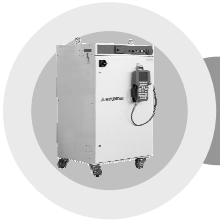
WARNING

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

Hyundai Robot

Hi4aJL071001FMEN3



Hi4a Controller Function Manual

Joint Link

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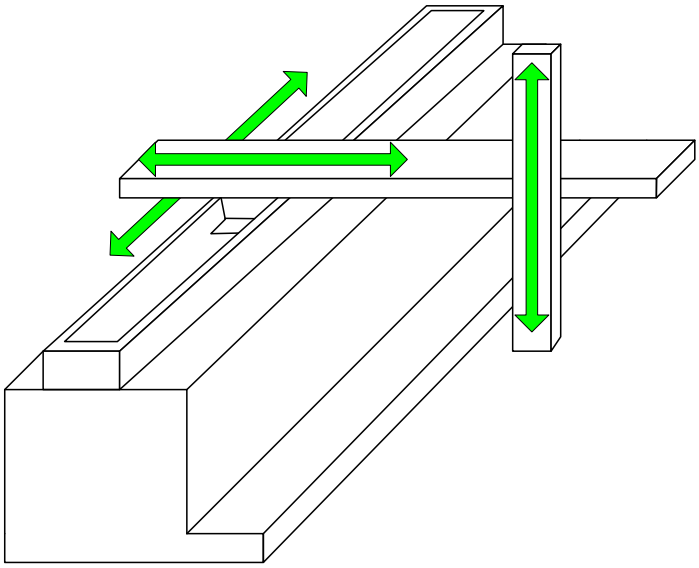
Contents

1 Overview

1. Overview

Hi4a is the peculation controller and the application is possible about company's own robot model and specially designed model. The specific robot model of our company is included mechanism parameter and dynamic model at controller but robot form at controller is not registered in the case of not using standard main body of machinery.
At this time, it can drive about the unregistered robot using the function as selecting robot type as jointlink and setting up motor parameter of each axis. The purpose of main function is to set up the same method of additional-axis like the parameter for motor driving of each axis and to drive the machinery of robot type that is not registered.



Main Function Setting	Remarks
Maximum number of axis	6
Jog	Operation of each axis is possible / No operation of orthogonal and tool coordinate system
Interpolation	Support only interpolation OFF (no straight line and circular arc)
Control method	PPI
Vibration control, Conveyor inducement	Support is impossible.

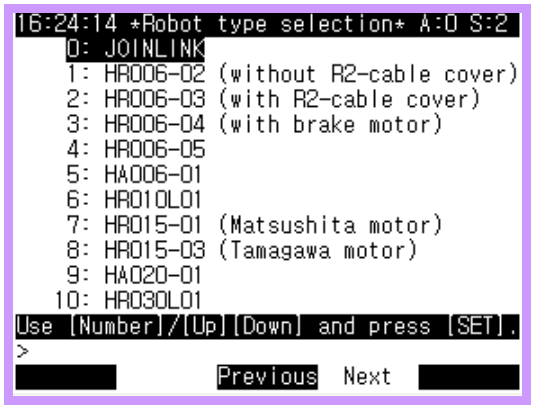
2
Controller Setting

This function is to register the setting in additional-axis of each axis and shows the special feature in activation of axis interpolation (Interpolation OFF) is possible.

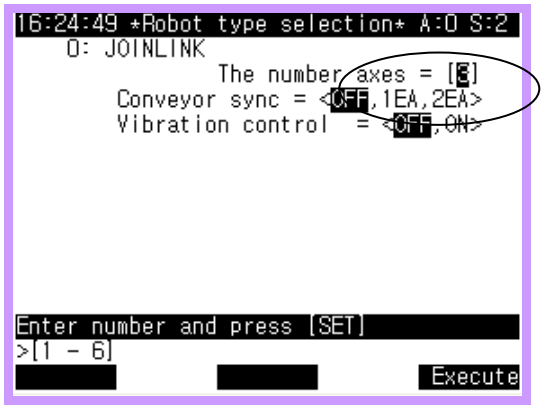
2.1. Initialize

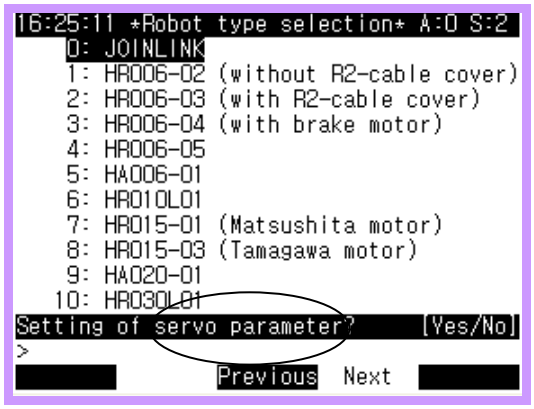
(1) Initialize a system

(2) Select the JOINLINK form of robot type

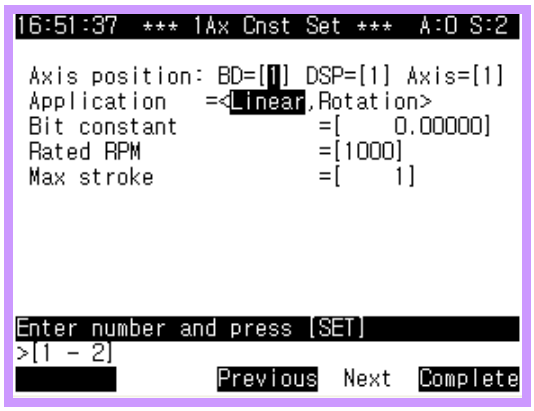


(3) Select the robot type and select the axis of robot. It is possible to select the axis of robot from 0 to 6 but it is not possible to select the vibration controller and conveyor motor.

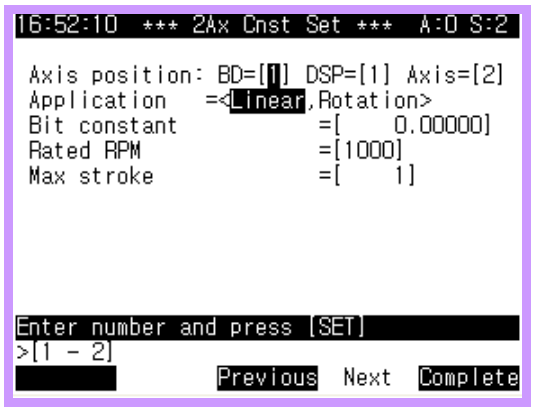


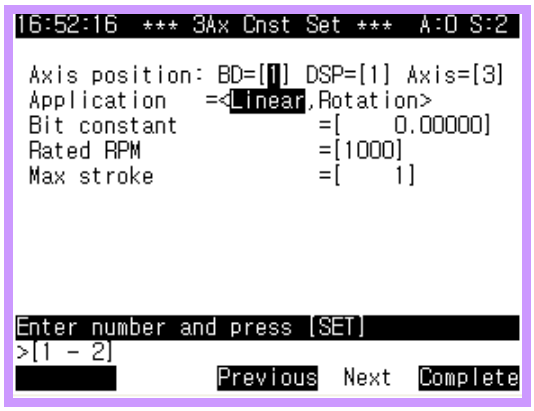


(4) Setting method in integer of each axis is identical with the setting method in integer of additional-axis.



(5) Information about the following axis will be indicated if you use [PF4] key. Setting about every axis you want to setting.



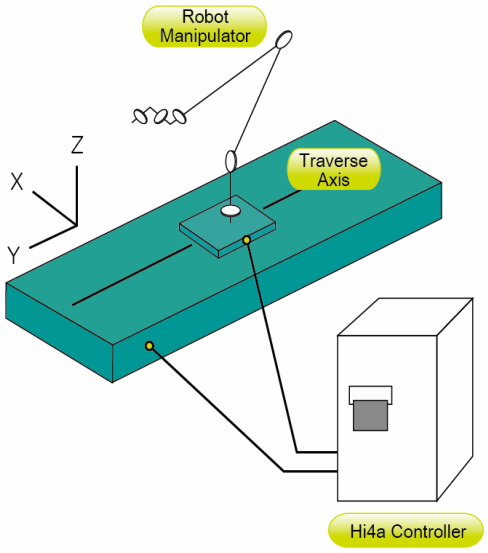


◆【Additional-Axis Constant Explanation 】◆

① Axis position
Users can use it by designating physical configuration of Additional-Axis.
BD =[1](1~2) => Designate the number of servo DSP board.
(2DSP/1Board)
DSP =[1](1~2) => Designate the number of DSP in the servo DSP board.
(4 Axis/1DSP)
Axis =[4](1~4) => Designate Axis No.

Ex) In case of designating it as 1,1,4 to set up 7th Additional-Axis,
Basic 6 axes – Main 3 axis (1st BD440, 1st DSP, 1~3 axis)
Wrist 3 axis (1st BD440, 2nd DSP, 1~3 axis)
Additional 1 axis (1st BD440, 1st DSP, 4th axis)

② Application
Select a kind of Additional-Axis between <Traverse, GUN, JIG,Hand>.
When deciding Additional-Axis spec, you should set the sequence Traverse → GUN → JIG → Hand followed by logical Additional-Axis order.



③ Axis configuration
Select moving direction of axis between <None, X, Y, Z, & Rxyz>.
In case of traverse axis, it is operated as <X> if it is left/right axis running, and it is operated as <Y> if it is forward/backward axis running. Select <Y> if it is parallel to original position of Robot body. Please refer to 『SERVO GUN Function Manual』 to set up the GUN and 『Positioner Synchronization Function Manual』 to setup the JIG.

④ Bit constant [-9999.99999 ~ 9999.9999] :
Register moving quantity according to Encoder pulse process of 10000bit.
Register rotation axis as deg/10000bit, and transmit axis as mm/10000bit.
Encoder pulse per 1 rotation used in the Hi4a controller is fixed as 8192bit.

Please refer to below example.
The sign is decided as below.
In case forward rotation of motor is correspond with the axis direction , set it as “+” and coordinate value is increased, and reversely fix it as “-“ and coordinate value is decreased.

Ex 1) If it is the rotation axis using 1/100 reducer only,
the axis rotates 360deg by 100 rotations of motor.
Therefore Bit Constant = 360[deg] / (100[rev] X 8192[bit]/[rev]) X 10000[bit] = 4,39453

Ex 2) If it is the transmit axis using 1/20 reducer and rack pinion of PCD 110mm,
110xPhi(=3.14159)[mm] is moved by 20 rotation of motor.
Bit Constant = 110xPhi[mm] / (20[rev] x 8192[bit]/[rev]) X 10000[bit] = 21.09223

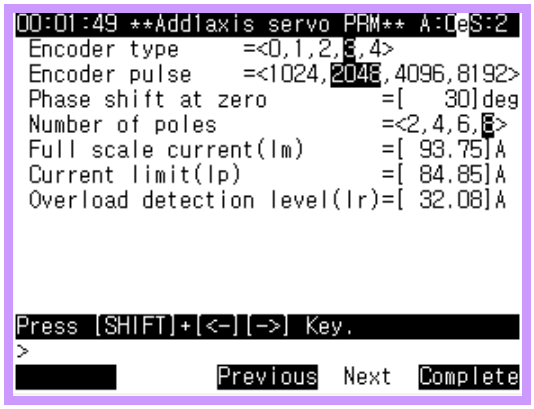
Ex 3) If it is the transmit axis using reducer and ball screw of lead 5mm,

The axis moves 5mm by 5 rotation of motor.
Therefore, Bit Constant = 5[mm] / (5[rev] × 8192[bit/rev]) = 1.22070

⑤ Rated RPM [1000 - 5000] :
Set the rotation speed of motor used in Additional-Axis. Decide it in the range of not exceeding rated speed of motor. By setting the speed and bit constant, max speed of additional axis is set up automatically in 『[PF2]: System』 → 『3: Machine Parameter』 → 『6: Accel & Decel parameters』.
It is possible to change the speed of axis directly in Accel & Decel Parameters menu.
However, users should tune accelerating time and decelerating rate in the process of system tuning because accel/decelerating time is designated by default value.

⑥ Max. Stroke [1 - 30000] :
This is the information to set up valid moving range of the Robot (Additional-Axis soft limit) in the menu of 『[PF2]: System』 → 『3: Machine Parameter』 → 『3: Softimit』automatically.

(6) It sets up servo parameter about entire axis. Setting method of servo parameter is『identical with setting method of additional axis servo parameter』.



◆【Additional-Axis Servo Parameter Explanation】◆

- Please use it for reference only because written as Commonly below the explanation can be changed by manufactures.

- After setting up each items, followed by load state 『[PF2]: System』 → 『3: Machine Parameter』 → 『6: Accel & Decel parameters』 → Accel/decelerating information, 『[PF2]: Service』 → 『3. Machine parameter』 → 『12: Servo Parameter Setting』 → 『1: Servo Loop Gain』 → Use it adjusting Position Loop Proportional Gain(Kp) of and Speed Loop Proportional Gain (Kv).

① Encoder Type
0 : Yaskawa, 1 : Tamakawa, 2 : Panasonic, 3 : PanasonicCompact
In Hi4a controller, it corresponds with absolute value encoder only.
Currently the encoder of motor used in our mass production(MP) model robot corresponds to 『3 : PanasonicCompact』.
Motors are supplied by Tamagawa is supplied to our company mounting the encoder of 『3 : PanasonicCompact』Type.

② Encoder Pulse
< 1024, 2048, 4096, 8192 >
This is the number of Incremental Purse outputted by the encoder per motor 1 rotation.
Setting up the encoder pulse outputted by motor, the inside of Hi4a controller calculates it by converting all encoders to 8192 pulse automatically. Therefore, when calculating Additional-Axis Bit Constant, it is always calculated in the basis of 8192 pulse regardless of encoder pulse setting value.
Commonly Yaskawa 12bit Encoder is 1024, Yaskawa 15bit Encoder is 8192, Panasonic is 2048, and Tamakawa is 4096.
Currently the encoder of motor used by our MP model robot same as encoder type is 2048 pulse, and motors supplied by Tamagawa are supplied by mounting encoder of 2048 pulse.

③ Phase shift at zero
θ [deg]
Input current phase angle at encoder zero point.
Commonly Yaskawa & Tamakawa are 0, and Panasonic is 30.
Current phase angle at encoder zero point of the motors used by our MP model robot currently same as encoder type is 30deg, and motors supplied by Tamagawa are supplied by fitting in the phase angle of 30 deg.

④ Number of poles
< 2, 4, 6, 8 >
Input the number of motor pole.
Currently the number of motor pole used by our MP model robot is 8 pole.

⑤ Full Scale Current
Im [Apeak]
This is the current value corresponded to full scale of current variable(torque command) when calculating S/W Servo Controller. Full Scale Current Value is saved by Formula 1) and it is changed by Shut Resistance and Hall Sensor Output Spec.

$$Fullscale\ Current = Current\ value\ in\ case\ of\ current\ feedback\ Voltage\ 8Volt \times \frac{7.5}{8}$$ Formula 1)

AMP Model	Hall Sensor Signs (Specifications)	Shunt Resistance Sign (Resistance Value)	Full Scale Current(Im)	Usable IPM (rated Current)
Large-sized 6Axis /Additiona l-Axis AMP	0 (4V/75A)		**140.62Apeak**	PM150CSD060 (150A)
	1 (4V/50A)		**93.75Apeak**	PM150CSD060 (150A) PM100CSD060 (100A) PM75CSD060 (75A)
	2 (4V/25A)		**46.87Apeak**	
	3 (4V/15A)		**28.12Apeak**	
	4 (4V/10A)		**18.75Apeak**	
	5 (4V/5A)		**9.37Apeak**	
Medium-sized 6 Axis /Additional -Axis AMP		1 (2mΩ)	**93.75Apeak**	PM100CSD060 (100A) PM75CSD060 (75A)
		2 (4mΩ)	**46.87Apeak**	
		3 (8mΩ)	**23.44Apeak**	
		4 (12mΩ)	**15.58Apeak**	
		5 (16mΩ)	**11.72Apeak**	
Small-sized 6 Axis /Additional -Axis AMP	1 (4V/15A)		**28.12Apeak**	PM30CSJ060 (30A)
	2 (4V/10A)		**18.75Apeak**	PM30CSJ060(30A)
	3 (4V/5A)		**9.37Apeak**	PM30CSJ060(30A) PM10CSJ060(10A)

⑥ Current limit
Ip [Apeak]
This means Motor Output Max. Current. The setting of current limit value sets up necessary current value from motor to satisfy working spec of applied equipment. Available range for setting should satisfy three conditions as below, and for improvement of control performance, set up to use Full Scale Current nearby as possible as it can.

Condition 1) Within Instantaneous Max. Current on Motor Catalog

Condition 2) Within AMP Max. Output Current

Condition 3) Full Scale Current(Im) 97%≥ Current Limit (Ip)≥ Full Scale Current(Im) 40%

※ AMP Max./Continuous Output Current(IPM Max. rated)
AMPMax. Output Current is limited as Formula 2) by the rated of use IPM. Also for the continuously used current, the range of use calculated through the evaluation test with the junction temperature within the permitted range by the heating condition of IPM (Heat sink, forced cooling etc.) and operating condition (Switching loss, on resistance etc.), is about within 60% of the rated current of IPM.
However, instantaneous Max. Output of Large-sized AMP is limited as allowable current of below table related to the structure of AMP regardless of Formula 2).

$$IPM\ Rated\ Current \geq MaxCurrent \times 1.1(10\%\ margin\ of\ Current) \quad \text{---------- Formula 2)}$$

IPM Type	Rated Current[Sign]	Item	Allowable Current(Apeak)	Use Model
PM150CSD060	150A [L]	**AMP Max. OutputCurrent**	**125**	Large-sized 6 Axis AMP
		AMP Continuous OutputCurrent	**60**	
PM100CSD060	100A [X]	**AMP Max. OutputCurrent**	**90.9**	Large-sized 6 Axis AMP, medium-sized 6 Axis AMP, Large-sized Additional-Axis medium-sized Additional-Axis
		AMP Continuous OutputCurrent	**60**	
PM75CSD060	75A [Y]	**AMP Max. OutputCurrent**	**68.18**	
		AMP Continuous OutputCurrent	**45**	
PM30CSJ060	30A [A]	**AMP Max. OutputCurrent**	**27.27**	Small-sized 6 Axis AMP, Small-sized Additional-Axis
		AMP Continuous OutputCurrent	**18**	
PM10CSJ060	10A [D]	**AMP Max. OutputCurrent**	**9.09**	
		AMP Continuous OutputCurrent	**6**	

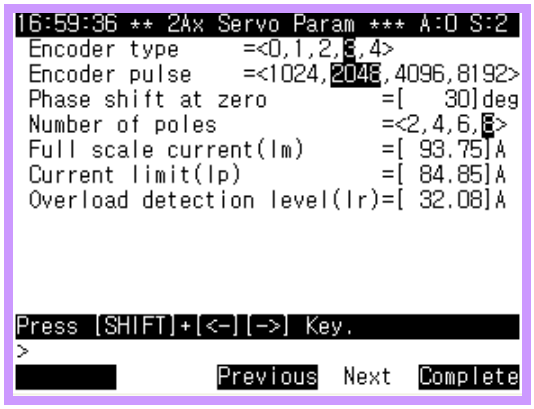
■ The case below 40% of Full Scale Current(Im) corresponds with changing Shunt Resistance/ Hall Sensor.

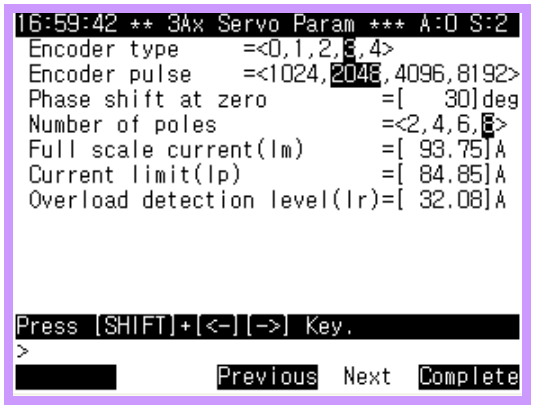
AMP Model	IPM Sign	Hall Sensor/ Shunt Resistance Sign	Available Range for Current Limit Settings (Apeak)
Large-sized 6 Axis/ Additional-Axis AMP	L	0	125 ~ 70.31
	L,X	1	90.90 ~ 37.50
	Y		68.18 ~ 37.50
	L,X,Y	2	45.46 ~ 18.75
	L,X,Y	3	27.27~11.25
	L,X,Y	4	18.19~7.50
	L,X,Y	5	9.08 ~ 3.75
medium-sized 6 Axis / Additional-Axis AMP	X	1	90.90 ~ 37.50
	Y		68.18 ~ 37.50
	X,Y	2	45.46 ~ 18.75
	X,Y	3	22.75 ~9.38
	X,Y	4	15.11~6.23
	X,Y	5	11.37~4.69
Small-sized 6 Axis / Additional-Axis AMP	A	1	27.27~11.25
	A	2	18.19~7.50
	A,D	3	9.08 ~ 3.75

⑦ Overload detection level
Is [Apeak]
This means Motor Output Continuous Current. The setting of overload detecting level sets up current value corresponded by calculating or measuring Trms(Max. Load, Max. Speed, torque mean value of Max. repeat working pattern). Available range for setting should satisfy below two conditions.

Condition **1)** Within rated Current on **Motor Catalog**
Condition **2)** Within **AMP** Continuous OutputCurrent

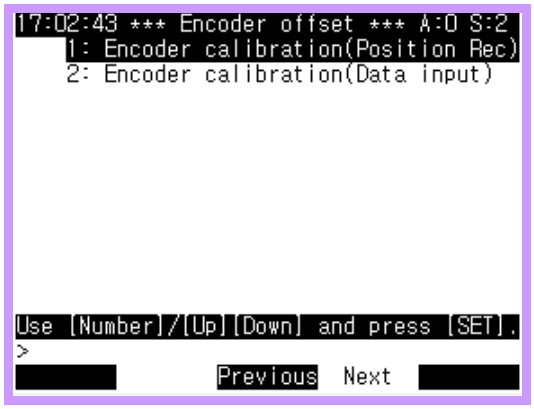
(7) Information about next axis will be indicated when using [PF4] key. Set every axis you want to setting.





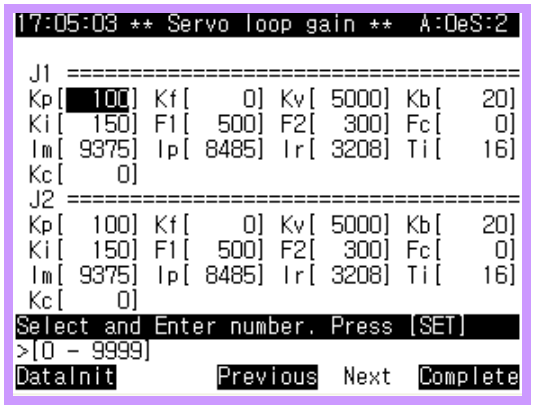
(8) Re-input the power after completing setting.

(9) Set up the ender offset. (Set the standard location of each axis.)
Execute at『[PF2]: System』 → 『3: Machine parameter』 → 『5: Setting encoder offset』.



(10) Setting gain of electric current loop.

(11) Tune the servo loop gain.



Meaning in each parameter of servo loop gain is same as following.

Kp : Locational loop proportional gain
Kf : Feed Forward gain
Kv : Speeding loop proportional gain
Kb : Speed Feedback integer
Ki : Speed integral calculus gain
F1 : Integer when 1st Filter
F2 : Integer when 2nd Filter
Fc : Filter coefficient
Im : AMP maximum electric current
Ip : Setting maximum electric current
Ir : MOTOR continuous electric current
Ti : Integer when testing MOTOR overload

(12) Move each axis at zero location and set correct standard location by redoing offset of encoder after setting up the entire motor parameter.

◆【Caution】◆

- Refer to headquarter of the company when tuning servo parameter.
- Make sure to consult with headquarter of the company when setting up the electric current loop gain.
- If you set up the parameter that doesn't fit to the setting about the motor of each axis, you can damage the motor.

2.2. Jog

(1) Selection is possible on axis coordinate system.

(2) Operation is possible about setting axis within 1 to 6 axis.

(3) Activate identically in the case of pressing the key of additional-axis.

2.3. Step recording

(1) Move each axis to the position wanted.

(2) Record the step position by pressing the recording key. The recording is impossible in the case of orthographic and circular arc interpolation.

2.4. Playback

(1) Switch into the auto mode.

(2) Motor on.

(3) Start using starting switch.

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