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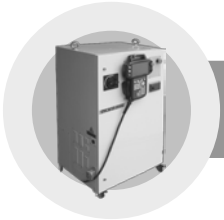

Hi5 Controller Function Manual

Sensor synchronization (Conveyor, press)

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Printed in Korea – April. 2013. 1st Edition
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1 Overview

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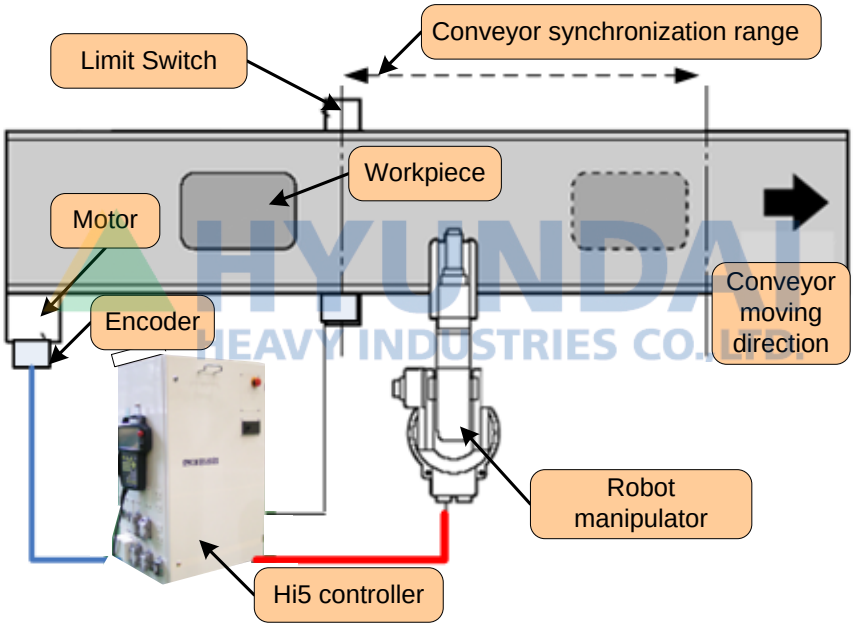
Sensor synchronization is a function for executing synchronization by receiving signals from external sensors. The external sensors support encoders and are divided into the ones for conveyor operation and the others for press operation.

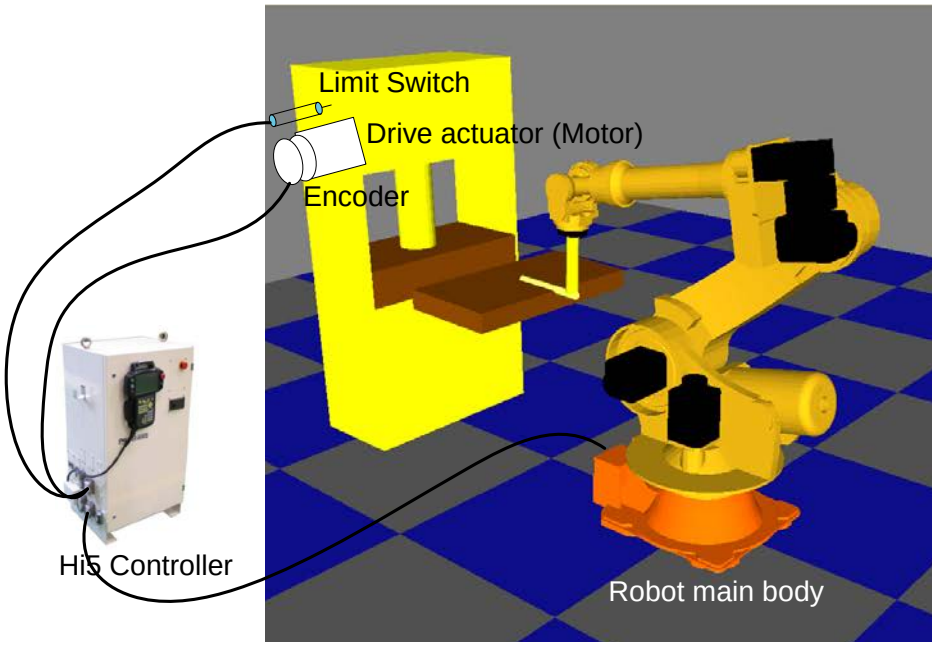
When it comes to the conveyor synchronization function, a robot performs operation for a workpiece that is loaded and transported on the conveyor while tracking it.

Press synchronization is a function to control the moving distance of a press by interlocking it with the position of the robot.

1.1. System configuration

The following figure shows the general configurations of the synchronization systems for conveyors and presses.





- **Limit switch**
  This unit is for providing the controller with the information that a workpiece is entering a specific position on the conveyor or passing a specific position on a press. The position of the limit switch is a reference point for determining a position.

- **Encoder**
  The motor drive part is connected with an encoder that generates pulses equivalent to the amount of the rotation of the motor. The encoder is connected with the robot controller to feed the pulses generated from the encoder into the robot controller.

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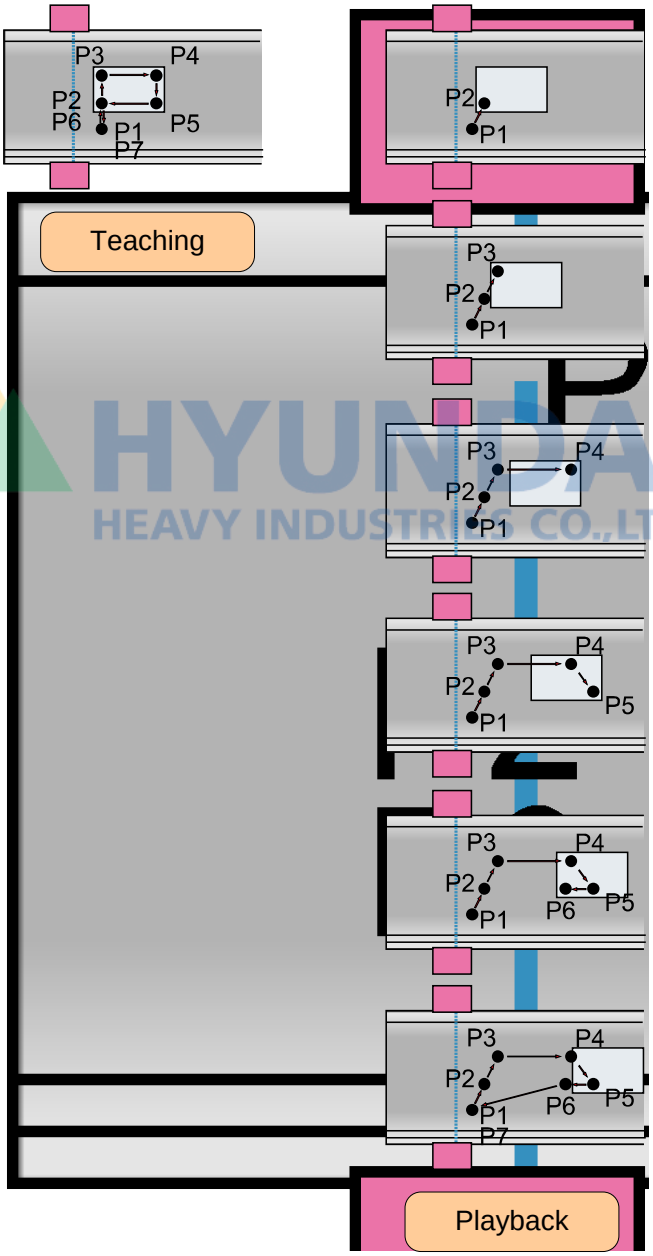
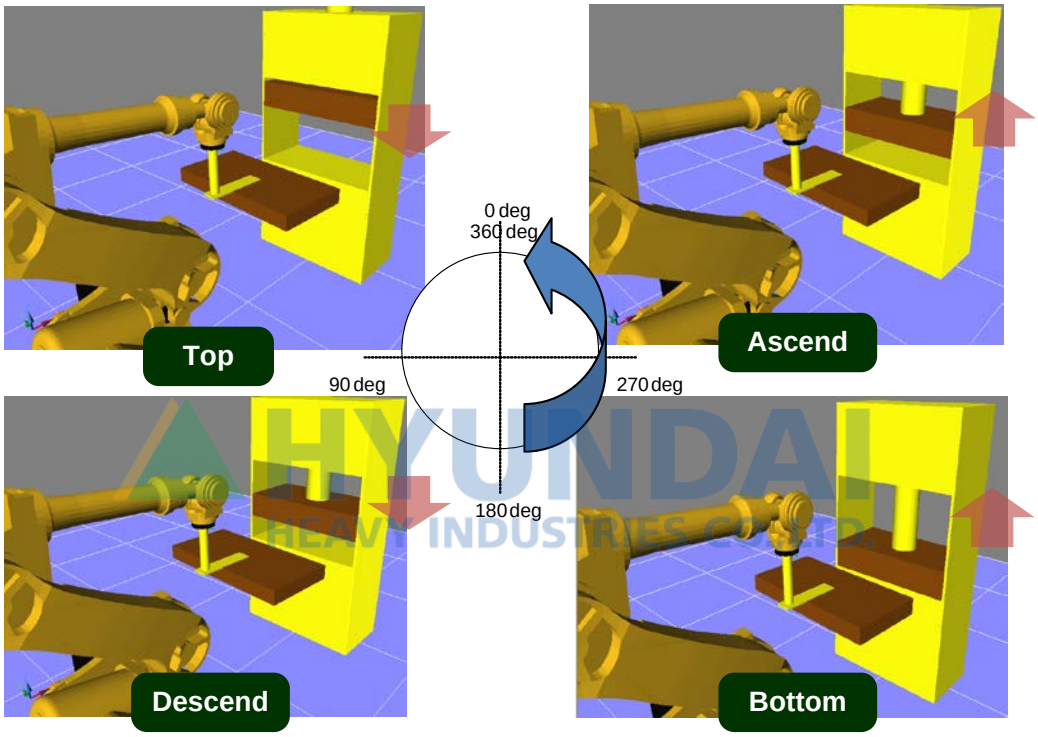
1.2. The principle of conveyor synchronization

In order to playback the teaching trajectory P1~P7 (P2~P6 for conveyor synchronization) while the conveyor is stopped, as shown in the following figure, firstly, it is required to calculate the amount of the distance that a workpiece moved from the limit switch while being loaded and transported on a conveyor, and then add thus calculated value to the reference position. In order for this operation to take place, the robot needs to be synchronized with the change in the speed of a conveyor, and the relative position and pose between the workpiece and the tool need to be maintained.



1.3. The principle of press synchronization

A press carries out a pressing work by moving from the top to the bottom point. And then, it moves back up to the top to finish one cycle. The press synchronization takes place in a way that the positions of the press and robot are recorded in the step data to synchronize the position of the robot with the moving speed of the press. However, when it comes to the performance of synchronization, it will be limited by the acceleration and deceleration as well as of the maximum speed of a robot, and errors could occur if the variation from the expected speed is high.



1.4. Key specifications

Items	Specifications
Sensor synchronization parameter setting file	ROBOT.CON
Count of synchronizable sensors (conveyors, presses)	2 units
Conveyor (Press) type	Linear and circular
Conveyor angle setting	Support for auto setting
Pulse input method	Open collector and line driver
Pulse counting method	Up and up/down
Encoder resolution setting	Support for auto setting
Allowable count of workpieces that can be handled on the conveyor	100 units (per conveyor)
Synchronizable sensor moving distance	21m
Kinds of interpolation that can be supported within the conveyor synchronization range	Linear (L), circular (C)
Kinds of interpolation that can be supported within the press synchronization range	Axis interpolation (P), linear (L) and circular (C)

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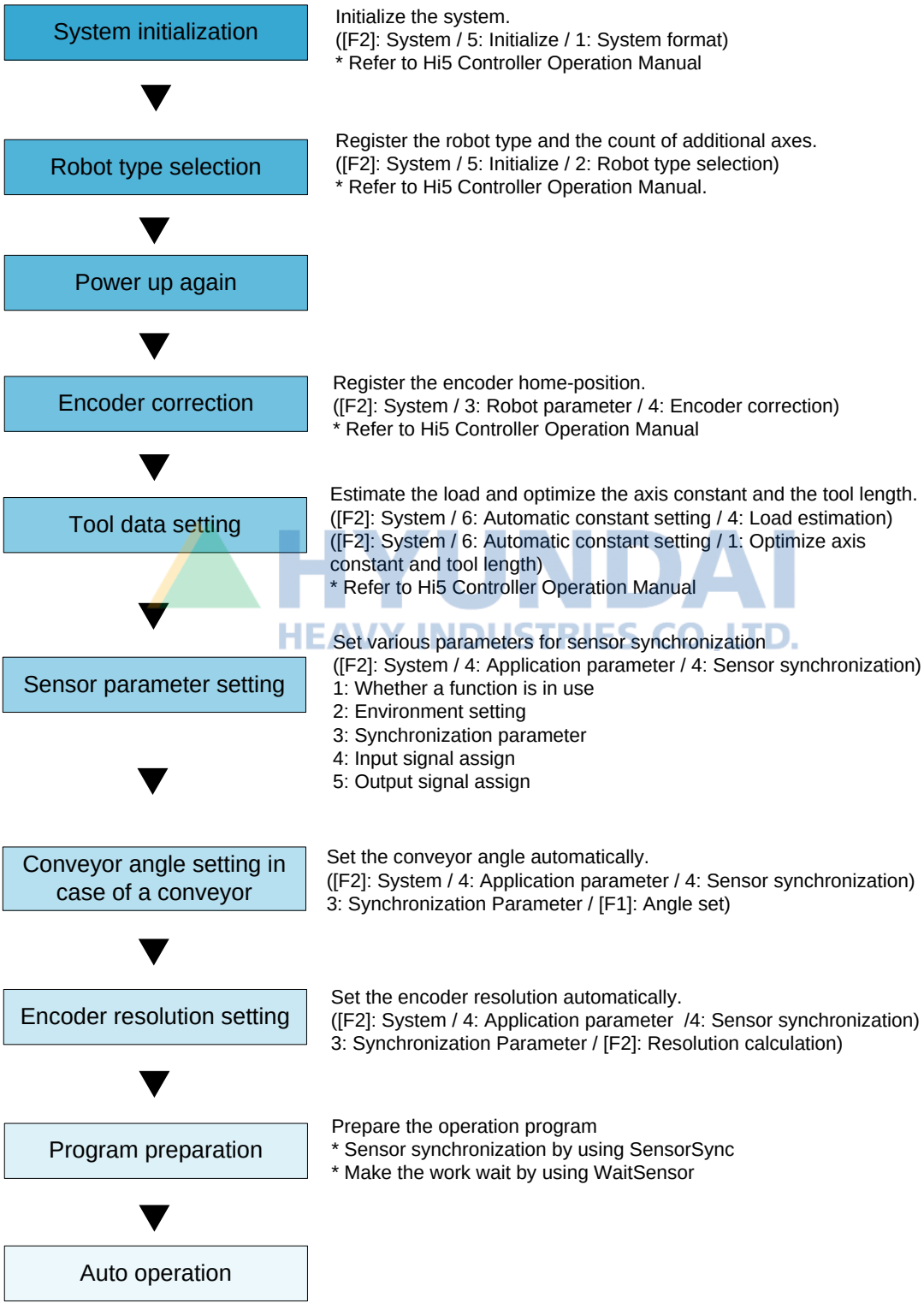
1.5. Operation sequence



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2 Hardware

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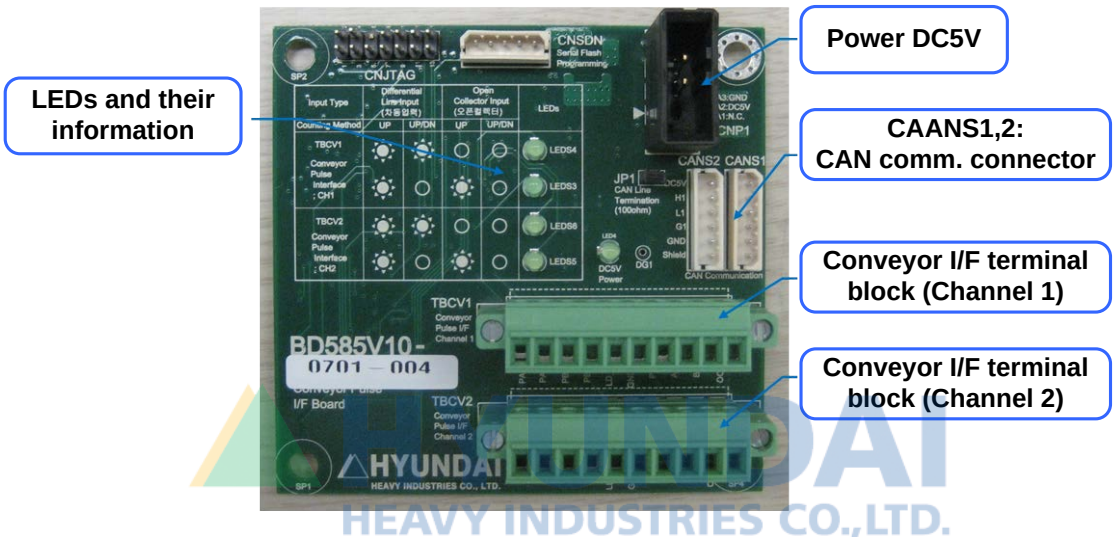
2.1. Conveyor I/F board (BD585)

Refer to Hi5 Controller Maintenance Manual for more details.

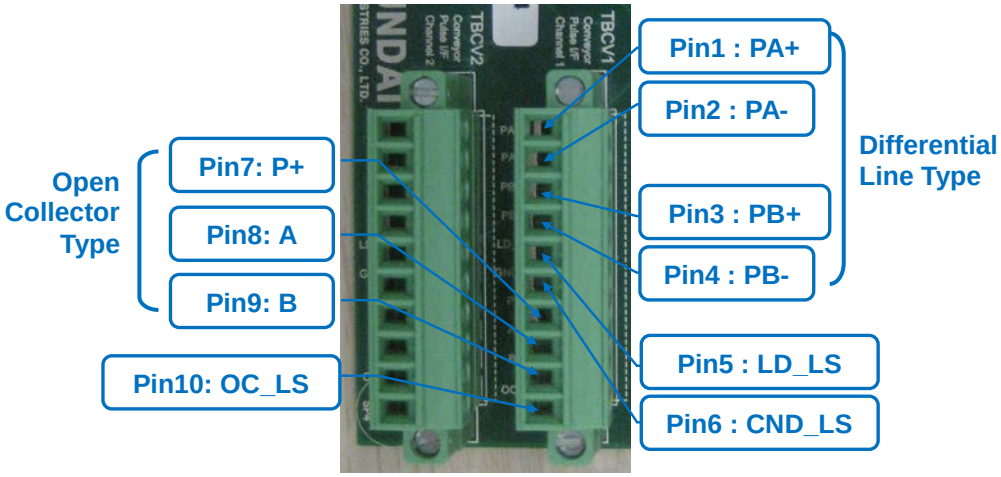
2.1.1. Overview

The following figure shows the configuration of the conveyor I/F board (BD585).



2.1.2. Terminal blocks (TBCV1, TBCV2)

The following figure shows the connection specifications for the terminal blocks that are to be connected to the conveyor I/F board and external units.



Terminal	PIN	Explanation	Input specification
PA+,PA-	1, 2	Line driver A phase pulse input	0 ~ 5V, 100kHz or below
PB+,PB-	3, 4	Line driver B phase pulse input	0 ~ 5V, 100kHz or below
LD_LS	5	Line driver Workpiece detection limit switch input	0 ~ -30V
GND_LS	6	Line driver Power GND input	0V
P+	7	Open collector Power input	20 ~ 30V
A	8	Open collector A phase pulse input	0 ~ -30V, 100kHz or below
B	9	Open collector B phase pulse input	0 ~ -30V, 100kHz or below
OC_LS	10	Open collector Workpiece detection limit switch input	0 ~ -30V

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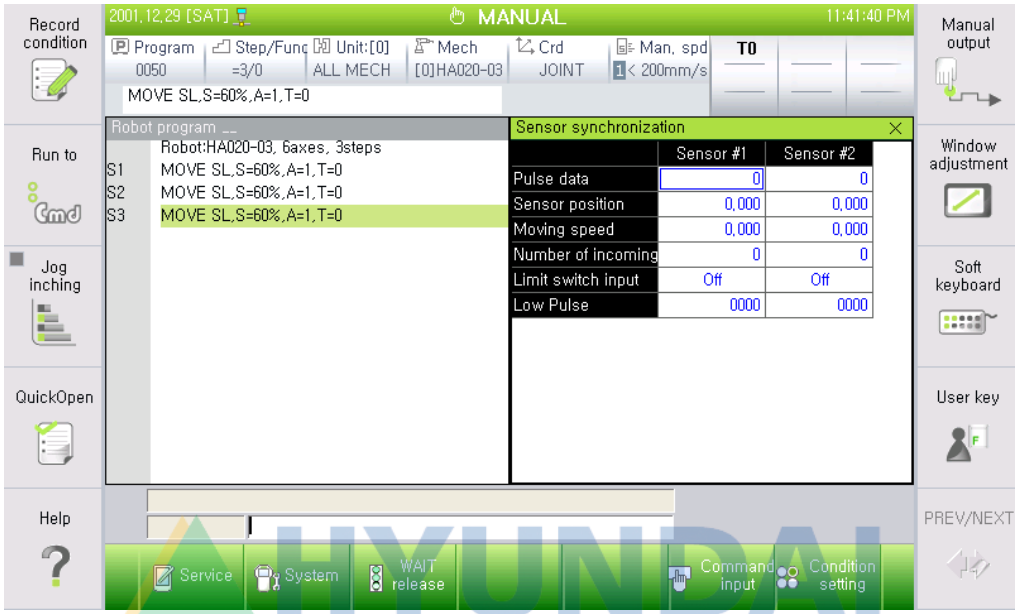
2.2. Hardware inspection

The sensor synchronization related data can be checked by selecting the screen of “『[F1]: Service』 → [1: Monitoring] → [4: Sensor Synchronization]”.



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- **Limit switch**
  If the “Limit Switch Input” status is “On” while the switch is activated and “Off” while not activated, it means that the switch is normal. If it does not function normally, its hardware needs to be checked.

- **Encoder**
  When it comes to the “Low Pulse” item, the value will keep increasing or decreasing within the range of 0 ~ FFFF if the encoder pulse is fed normally. If it does not work normally, it is required to check the hardware.

3 User Interface

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3.1. Conveyor angle auto setting

In order for a robot to be synchronized with the moving conveyor, the robot controller must be aware of the moving direction of the conveyor within the coordinates for the robot.

If the conveyor moves in an arbitrary direction, it would take lots of time to calculate the exact position of the moving conveyor in a three-dimensional space. For this case, the conveyor angle auto calculation function can be used.

3.1.1. Program teaching

In order to get the conveyor angle calculated automatically, it is required to prepare the program designed for the auto calculation as shown below.

In case of a circular type conveyor, the positions of 3 points are needed to calculate the angle. The Step (3) of the following steps needs to be repeated once more.

Their individual positions need to be distant from each other to make sure that the angle can be set correctly (Linear: 1m or longer).

(1) Select a new program for calculating the conveyor angle automatically.

(2) Move the tip of the robotic tool to a specific position on the workpiece on the conveyor and record it as S1.

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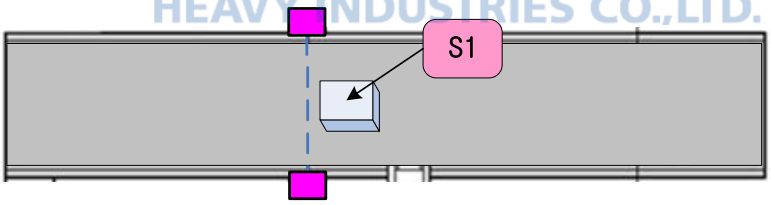
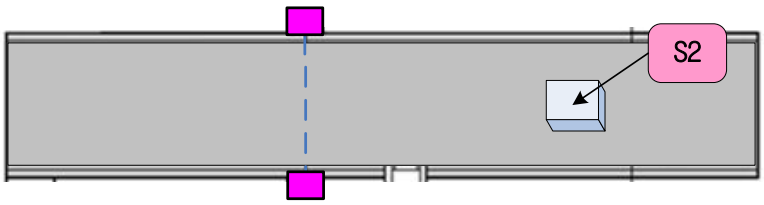
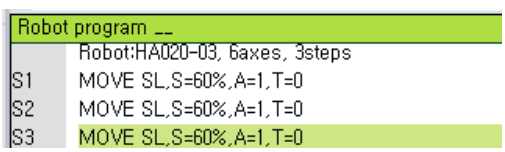


(3) Transport the workpiece by running the conveyor, and then move the tip of the robotic tool to the specific position of Step (2) and record it as S2.



(4) Then, the program will be prepared as shown below.



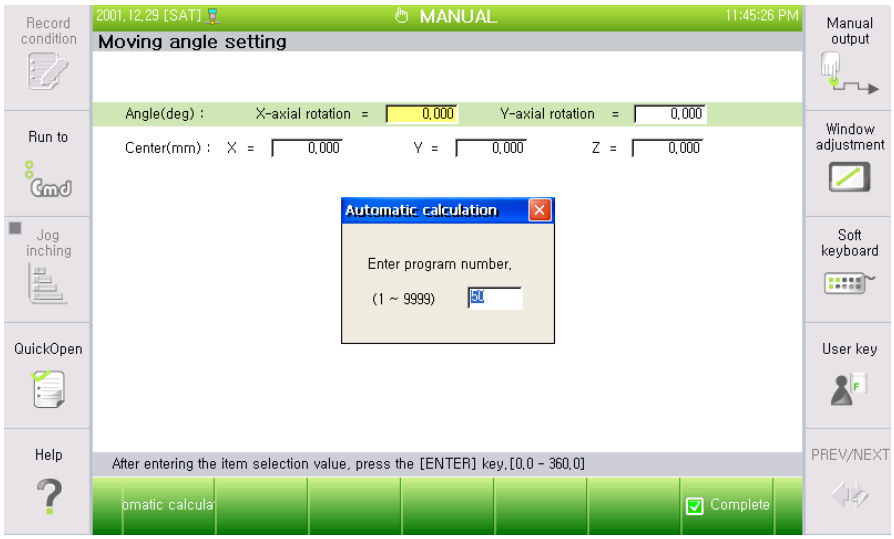
3.1.2. Auto calculation execution

The following screen will be displayed when pushing the [F1: Angle set] key on the setting screen of "『[F2]: System』 → [4: Application Parameter] → [4: Sensor Synchronization] → [3: Synchronization Parameter]".

If the conveyor type is set as <Circle>, the following display will be changed for setting the angle and center of the circular type conveyor.

(1) Possible to check the currently set conveyor angle and set the angle manually.

(2) Pushing the [F1: Automatic Calculation] key will bring up the following screen to calculate the conveyor angle automatically. The calculated result will be displayed when entering the teaching program number.

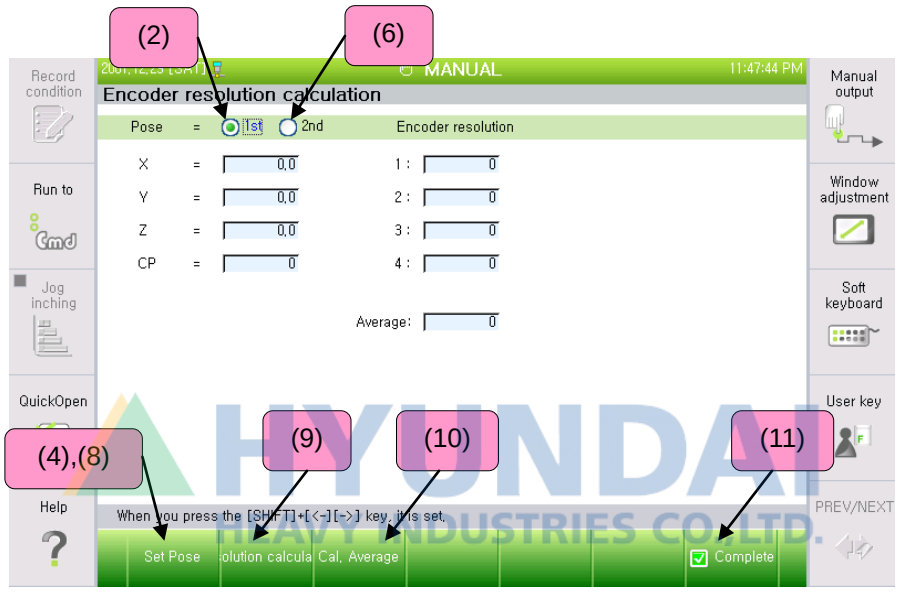


(3) The set value will be saved when pushing the [F7: Complete] key.

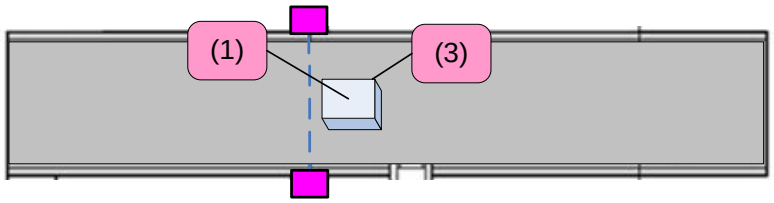
3.2. Encoder resolution auto setting

Encoder resolution can be defined by the count of pulses that will be generated when a linear type conveyor (press) moves 1m or when a circular type conveyor (press) turns 1 degree.

In order to calculate the encoder resolution automatically, it is needed to push the [F2: Resolution calculation] key on the setting screen of "『[F2]: System』 → [4: Application Parameter] → [4: Sensor Synchronization] → [3: Synchronization Parameter]".



(1) As shown below, after a workpiece passes through the limit switch, the conveyor will stop.

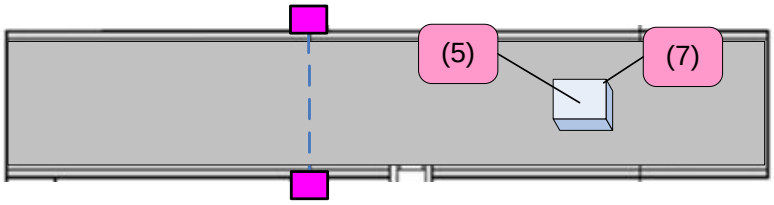


(2) Select the position as <1st>.

(3) Move the end part of the robotic tool to a specific position on the workpiece.

(4) Push the [F1: Set Pose] key to record the current position of the robot as well as the encoder pulse value.

(5) Move the workpiece by running the sensor as shown below (1m or longer).



(6) Select the position as <2nd>.

(7) Move the tip of the robotic tool to the specific position designated at Step (3).

(8) Push the [F1: Set Pose] key to record the current position of the robot as well as the encoder pulse value.

(9) Push the [F2: Resolution calculation] key to calculate the encoder resolution and record the value in the encoder resolution section. Repeat the steps of (1) ~ (9) to calculate the resolution of totally 4 encoders.

(10) Push the [F3: Cal. Average] key to calculate the average of the recorded resolution values of encoders.

(11) Push the [F7: Complete] key to set the average value as the encoder resolution.

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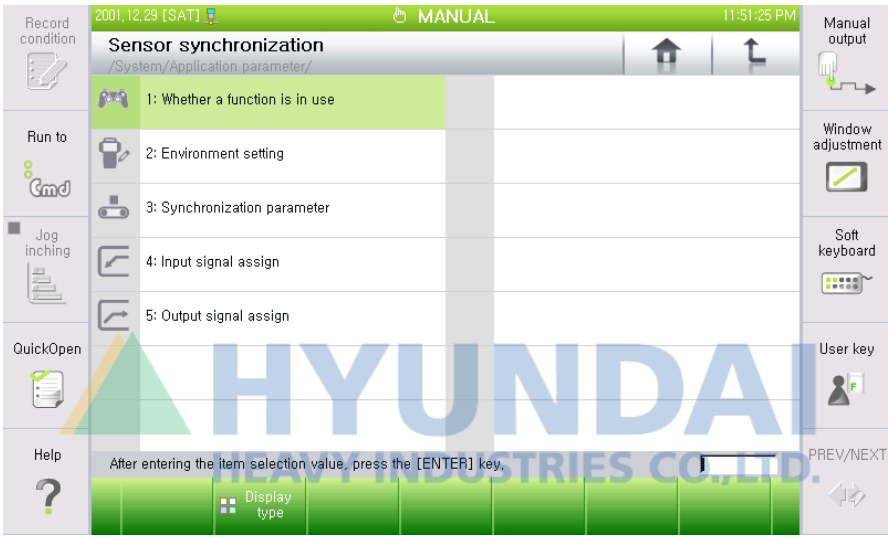
3.3. Sensor synchronization parameter

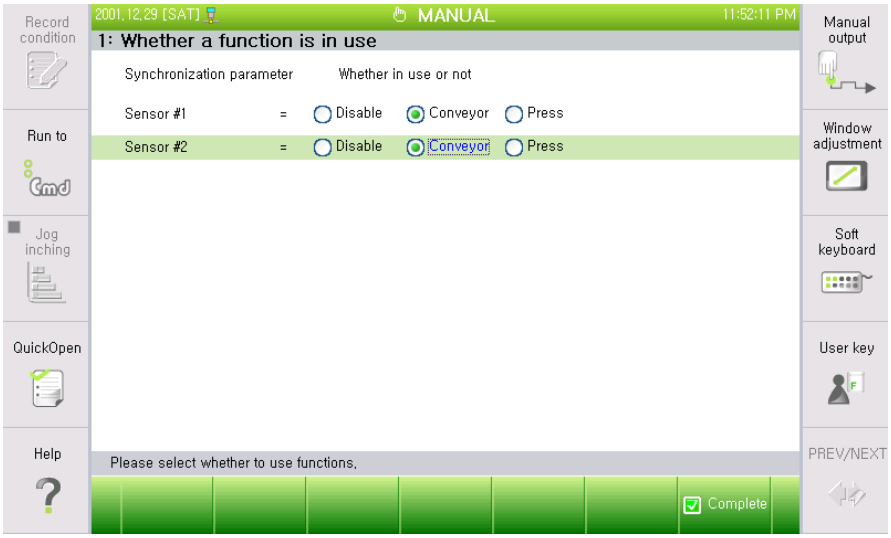
In order to playback the robot while applying the conveyor (press) synchronization function, the robot controller should be aware of various data related to the conveyor (press) that needs to be synchronized. The activity of feeding the necessary data into the controller is called sensor synchronization parameter setting process.

That is why the sensor synchronization parameter must be set before preparing the work program. The relevant process can be handled on the setting screen of "『[F2]: System』 → [4: Application Parameter] → [4: Sensor Synchronization]".



3.3.1. Function selection

Decide whether to apply the sensor synchronization for a conveyor or a press



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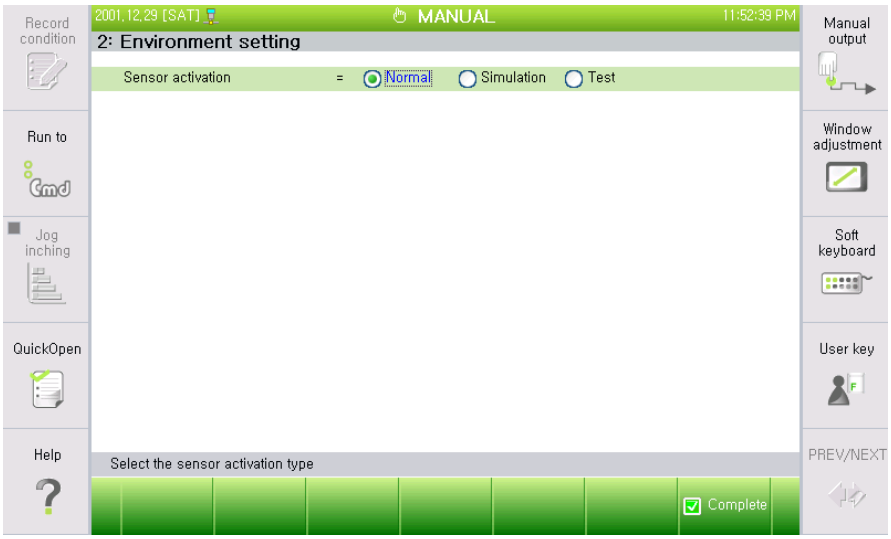
3.3.2. Use environment setting



■ **Sensor activation**

- **Normal**
  The robot operates synchronized with the workpiece on the moving conveyor (press).

- **Simulation**
  The robot operates according to the simulation speed set by the user without the conveyor (press) operating. The soft limit as well as the cycle time of the robot can be checked.

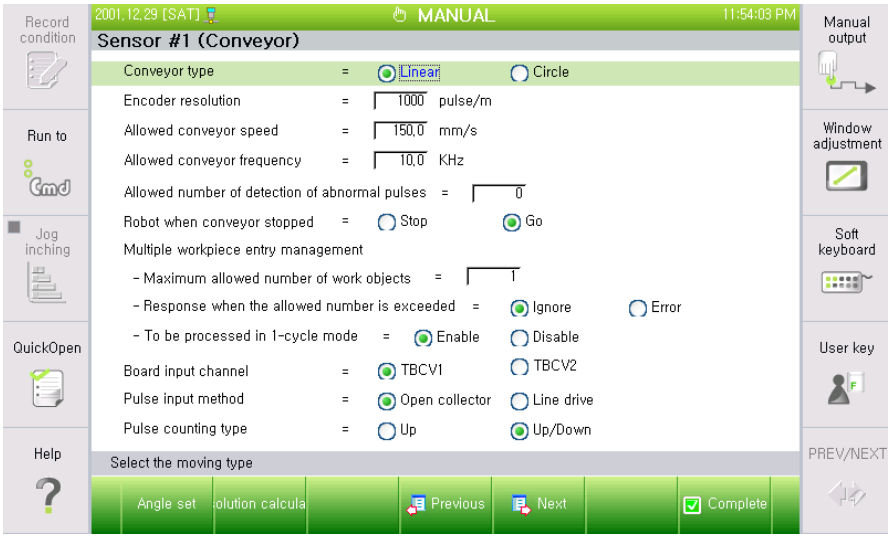
- **Test**
  The operation of the robot can be checked through the conveyor (press) data entered in advance. A test can be performed for checking the working position after the teaching process is completed. As the pulse count is not to be cleared when ending the program, the operation of the robot can be checked while the workpiece is stopped.

Signal processing according to the operation type while the conveyor is operating

	Signal while the sensor is activated	
	On	**Off**
Normal	Normal	Stops or runs (As set by the user)
Simulation/Test	Error	Normal

3.3.3. Synchronization parameter (Conveyor)

The following screen will be displayed if <Conveyor> is selected at Function Selection.



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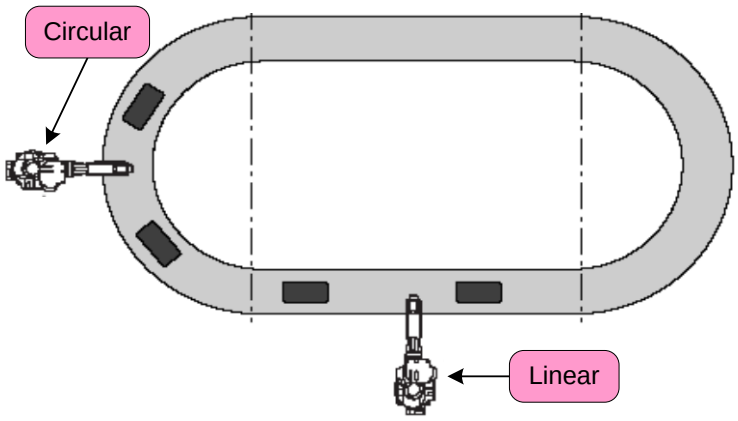
- **Conveyor type**
  Select the type of a conveyor by referring to the figure shown below.



- **Encoder resolution**
  Encoder resolution can be defined by the count of pulses that will be generated when a linear type conveyor (press) moves 1m or when a circular type conveyor (press) turns 1 degree.

  Refer to “3.2 Encoder resolution auto setting” to calculate the encoder resolution automatically.

- **Allowable conveyor speed**
  When the conveyor speed is abnormally high, this function will handle the situation as an error. When the maximum allowable speed is set once by taking into consideration the general speed of the conveyor that is to be used, the controller will calculate the conveyor speed internally and generate the relevant error signal if the conveyor speed exceeds the set conveyor speed.

  In general, as the encoder pulse has some ripples centered around the average value, the conveyor speed has also some ripples centered around the average speed accordingly. It is needed to set the value to be slightly higher than the conveyor speed.

- **Allowable conveyor frequency**
  The allowable conveyor frequency needs to be set at the upper limit of the count of pulses that are to be generated normally from the pulse generator at every second. The robot controller will count pulses that are fed at every second, and generate an error signal if the controller determines the fed pulse as an error that is caused by some reasons, such as noise

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- **Allowable number of detection of abnormal pulses**
  When the conveyor pulse is fed abnormally, the robot controller generates an error “E0019 Exceeded conveyor pulse permitted frequency”. This function can be set for the purpose of allowing the robot to proceed even when there is an error with the pulse, in order to protect the workpiece that is being handled through synchronization.

  For example, if the allowable pulse error detection count is set at 3, then, the robot controller will not generate an error even when it is detected that one workpiece shows errors with the pulse value up to 3 times during the synchronized operation, and rather generate suitable pulse values internally. The controller will generate an error signal when the same error occurs with the pulse 4 times or more. Thus generated information about the errors with the pulse value will be initialized when the playback for the workpiece is completed.

- **Robot when conveyor stopped**
  This is for setting the conditions for deciding the operation of the robot when there is no signal input, in other words, when the conveyor stops in the middle of the conveyor operating in a general mode.

- **Multiple workpiece entry management**
  This is for setting the conditions for deciding the operation of the robot if there is one workpiece already being handled on the conveyor in a synchronized manner and another workpiece is just entering the working range after passing through the limit switch.

  - Maximum allowed number of work object
    For setting the maximum count of workpieces that are allowed to enter.

  - Response when the allowed number is exceeded.
    For setting whether to handle or reject the workpiece that exceeds the maximum count when the allowable maximum workpiece count is exceeded.

  - To be processed in 1-Cycle mode
    For deciding whether to handle the entered workpiece if the <1Cycle> mode is set at Condition Setting/Operation Mode.

- **Pulse input method**
  For deciding the input method for the conveyor pulse to be from the conveyor interface board.

- **Pulse counting type**
  The <Up> mode needs to be selected if the user want the forward counting even when the conveyor moves in reverse direction.

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■ **Detection of the system errors associated with synchronization**
For setting the conditions to prevent conveyor synchronization related system errors from being generated when needed to operate the robot regardless of the synchronized operation, because there are some cases in which the robot cannot be made ready for operation as conveyor synchronization related system errors are caused due to incomplete installation of the system or due to damage to the board.

Error code	Synchronization related system errors
E0017	Conveyor pulse line error
E0019	Exceeded conveyor pulse permitted frequency
E0020	Conveyor I/F board connection error
E0021	Exceeded conveyor permitted speed

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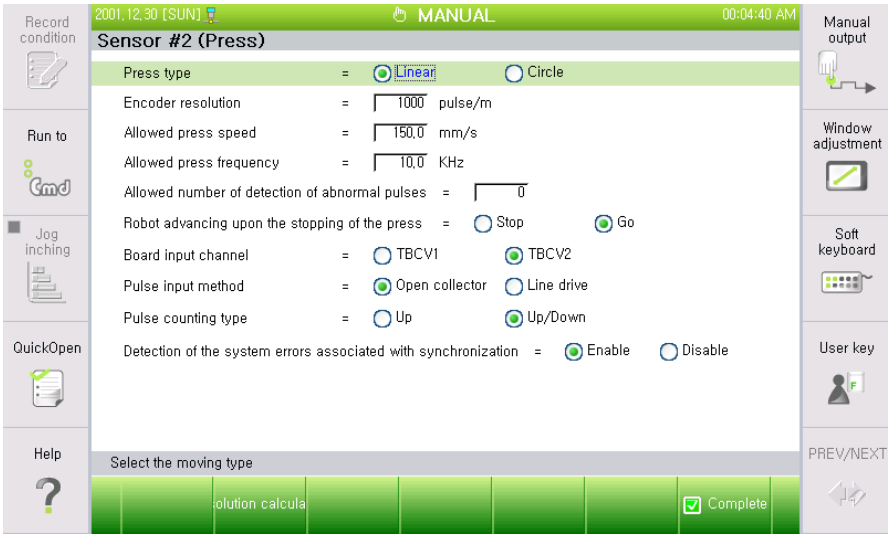
3.3.4. Synchronization parameter (Press)

The following screen will be displayed if <Press> is selected at Function Selection.



- **Press type**
  Select between the linear type and the circular type depending on the data from the sensor are linear (mm) or related to angle (degrees) of the turn.

- **Encoder resolution**
  Enter the count of encoder pulses that are generated when the press moves 1m in case of a linear type press.
  Enter the count of encoder pulses that are generated when the press moves 1m in case of a circular type press.

- **Allowable press speed**
  Enter the normal moving speed of the press. The normal moving speed is the press speed when the robot is synchronized. If the speed is not entered correctly, synchronization will not take place normally.

- **Allowable press frequency**
  Same as the case of selecting a conveyor.

- **Allowed number of detection of abnormal pulses**
  Same as the case of selecting a conveyor.

- **Robot advancing upon the stopping of the press**
  Even when the press stops, the robot moves. The robot will stop due to an error when exceeding a certain range of error.

- **Pulse input method**
  Same as the case of selecting the conveyor.

- **Pulse counting type**
  Same as the case of selecting the conveyor

- **Detection of the system errors associated with synchronization**
  Same as the case of selecting the conveyor..

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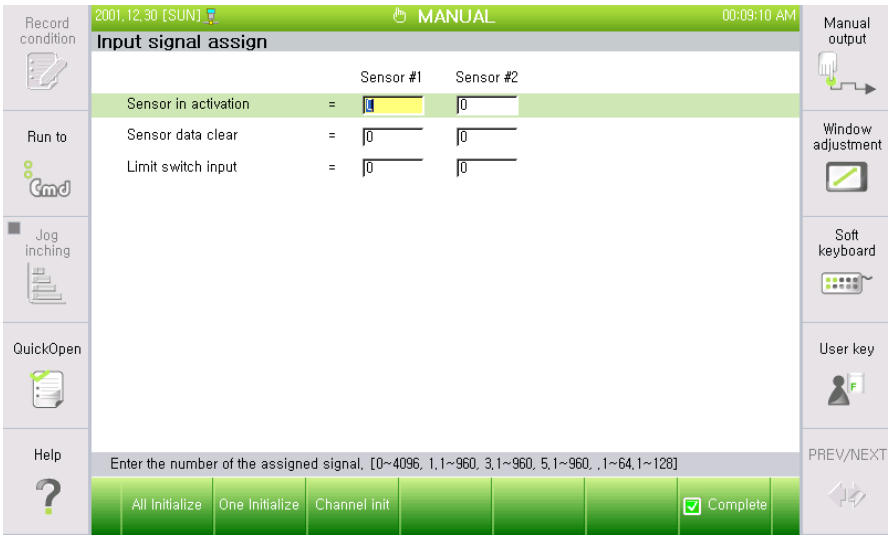
3.3.5. Input signal assignment



- **Sensor activation**
  This signal should be fed in the synchronized playback range of the conveyor (press) while in the normal mode. However, the signal should not be fed in the test or simulation mode.

- **Sensor data clear**
  The conveyor (press) data can be cleared through an externally fed signal. If this signal is fed when the robot stops, the conveyor (press) data (pulse data, sensor position and moving speed) will be cleared.

- **Limit switch input**
  The limit switch status can be received through an externally fed signal. If the input signal is not registered, the limit switches status that will be fed through the conveyor IF board will be used.

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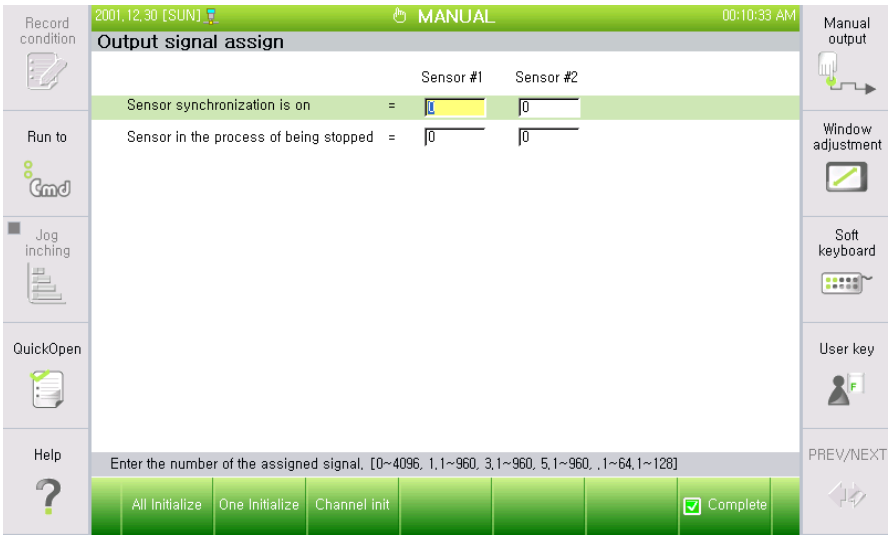
3.3.6. Output signal assignment



- **Sensor synchronization is on**
  This will generate the synchronized playback on/off status signal of the conveyor (press). When the command, SensorSync Sensor=1, Sync=1, is executed, the signal output will be switched on. If the command, SensorSync Sensor=1, Sync=0 or SensorSync Sensor=1, Sync=2 is executed, the signal output will be switched off.

- **Sensor in the process of being stopped**
  When the input signal is switched off while the sensor is activated, the status will be detected and notified externally.

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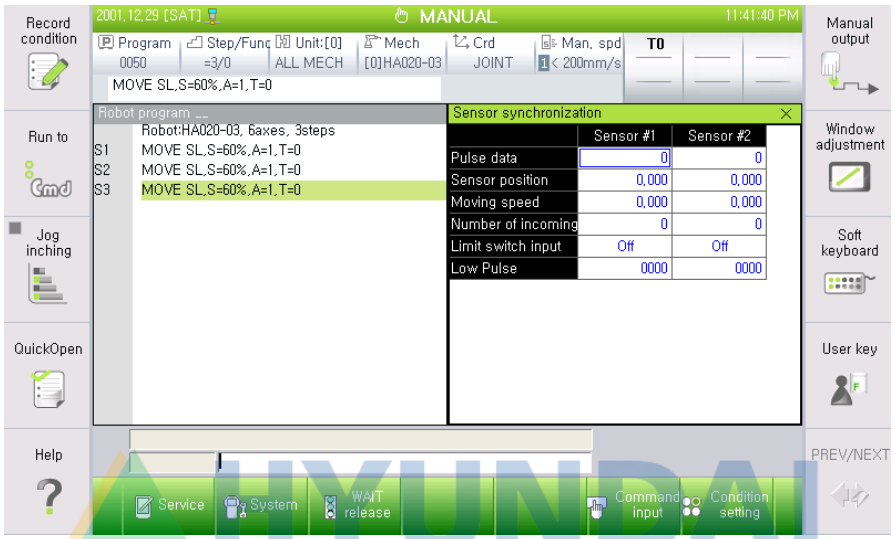
3.4. Monitoring

3.4.1. Sensor synchronization data

Sensor synchronization related data can be checked by selecting the screen of “[F1]: Service → [1: Monitoring] → [5: Sensor Synchronization Data]”.



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- **Pulse data**
  Variable for controlling the count of pulses received from the pulse generator.

- **Sensor position**
  Variable for keeping the distance the workpiece traveled from the limit switch.

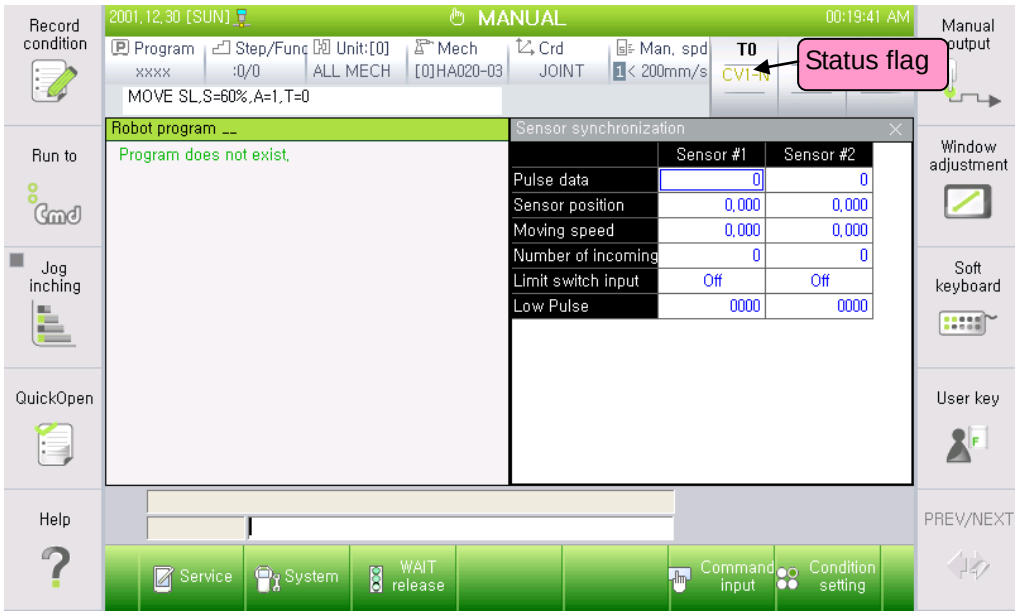
- **Moving speed**
  Variable for controlling the moving speed of the conveyor (press).

- **Number of incoming job objects**
  The count of workpieces that entered after passing through the limit switch.

- **Limit switch input**
  This is for displaying whether the limit switch is activated

- **Low Pulse**
  This is for displaying the values of processed encoder pulses that are fed from the conveyor I/F board. In normal situation, repetition will take place from 0 to FFFF

3.4.2. Status flag



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- **Sensor activation type**
  In case of a conveyor, 『CV1-N』, 『CV1-S』 and 『CV1-T』 strings will be generated for the normal situation, the simulation and the test individually. In case of a press, 『PR1-N』, 『PR1-S』 and 『PR1-T』 strings are to be generated individually.

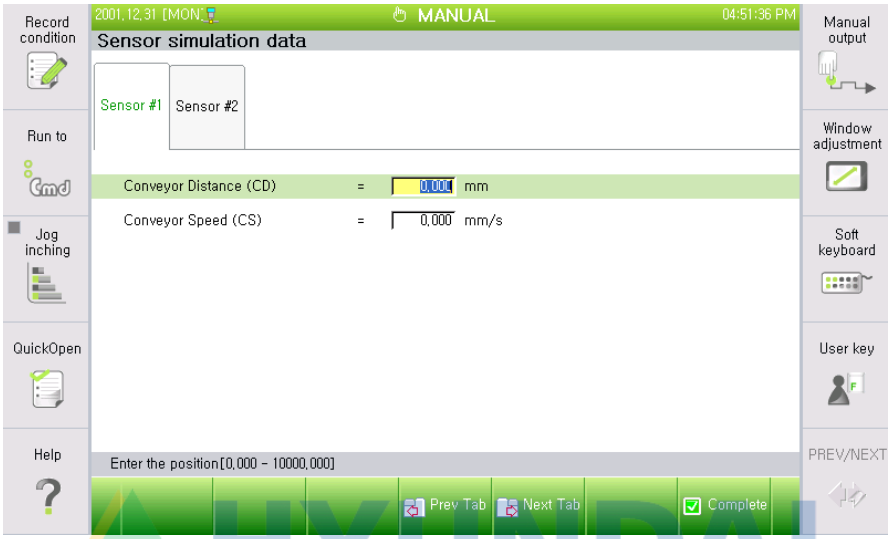
- **Signal input status while the sensor is activated**
  If a signal is turned on while the sensor is activated, a string, which indicates the sensor activation status, will be generated in a way that the characters, which are constituents of the full string, are added up sequentially one by one to create the full string.

  Ex) When the conveyor in the 『Normal』 activation
  Conveyor activated: 『』 → 『C』 → 『CV』 → 『CV1』 → 『CV1-』 → 『CV1-N』
  Conveyor stopped: Fixed as 『CV1-N』
  Ex) When the press in the 『Normal』 activation
  Press activated: 『』 → 『P』 → 『PR』 → 『PR1』 → 『PR1-』 → 『PR1-N』
  Press stopped: Fixed as 『PR1-N』

- **Sensor synchronized playback on/off status**
  The string that indicates the sensor activation status will change in its color depending on the sensor synchronized playback on or off status.

3.5. Sensor simulation data

When the user selects the setting screen of “[F1]: Service → [2: Register] → [6: Sensor simulation data]”, the robot will perform simulated playback according to the speed and distance set by the user if the sensor activation mode is set for the simulation.



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3.6. Commands

- **SensorSync (Sensor synchronized playback)**
  For designating the conveyor synchronization range when the program is played back.

SensorSync Sensor=<Sensor Number>, Sync=<Synchronization>

	Content	
Sensor number	Enter the number of the sensor that is to be synchronized.	
Synchronization	0	Sensor synchronization off
	1	Sensor synchronization on
	2	Sensor synchronization off + Conveyor data clearing

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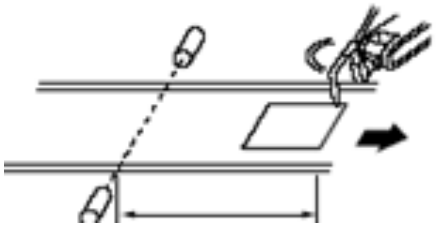
- **WaitSensor (Sensor interlock wait)**
  For making the robot wait until the workpiece reaches a specific position from the limit switch as shown below.



DIST

WaitSensor Sensor=<Sensor Number>,Sync=<Synchronization>,Pos=<Wait Distance>

	Content
Sensor number	Enter the number of the sensor that is to be synchronized.
Synchronization	Sensor synchronization status while waiting (0=Asynchronization, 1=Synchronization : Only the “Asynchronization” mode will be supported in case of a “press”)
Wait distance	The distance the workpiece travelled from the limit switch

3.7. R codes

- **R44 (Sensor synchronization data clearing)**
  Can be used while the operation mode is not the simulated test mode while the robot is stopped. Various sensor related data (Such as encoder pulses, sensor position, sensor speed, count of entered workpieces and status of simulated playback) can be cleared manually.

- **R45 (Sensor moving distance manual input)**
  Can be used only in manual mode. The sensor position value (Linear data in mm and circular data in deg.) can be entered manually.

- **R46 (Limit switch manual input)**
  Can be used only in manual mode. It is to be used when it is necessary to enter the limit switch value manually.

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4 Teaching

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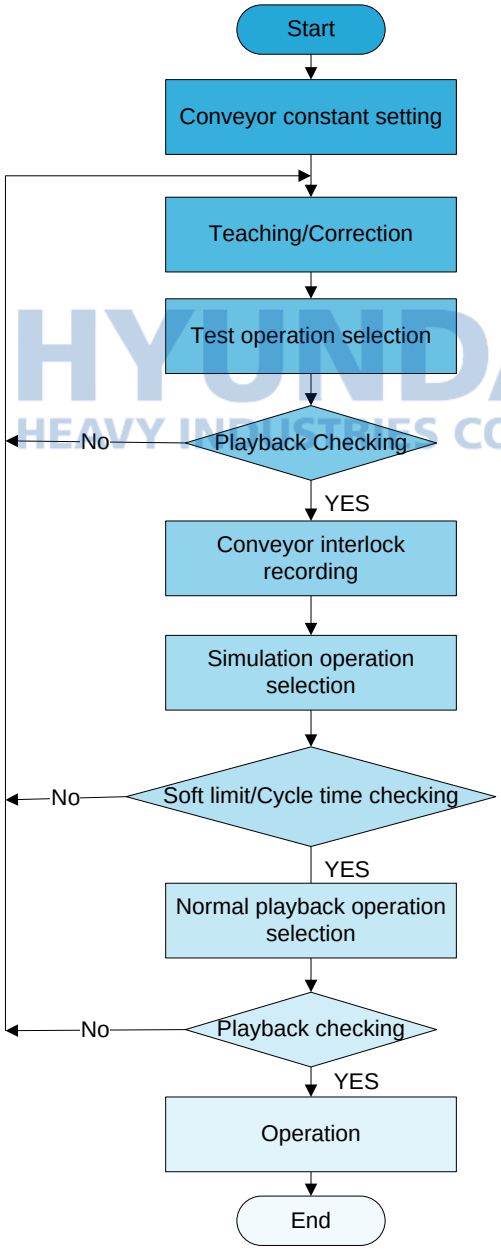
The sensor synchronization program can be prepared by using the same method that is generally applied. However, in order to check the teaching and execute the sensor synchronized playback, it is required to use the commands, 『SensorSync (Sensor synchronized playback)』 and 『WaitSensor (Sensor interlock wait)』. These commands need to be recorded before playing back for checking the program for which teaching is completed.

4.1. Conveyor synchronized operation sequence

The conveyor synchronization operation takes place in a sequence that is shown below, which includes synchronization parameter setting, teaching and correction, playback for checking, and normal playback.



- **Conveyor parameter setting**
  This step is required at the initial stage after installing the conveyor system. As this step will decide the level of position errors of all types of synchronized playback operations, the setting should be handled carefully.

- **Teaching and correction**
  Once the conveyor parameter setting is completed, it is required to operate the conveyor to make the workpiece pass through the limit switch and enter the working range. When the workpiece reaches the desired position, it is required to stop the conveyor and carry out teaching and correction.

- **Playback for checking**
  Once the teaching and correction processes are completed, it is required to carry out playback for checking, depending on the conveyor operation type, in the order of the test mode, the simulation mode and the normal mode. Of those processes, the playbacks for checking for the test mode and the simulation mode are not essential, so the playbacks for them can be performed when necessary based on the user's judgment in line with the system environment.

- **Normal playback**
  When the playback for checking is completed and no problem is found, it is required to set the conveyor at the normal operation mode and execute playback for the actually moving conveyor.

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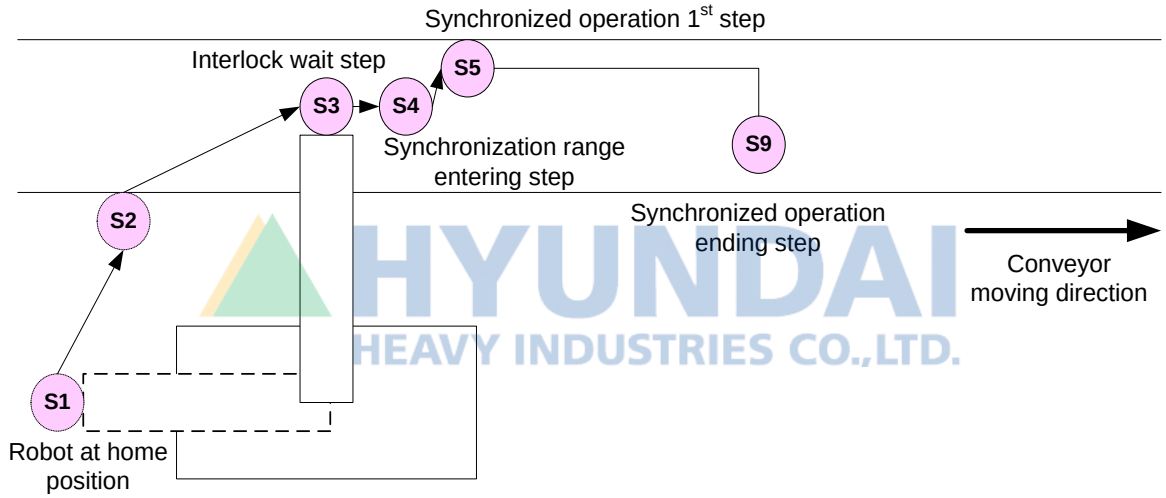
4.2. Synchronization program configuration

- **Home-position wait**
  The robot will wait at the home position until the startup command is entered.

- **Interlock wait**
  The robot will move to an area near the synchronized operation range in advance and wait until the workpiece travels a certain distance as recorded in the relevant command.

  The following figure shows a painting program designed for a workpiece being transported on the conveyor. When the robot moves to Step 4, conveyor synchronization will start. When the robot moves to Step 5, paint will be sprayed on the workpiece in synchronized operation. In this process, the wait step (Step 3) needs to be recorded near the step for entering the synchronized operation range



The above steps can be programmed as shown below.

```
Step 1                                  → Robot at home position
Step 2
Step 3                                  → Interlock wait step
      SensorSync Sensor=1,Sync=1        → Conveyor synchronized playback on
      WaitSensor Sensor=1,Sync=0,Pos=500 → Conveyor interlock wait
Step 4                                  → Synchronization range entering step
                                        → Paint spray signal on
      DO1 = 1                           → Synchronized operation 1st step
Step 5
 :
Step 9                                  → Synchronized operation ending step
      DO1 = 0                           → Paint spray off signal
      SensorSync Sensor=1,Sync=0        → Conveyor synchronized playback off
Step 10
 :
Step 13                                 → Robot at home position
       END
```

- **Synchronized playback**
  In the above figure, the conveyor synchronized playback range runs from Step 4 to Step 9. All the commands for this range are to be executed by being synchronized with the conveyor

- **Back to home position**
  When completing one operation, the robot goes back to the home position and waits for the next startup command.

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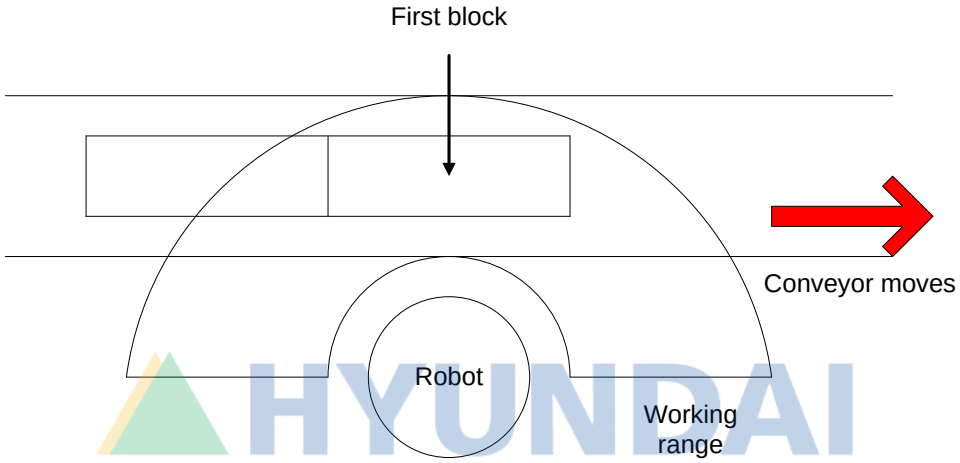
4.3. Teaching after splitting the work into blocks

When teaching needs to be performed for a workpiece that is larger than the working range of the robot, it is required to perform teaching after splitting the work into blocks considering that it will be impossible to perform teaching at one go.

4.3.1. Sequence for teaching after splitting the work into blocks

(1) Make the workpiece stop at the position as shown below.



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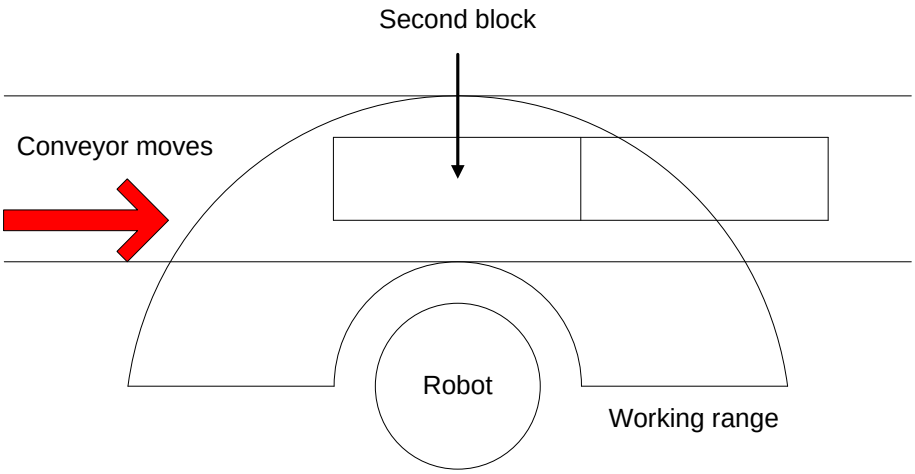
(2) It is required to perform teaching for the first block of the workpiece by using Program 1 and then operate the conveyor to carry out teaching at the position as shown below.

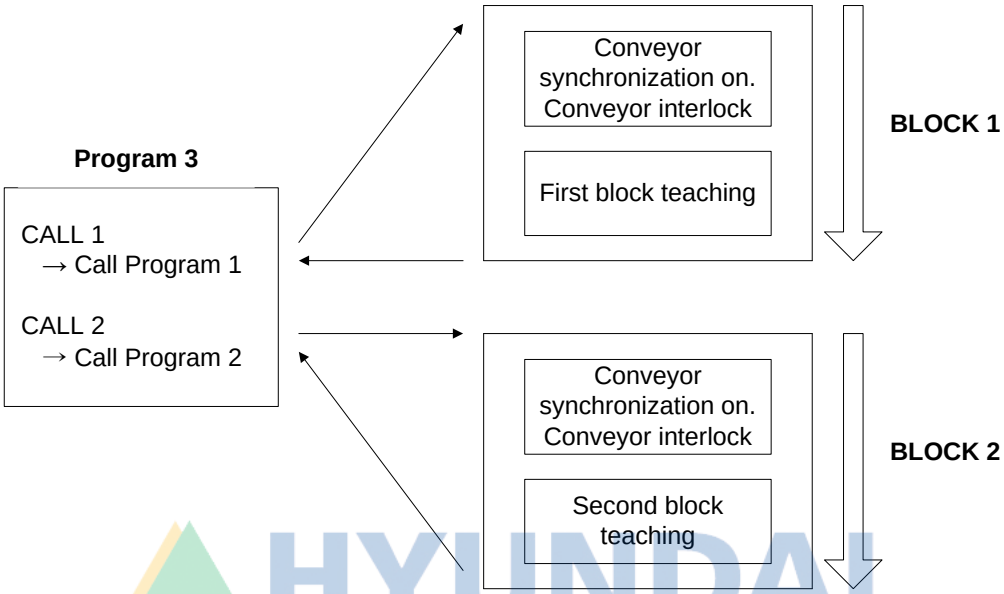


(3) It is required to perform teaching for the second block of the workpiece by using Program 2 and then call Program 1 and 2 to prepare Program 3.

(4) Then, it will be possible to operate for the whole range of the workpiece by playback Program 3.

4.3.2. Preparing programs after splitting the work into blocks

When needed to split the work into blocks for preparing programs, the below sequence needs to be followed



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■ **Teaching for the first block**

(1) Check whether the conveyor data are cleared.

(2) Move the conveyor to allow the limit switch to be activated by the workpiece, and then stop the conveyor when the teaching position is placed in front of the robot. The conveyor pulse counter and register values corresponding to the current workpiece position will be calculated.

(3) Carry out teaching for the workpiece at the current position and check the teaching by using the step forward/backward function.

(4) At the setting screen of System/Application Parameter/Sensor Synchronization/Service Environment, the sensor activation item needs to be set as <Test>. In the normal mode, if the conveyor data are cleared when the program ending is executed, signals need to be fed while the conveyor is working. For avoiding the situation, it is needed to select the test mode.

(5) Leave the workpiece at the current position and push the startup button to perform playback for checking.

(6) Record the CNVYSYNC, WAITCNVY command for Step 0.

■ **Teaching for the 2nd block**

(1) Select and play back the final step of Program 1.

(2) Move the conveyor and stop it when the teaching position of the second block is placed in front of the robot.

(3) Select the manual mode and then select Program 2.

(4) Perform the teaching applying the same method that is used for first block.

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4.4. Teaching by applying conveyor desynchronization

When it comes to a program that runs to the final step while being synchronized with the conveyor, the position of the robot may vary depending on the conveyor speed. In particular, if the conveyor moves fast, it will take a long time to shift from the final step of the current cycle to the 1st step of the next cycle, which will cause the position of the final step of the next cycle to move downstream further. Such phenomenon will repeat itself at every cycle with accumulative effect, causing the robot to be inoperable finally due to the errors with the soft limit of the robot.
In order to avoid the situation, it is needed to desynchronize the conveyor ahead of the final step to make the robot carry out the next cycle at the same position for each cycle.

- **Teaching example 1**

  The following shows a program example that applies conveyor desynchronization.

```
Step 1
        SensorSync Sensor=1,Sync=1              → Conveyor synchronized playback on
        WaitSensor Sensor=1,Sync=0,Pos=500      → Conveyor interlock wait
Step 2
Step 3
Step 4
        SensorSync Sensor=1,Sync=0              → Conveyor synchronized playback off

Step 5
        END
```

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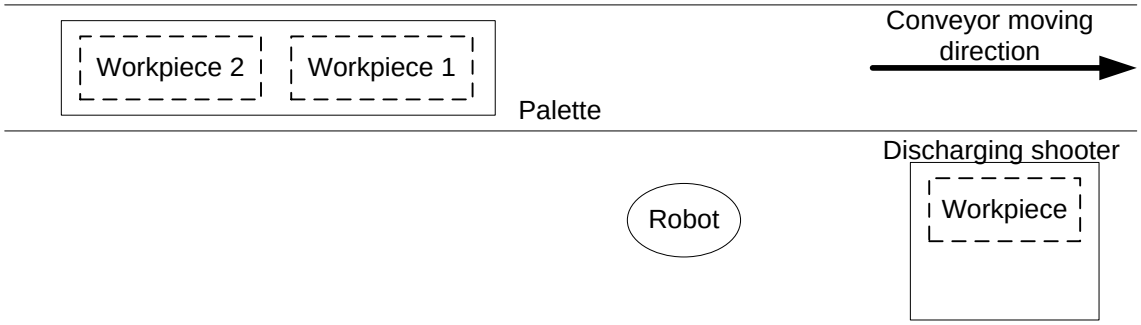
If the conveyor synchronized playback off command is recorded for Step 4, the robot will move to the position where Step 5 is recorded, without being synchronized with the conveyor at Step 5. In other words, the robot will stop at the same position (where Step 5 is recorded first) always regardless of the conveyor, ensuring that it will take the same time constantly to move to the first step of the next cycle

■ **Teaching example 2**

Let's learn about how to perform teaching for a system that can move workpieces one by one to the discharging shooter when two workpieces are placed on one pallet and transported on a conveyor as shown below.



(1) Take Workpiece 1 on the palette while being synchronized with the conveyor.

(2) Place Workpiece 1 on the discharging shooter. At this moment, the conveyor should be unsynchronized as the discharging shooter is not on the conveyor.

(3) Take Workpiece 2 on the palette while being synchronized with the conveyor.

(4) Place Workpiece 2 on the discharging shooter. At this moment, the conveyor should be unsynchronized as the discharging shooter is not on the conveyor.

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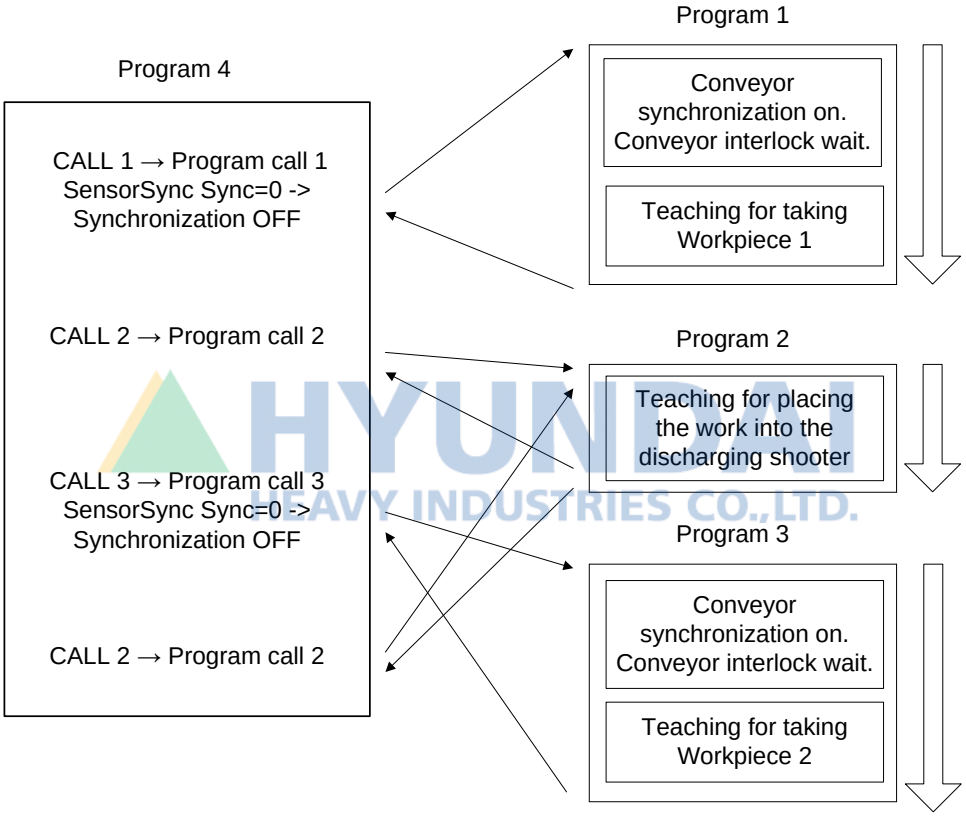
If it is needed to perform this operation, it would be convenient to split the works into blocks. The following figure shows the example of the teaching for such operation.

For this system, 4 programs need to be prepared and applied.

Program 1 is for carrying out teaching for Workpiece 1, and Program 2 is for carrying out teaching for transporting the workpiece to the discharging shooter, and Program 3 is for carrying out teaching for taking Workpiece 2. Then, the three programs are to be called by Program 4. However, the conveyor synchronized playback should be turned off before Program 2 is called.



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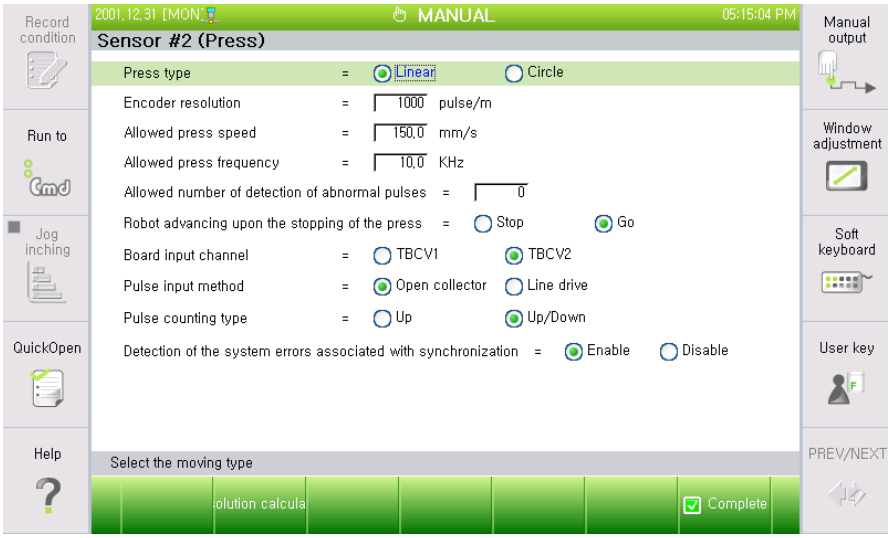
4.5. Teaching for press synchronization



When it comes to press synchronization, the robot performs synchronization in line with the press speed. The synchronization is based on the assumption that the press speed is constant always, which means the synchronization performance will be degraded if the press speed varies. The current working speed of the press needs to be set at the allowable press speed on the above menu.

The following shows a program example that applies press synchronization

Step 1		
	SensorSync Sensor=1,Sync=1	→ Press synchronized playback on
	WaitSensor Sensor=1,Sync=0,Pos=500	→ Press interlock wait
Step 2	MOVE P,S=60%	→ Sensor 1 position registration
Step 3	MOVE P,S=60%	→ Sensor 1 position registration
Step 4	MOVE P,S=60%	→ Sensor 1 position registration
	SensorSync Sensor=1,Sync=0	→ Press synchronized playback off
Step 5		
	END	

In the above program, teaching needs to be performed in a way that the sensor positions of the steps 2, 3 and 4 must be incremental. Otherwise, the following error would be generated.

E0239 The sensor position for the step does not increase sequentially.

In addition, the speeds recorded at the steps 2, 3 and 4 will be ignored, and speed needs to be planned based on the allowable press speed basically set by the user. Even when the highest speed is planned, if the positions of the sensor and the robot are recorded in a way to exceed the performance of the robot, the following error will be generated in the middle of operation.

E0238 Can not follow the sensor speed.

5
FAQ

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- How does a conveyor perform a synchronized operation if the specification of the additional axis is the base and the configuration of the axis is for the direct acting?
  If there is an additional axis when the conveyor is synchronized, the robot will track the conveyor considering the additional axis first. If the robot cannot track considering the additional axis due to some reasons such as soft limit and interference with the arm, the robot will track the conveyor by using Axis 6.

- How does the conveyor perform a synchronized operation if the angle of Axis B is near 0 degree?
  When the angle of Axis B becomes near 0 degree while the conveyor is synchronized, the robot cannot maintain the pose of a tool in a constantly uniform manner. That is why the direction of a tool needs to be set in a way that an angle near 0 degree will not be used, while attaching a tool.

- When will the conveyor (press) data get incremental?
  The following table summarizes the time when the conveyor (press) data are incremental in line with the mode of sensor activation.

	Normal	Simulation	Test
Encoder pulse	LS input	Constantly uniform	Constantly uniform
Sensor position	Same as above	1) Set the simulation speed, and then execute the sensor synchronization on 2) Will be incremental while the simulation position value is used as the initial value.	Constantly uniform
Sensor speed	Same as above	1) Simulation speed setting 2) When Step 0 is executed, the simulation speed will be read	Constantly 0

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■ When will the conveyor (press) data get cleared?
The following table summarizes the time when the sensor data get cleared in line with the mode of sensor activation.

	Normal	Simulation	Test
Encoder pulse	① Program cycle end execution ② Sensor synchronization reset command execution(SensorSync Sensor=1, Sync=2) ③ Sensor data manual reset (While the robot is stopped) ④ Sensor data clearing input signal on (While the robot is stopped)	① Sensor synchronization reset command execution (SensorSync Sensor=1, Sync=2) ② Sensor data clearing input signal on (While the robot is stopped)	① Sensor synchronization reset command execution (SensorSync Sensor=1, Sync=2) ② Sensor data manual reset (While the robot is stopped) ③ Sensor data clearing input signal on (While the robot is stopped)
Sensor position	Same as above	① Program cycle end execution ② Sensor synchronization reset command execution (SensorSync Sensor=1, Sync=2) ③ Sensor data clearing input signal on (While the robot is stopped)	① Sensor synchronization reset command execution(SensorSync Sensor=1, Sync=2) ② Sensor data manual reset(While the robot is stopped) ③ Sensor data clearing input signal on (While the robot is stopped)
Sensor speed	Same as above	① Sensor synchronization reset command execution (SensorSync Sensor=1, Sync=2) ② Sensor data clearing input signal on (While the robot is stopped)	Constantly 0

■ How can get the limit switch signal fed manually?
R46: It is recommended to use the sensor limit switch manual input function.

■ How can get the current conveyor (press) data initialized manually?
R44: It is recommended to use the sensor data clearing function.

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