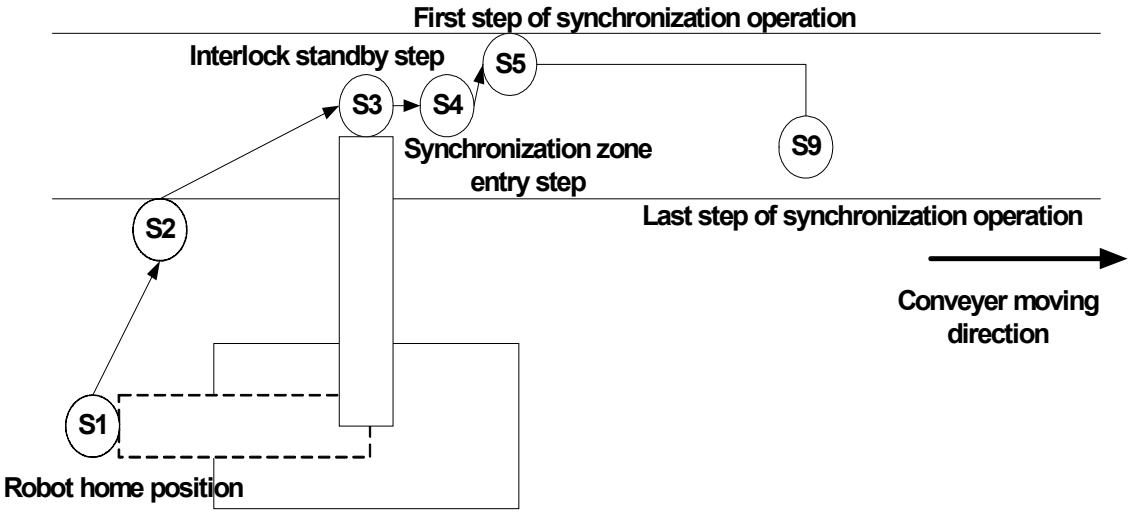
Preparing the program for conveyor synchronization is the same as general teaching. But to execute teaching check and conveyor synchronization playback, you must use the 『CNVYPOS(Reference position record)』, 『CNVSYNC(Conveyor synchronization playback)』 and 『WAITCNVY(Conveyor interlock wait)』 commands. These commands must be recorded before doing a playback check for the programs completed for teaching.

6.1. Synchronization operation program composition

- Home position wait
  The robot waits in the designated home position until a command is entered.

- Interlock wait
  The robot moves to the position near the synchronization operation zone and waits until the work piece reaches the distance set in the WAITCNVY (Conveyor interlock wait) command. At this time, it is decided whether the robot should wait or synchronize with the conveyor according to the parameter of this command.

  The following figure is a paint process program for the work piece flowing on the conveyor. When the robot moves to step 4, the synchronization process starts and when the robot enters step 5, the paint is sprayed in synchronized condition. Here the interlock wait step (step 3) is recorded near the synchronized work zone entry step (step 4).



The program for the above work process would be as follows.

```
Step 1                          → Robot home position
Step 2
Step 3                          → Interlock wait step
      CNVYPOS C=1,D=1000        → Reference position record
      CNVSYNC 1                 →Conveyor synchronization playback ON
      WAITCNVY S=1,D=500        → Conveyer interlock wait
Step 4                          → Synchronization zone entry step
      DO1 = 1                   → Paint spray ON signal
Step 5                          → First step of synchronization operation
 :
Step 9                          → Last step of synchronization operation
      DO1 = 0                   → Paint spray OFF signal
      CNVSYNC 0                 → Conveyor synchronization playback OFF
Step 10
 :
Step 13                         → Robot home position
      END
```

- Synchronization playback
  The conveyor synchronization playback zone in the figure refers to the zone between step 4 and step 9, and all the command in this zone is executed in synchronized way.

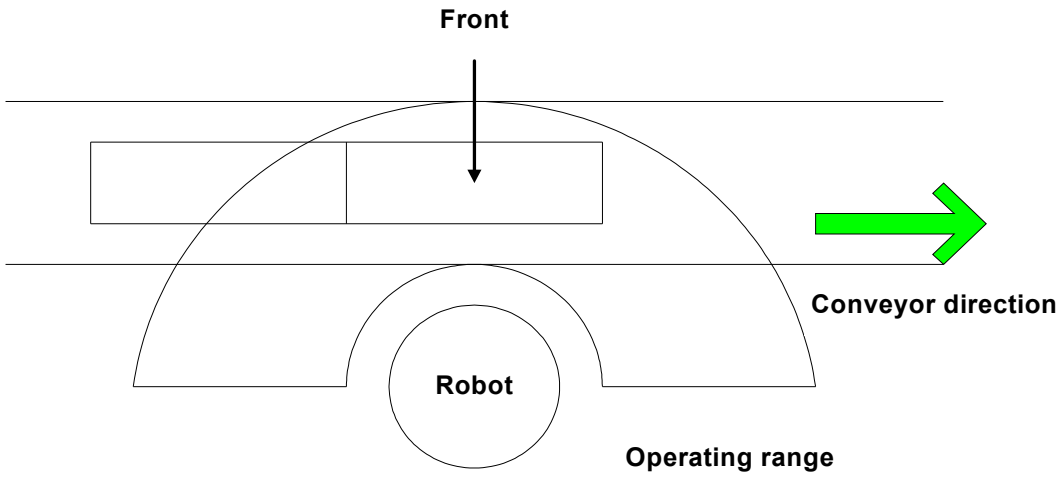
- Return to home position
  Robot that completed the work returns to the home position for next start command.

6.2. Block division teaching

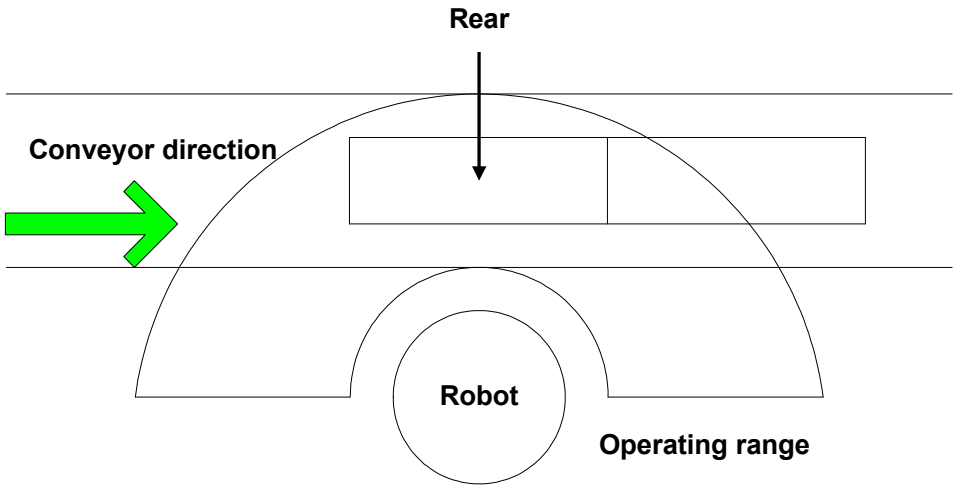
When teaching a work piece larger than the robot operating range, it executes block division teaching because it is impossible to teaching at one time.

6.2.1. Block division teaching procedure

(1) Stop the work piece at the position in the figure.



(2) After teaching the front side of the work piece in program1, operate the conveyor to teaching the work piece the position in the following figure.



(3) After teaching the rear side of the work piece in program 2, prepare program 3 that calls program 1 and 2.

(4) By playing the program 3, you can operate the whole zone of the work piece.

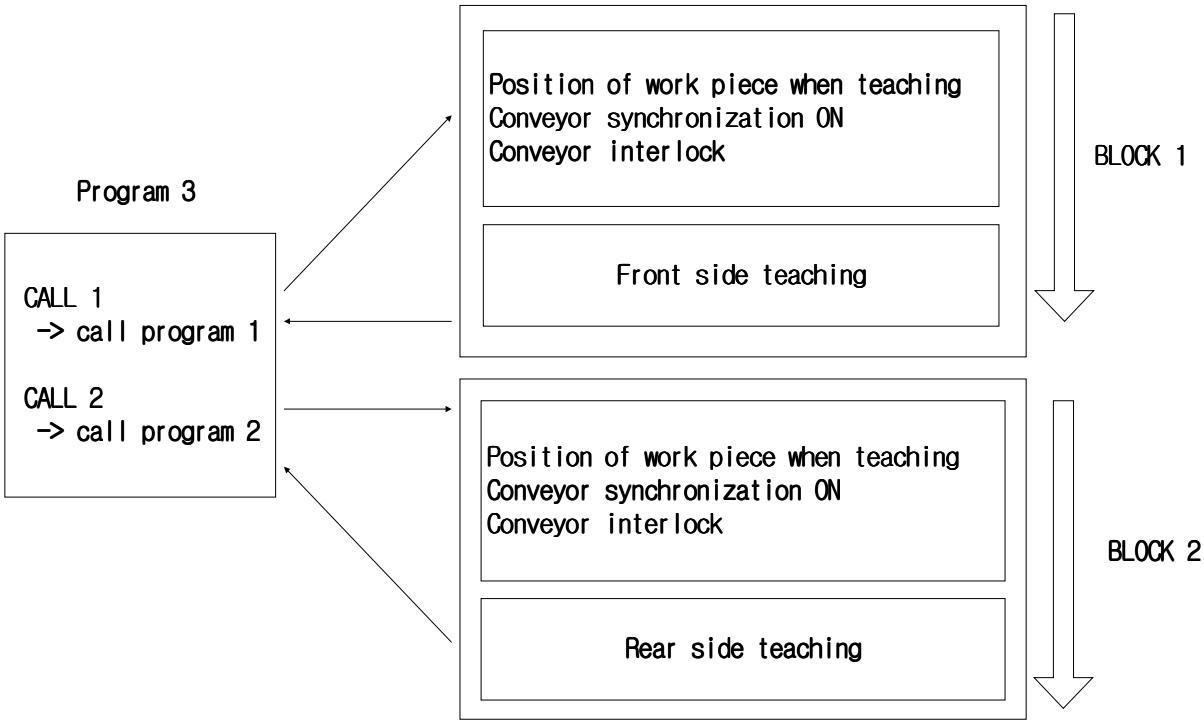
6.2.2. Smooth connecting method between blocks

To make a smooth transition when moving from program 1 to 2, you must teach the same point for the last step of program 1 and for the first step of program 2, as follows.

After selecting and playing the last step of program 1, select program 2 to record step 1. By this the last step of the 1st block and the first step of the last block becomes the same.

6.2.3. Block division program preparation

The procedure for block vision program preparation is as follows.



■ **Block 1 teaching**

(1) Check whether the conveyor data is cleared.

(2) After operating the limit switch with work piece by moving the conveyor, stop the conveyor when the teaching part of the work piece is in front of the robot. Conveyor pulse counter and registry value corresponding to the current work piece position are calculated.

(3) Teach the work piece in current position and check the teaching using step forward/backward function.

(4) Select auto mode to check the playback, and select <Test> for conveyor operation of application condition. In normal mode, the conveyor data is cleared when executing program end command, and conveyor run signal input is required during conveyor operation. To avoid this, select the test mode.

(5) Keeping the work piece in the current position, press the start button to check the playback.

(6) Record CNVYPOS (Refenence position record), CNVSYNC (conveyor synchronization playback), and WAITCNVY (conveyor wait) command in step 0.

■ **Block 2 teaching**

(1) Select and play the last step of program 1.

(2) Move the conveyor and stop the conveyor when the block 2 teaching part is in front of the robot.

(3) Select manual mode and then program 2.

(4) Execute teaching as the same as block 1.

6.3. Teaching applied to conveyor synchronization cancel

The position of the robot changes according to the conveyor speed for the program operated by conveyor synchronization up to the last step. Especially when the conveyor is fast, the time from the last step to the first step of the next cycle takes long. And due to this reason, the position at the last step of the next cycle is shifted even more to the end stream. This phenomenon is repeated accumulated for each cycle and results in a soft limit error by the robot to disable the operation.
To avoid this phenomenon, cancel the conveyor synchronization prior to the last step and execute the next cycle so that the robot can start from the same position.

- **Teaching example 1**

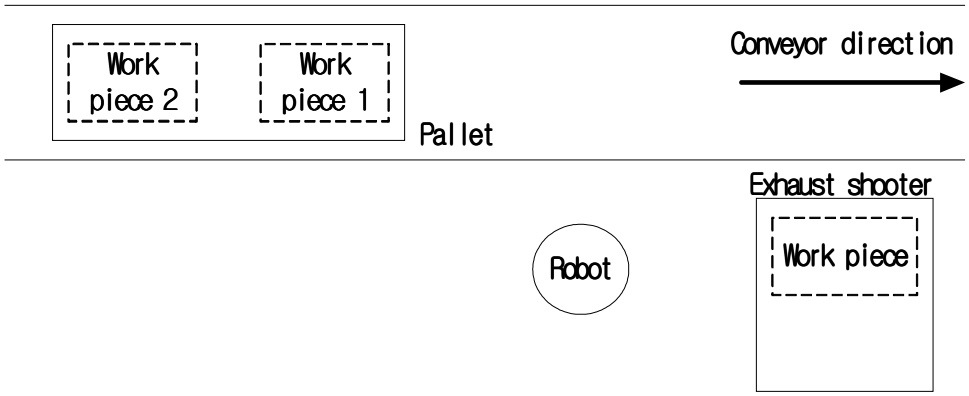
  Next is the program example used for canceling conveyor synchronization.

```
Step 1
      CNVYPOS C=1,D=1000        → Reference position record
      CNVSYNC 1                 → Conveyor synchronization playback ON
      WAITCNVY S=0,D=500        → Conveyor interlock wait
Step 2
Step 3
Step 4
      CNVSYNC 0                 → Conveyor synchronization playback OFF
Step 5
      END
```

  If you record the conveyor synchronization playback OFF command in step 4, the robot will not synchronize to the conveyor in step 5 and move to the position of step 5. In other words, the robot is stopped in a specific position (first recorded position of step 5) irrelevant from the conveyor and the moving time to the first step of the next cycle is kept consistent. Therefore this can prevent the robot operation position from moving gradually to the low stream of the conveyor as the playback is repeated even under high conveyor speed.

■ **Teaching example 2**

Let's learn about the teaching method of the system where the work piece is moved with the exhaust shooter one at a time, as shown in the next figure, when there are two work pieces on pallets moving on the conveyor.



(1) Hold the work piece 1 on the pallet while synchronizing with the conveyor.

(2) Place the work piece 1 on the exhaust shooter. At this time, the conveyor synchronization must be canceled because the exhaust shooter is not on the conveyor.

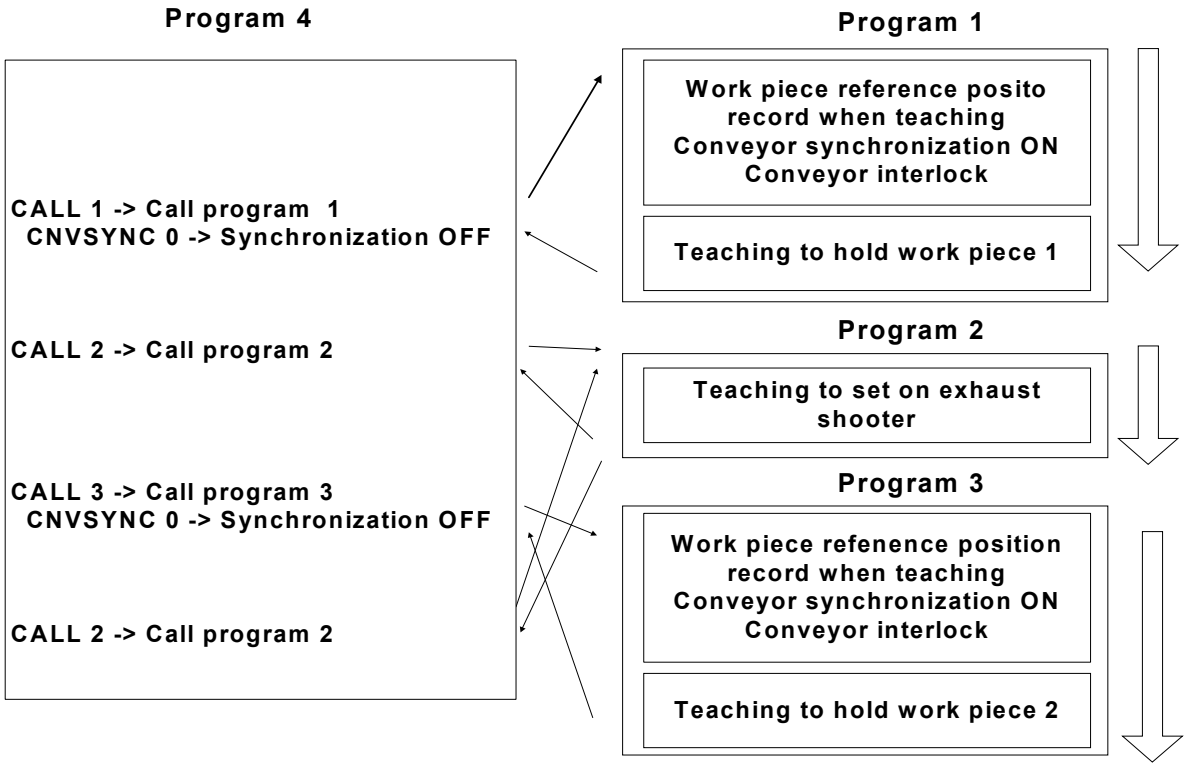
(3) Hold the work piece 2 on the pallet while synchronizing with the conveyor.

(4) Place the work piece 2 on the exhaust shooter. At this time, the conveyor synchronization must be canceled because the exhaust shooter is not on the conveyor.

When executing this kind of operation, it is convenient to use the block division method. Teaching example is as follows.

In this system, 4 programs are prepared for use.

Program 1 for teaching to hold work piece 1, program 2 for teaching to conveyor the work piece to exhaust shooter, program 3 for teaching to hold work piece 2 and program 4 to call program 1, 2 and 3. But the conveyor synchronization playback must be OFF before calling program 2.



Reference

- When you move to different steps through step SET or step JUMP during conveyor synchronization playback, this step is synchronized with general conveyor. In reverse, if you do not execute the conveyor synchronization playback ON command and try to move to another step through step SET or step JUMP, this step is not synchronized to the conveyor.

- At the program step end of a called program, the conveyor synchronization cannot be canceled.

6.4. Checking teaching trace

After teaching a work piece on the stopped conveyor and selecting the <Test> mode for the conveyor operation of application condition, it checks the teaching trace. At this time in the test operation mode, the signal during conveyor operation must not be received.

Order of checking teaching trace

(1) Check the teaching point by using the step forward/backward function from the current conveyor position.

(2) Check the teaching trace by 1 cycle playback from the current conveyor position.

(3) If there is a problem in the trace, re-execute teaching and move to the next step.

6.5. Checking soft limit and cycle time

After checking the teaching trace with test operation, select the <Simulation> mode for conveyor operation of application condition and enter to 『[PF1]: Service』 → 『2: Register setting』 → 『6: Conveyor data』 → 『1: Conveyor simulation data [R45]』 to set the conveyor simulation speed. You can check soft limit detection and cycle time by Executening playback in simulation mode.

- **Solution when the robot is stuck at soft limit**

  When a soft limit error occurs in the robot, it can be resolved in the following method.

  ① Trace edit
  - Change the position of the soft limit generation step (arm/wrist position or position).
  - Change the work order or teaching position to upper stream.

  ② Interlock wait distance edit
  - See if you can change the interlock wait to start the work faster.

7
Playback

7.1. Test operation playback

This operation is to check the teaching, keeping the conveyor at the same condition (position of conveyor during teaching) when the teaching is completed. Even though the conveyor registry is cleared at program END command during normal playback operation or simulation, it will not be cleared in test operation.
Since you can check the program with robot lock function in test operation mode, use it as needed.

Reference

If you have cleared the conveyor data by mistake, the robot can shift heavily during playback and cause interference with peripheral devices. Therefore, check if the conveyor registry value shown in monitoring is the same as the teaching value before operation.

7.2. Playback of simulation operation

Even though the conveyor is not actually moving, the robot can execute the synchronization operation by setting a virtual speed of the conveyor. Therefore this is used to check the robot operation, operating range or cycle time before actually executing the robot for playback. Since you can check the program playback with robot lock function in simulation mode, use it as needed.

When CNVSYNC 1 (conveyor synchronization On) command is executed during playback, the controller counts up the conveyor registry according to the conveyor simulation speed.

Reference

The conveyor registry starts Count Up after executing the CNVSYNC 1 (conveyor synchronization On) and resets at program END command. But it is not reset at the program END command of called program.

7.3. Playback of normal operation

It actually operates conveyor to make the robot follow the work piece movement and plays the synchronization.

7.4. Conveyor synchronization DSBLion condition

Following the conveyor is done in the zone where conveyor synchronization playback is ON and it is not done in the zone where conveyor synchronization playback is OFF. The cases when the robot cannot follow the conveyor in zone where the conveyor synchronization is on are as follows.

- **When robot is temporarily stopped**
  This is when “CNVY TRACKg during hold” is set to 『DSBL』 in 『[PF2]: System』 → 『4: Application parameter』 → 『6: Conveyor』.
  If it is set to 『ENBL』, the robot will follow the conveyor.

  If the robot stops with the stop command during conveyor synchronization, the conveyor synchronization also stops. And when the restart command is executed to move the robot, the robot will follow the conveyor.

  In following cases, the robot will not follow even though the conveyor moves.

  - When the robot reached to a step to stop using step forward/backward in manual mode,
  - When the robot stopped because the key input was Off when using the step forward/backward in manual mode.
  - When the robot stopped because the STOP command was executed during program playback.
  - When the robot stopped with stop command input.

- **When robot is stopped by emergency stop**
  When the robot stopped by emergency stop input from the control panel or the teach pendant, the robot will not follow the conveyor.

- **When robot is stopped from an error**
  When the robot stopped from an error during playback, the robot will not follow the conveyor.

- **For WAITCNVY S=0**
  When the WAITCNVY S=0 recorded on the program is executed during playback, in other words when the conveyor interlock wait (synchronized off) command is executed, the robot will not follow the conveyor until the work piece reaches the interlock distance.

- **When 『RESET』+『SET』 is executed**
  When you press the『RESET』+『SET』key, it initializes various data to execute the program and clears the conveyor synchronization condition. Therefore, in other words CNVSYNC 1 command execution state is cleared.

7.5. Synchronization playback in permitted multiple work pieces

While the robot is counting the pulse for work piece 1, and new work piece 2 passes the limit switch to enter the work zone, the robot starts internal pulse counting for both work pieces 1 and 2. When the playback is completed for work piece 1, in other words when the 『Program END』 command is executed, the conveyor data for work piece 1 (CP, CR, CS) is updated to the conveyor data for work piece 2 (CP, CR, CS). After on, the robot starts the operation for new work piece 2.

- **Conveyor data process when executing 「Program END」 command**
  When multiple work piece entry is set to <ENBL> and the program END command is executed, the conveyor data (CP, CR, CS) is updated for the work piece when an additional work piece entered. If no additional work piece is entered, all conveyor data is cleared.

8
Error Code

8.1. System error

Code	E0017 Conveyor pulse line trouble
Cause	Conveyor pulse is not input.
Action	- Check the conveyor encoder power. - Check the connection of conveyor encoder pulse line. - Replace the optional BD48X board.
Code	E0018 BD481 interface error
Cause	Receiving data from the optional BD48X board is poor.
Action	Check if the optional BD481X board is correctly mounted on I/O board. Check if No. 3 is ON in the DIP switch of I/O board.
Code	E0019 CNVY pulse count changed a lot
Cause	Conveyor pulse number exceeds “ENBL frequency” set in System/Application condition/Conveyor/Application parameter.
Action	Check the set value of “Conveyor max frequency” . (Menu: [PF2]:System – 4: Application parameter – 6: Conveyor – 1: Conveyor parameter setting) Check if there is noise received in the pulse line.
Code	E0021 Conveyor speed is too high
Cause	“ENBL conveyor speed” is high.
Action	Check the “Conveyor max speed”. (Menu: [PF2]:System – 4: Application parameter – 6: Conveyor – 1: Conveyor parameter setting) Check if there is noise received in the pulse line.

8.2. Operation error

Code	E1300 Reference position doesn't record.
Cause	For conveyor synchronization, the reference position (distance from the limit switch to the work piece during teaching) of the work pice must be recorded .
Action	The reference position (M37 or CNVYPOS) command of the work piece must be executed prior to the conveyor synchronization On command (MS55 [1] or CNVSYNC 1).
Code	E1301 Not available under CNVY Syncro.
Cause	You cannot use a stud gun during conveyor tracking.
Action	1) Change the gun type to a different one than stud in the menu of [PF2]: System – 5: Initialize – 4: Setting usage of the robot 2) Delete the (stud) gun function recorded in step condition data.
Code	E1302 Conveyor interpolation error
Cause	Conveyor synchronization operation only supports the straight interpolation function. During the conveyor synchronization zone, interpolation OFF function is not supported.
Action	Change the interpolation type to straight line or arc for the conveyor synchronization step.
Code	E1304 Conveyor running signal is given
Cause	The signal should not be received during conveyor operation for “Test” or “Simulation”
Action	Stop the conveyor or change the operating mode of the conveyor to “Normal”.
Code	E1305 Create Robot.CO1 file for conveyor
Cause	Command related to conveyor synchronization has been executed in an environment where conveyor synchronization is not used.
Action	Delete the applicable command.

9
Others

9.1. Conveyor synchronization with additional axis

If there is an additional axis for conveyor synchronization, the robot follow the additional axis first. If the robot cannot follow the additional axis due to the soft limit, arm interference etc. of the robot, the robot follows the conveyor using the robot 6 axis.

9.2. Conveyor synchronization in B axis dead zone

When the B axis angle is taught near 0 degrees or B axis angle passes near 0 degree during conveyor synchronization, the robot cannot maintain the tool position consistently. Therefore when adding a tool, select the tool direction that does not use near 0 degree angle of B axis.

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