

HIWIN®



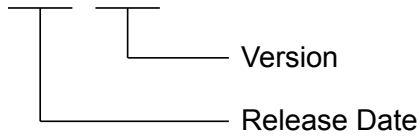
D2 Series Servo Drive

User Manual

Revision History

The version of the manual is also indicated on the bottom of the front cover.

MD07UE01-2010_V2.1



Release Date	Version	Applicable Product	Revision Contents
Oct. 28 th , 2020	2.1	D2 series servo drive	(1) Revise figure 8.3.3, figure 8.3.4 and figure 8.3.5 in section 8.3 Brake output .
Jun. 2 nd , 2020	2.0	D2 MDP 0.055 or above D2COE MDP 0.131 or above Lightening 0.197 or above	(1) Revise the input voltage in section 2.1.2 Nameplate information . (2) Revise the input voltage of figure 4.3.1.1 in section 4.3.1 AC power wiring (single-phase) .
May 4 th , 2020	1.9	D2 MDP 0.055 or above D2COE MDP 0.131 or above Lightening 0.197 or above	(1) Revise table 2.1.1.1 in section 2.1.1 Safety certification . (2) Modify the input power for servo drive. The suggested input power is 220 V. (3) Add the description of CN6 in section 2.2 Drive specifications . (4) Add the frequency range of velocity control and bandwidth limit in section 2.2 Drive specifications . (5) Add the description of the delay time of emulated encoder in section 2.2 Drive specifications . (6) Add the figure of emulated encoder output in section 3.3 Encoder signal output . (7) Add the description of grounding in section 4.1.1.1 Grounding . (8) Add the specifications and wiring diagram of DC reactor in section 4.1.2.4 DC reactor wiring . (9) Add the description of turning off power supply in section 4.1.2.4 DC reactor wiring . (10) Add the description of Modbus communication cable in section 4.1.5 CN4 Modbus communication . (11) Revise table 4.1.7.1 in section 4.1.7 CN6 control signal . (12) Add the wiring diagram of differential interface for low-speed pulse in section 4.6.1.2 Differential interface for low-speed pulse . (13) Revise section 5.1.2 Communication setup . (14) Revise the content in table 5.5.1.2 in section 5.5.1 Digital input . (15) Revise the output status of Lightening in section 5.5.2 Digital output . (16) Add the description of the start position of error map function in section 6.9.4 Change start position . (17) Revise figure 8.3.5 in section 8.3 Brake

			<p>output.</p> <p>(18) Revise section 9.3 Error codes and troubleshooting.</p> <p>(19) Revise section 9.4 Warning codes and troubleshooting.</p> <p>(20) Add section 12.3 Load parameter patch.</p>
Nov. 7 th , 2014	1.8	D2 MDP 0.043 or above D2COE MDP 0.119 or above Lightening 0.189 or above	Rewrite and reorganize the User Manual based on Chinese version of D2 Drive User Manual v1.8.
Nov. 21 st , 2014	1.4	D2 series servo drive	<p>(1) Modify the model number by combining D2-model and D2T-model drives.</p> <p>(2) Add the description of ZeroTune.</p> <p>(3) Add the description of setting parameters to factory default.</p> <p>(4) Renew the description of LCD operation.</p> <p>(5) Add LCD common parameters table.</p> <p>(6) Add the input range of LCD parameters.</p> <p>(7) Add the PDL information to drive specifications.</p> <p>(8) Add the description of VSF operation.</p>
Aug. 20 th , 2014	1.3	D2 series servo drive	<p>(1) Add the information for D2T drive.</p> <p>(2) Renew the dimension of D2 drive.</p> <p>(3) Add the dimension of D2 drive with EtherCAT (CoE/mega-ulink).</p> <p>(4) Remove the brake wiring without a relay.</p> <p>(5) Remove the input function of clear position error.</p> <p>(6) Add the description of using PDL to assist with data capture.</p> <p>(7) Add the description of using PDL to assist with data capture.</p> <p>(8) Add motor models with HIWIN 17 encoder to Table 4-1.</p>
May 15 th , 2014	1.2	D2 series servo drive	<p>(1) Update the description of LCD operation.</p> <p>(2) Update the description according to motor model.</p>
Aug. 30 th , 2012	1.1	D2 series servo drive	<p>(1) Renew Figure 2-1 and Figure 2-2.</p> <p>(2) Renew CN6 connector part number.</p>
Jun. 5 th , 2012	1.0	D2 series servo drive	First edition.

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1. About this user manual

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1.1 Instructions before use

Before using the product, please carefully read through this manual. HIWIN Mikrosystem (HIWIN) is not responsible for any damage, accident or injury caused by failure in following the installation instructions and operating instructions stated in this manual.

- Do not disassemble or modify the product. The design of the product has been verified by structural calculation, computer simulation and actual testing. HIWIN is not responsible for any damage, accident or injury caused by disassembly or modification done by users.
- Before installing or using the product, ensure there is no damage on its appearance. If any damage is found after inspection, please contact HIWIN or local distributors.
- Carefully read through the specification noted on product label or technical document. Install the product according to its specification and installation instructions stated in this manual.
- Ensure the product is used with power supply specified on product label or in product requirement. HIWIN is not responsible for any damage, accident or injury caused by incorrect power supply.
- Ensure the product is used with rated load. HIWIN is not responsible for any damage, accident or injury caused by improper usage.
- Do not subject the product to shock. HIWIN is not responsible for any damage, accident or injury caused by improper usage.
- If an error occurs in the drive, please refer to Chapter 9 and follow the instructions for troubleshooting. After the error is eliminated, power on the drive again.
- Do not repair the product by yourself when it malfunctions. The product can only be repaired by qualified technician from HIWIN.

HIWIN offers 1-year warranty for the product. The warranty does not cover damage caused by improper usage (Refer to the precautions and instructions stated in this manual.) or natural disaster.

ATTENTION





- ◆ The maximum ambient temperature for the product is 55°C.
- ◆ The drive can only be installed in the environment that the degree of contamination is below 2.
- ◆ The rated input voltage of the product is 240V. The power supply voltage cannot exceed 240V, and the short-circuit current cannot be over 5000A.
- ◆ The drive provides neither motor over-temperature sensor, nor motor over-temperature protection.
- ◆ The short-circuit protection of the drive cannot be used as a shunt-circuit protection. The shunt-circuit protection should be selected based on US National Electrical Code (NEC) and local regulations.
- ◆ Power off and wait at least five minutes before examining the drive. To avoid electric shock, please use a multi-meter or a similar apparatus to check if the residual voltage between P and N terminals has dropped to the safety level (50Vdc or lower).

**WARNING**

- ◆ If the sequence of connection is not correctly followed when installing or replacing motor power cables, the motor may run abnormally. It may cause serious damage to equipment or injury to people. Please use correctly labelled wires.
- ◆ If you decide to use your self-made extension cord for motor encoder, please look up this User Manual in detail or contact HIWIN Customer Service Department. Wrong connection may cause abnormal motion or injury to people.
- ◆ When applying the open type of optical feedback system (e.g. optical scale), please make sure the scale is not stained or scratched. Otherwise, it may cause abnormal motion to the motor, damage to the motor or equipment, or injury to people.
- ◆ When applying the open type of magnetic feedback system (e.g. magnetic scale), please make sure the strong magnetic object is not close to the scale. Otherwise, it may cause abnormal motion to the motor, damage to the motor or equipment, or injury to people.
- ◆ Each motor model has its own rated maximum payload. If exceeds, it may cause abnormal motion to the motor, even damage to equipment or injury to people.
- ◆ If you accidentally touch or move the encoder connector on the drive during the operation of motor, please make sure the drive is undamaged. It is recommended to power cycle the drive, or it may cause damage to equipment or injury to people.
- ◆ During the usage of motor, please do not unplug the extension cord for motor encoder, move the motor and plug it back when power on. It may cause abnormal motion to the motor, even damage to equipment or injury to people.

1.2 Safety instructions



- Carefully read through this manual before installation, transportation, maintenance and examination. Ensure the product is correctly used.
- Carefully read through electromagnetic (EM) information, safety information and related precautions before usage.
- Safety precautions in this manual are classified into “Warning”, “Attention”, “Prohibited” and “Required”.

Signal Word	Description
 Warning	It indicates if the precaution is not observed, it is likely to cause property loss, serious injury or death.
 Attention	It indicates the precaution must be observed.
 Prohibited	It indicates prohibited activity.
 Required	It indicates mandatory activity.


DANGER

- ◆ Ensure the drive is correctly grounded. Use PE bar in the control cabinet as reference potential. Perform low-ohmic grounding for safety reason.
- ◆ Do not remove motor power cable from the drive when it is still power-on, or there is a risk of electric shock or damage to the contact.
- ◆ Do not touch the live part (contact or bolt) within 5 minutes after disconnecting the drive from power supply. For your own safety, we suggest measuring the voltage in the intermediate circuit and wait until it falls to 40Vdc before touching the live part.


■ Operation

 Warning	<ul style="list-style-type: none"> ◆ Do not touch the terminals and the internal part of the product when power on, or it may cause electric shock. ◆ Do not touch the terminals and internal part of the product within 10 minutes after power off, or the residual voltage may cause electric shock. ◆ Do not modify wiring when power on, or it may cause electric shock. ◆ Do not damage, apply excessive force to, place any heavy object on the cable or put the cable between two objects, or it may cause electric shock or fire.
 Attention	<ul style="list-style-type: none"> ◆ Do not use the product in location which is subject to humidity, corrosive materials, flammable gas or flammable materials.


■ Storage

 Prohibited	<ul style="list-style-type: none"> ◆ Do not store the product in location which is subject to water, water drop, direct sunlight, harmful gas or liquid.
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■ Transportation

 Attention	<ul style="list-style-type: none"> ◆ Carefully move the product to avoid damage. ◆ Do not apply excessive force to the product. ◆ Do not stack the products to avoid collapse.
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■ Installation site

 Required	<ul style="list-style-type: none"> ◆ Do not install the product in location with high ambient temperature and high humidity or location which is subject to dust, iron powder or cutting powder. ◆ Install the product in location with ambient temperature stated in the manual. Use cooling fan if the ambient temperature is too high. ◆ Do not install the product in location which is subject to direct sunlight. ◆ The product is not drip-proof or waterproof, so do not install or operate the product outdoor or in location which is subject to water or liquid. ◆ Install the product in location with less vibration. ◆ Motor generates heat when running for a period of time. Use cooling fan or disable the motor when it is not in use, so the ambient temperature will not exceed product specification.
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■ Installation


 Attention	<ul style="list-style-type: none"> ◆ Do not place heavy object on the product, or it may cause injury. ◆ Prevent any foreign matter from entering the product, or it may cause fire. ◆ Install the product in the specified orientation, or it may cause fire. ◆ Avoid strong shock to the product, or it may cause malfunction or injury. ◆ When installing the product, take the product weight into consideration. Improper installation may cause damage. ◆ Install the product on noncombustible objects, such as metal to avoid fire.
--	---

■ Wiring


 Attention	◆ Ensure wiring is correctly performed, or it may cause malfunction or burn. There is a risk of injury or fire.
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■ Operation and transportation

 Attention	◆ Use power supply specified in product specification, or it may cause injury or fire. ◆ The product may suddenly start to operate after power supply recovers. Please do not get too close to the product.
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 Required	◆ Set external wiring for emergency stop to stop the motor at any time.
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■ Maintenance

 Prohibited	◆ Do not disassemble or modify the product. ◆ Do not repair the product by yourself when it malfunctions, please contact HIWIN for help.
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2. Specifications

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2.1 Drive information

2.1.1 Safety certification

The drive complies with the following safety regulations.

Table 2.1.1.1

EMC	EN 61800-3: 2004 (Category C2)/2012(Category C3)
	EN 61000-3-2: 2006/A1: 2009/A2: 2009/A3:2014
	EN 61000-3-3: 2013
	IEC CISPR 11: 2015/A1: 2016
	IEC 61000-4-2: 2008
	IEC 61000-4-3: 2006/A1: 2007/A2: 2010
	IEC 61000-4-4: 2012
	IEC 61000-4-5: 2014
	IEC 61000-4-6: 2013
	IEC 61000-2-1: 1990
	IEC 61000-2-4: 2003
LVD	IEC 61800-5-1: 2007(2nd Edition)
	EN 61800-5-1:2007
UL	E348161

2.1.2 Nameplate information

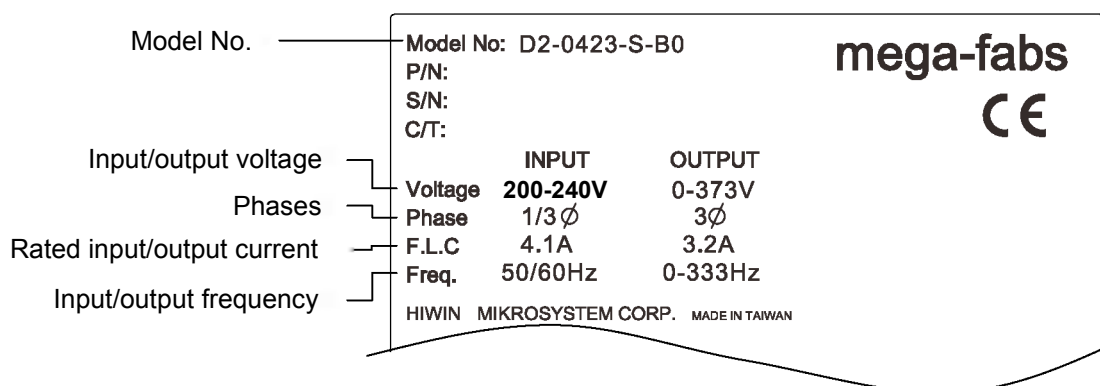


Figure2.1.2.1

2.1.3 Model number

Table 2.1.3.1

Code	1	2	3	-	4	5	6	7	-	8	-	9	10
Example	D	2		-	0	4	2	3	-	S	-	B	0
1, 2: Product	D2 = D2 series servo drive												
3: Type	T = 13-bit / 17-bit encoder blank = 13-bit encoder only												
4, 5: Rated output	01 = 100W 04 = 400W 10 = 1.0KW 20 = 2.0KW												
6, 7: Voltage range	23 = 1/3-phase 220Vac 32 = 3-phase 220Vac												
8: Interface	S = Standard E = EtherCAT (CoE) F = EtherCAT (mega-ulink) K = Standard with extension I/O module T = Standard with Modbus												
9: Frame size	A = A frame (100W) B = B frame (400W) C = C frame (1.0KW) D = D frame (2.0KW)												
10: Encoder type	0 = 13-bit less-wire incremental encoder 4 = 17-bit serial incremental encoder (HIWIN 17) 5 = Dual loop (full closed loop) and 17-bit serial absolute encoder												

Note:

- (1) The standard model supports the pulse and +/- 10 V input interfaces.
- (2) The EtherCAT (CoE) and EtherCAT (mega-ulink) models do not have the extension I/O module and Modbus module.
- (3) The frame D model requires the voltage range of 3-phase 220 Vac.
- (4) D2 model does not support the extension I/O module and the rated output of 2.0 KW.
- (5) D2T frame A, B, and C models do not have the Modbus module.
- (6) For the dual-loop model, the rotary encoder should be the 17-bit serial absolute encoder and the linear encoder should be the digital AqB encoder.
- (7) The EtherCAT (CoE) model does not support the dual-loop control.

2.2 Drive specifications

Table2.2.1 Drive specification

Basic specifications	Input power	220V	Main power	Frame A-C	Single/three-phase, 200 - 240 Vac 50/60Hz	
				Frame D	Three-phase, 200 - 240 Vac 50/60Hz	
			Control power	Frame A-D	Single-phase, 200 - 240 Vac 50/60Hz	
	Output power	Power		Frame A: 100 W; frame B: 400 W; frame C: 1.0 KW; frame D: 2.0 KW.		
		Continuous current		Frame A: 0.9 A _{rms} ; frame B: 2.5 A _{rms} ; frame C: 5.1 A _{rms} ; frame D: 11 A _{rms} .		
		Peak current		Frame A: 2.7 A _{rms} ; frame B: 7.5 A _{rms} ; frame C: 15.3 A _{rms} ; frame D: 33 A _{rms} .		
		Sustainable duration of peak current		1 second maximum.		
	Environment	Temperature		Operation temperature: 0°C to 45°C (if over 55°C, the forced ventilation is needed) Storage temperature: -20°C to 65°C		
		Humidity		0 to 90% RH (non-condensing)		
		Altitude		Below 1,000 meters		
		Vibration		1G (10 to 500Hz)		
	Installation pollution level			II		
	Control method			IGBT PWM space vector control		
	Encoder input	Resolution/Feedback resolution		13-bit (10,000 count/rev) less-wire incremental encoder; 17-bit (131,072 count/rev) serial incremental encoder (5 lines).		
		Frequency		5M pulse/sec (Before Quadrature); 20M count/sec (After Quadrature).		
		Other		For the dual-loop model, the rotary encoder should be the 17-bit serial absolute encoder and the linear encoder should be the digital AqB encoder.		
	Parallel I/O connector	Control signal	Input	9 (general purpose) for D2 model 10 (general purpose) for D2T model Optical coupler component, general-purpose input 5 V/1 mA, 24 V/5 mA (Each input pin)		
			Output	4 (general purpose) for D2 model 5 (general purpose) for D2T model Optical coupler component, general-purpose output 24 V/0.1 A (Each output pin)		
		Analog signal	Input	1 (12-bit A/D)		
			Output	2 (analog monitor: 2 outputs)		
Pulse signal		Input	2 (low-speed channel, high-speed channel)			
		Output	4 (line driver: 3 outputs; open collector: 1 output)			
Brake connector	Control signal	Output	Used to connect with brake (1 Adc max). Also, it is programmable for general-purpose output.			

	Dynamic brake		Frame D model has one built-in dynamic brake resistor (line resistance: $2.6 \Omega \pm 5\%$; continuous power: 120 W; peak power: 600 W).		
	Communication function	USB	Used to connect with PC, 115,200 bps		
	Front panel		LCD status display: dot matrix 8*2 characters with 4 buttons; LED status indicator lights (green, red)		
	Control mode		Switchable control modes (1) Position control; (2) Velocity control; (3) Torque control ; (4) Position/velocity control; (5) Position/torque control ; (6) Velocity/torque control;		
Function specifications	Position control	Control input		(1) Inhibit pulse command; (2) Axis enable; (3) Switch between primary and secondary CG; (4) Electronic gear selection; (5) Left limit switch; (6) Switch between primary and secondary mode; (7) Clear error; (8) Right limit switch, etc.	
		Control output		(1) Servo ready; (2) Errors; (3) In-position; (4) Zero speed detected, etc.	
		Pulse input	Maximum input pulse frequency		Photo-coupler interface (single-ended input): 500 Kpps; Line driver interface (differential input): 4 Mpps (16M count/s with AqB).
			Signal format of input pulse		(1) Pulse/direction (Pulse/Dir); (2) Pulse up/pulse down (CW/CCW); (3) Quadrature (AqB).
			Electronic gear (Division/ Multiplication of command pulse)		Gear ratio: pulses/counts Pulses: 1 - 2,147,483,647; counts: 1 - 2,147,483,647.
			Smoothing filter		Smooth factor: 1 - 500
		Vibration suppression feature (VSF)		VSF can remove the vibration frequency that occurs during movement. It can reduce the vibration caused by the system's structure and improve the machine's productivity.	
	Velocity control	Control input		(1) Zero speed clamp; (2) Axis enable; (3) Switch between primary and secondary CG (4) Left limit switch (5) Switch between primary and secondary mode (6) Clear error (7) Right limit switch, etc.	
		Control output		(1) Servo ready; (2) Errors; (3) In-velocity; (4) Zero speed detection, etc.	
		PWM input	Velocity command input	Velocity commands can be provided by the duty cycle of PWM input. Parameters are used to set the scale and command direction.	

Torque control	Analog input	Velocity command input	Velocity command can be provided by the analog voltage. Parameters are used to set the scale and command direction.
	Zero speed clamp		The input of zero speed clamp is possible.
	Frequency range		36.5KHz minimum, 100KHz maximum
	Bandwidth limit		220ns minimum
	Control input		(1) Axis enable; (2) Switch between primary and secondary CG; (3) Left limit switch; (4) Switch between primary and secondary mode; (5) Clear error; (6) Right limit switch, etc.
	Control output		(1) Servo ready; (2) Errors; (3) In-velocity; (4) Zero speed detected, etc.
	PWM input	Torque command input	Torque commands can be provided by the duty cycle of PWM input. Parameters are used to set the scale and command direction.
	Analog input	Torque command input	Torque commands can be provided by the analog voltage. Parameters are used to set the scale and command direction.
	Speed limit function		The parameter for speed limit can be set.
	Common	Auto tune	
Emulated encoder feedback output		Can be arbitrarily set (The maximum frequency of frame A - C models is 18M count/s; while that of frame D model is 9M count/s). The maximum delay time between the time the servo drive receives encoder signal from the encoder and the time the servo drive outputs signal is 66.67 us.	
Protective function		(1) Motor short detected; (2) Over voltage detected (> 390 Vdc ± 5%); (3) Position error too big; (4) Encoder error; (5) Soft-thermal threshold reached; (6) Motor maybe disconnected; (7) Amplifier over temperature (IGBT > 80°C ± 3°C); (8) Under voltage detected; (9) 5V for encoder card fail; (10) Phase initialization error; (11) Serial encoder communication error.	
Error log		Errors and warnings are saved in the non-volatile memory.	
Process description language (PDL)		Maximum code capacity: 32 KBytes	
		Variable storage capacity: 800 Bytes	
		Supported variable type: (1) Float type: 32 bits; (2) Integer type: 16 and 32 bits; (3) Array and pointer supported.	

				Execution cycle: 66.67 us		
				4 tasks can be executed simultaneously.		
				Support if, else, while loop, for loop, goto, till, and other commands to control program flow.		
				Support arithmetic operators, logical operators, and comparison operators.		
				Support lock and unlock commands to control the synchronization of multi-tasks.		
				Maximum length of user-defined name: (1) variable: 17 characters (2) label: 24 characters (3) proc: 24 characters		
Error mapping				Method: Establish compensation table to compensate the encoder error by using the linear interpolation.		
				Samples: Maximum 5,000 points.		
				Storage location: Flash ROM; disc file.		
				Unit: um, count.		
				Enable method: it is activated after the internal homing is completed, or by an external input signal.		
Regeneration		Resistor		Frame A - C: need external connection (option), and have no built-in regenerative resistor. Frame D: need external connection (option), and also have one built-in regenerative resistor (resistance: $13 \Omega \pm 5\%$; continuous power: 120 W; peak power: 600 W).		
				Cut-in voltage		+HV > 370 VDC
				Drop-out voltage		+HV < 360 VDC
				DC link capacity		Frame A: 560 uF; frame B: 820 uF; frame C: 1,410 uF; frame D: 2,000 uF.
Others				Friction compensation, backlash compensation.		

2.3 Drive dimensions

Dimensions and mounting holes of D2-series drives, D2-series drives with the EtherCAT (CoE/ mega-ulink) module, and D2-series drives with the extension I/O module are shown in the following figures. The dimension unit is in mm, and the diameter of mounting hole is 4 mm.

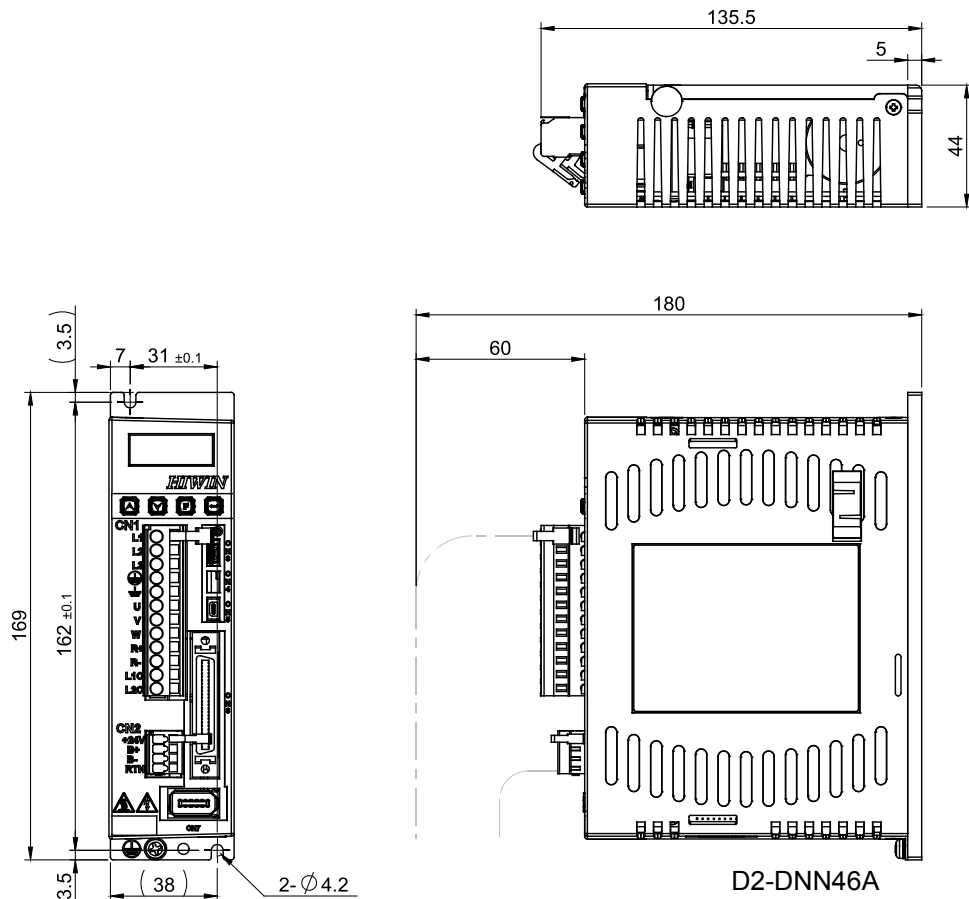


Figure2.3.1 Dimensions of frame A model

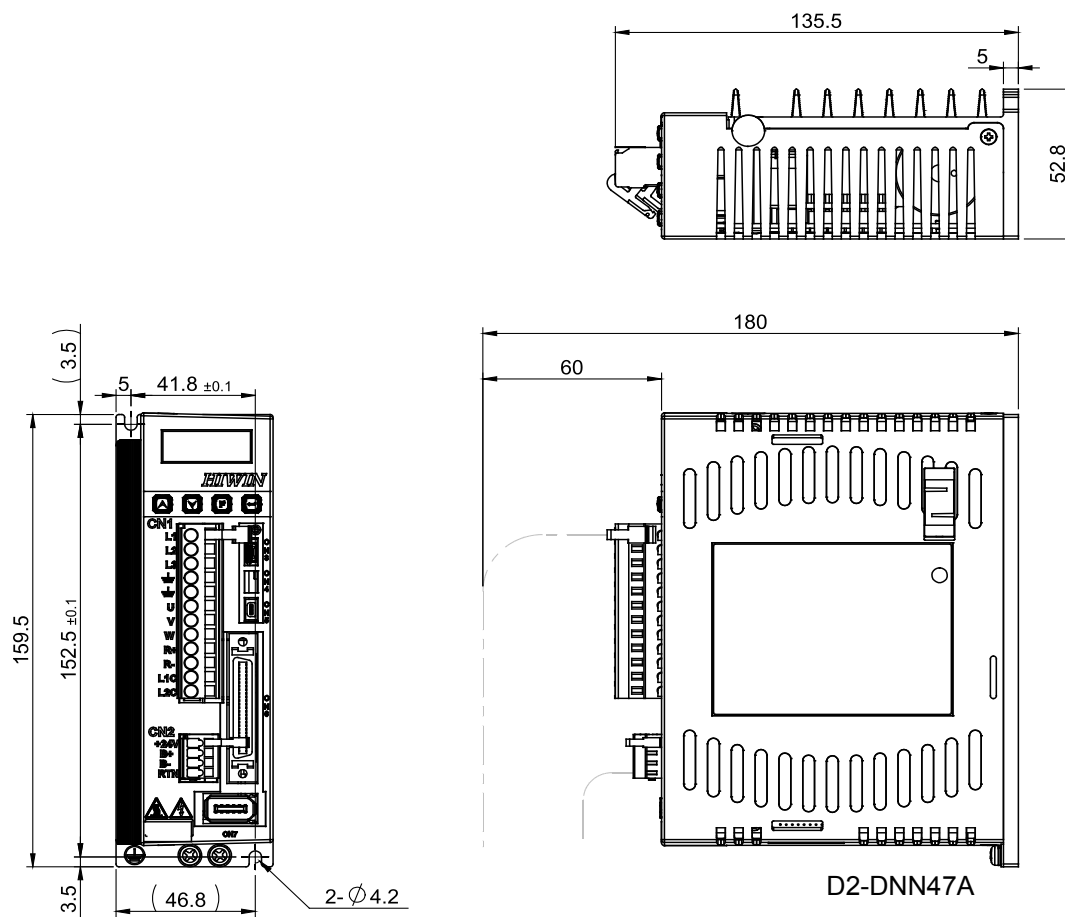


Figure2.3.2 Dimensions of frame B model

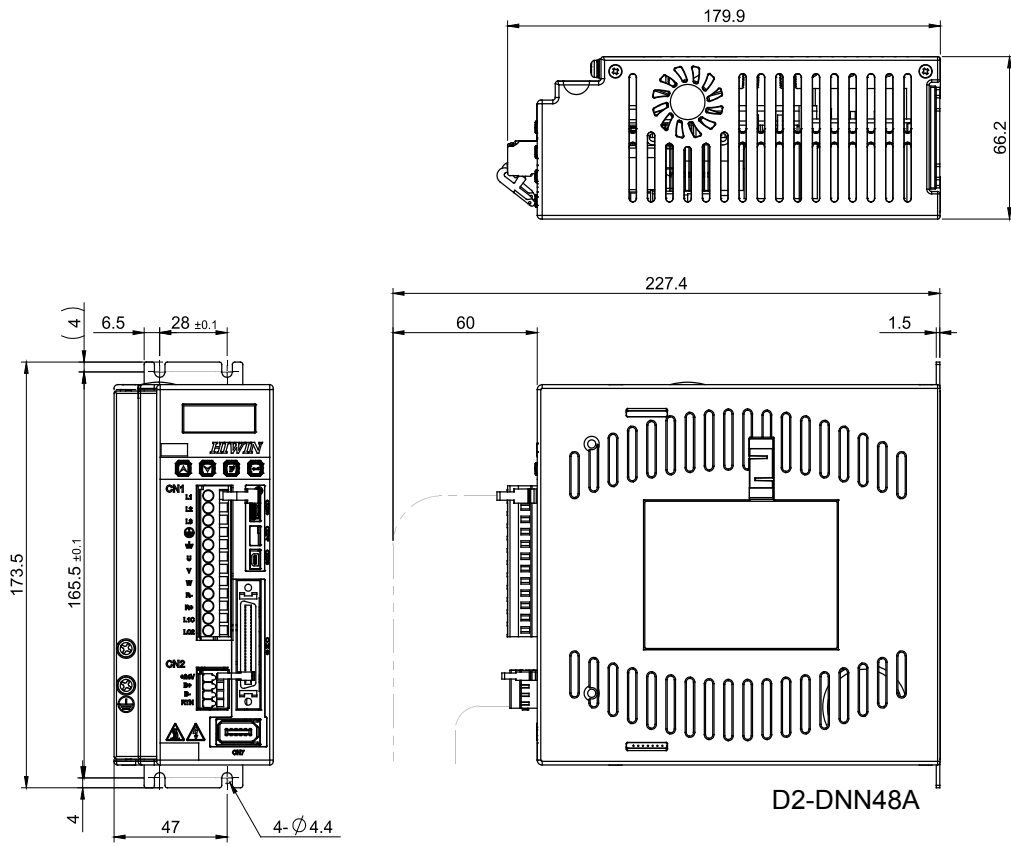


Figure2.3.3 Dimensions of frame C model

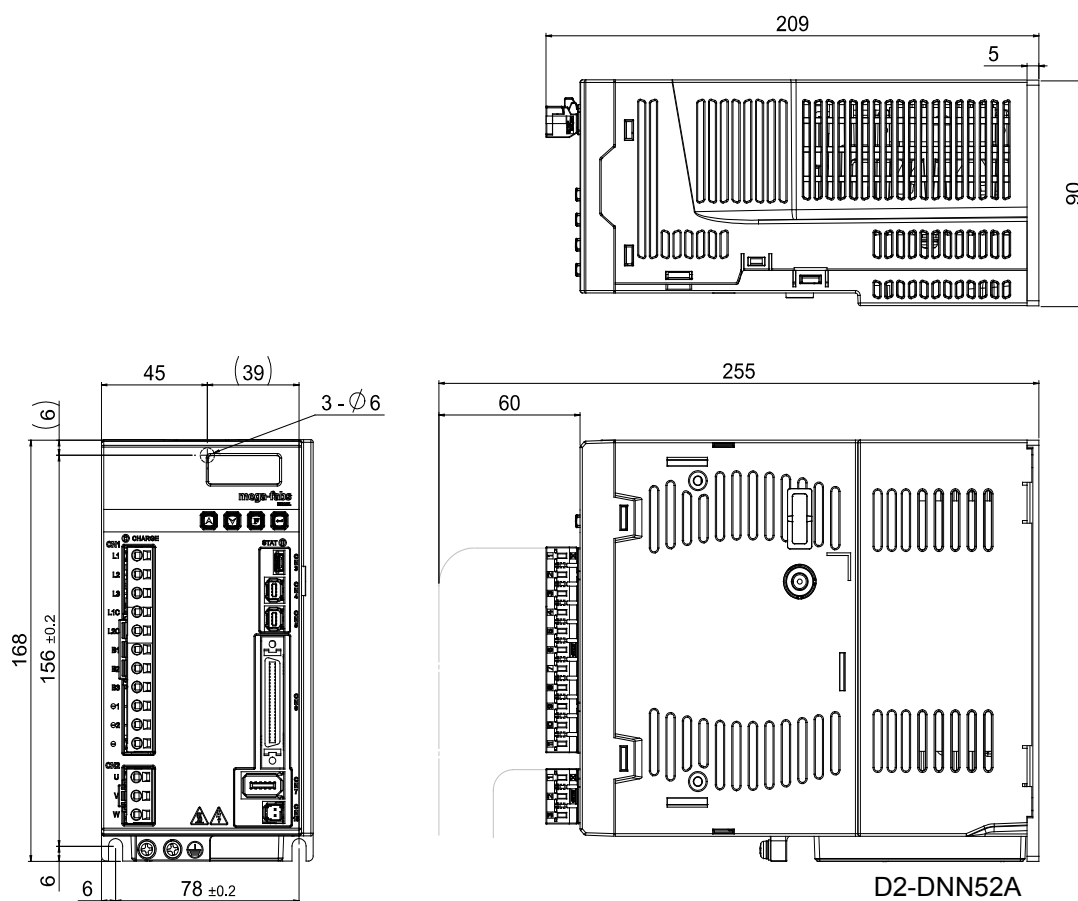


Figure2.3.4 Dimensions of frame D model

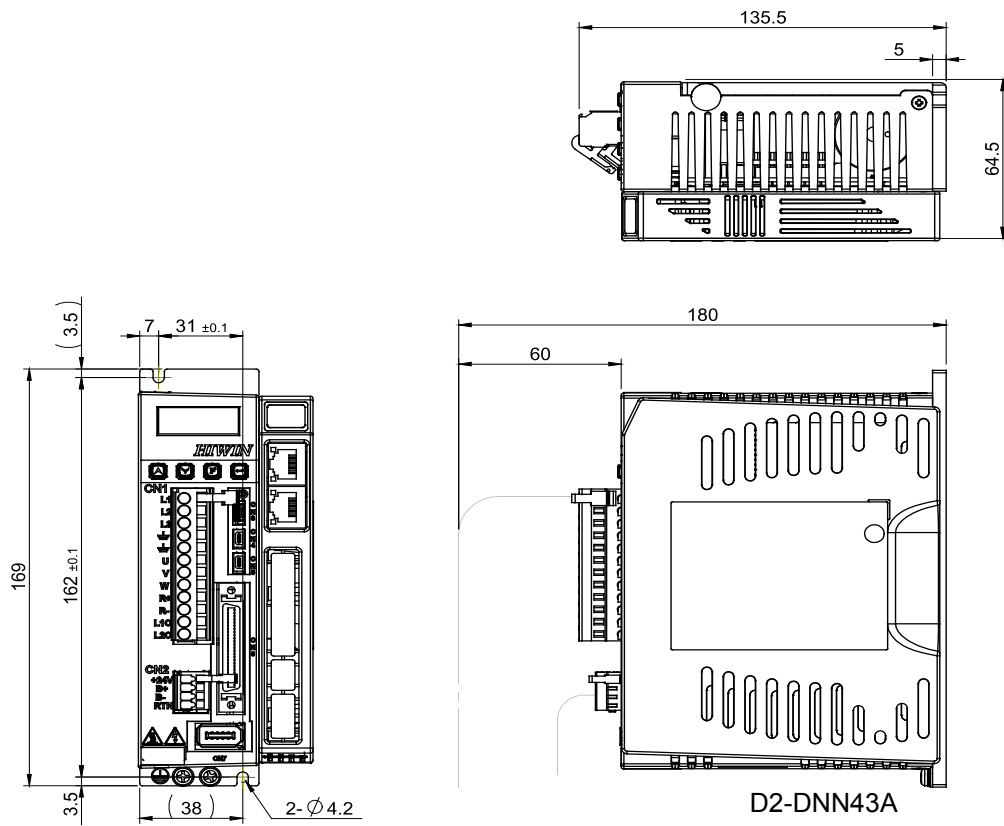


Figure2.3.5 Dimensions of frame A model with the EtherCAT module

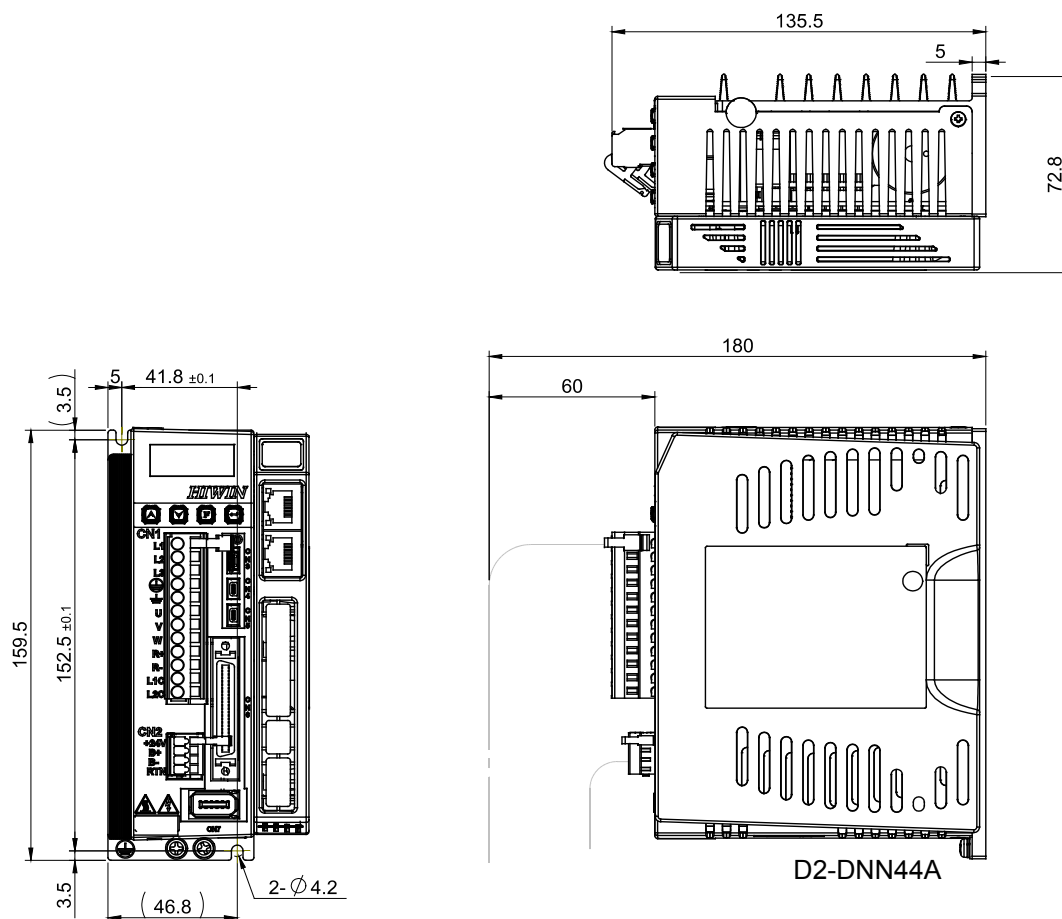


Figure2.3.6 Dimensions of frame B model with the EtherCAT module

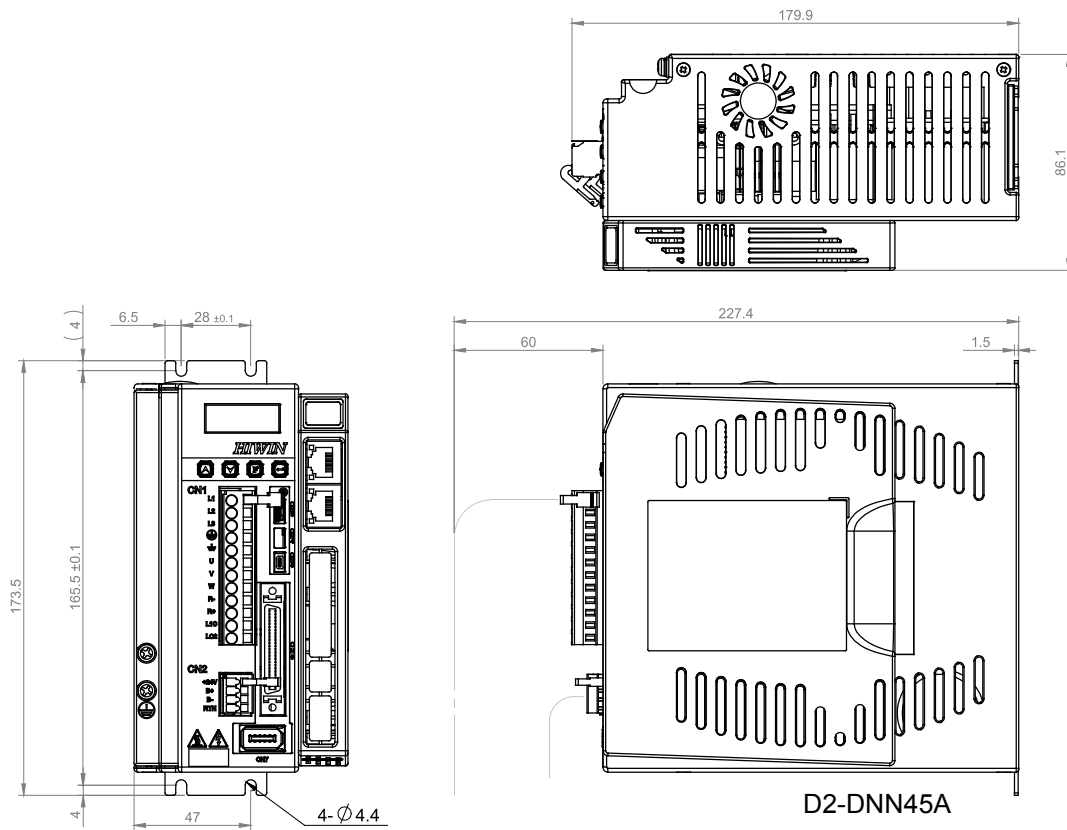


Figure 2.3.7 Dimensions of frame C model with the EtherCAT module

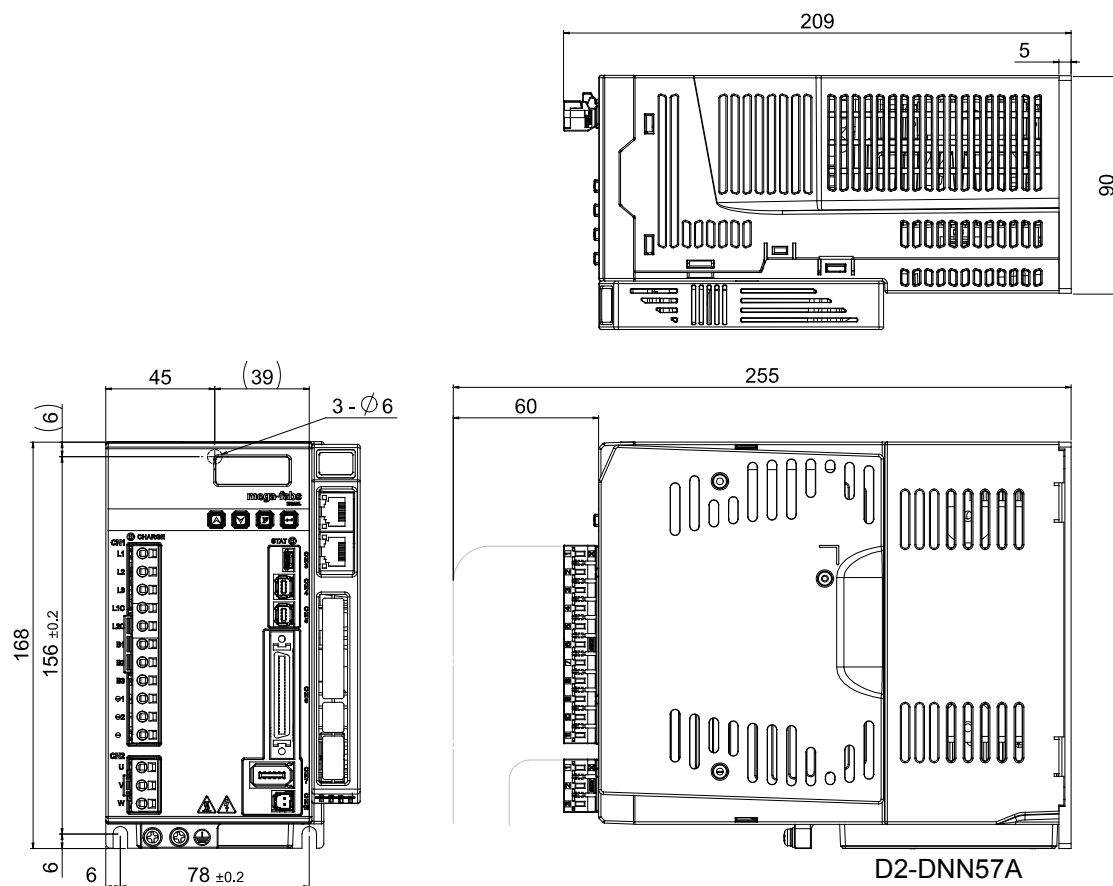


Figure2.3.8 Dimensions of frame D model with the EtherCAT module

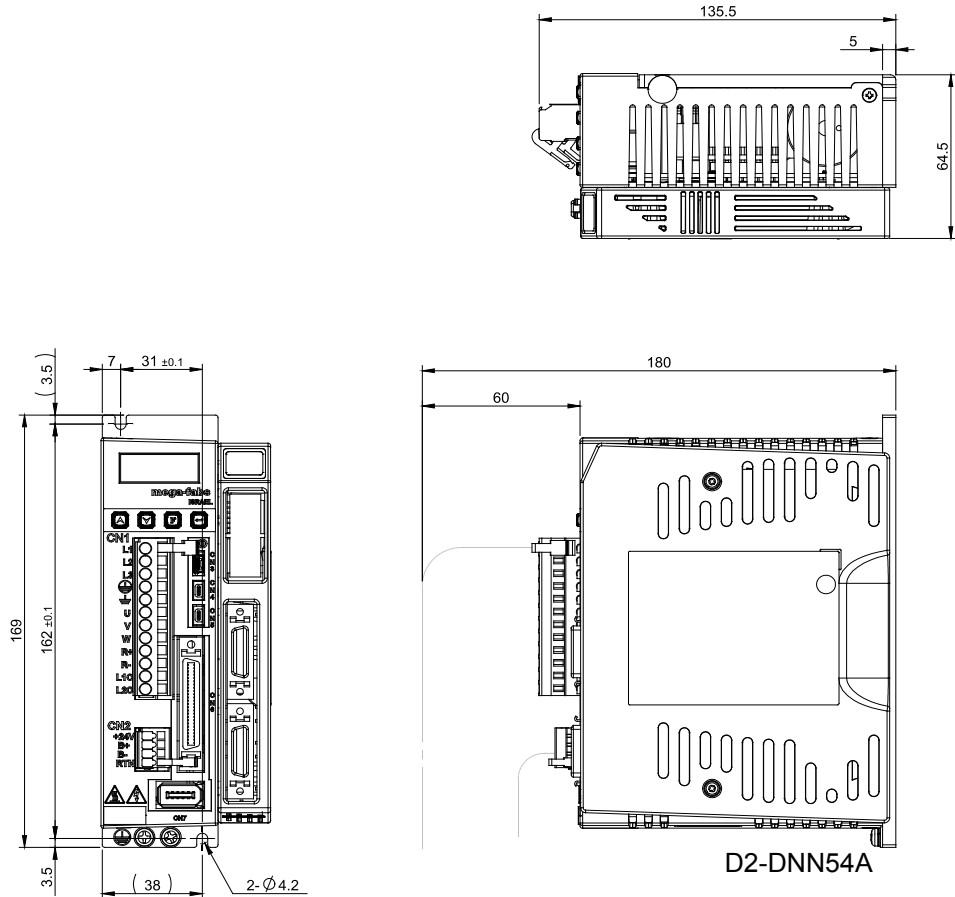


Figure 2.3.9 Dimensions of frame A model with the extension I/O module

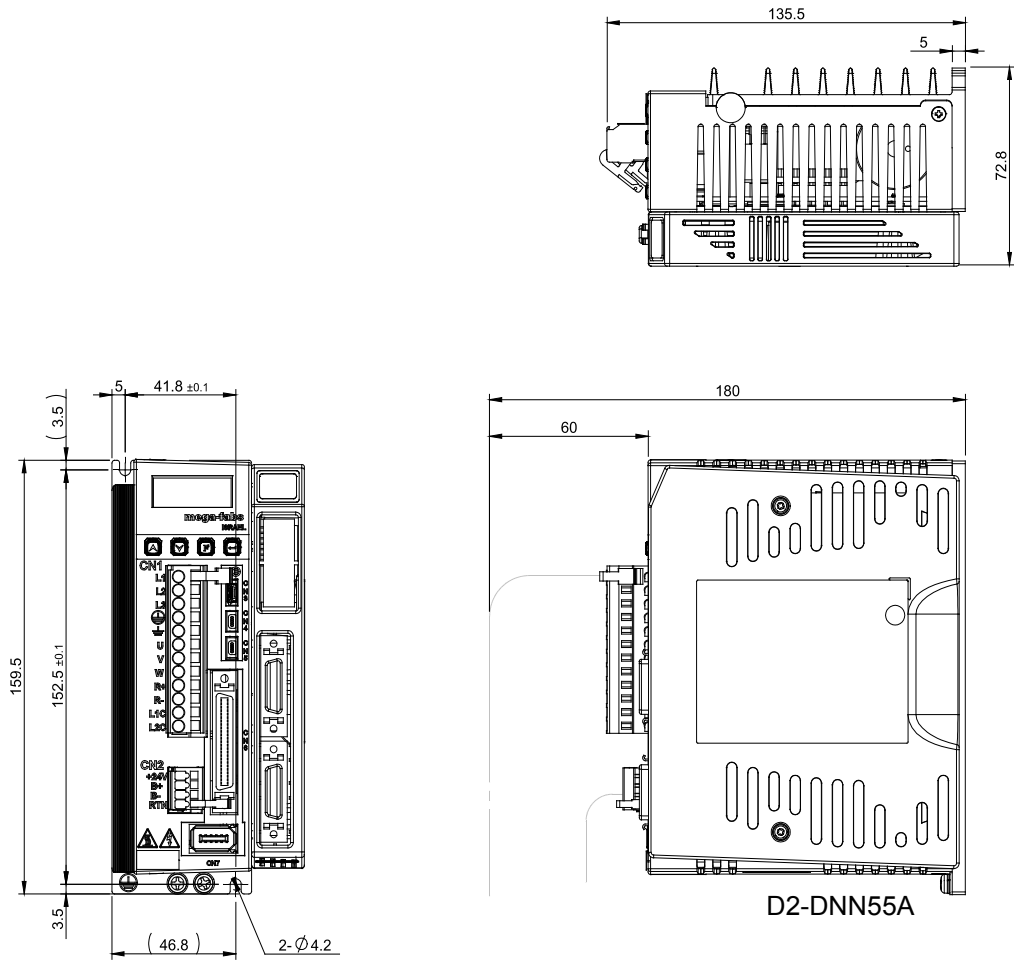


Figure 2.3.10 Dimensions of frame B model with the extension I/O module

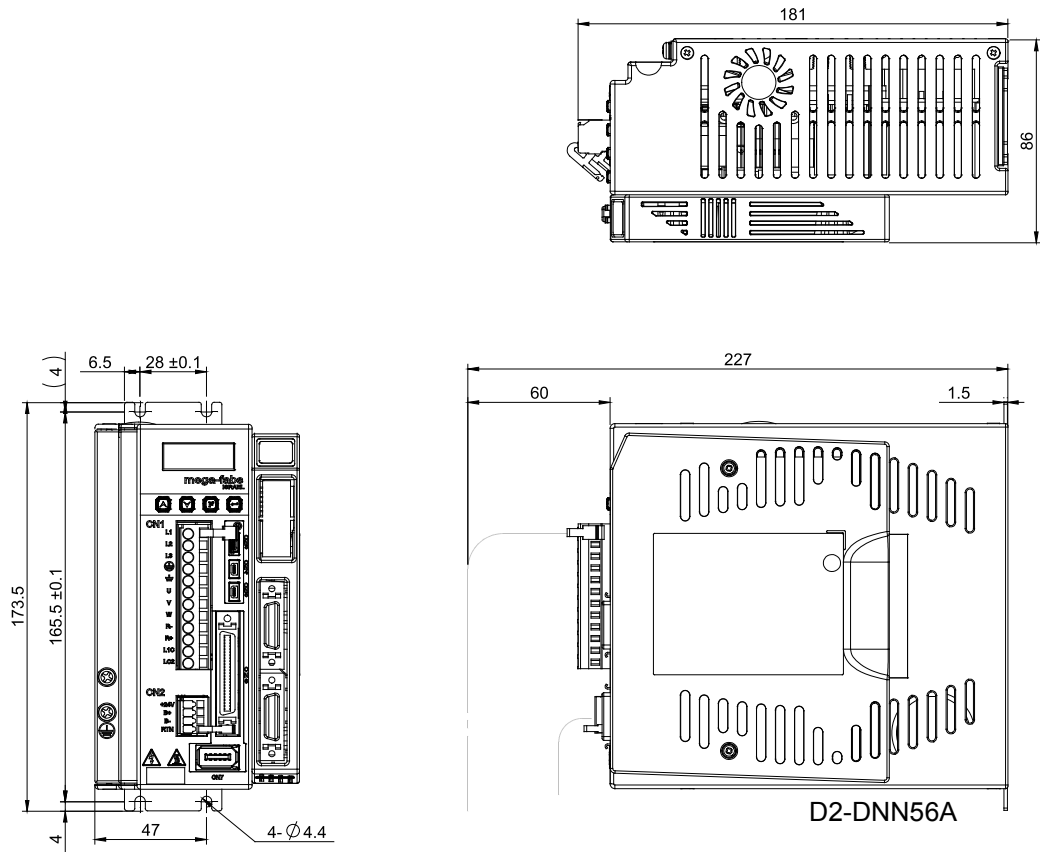


Figure 2.3.11 Dimensions of frame C model with the extension I/O module

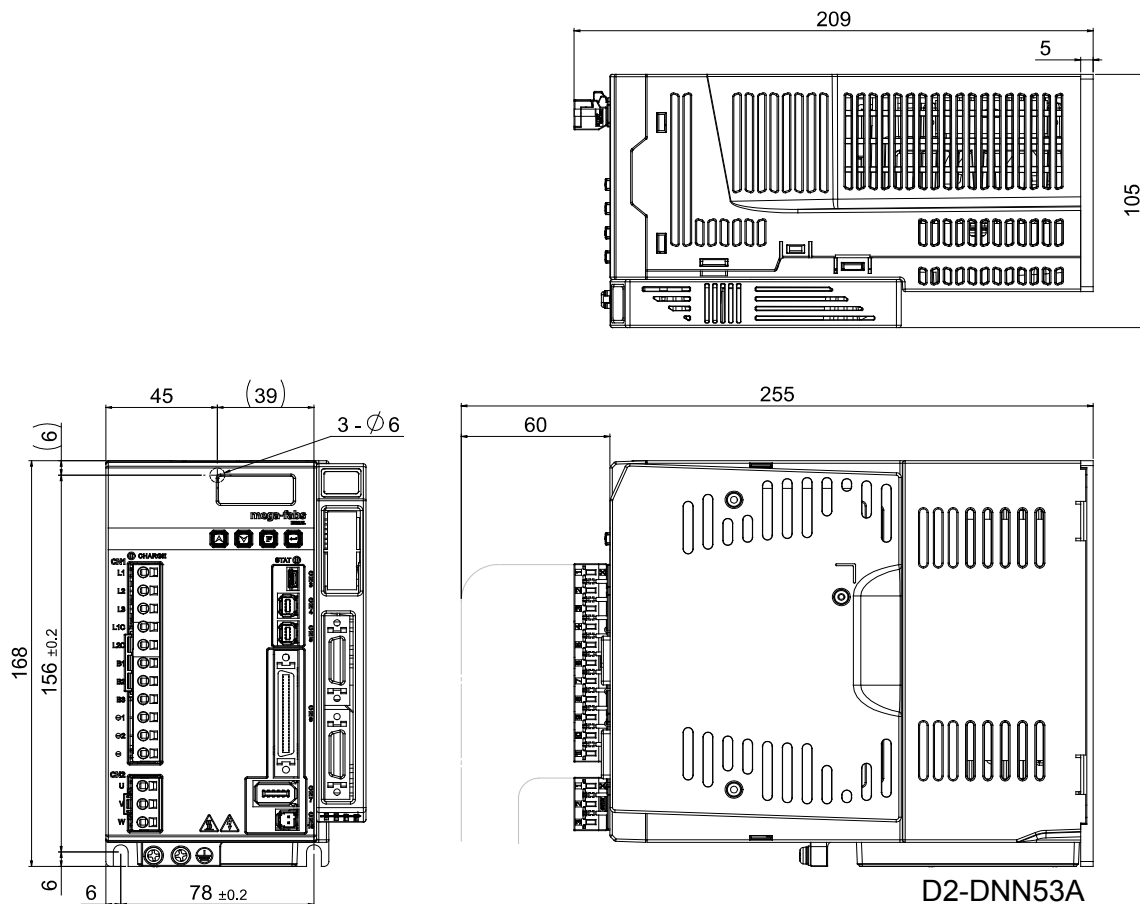


Figure2.3.12 Dimensions of frame D model with the extension I/O module

2.4 Drive installation

To fix drive in the used environment (e.g. electric cabinet), conductive screws must be used to secure drive to electric cabinet. Moreover, insulating materials (e.g. paint) on the contact surface of electric cabinet must be removed, so that the drive can connect to ground through the machine. If the main power of drive is 220 V, the grounding resistance must be less than 50 Ω.

Installing drive must be careful, not to shut suction hole and vent, and not place it in the inclined position. Otherwise, it will cause drive failure. In order to ensure that the effect of cooling circulation is well, installing drive should keep an enough space between the drive and the adjacent article or baffle. If more than one drive is installed, keep the space between drives more than 20 mm, such that the drive has an enough space for heat dissipation. Fans can be set in the electric cabinet to facilitate the heat dissipation of drives.

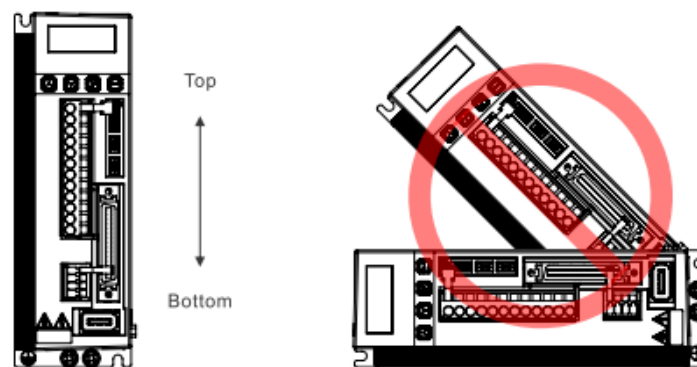


Figure2.4.1

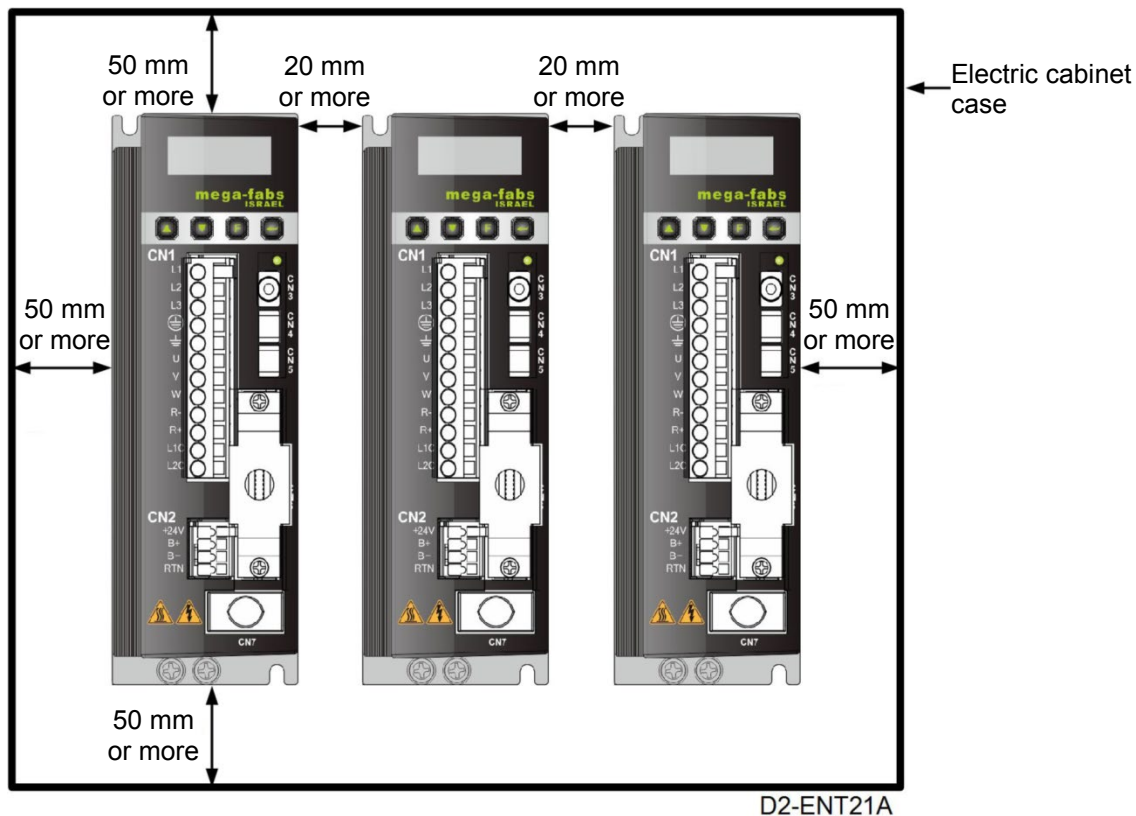


Figure2.4.2 Space between drives

2.5 Computer requirements

Table2.5.1

CPU	1.0 GHz or more
RAM	512 MB or more
Available space on the hard disk	50 MB or more
Communication port	USB
Operating system	Windows 2000, Windows XP, Windows 7
Screen resolution	1024 x 768 pixels or more

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3. Operation principles

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3.1 Operation modes

The following operation modes can be used to implement the interface between the standard D2 drive and the host controller.

- (1) Position mode
- (2) Velocity mode
- (3) Force/torque mode
- (4) Stand-alone mode

Each mode is described as follows.

3.1.1 Position mode

The host controller sends pulses to drive. These pulses are equal to position commands. When the drive receives a pulse, it moves the motor with a corresponding distance. The host controller is responsible for path planning. The pulse is sent faster and faster at the acceleration, and is sent with a fixed frequency at the constant speed. As shown in figure 3.1.1.1, there are three formats of pulse signal: pulse/direction (pulse/dir), pulse up/pulse down (CW/CCW), and quadrature (AqB). Based on the hardware wiring, the pulse signal can be classified into the differential and single-end TTL logic signals.

The electronic gear can be set in the position mode. One input pulse is normally set to be equal to one encoder count. For example, the gear ratio of 2:3 means that 2 input pulses is equal to 3 encoder counts.

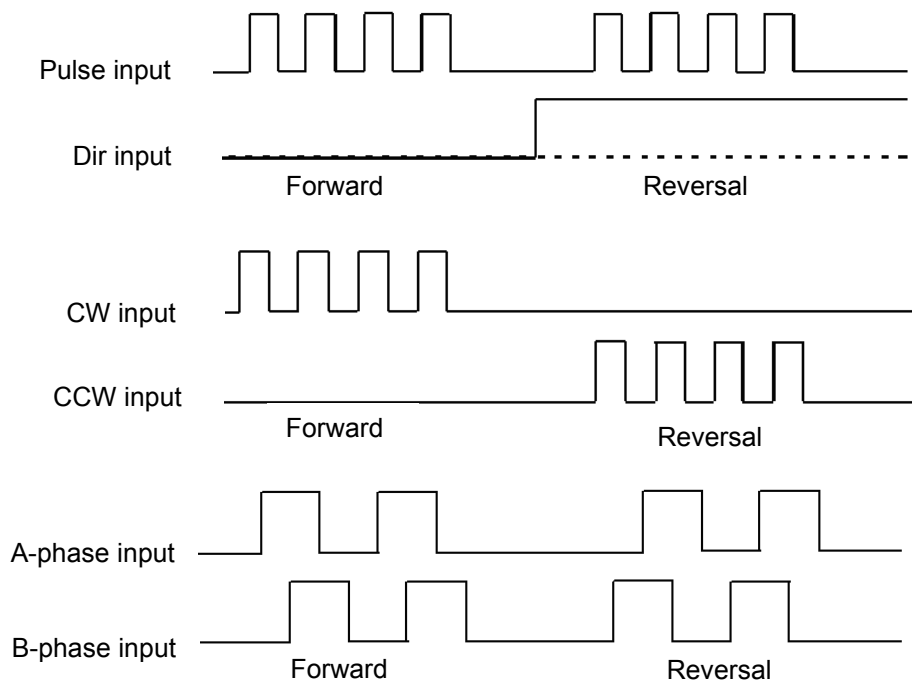


Figure3.1.1.1

3.1.2 Velocity mode

The drive can receive the command from the host controller via voltage, so as called V command. The input voltage range is from -10 V to +10 V. The drive converts the received external voltage to the corresponding velocity command to drive the motor. Besides the voltage, the host controller can also send the velocity command via PWM signal, so as called PWM command. It utilizes different duty cycles to correspond to different velocity commands. There are two types of PWM command: single-line type (PWM 50%) and dual-line type (PWM 100%). The single-line type (PWM 50%) takes the duty cycle of 50% as the basis. If the duty cycle of PWM command is less than 50%, the motor performs the reverse motion; while if greater than 50%, the motor performs the forward motion. In addition to using one pin to transmit PWM command, the dual-line type (PWM 100%) needs another pin to control motion direction.

(1) Use voltage command

The drive converts the analog voltage to the velocity command to control the speed of motor movement. The higher the voltage is, the faster the output speed is. However, the maximum output speed is limited by the maximum motor speed. The lower the voltage is, the slower the output speed is. When the voltage value is negative, the output speed is negative and the motor moves in the reverse direction. The drive can set the command speed corresponding to the voltage per unit.

(2) Use PWM command

The drive converts the PWM signal to the velocity command to control the speed of motor movement. It can set the command speed corresponding to "Full PWM".

3.1.3 Force/torque mode

In the force/torque mode, the command from the host controller, which can be received by the drive, is the same as that in the velocity mode. There are V command and PWM command. After the drive receives these two commands, it converts them to the corresponding current to drive the motor.

(1) Use voltage command

The drive converts the analog voltage to the current command. By controlling the output current of drive, it can control the force or torque of motor movement. The higher the voltage is, the larger the output current is. However, the maximum output current is limited by the maximum motor current. The lower the voltage is, the smaller the output current is. When the voltage value is negative, the output current is negative and the motor moves in the reverse direction. The drive can set the command current corresponding to the voltage per unit.

(2) Use PWM command

The drive converts the PWM signal to the current command to control the force or torque of motor movement. It can set the command current correspond to “Full PWM”.

3.1.4 Stand-alone mode

There is one high-speed DSP on the inside of drive. Therefore, the drive can plan the motion profile by itself. If the drive needs to do test alone or without any host controller (e.g. only the servo motor and drive), the stand-alone mode can be selected to let drive be responsible for all control loops.

3.2 Encoder type

The encoder usually plays an important role in the servo motor control. It provides the information of drive position or angle to realize the servo-loop control. There are two types of commonly used encoder: digital type and analog type. D2-series drives only support the digital encoder presently, but not analog encoder.

(1) Digital type

The digital or so-called incremental encoder normally outputs the differential signal of TTL RS422. The main feature of this signal is two digital pulses with the 90°-phase difference. The definition of resolution for this signal is given in figure 3.2.1.

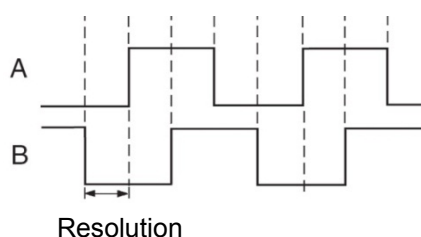


Figure3.2.1

(2) Analog type

The analog encoder has two-phase signals: sin and cos. The hardware normally takes the differential signal of 1 Vpp. The main feature of this signal is two sinusoidal signals with the 90°-phase difference. Its specification is normally represented by the grating period. For example, the grating period of common linear analog scale is 40 μm .

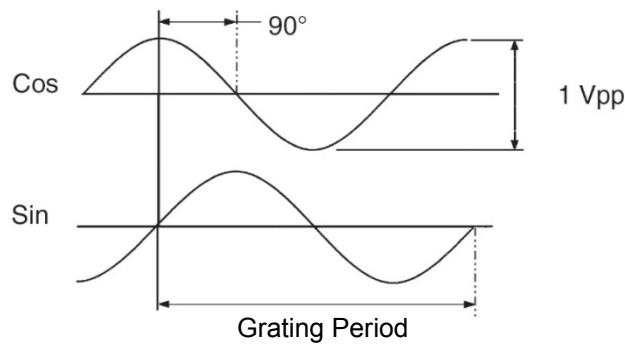


Figure3.2.2

3.3 Encoder signal output

The input signal of encoder is used to perform the servo control by the servo drive. When the drive works with the host controller, the host controller also has the requirement of receiving position signal. Normally, the drive will transmit the position or angle signal received from the encoder to the host controller. D2 drive provides the following two modes of encoder output.

- Buffered encoder output

When this mode is selected, the drive sends the received encoder signal to the host controller directly. Besides, if the invert of encoder signal is required, check the option of invert function. At this time, the drive inverts the received encoder signal and sends it out.

- Emulated encoder output

When this mode is selected, the drive multiplies the received encoder position by a scale and sends it out to the host controller. For some cases, if the host controller cannot receive the encoder signal with a too high frequency, the scale can be set to lower the frequency of encoder output. In addition, if the multiplier factor of analog encoder is set too high, the scale can also be set to lower the resolution of encoder output. When motor reaches home position for the first time, the width of output Z-phase signal is half of its original width.

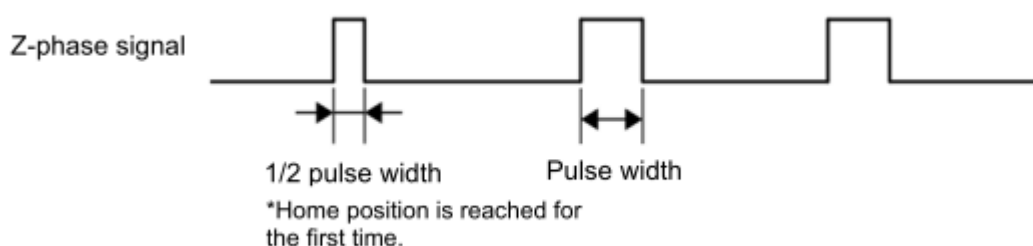


Figure3.3.1

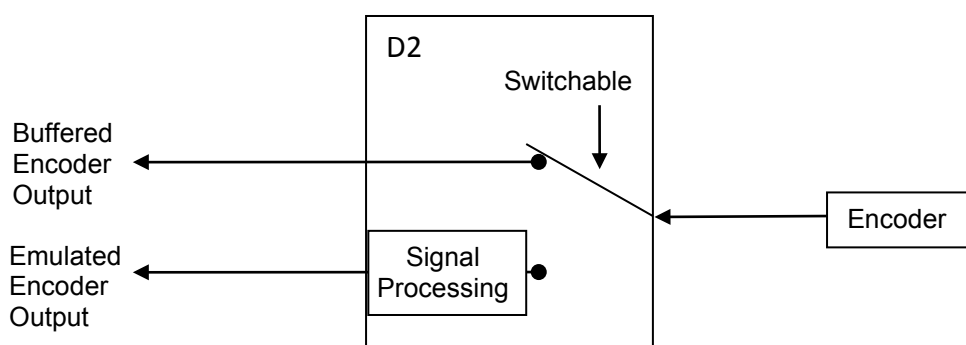


Figure3.3.2

3.4 Path planning

The main purpose of path planning is that the host controller calculates the suitable motion command based on the user's actual requirement of distance, velocity, acceleration, and smooth factor, as shown in figure 3.4.1. This command (pulse or V command) is sent to the drive by the host controller, or calculated by the drive itself (stand-alone mode). Different configurations are adopted according to different applications.

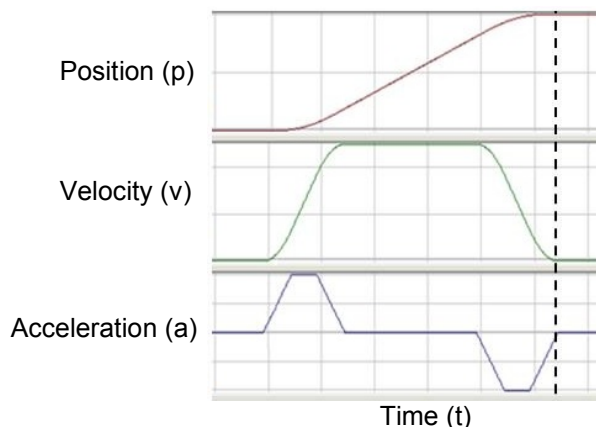


Figure3.4.1

(1) Position

The encoder provides the position information of motor to the drive, such that the drive can realize the current motor position. For the linear motion, common position units are μm , mm , and m ; while for rotary motion, it is the encoder count. For D2 drive, "Reference position" denotes the position command, which is calculated by the path generator based on the related parameters. However, "Target position" is the target position set by the user or host controller. After this parameter is sent to the drive, normally, it needs to be calculated by the path generator so as to let motor move.

(2) Velocity

The velocity is defined as the difference of position per unit time. For linear motion, velocity units are $\mu\text{m}/\text{sec}$, mm/sec , m/sec ; while for rotary motion, they are count/sec , rps , and rpm .

(3) Acceleration

The acceleration is defined as the difference of velocity per unit time. For linear motion, acceleration units are $\mu\text{m}/\text{sec}^2$, mm/sec^2 , and m/sec^2 ; while for rotary motion, it is rps^2 .

(4) Smooth factor

When the acceleration is rapidly increased or decreased in a short time, it means that the force applied to moving object is suddenly increased or decreased. Sometimes, to reduce such impact, the technique of smooth motion is introduced to the motion control loop, so as to enhance the performance. D2-series drives adopt the technique of smooth factor to achieve this effect. By using the smooth factor, the motion trajectory can be planned to S-type or T-type curve. Its value can be set from 1 to 500. If this value is larger, the trajectory is closer to S-Type curve and the impact is smaller. On the other hand, if this value is smaller, the trajectory is closer to T-Type curve. As this value being 1, it means that there is no effect of smooth function. When the value of smooth factor is increased, in some case, the settling performance during positioning process will be enhanced, since the impact of motor force is reduced. However, when the motion becomes smoother, the move time of path planning is unavoidably increased. Tests on the practical machine are needed to adjust the smooth factor, so as to get the balance between them.

(5) Emergency stop

D2-series drives have the function of emergency stop. When the drive deactivates the signal of "Axis enable" on the pin I3, this function is activated. At this moment, the drive immediately stops the motor in any motion by using the deceleration for emergency stop to guarantee safety.

3.5 Servo loops and gains

(1) Servo loops

There are three types of control loop for D2 drive: current, velocity, and position control loops to implement the servo motor control. The architecture of drive's servo loop is described in figure 3.5.1. In the position mode, three loops should be connected in sequence to perform the position control for the motor. In the velocity mode, the velocity loop should use the current loop to drive the motor. However, in the current mode, the current loop only controls the phase commutation mechanism of motor, and its command is controlled by the voltage command from the host controller. To simplify gain parameters of servo loops, D2 drive only uses one common gain (CG) to set and adjust the overall control-loop architecture.

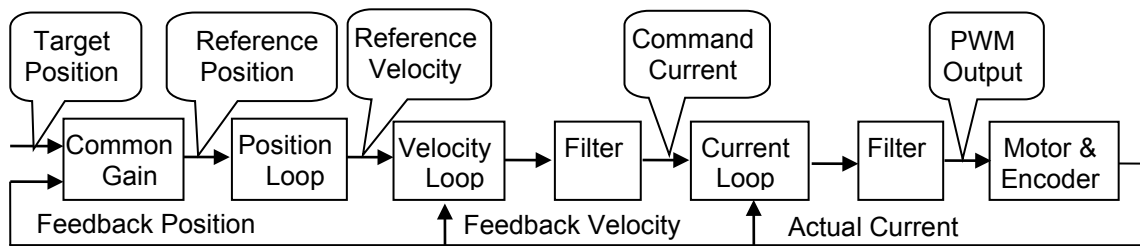


Figure3.5.1

(2) Servo gains

D2 drive uses one high-speed DSP to implement the motor control. Generally, when the servo loop is implemented by the digital method, it needs to adjust many servo gains. However, this drive adopts an ingenious control design to simplify servo gains as one common gain to significantly improve convenience.

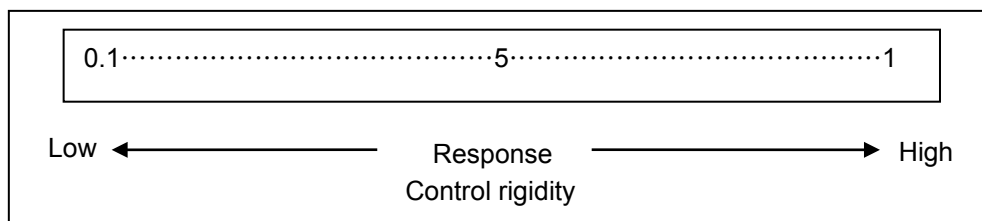


Figure3.5.2

3.6 Gain margin and phase margin

3.6.1 Nyquist diagram

Gain margin (GM) is defined as that the loop gain, calculated by dB, can be increased before the close-loop system becomes unstable. On the other hand, phase margin (PM) is defined as that the phase delay can be increased before the close-loop system becomes unstable.

■ Gain margin

Denote $G(j\omega_p)$ as the relative distance from the intersection of Nyquist diagram and the negative real axis to the point $(-1, j0)$, where ω_p is the frequency at the phase crossover. The example of $\angle G(j\omega_p) = 180^\circ$ is shown in figure 3.6.1.1. For the transfer function $G(s)$ in a loop system, gain margin = GM =

$$20\log_{10} \frac{1}{|G(j\omega_p)|} = -20\log_{10}|G(j\omega_p)| \quad \text{dB.}$$

Following results can be derived from figure 3.6.1.1 and characteristics of Nyquist diagram.

- a If $G(j\omega)$ does not intersect with the negative real axis, $|G(j\omega_p)| = 0$ and GM = ∞ dB. When the Nyquist diagram does not intersect with the negative real axis at any non-zero and finite frequency, GM = ∞ dB. Theoretically, the loop gain can be increased to be infinite before the system becomes unstable.
- b If $G(j\omega)$ intersects with the negative real axis between 0 and -1, $0 < |G(j\omega_p)| < 1$ and GM > 0 dB. When the Nyquist diagram intersects with the negative real axis between 0 and -1 at any frequency, the system is stable as increasing loop gain.
- c If $G(j\omega)$ is at the point $(-1, j0)$, $|G(j\omega_p)| = 1$ and GM = 0 dB. When the Nyquist diagram $G(j\omega)$ is at the point $(-1, j0)$, GM = 0 dB. This means that the system reaches the unstable boundary and the loop gain cannot be increased any more.
- d If $G(j\omega)$ passes by the point $(-1, j0)$, $|G(j\omega_p)| > 1$ and GM < 0 dB. When the Nyquist diagram $G(j\omega)$ passes by the point $(-1, j0)$, GM < 0 dB. At this time, GM must be reduced to achieve the steady state of loop gain.

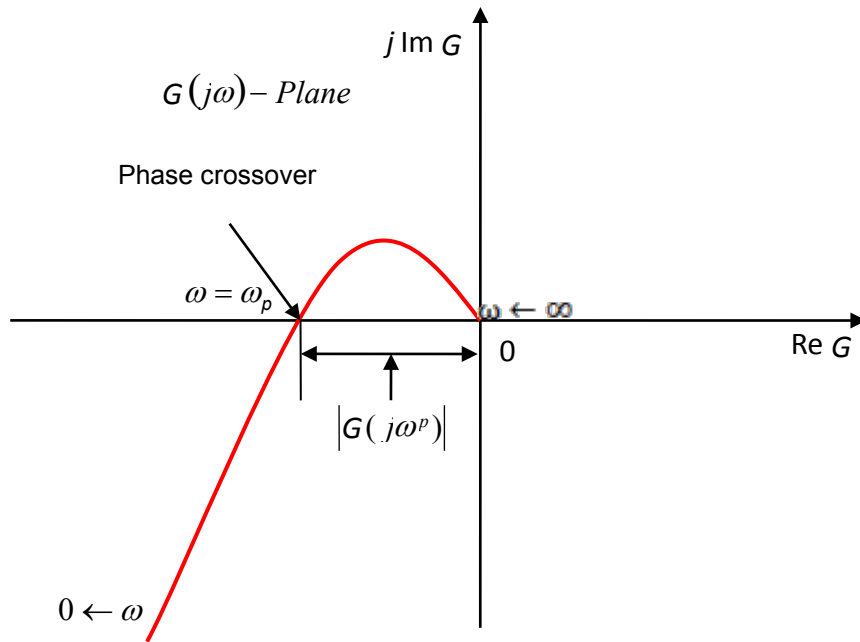


Figure3.6.1.1 Gain margin of Nyquist diagram

■ Phase margin

Phase margin is defined as that the angle between the straight line passing through the gain crossover and the negative real axis of $G(j\omega)$ -plane, as shown in figure 3.6.1.2.

$$\text{Phase margin} = \text{PM} = \angle G(j\omega_g) - 180^\circ$$

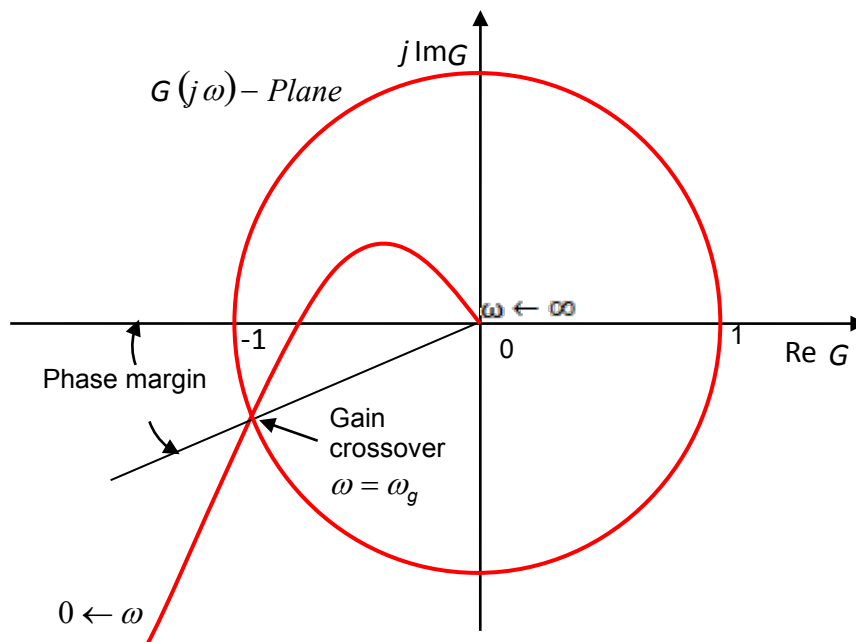


Figure3.6.1.2 Phase margin of Nyquist diagram

3.6.2 Bode diagram

The gain margin and phase margin of Bode diagram are given in figure 3.6.2.1.

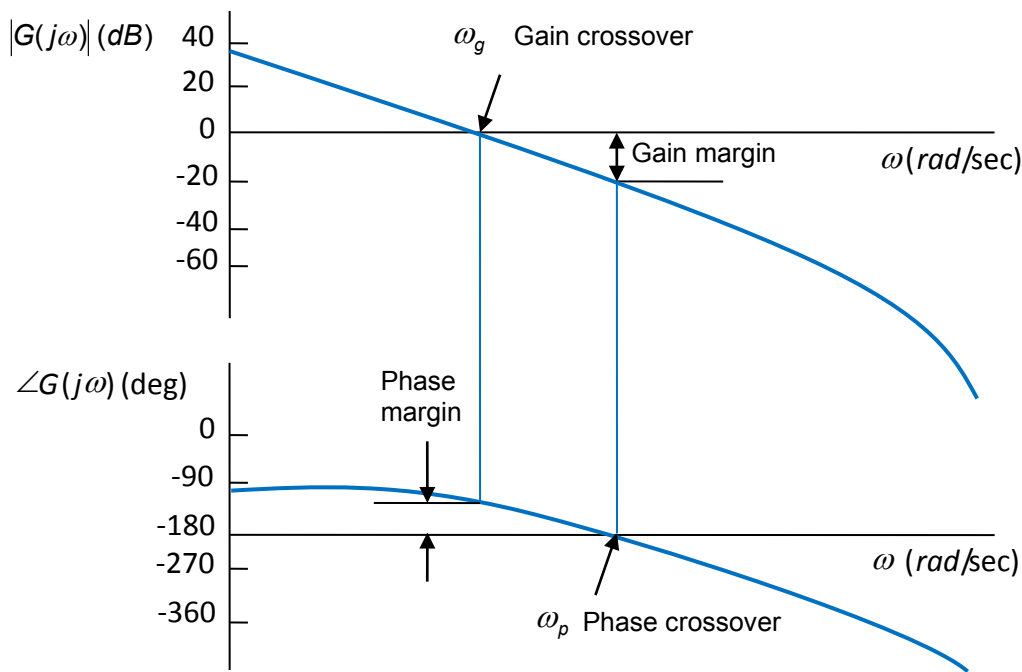


Figure3.6.2.1 Gain margin and phase margin of Bode diagram

The bandwidth of Bode diagram is defined as the frequency at -3 dB, as shown in figure 3.6.2.2.

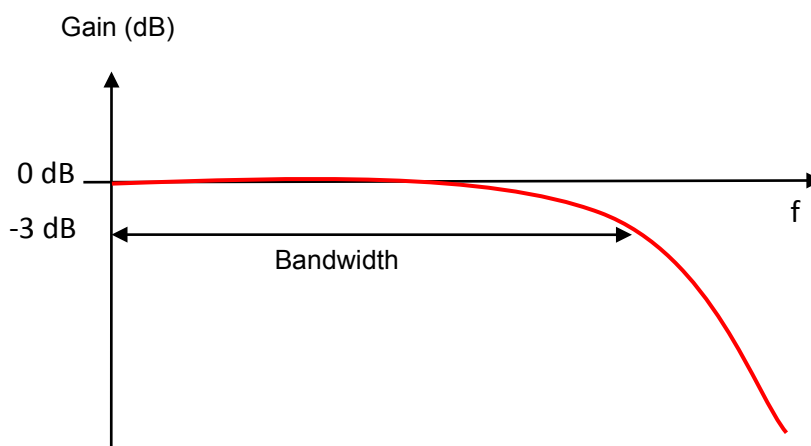


Figure3.6.2.2 Bandwidth of Bode diagram

3.7 Move and settling

The motor moves based on the path planned by the host controller. When it arrives at the target position, it is able to position accurately and stop motion. This is called move and settling.

- **Position error**
In the servo system, there is a certain difference between the target position and the encoder feedback position. This is called position error.
- **Target radius**
After the motor arrives at the target position, the difference between the feedback position and the target position must be controlled and kept within a specific positive/negative small range. This range is called target radius.
- **Total time of move and settling**
As shown in figure 3.7.1, after the motor arrives at the target position, the position error should be smaller than the setting of target radius and keep for a certain time (debounce time). After that, the “In-position” signal is set and called in position. If the position error is continuously out the radius, it is called not yet in position. The total time spent from the motion start to the settling achievement is the amount of move time and settling time.

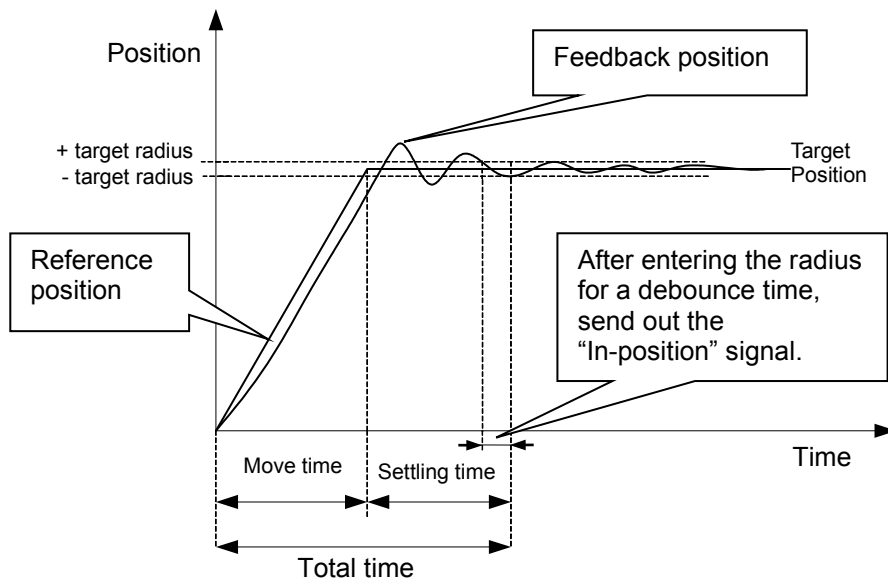


Figure3.7.1

3.8 Error compensation

Normally, the positioning accuracy of drive is determined by the performance of encoder. But sometimes, the encoder cannot completely meet the requirement of accuracy. In this case, instruments with the higher level of accuracy (e.g. laser interferometer) should be applied to measure the system error. D2 drive has one high-performance control method. It saves the measured error data into the error map of drive, as shown in figure 3.8.1, and uses this data during motion. By adopting the method of linear interpolation between the fixed distance, it calculates the value of error compensation to enhance the positioning accuracy.

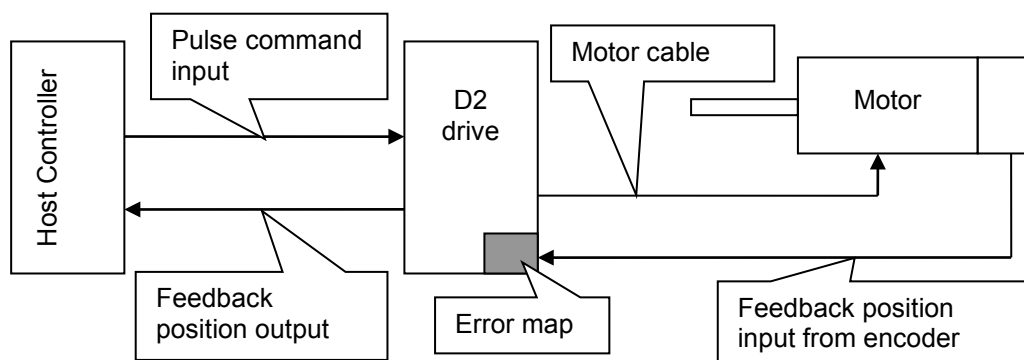
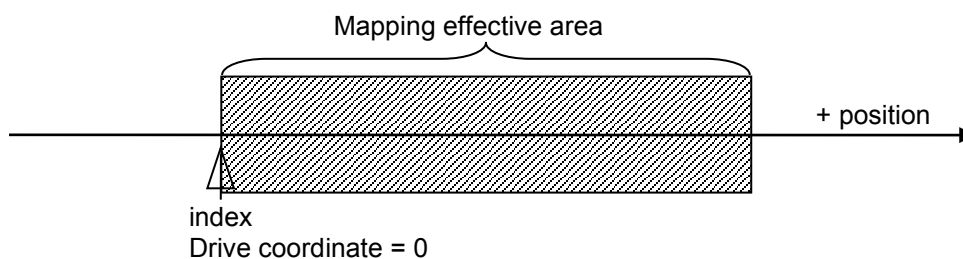


Figure3.8.1

The mapping effective area is determined by the index signal. The area from the index towards positive direction is the mapping effective area; while the area from the index towards negative direction is the area without mapping. As shown in the following figure, the mapping effective area for non-zero home offset is the same as that for zero home offset.

(1) Home offset = 0



(2) Home offset = 100

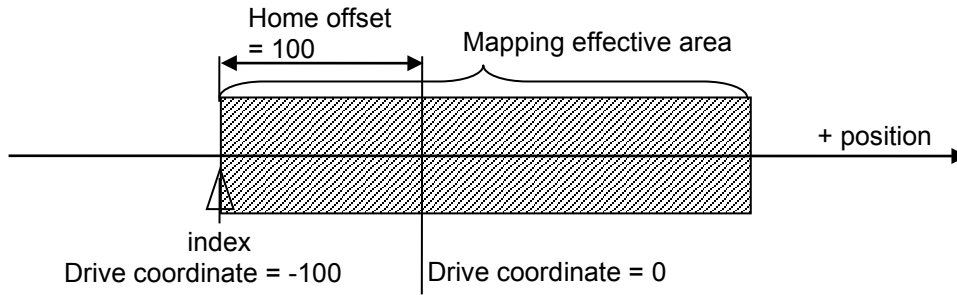


Figure3.8.2

3.9 Velocity ripple

Generally in the motion control, it is always desirable that the motion in the constant-speed phase is as smooth as possible. The motion stability can be estimated by the index of velocity ripple. Main factors causing the variation in the constant-speed phase are the motor cogging force, cable chain, air pipeline, and guideway friction, and so on. This velocity ripple is usually used for scanning or detecting machines required high stability in the constant-speed phase. The equation of velocity ripple is:

$$\text{Velocity Ripple} = \pm \frac{1}{2} \frac{V_{max} - V_{min}}{V_{target}} \times 100\%$$

where V_{target} is the target velocity, V_{max} is the maximum velocity in the constant-speed phase, and V_{min} is the minimum velocity in the constant-speed phase. As shown in figure 3.9.1, the velocity ripple of (a) is larger indicated less steadiness; while (b) is smaller indicated better steadiness.

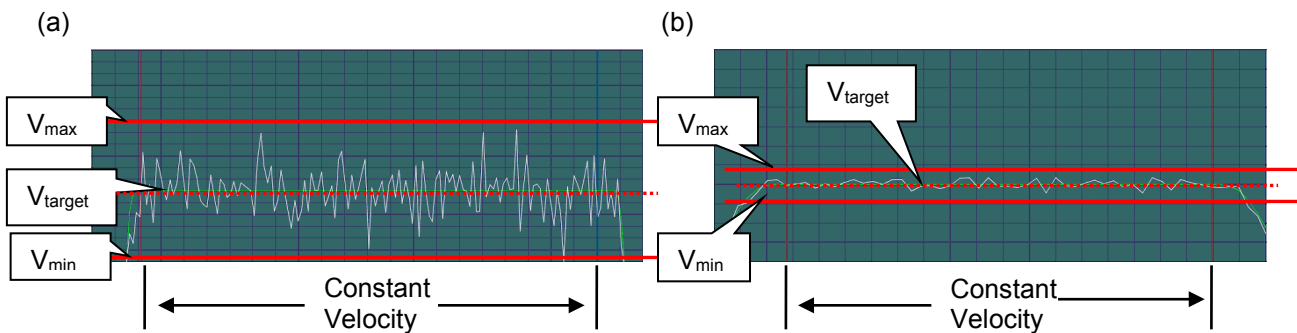


Figure3.9.1

3.10 Enable

The enable is a necessary step before the drive starts to receive any motion command. Only at the enable state, the drive can receive the pulse or voltage command from the host controller to do motion.

■ Step motion mode

The step motion (SM) mode is an open-loop architecture. At this mode, the motor behavior is similar as the stepper motor. The signal of feedback position is not adopted at the enable. This mode is used to ensure that the force direction of motor is consistent with the direction of encoder feedback. If not, it will cause the failure of phase initialization.

■ Phase initialization

For the drive with the incremental encoder, it needs to find the electrical angle at the first power-on, called phase initialization. For HIWIN servo motors, after the drive is booted, it is able to successfully find the electrical angle almost without any movement at the first enable process. The other common method of phase initialization is to add Hall sensor to achieve the same effect. Generally, the host controller sends an output signal to the drive (e.g. the input I3 of D2 drive) to complete the phase initialization and enable process.

3.11 Common physical quantities

Figure3.11.1

No.	Physical quantities	Description
1	Feedback position	Feedback position
2	Reference position	Position command
3	Target position	Target position
4	Position error	Position error
5	Single turn feedback position	Feedback position of single-turn encoder (only for the drive supporting single-turn encoder)
6	Dual loop feedback position	Feedback position of dual-loop encoder (only for the drive supporting dual-loop control)
10	Feedback velocity	Feedback velocity
11	Reference velocity	Velocity command
12	Velocity error	Velocity error
20	Reference acceleration	Acceleration command
30	Actual current	Actual current
31	Command current	Current command
32	Current effective value	Effective value of current during calculation period
40	Analog command	Voltage command (from the host controller)
41	Bus voltage	Line voltage
42	Servo voltage percentage	Servo voltage
45	PWM command	Torque/force/velocity command (from host controller)
51	Soft-thermal accumulator	Temperature estimation via software
53	Average load ratio	Average load ratio during calculation period
54	Peak load ratio	Peak load ratio during calculation period
61	I1	Input 1
62	I2	Input 2
63	I3	Input 3
64	I4	Input 4
65	I5	Input 5
66	I6	Input 6
71	I7	Input 7
72	I8	Input 8
67	I9	Input 9
68	I10	Input 10 (only for D2T model)
81	O1	Output 1
82	O2	Output 2
83	O3	Output 3
84	O4	Output 4
86	O5	Output 5 (only for D2T model)
85	CN2/BRK	Brake signal output

4. Wiring

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4.1 System configuration and wiring

This chapter describes the system configuration of drive and the function of each connector.

4.1.1 System wiring diagram

The following figure shows the name, function, and specification of each drive connector.

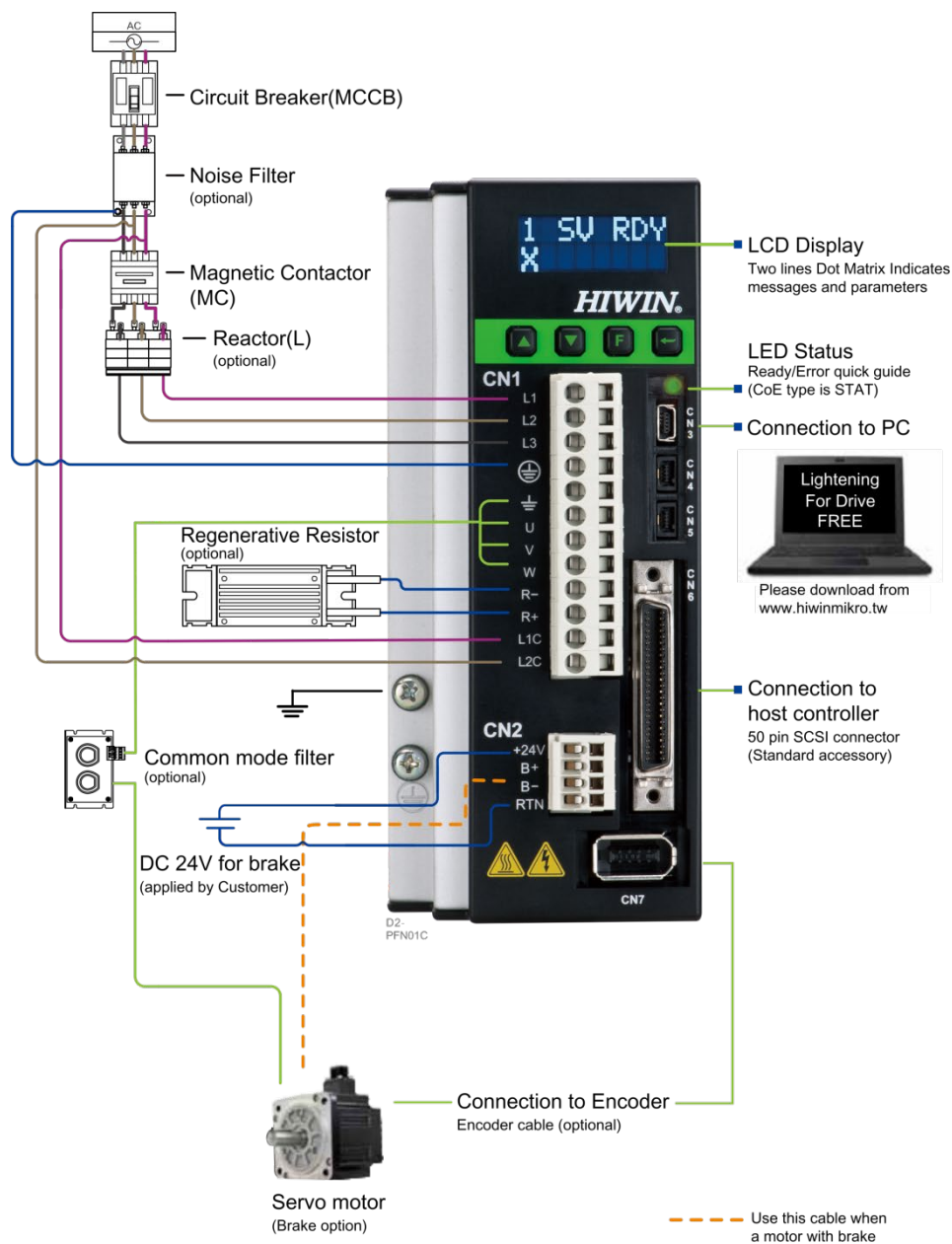


Figure4.1.1.1

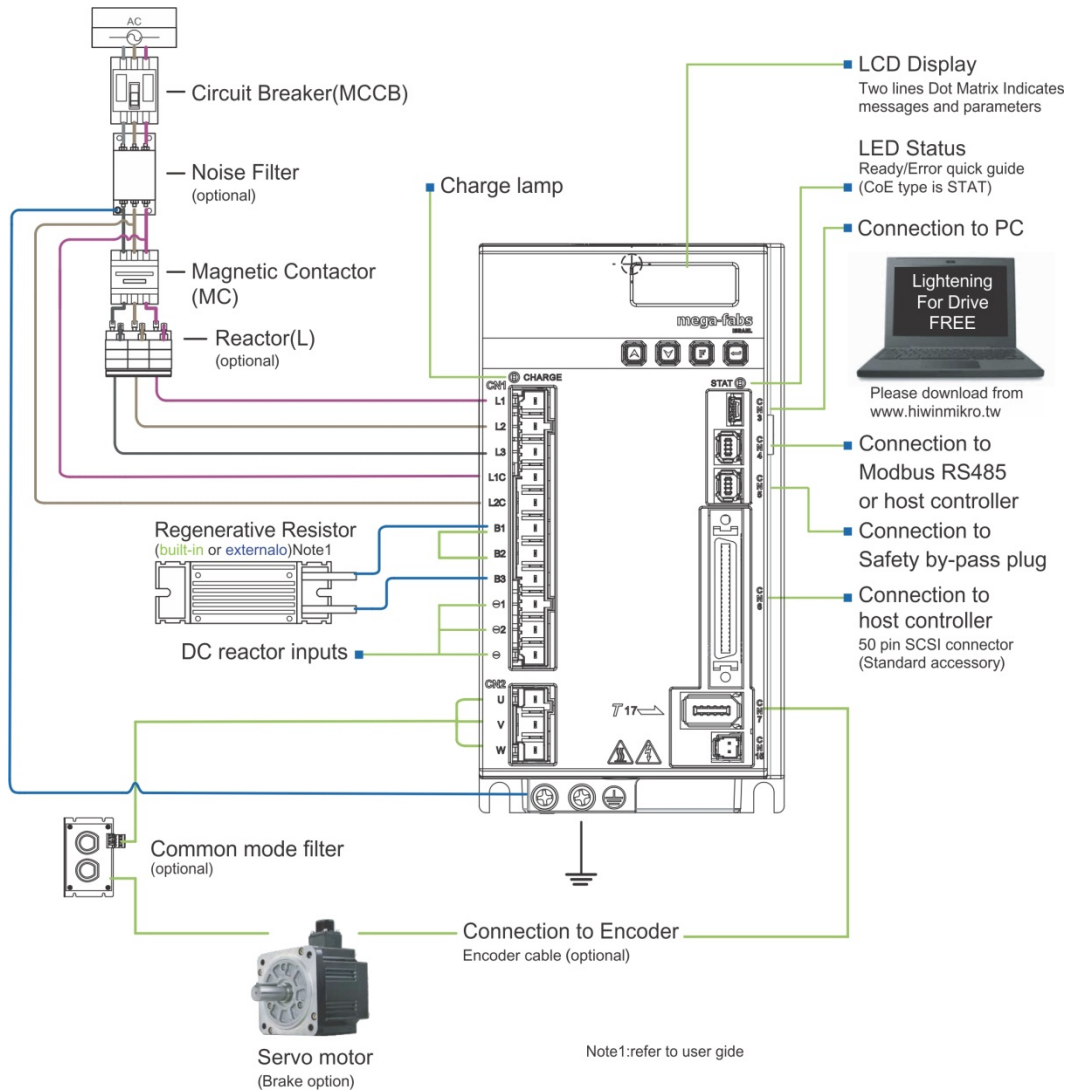


Figure4.1.1.2

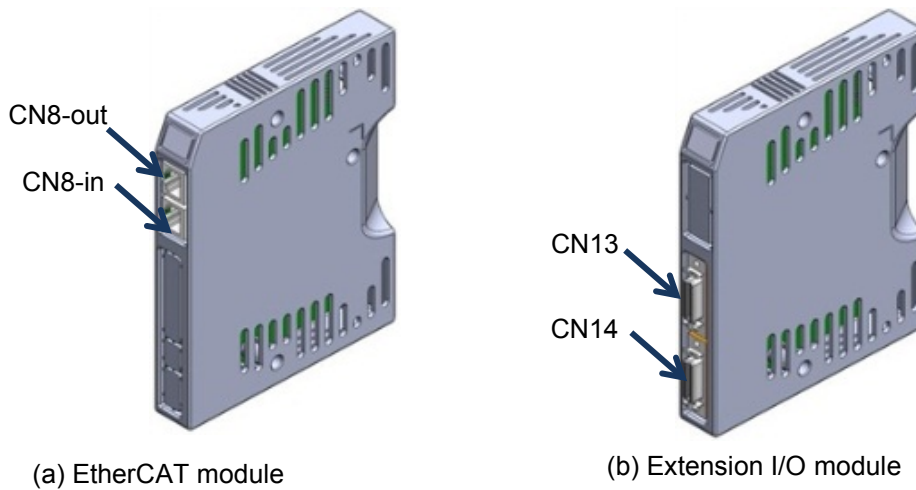


Figure4.1.1.3

Table4.1.1.1

Item No.	Name	Connector	Description
1	AC main power cable	Frame A-D: CN1	L1, L2: Single-phase 200-240 Vac, 50/60Hz L1, L2, L3: Three-phase 200-240 Vac, 50/60Hz (The frame D model is only allowed connecting to three-phase AC power)
2	Motor power cable	Frame A-C: CN1 (U, V, W) Frame D: CN2 (U, V, W)	Connected to motor, three-phase motor power
3	Regenerative resistor	Frame A-C: CN1 (R-, R+) Frame D: CN1 (B1, B2, B3)	Connected to regenerative resistor (optional/installed according to actual application)
4	Control power cable	Frame A-D: CN1 (L1C, L2C)	Drive control and I/O power (L1C, L2C: Single-phase 200-240 Vac, 50/60Hz)
5	Brake	Frame A-C: CN2 (B-, B+) Frame D: CN6 (O5-, O5+)	Connected to brake (optional/installed according to actual application)
6	Mini USB communication	Frame A-D: CN3	Connected to PC (for parameter setting; to be removed after setting) Using mini USB to connect with PC for monitoring drive, doing test runs, or writing parameters, etc.
7	Modbus communication	Frame A-C: CN4, CN5 Frame D: CN4	Connected to host controller by using Modbus communication protocol
8	Control signal	Frame A-D: CN6	Connected to host controller
9	Feedback signal	Frame A-D: CN7	Connected to motor encoder
10	EtherCAT communication	Frame A-D: CN8	Connected to host controller by using EtherCAT communication protocol
11	Extension I/O signal	Frame A-D: CN13, CN14	Extension I/O module
12	Safety function signal	Frame D: CN5	Connected to safety device
13	DC reactor	Frame D: CN1	Connected to DC reactor (optional/installed according to actual application)
14		Frame D: CN15	Reserved

4.1.1.1 Grounding

To prevent interference from causing false operation, perform grounding by following the instructions.

- (1) Use the third type grounding or D type grounding (Grounding resistance must be below 100 Ω.).
- (2) The servo drive cannot share the same power supply with electric welding machine or electric discharge machine. If there is high frequency generator near the servo drive, install noise filter at the input sides of main circuit power cable and control circuit power cable.
- (3) The ground wire must be as short as possible. Parallel and single-point grounding is suggested.
- (4) If servo motor is insulated from machine, ground the servo motor directly.
- (5) If there is high frequency generator (such as electric welding machine, electric discharge machine or frequency converter) in servo system, the high frequency generator must be grounded separately to avoid interference to other device.

- (6) When servo motor is grounded through a machine, switching noise current may flow out from the servo drive main circuit with the stray capacitance of the servo motor. To avoid the above situation, connect the frame or ground terminal of the servo motor to the ground terminal of the servo drive. Then ground the ground terminal of the servo drive. When linear motor is used, both the forcer and stator must be grounded.
- (7) When control signal cable is interfered, connect its shield to its connector shell. Then perform grounding.

4.1.2 CN1 power

The pin assignment of CN1 for frame A-C models is different with that for the frame D model. Check the pin assignment for each model before use. Descriptions of CN1 power wiring include: single/three-phase power input, motor power output (frame A-C), regenerative resistor wiring, single-phase control power input, and DC reactor wiring (frame D).

4.1.2.1 Power wiring

Before connecting the main circuit of drive, ensure that the drive is properly grounded. Frame D model is only allowed connecting three-phase 200 - 240 Vac.

- (1) Frame A-C

Connector model: Wago 721-112/026-000 (female).

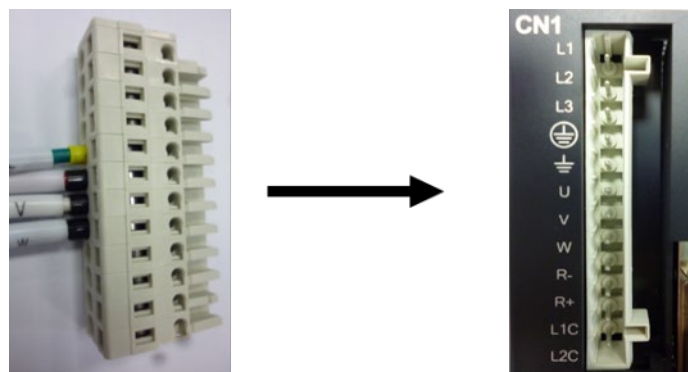


Figure4.1.2.1.1 CN1 connector type for frame A-C models

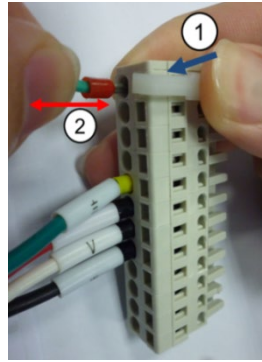


Figure4.1.2.1.2 Installation and removal methods

Table4.1.2.1.1

No.	Signal	Function
1	L1	AC main power, 220 Vac (50/60 Hz) single/three phase
2	L2	AC main power, 220 Vac (50/60 Hz) single/three phase
3	L3	AC main power, 220 Vac (50/60 Hz) three phase
4	⊕	Ground input of AC main power
5	⊕	Motor ground input
6	U	Motor U-phase input
7	V	Motor V-phase input
8	W	Motor W-phase input
9	REG-	Negative terminal of regenerative resistor
10	REG+	Positive terminal of regenerative resistor
11	L1C	Control power, 220 Vac (50/60 Hz) single phase
12	L2C	

(2) Frame D

Connector model: TE Connectivity 1-2229794-1 (female).

The ground wire of main power should be connected to the drive housing.

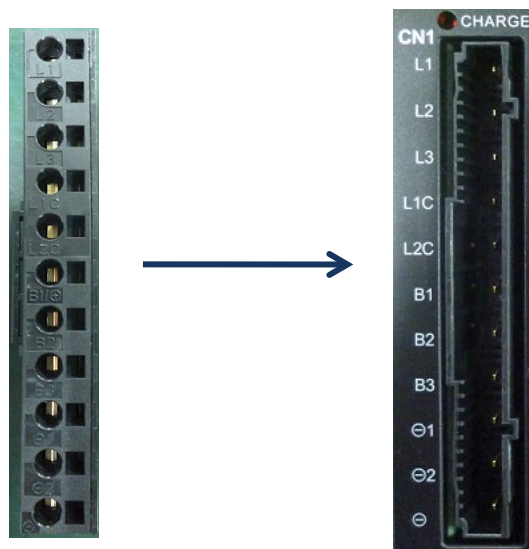


Figure4.1.2.1.3 CN1 connector type for frame D model

Table4.1.2.1.2

No.	Signal	Function
1	L1	AC main power, 220 Vac (50/60 Hz) three phase
2	L2	
3	L3	
4	L1C	Control power, 220 Vac (50/60Hz) single phase
5	L2C	
6	B1	Regenerative resistor input
7	B2	Regenerative resistor input
8	B3	Regenerative resistor input
9	⊖1	DC reactor input
10	⊖2	DC reactor input
11	⊖	DC reactor input

4.1.2.2 Motor wiring

Be sure to ground the drive and the motor. The following motor wiring is only suitable for frame A-C models.

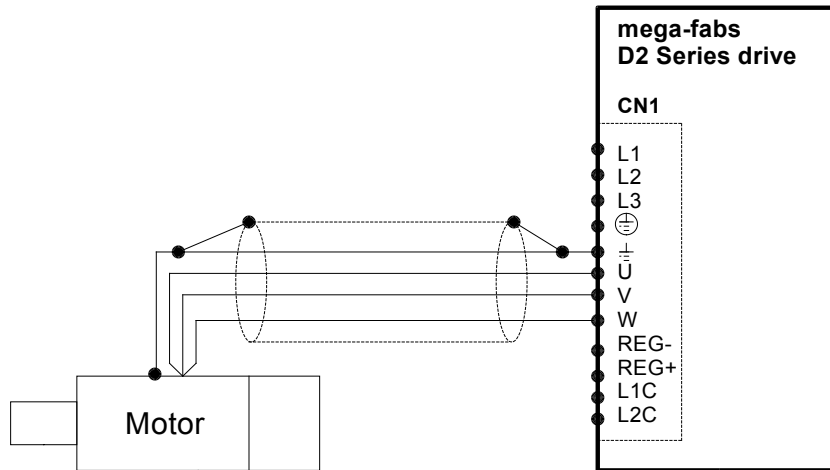


Figure4.1.2.2.1

4.1.2.3 Regenerative resistor wiring

The regenerative resistor is optional. However, the frame D model has one internal regenerative resistor (13 Ω/100 W). Install it according to the actual application.

(1) Frame A-C

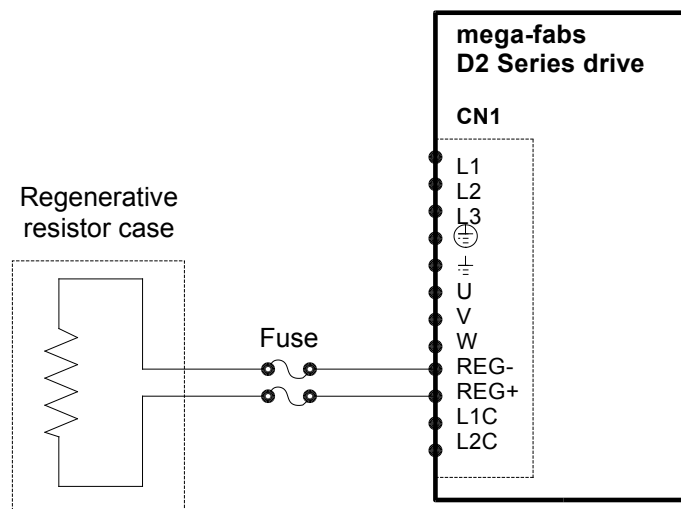


Figure4.1.2.3.1

(2) Frame D

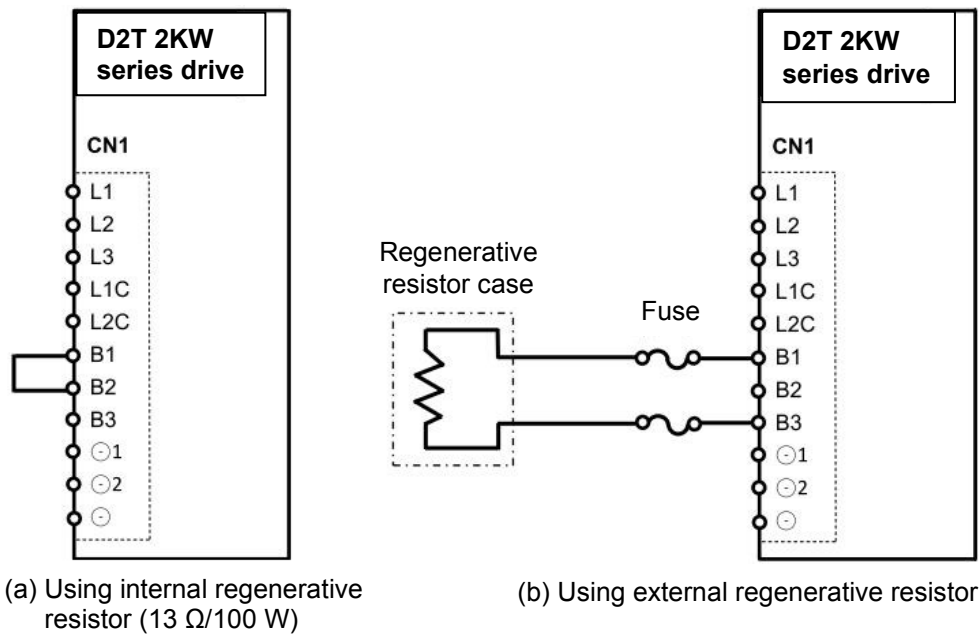


Figure4.1.2.3.2

4.1.2.4 DC reactor wiring

The DC reactor is optional. Its main function is to improve the input power factor and suppress the harmonic current. Only the frame D model supports this feature. Install it according to the actual application.

■ Specification

Table4.1.2.4.1

Part Number	Item	Specification	Description
051800200126	Reactor	R-B86732G15L712	440 V 14.2~196.6A _{dc}

The wiring diagram and instructions for installing DC reactor are given as below.

Note:

- (1) ① and ② on CN1 are connected when servo drive is shipped out. Do not disconnect them. Otherwise the servo drive cannot function normally.
- (2) If using DC reactor to suppress harmonic current, its wiring must be between ① and ②.

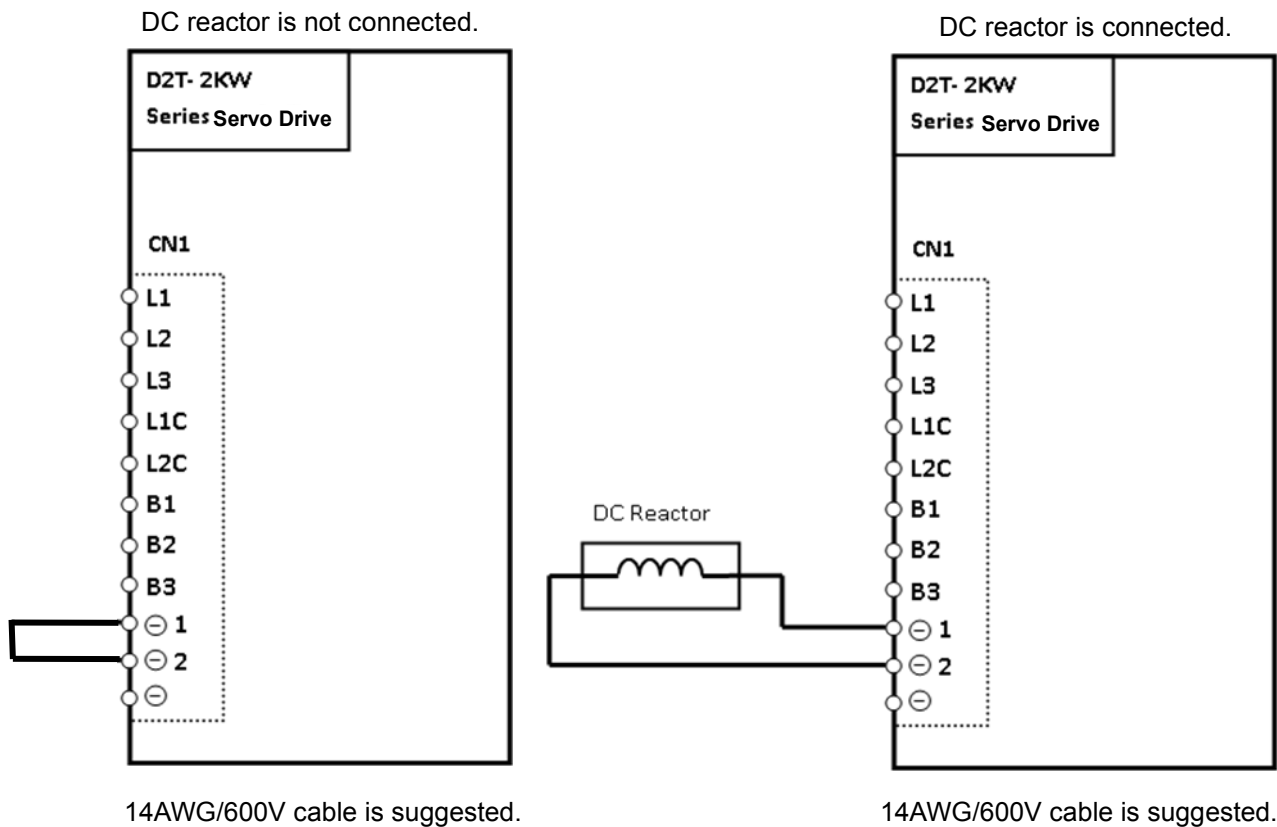


Figure4.1.2.4.1

⚠ CAUTION

- ◆ Wiring and the related inspection must be done by the professional technician.
- ◆ Turn off the power before wiring or inspection to avoid electric shock and other dangers.
- ◆ After the power is turned off, do not touch power terminals for a short time period (at least 5 minutes), since the power in the drive remains high.
- ◆ Perform wiring correctly and reliably; otherwise it may cause uncontrolled motor operation, personnel injury, machine malfunction, or other unexpected accidents.
- ◆ Do not connect the U, V, or W terminal of motor to power supply.
- ◆ Connectors of power and motor cables should be connected securely; otherwise it may cause fire.
- ◆ Ensure that the drive and motor are grounded properly.
- ◆ The drive and motor should be installed before wiring; otherwise it may cause electric shock.
- ◆ Do not damage, pull, or squeeze the wire; otherwise it may cause electric shock.
- ◆ The drive may interfere with the nearby electronic equipment. A noise filter could be used to reduce the effect of electromagnetic interference.
- ◆ Do not make any modification to the drive.
- ◆ Do not put the main circuit cable, I/O signal cable, or encoder cable in the same duct, or tie them together. The cable should be kept more than 30 cm away from each other at wiring.
- ◆ Following instructions must be observed for wiring main circuit terminals:
 - Do not insert more than two wires in the same socket.

- Check that there is no short circuit between the wire and its adjacent wire after inserting the wire.
- Use the specific power voltage; otherwise it may cause fire or drive damage.
- ◆ If the drive is used at the condition of poor or significantly fluctuating power, ensure that the power is supplied within the specified range of voltage fluctuation; otherwise it may cause drive damage.
- ◆ Install safety devices, such as breaker, to prevent the short circuit of external wiring from damaging the drive.
- ◆ The appropriate isolation and shielding measures must be adopted when the drive is used in the following environments; otherwise it may cause the poor operation of drive.
 - Environment with the interference generated by the static electricity or the like.
 - Environment with a strong electric field or a strong magnetic field.
 - Environment with the emitted radiation.
- ◆ Residual power still exists in capacitor even if main power is cut off. If you would like to stop the motor right after the main power is cut off, refer to the instructions below.
 - Control power must be cut off at the same time.
 - Disable hardware enable by using relay.
 - Enable dynamic brake after main power is cut off.

4.1.3 CN2 brake/motor power

For frame A-C models, CN2 is the brake connector; while for the frame D model, CN2 is the motor power connector. Check the pin assignment for each model before use. It is suggested that the brake power should be independent power and does not use the same power source with other power.

(1) Frame A-C

Use the brake wiring with a relay to connect the drive power of 24 Vdc to the brake.

Connector model: WAGO 734-104.

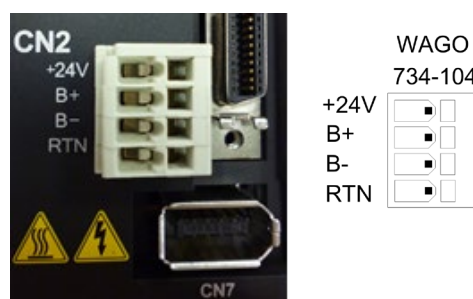


Figure4.1.3.1

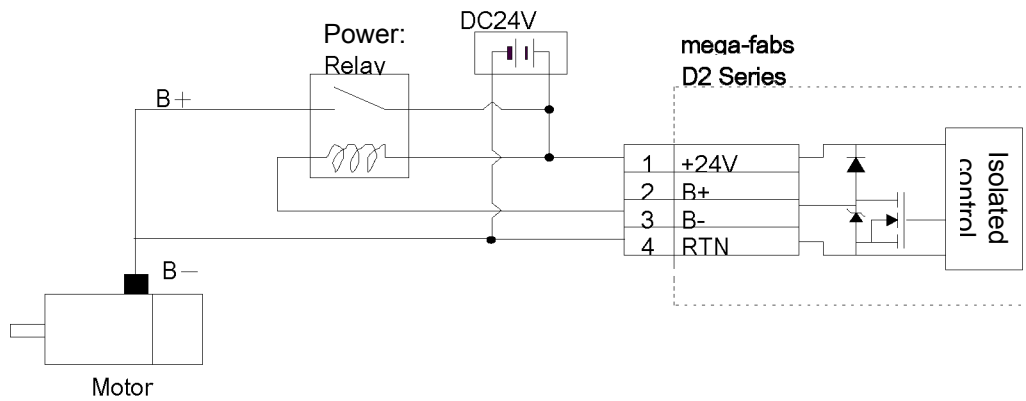


Figure4.1.3.2 Brake wiring with a relay

(2) Frame D

The motor ground wire should be connected to the drive housing.

Connector model: TE Connectivity 3-2229794-1 (female).

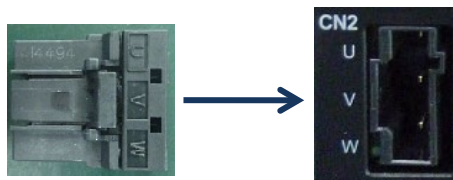


Figure4.1.3.3

Table4.1.3.1

No.	Single	Function
1	U	Motor U-phase input
2	V	Motor V-phase input
3	W	Motor W-phase input

4.1.4 CN3 USB communication

Use the mini USB to connect with PC for monitoring drive, doing test runs, or writing parameters, and so on. The corresponding operation please refers to Section 5.

■ Wiring diagram of mini USB communication

Use HIWIN cable with the shielding network. Its model is “USB 2.0 Type A to mini-B 5-pin (1.8M)”.

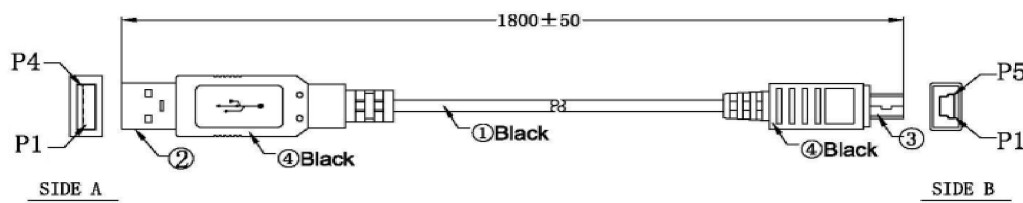


Figure4.1.4.1

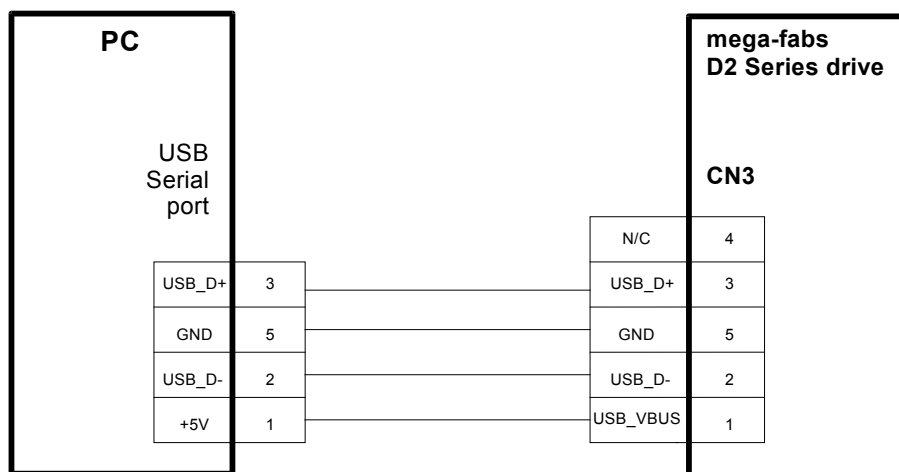


Figure4.1.4.2

4.1.5 CN4 Modbus communication

Use RS485 cable to connect with the host controller. By using the Modbus serial communication protocol, it can read and write drive parameters. All CN4 connectors of frame A-D models are Modbus communication ports, but their connector specifications are different. The Modbus communication cable must be AWG26/3-wire and double-shielded. It must comply with UL2464 standard and its copper braid must connect with the shell.

Note:

D2T models with frame A-C do not support the Modbus communication.

(1) Frame A-C

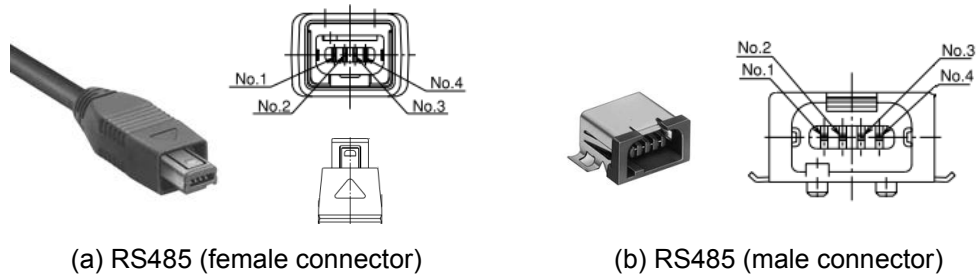


Figure4.1.5.1

Table4.1.5.1

PIN	Function	Description
1	DATA+	RS485 Modbus communication
2	DATA-	
3	N/A	Reserved
4	GND	Digital ground reference

(2) Frame D

Connector model: TE Connectivity 2040008-1 (female).



(a) RS485 (female connector) (b) RS485 (male connector)

Figure4.1.5.2

Table4.1.5.2

PIN	Function	Description
1	GND	Digital ground reference
2	N/A	Reserved
3	N/A	Reserved
4	N/A	Reserved
5	DATA1-	RS485 Modbus communication 1
6	DATA1+	
7	DATA2-	RS485 Modbus communication 2
8	DATA2+	

4.1.6 CN5 Modbus communication/safety function

CN5 connectors of frame A-C models are Modbus communication ports; while the CN5 connector of frame D model is the input of safety-function device. Check the pin assignment for each model before use.

(1) Frame A-C

They are Modbus communication ports. Refer to Section 4.1.5.

(2) Frame D

If the safety function is not used, connect the supplied safety jumper to CN5. When the safety jumper is not installed, the drive will not supply current to the motor, and the motor will not work normally.

Connector model: TE Connectivity 1971153-1 (female).



Figure4.1.6.1

Table 4.1.6.1

PIN	Function	Description
1		Not wiring.
2		Not wiring.
3	SF1-	Two independent circuits for turning off the operation signal of power module, so as to turn off the motor current.
4	SF1+	
5	SF2-	
6	SF2+	
7	EDM-	Output signal for monitoring the status of safety function.
8	EDM+	
Shell	FG	Frame ground reference.

4.1.7 CN6 control signal

For the pulse command and PWM command, the high-level input voltage should be greater than 2 V, and the low-level input voltage should be less than 0.8 V.

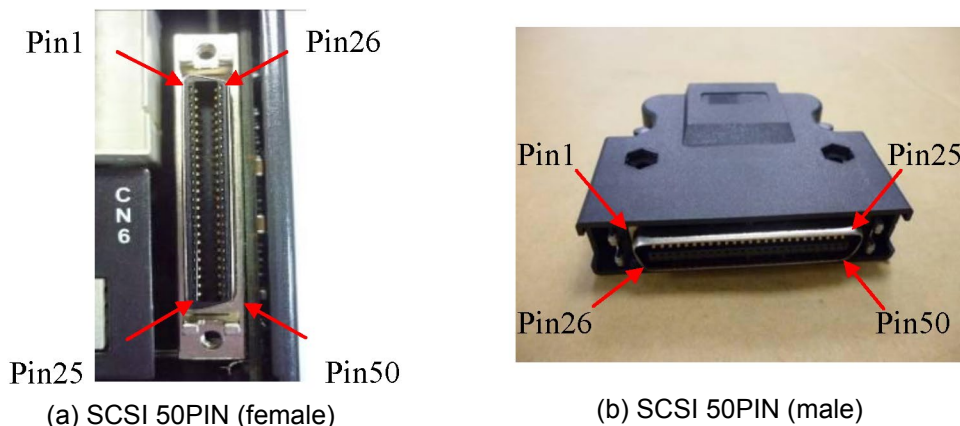


Figure4.1.7.1

■ CN6 pin assignment

Table4.1.7.1

Pin	Signal	Function
1	CWL	Low-speed (500 Kpps) pulse command Channel 1: Pulse, CW, A-phase
3	CWL+	
4	CWL-	
2	CCWL	Low-speed (500 Kpps) pulse command Channel 2: Dir, CCW, B-phase
5	CCWL+	
6	CCWL-	
13	SG	Ground reference for digital signal
21	A	Feedback pulse output (buffered encoder or emulated encoder) RS422
22	/A	
48	B	
49	/B	
23	Z	
24	/Z	
25	SG	Digital ground reference
19	CZ	Z-phase output (open collector)
14	ADC0+	Analog command input for the velocity/torque (+/- 10 V)
15	ADC0-	
16	ADC1+	N/A
17	ADC1-	
18	ADC2+	
20	ADC2-	
43	AO1	Analog voltage output (+/- 10V) for monitoring motor torque (only for D2T model)
42	AO2	Analog voltage output (+/- 10V) for monitoring motor speed (only for D2T model)
44	CWH+	High-speed (4 Mpps) pulse command

Pin	Signal	Function
45	CWH-	Channel 1: Pulse, CW, A-phase Maximum voltage: 12 V
46	CCWH+	High-speed (4 Mpps) pulse command
47	CCWH-	Channel 2: DIR, CCW, B-phase Maximum voltage: 12 V
7	COM	Common point for general-purpose input signal (Sink or Source)
33	I1	General-purpose input signal (programmable function)
30	I2	
29	I3	
27	I4	
28	I5	
26	I6	
32	I7	
31	I8	
9	I9	
8	N/A or I10	D2 model: N/A; D2T model: I10.
35	O1+	General-purpose output signal (programmable function)
34	O1-	
37	O2+	
36	O2-	
39	O3+	
38	O3-	
11	O4+	
10	O4-	
40	N/A or O5+	D2 model: N/A; D2T model with the frame A, B, or C: O5+; D2T model with the frame D: brake output/O5+.
12	N/A or O5-	D2 model: N/A; D2T model with the frame A, B, or C: O5-; D2T model with the frame D: brake output/O5-.
41	AGND	Analog ground reference
50	FG	Frame ground reference

4.1.8 CN7 encoder

Press and pull clamps on both sides to remove CN7 connector.

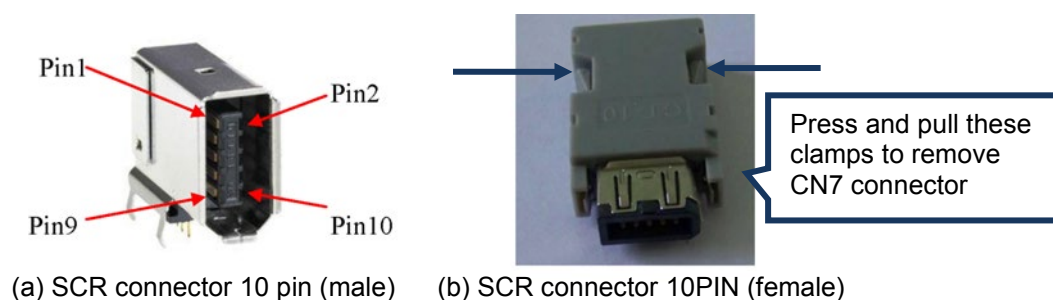


Figure4.1.8.1

Table4.1.8.1

Pin	Signal				Description
	13-bit incremental	17-bit incremental	17-bit absolute	Dual-loop architecture	
1	+5 Vdc	+5 Vdc	+5 Vdc	+5 Vdc	Encoder power output of +5 Vdc
2	SG	SG	SG	SG	Digital ground and ground for +5 Vdc
3	N/A	MA+	PS+	PS+	<ul style="list-style-type: none"> 17-bit incremental: timing output for serial communication (MA+, MA-) 17-bit absolute and dual-loop architecture: data transmission for serial communication (PS+, PS-)
4	N/A	MA-	PS-	PS-	
5	A	SL+	N/A	A	<ul style="list-style-type: none"> 13-bit incremental: digital signal transmission (A, /A, B, /B, Z, /Z) 17-bit incremental: data transmission for serial communication (SL+, SL-) Dual-loop architecture: digital signal transmission (Connecting to linear encoder)
6	/A	SL-	N/A	/A	
7	B	N/A	N/A	B	
8	/B	N/A	N/A	/B	
9	Z	N/A	N/A	Z	
10	/Z	N/A	N/A	/Z	
Shield	FG	FG	FG	FG	Frame ground reference

4.1.9 CN8 EtherCAT communication

To connect with the EtherCAT module, the connector of network cable should have the shielding protection.

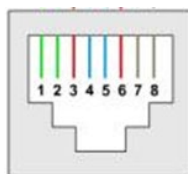


Figure4.1.9.1 CN8 connector

Table4.1.9.1 CN8 pin assignment

Pin	Signal	Function
1	TX+	Positive terminal of data transmit
2	TX-	Negative terminal of data transmit
3	RX+	Positive terminal of data receive
4	EtherCAT Gnd	EtherCAT signal ground
5	EtherCAT Gnd	EtherCAT signal ground
6	RX-	Negative terminal of data receive
7	EtherCAT Gnd	EtherCAT signal ground
8	EtherCAT Gnd	EtherCAT signal ground

4.1.10 CN13/CN14 extension I/O signal

CN13 and CN14 are 26-pin SCSI connectors.

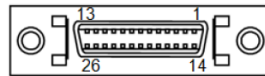


Figure4.1.10.1

Table4.1.10.1 Specification of extension I/O module

Connector	Function	Quantity	Specification
CN13 and CN14	Digital input	24	Suitable for power system between 9 and 28 Vdc.
	Digital output	12	Suitable for power system less than 24 Vdc. Maximum allowable current: 100 mA.

Table4.1.10.2

CN13			CN14		
Pin	Signal	Description	Pin	Signal	Description
1	DO 1+	Positive terminal of digital output 1	1	DO 7+	Positive terminal of digital output 7
2	DO 1-	Negative terminal of digital output 1	2	DO 7-	Negative terminal of digital output 7
3	DO 2+	Positive terminal of digital output 2	3	DO 8+	Positive terminal of digital output 8
4	DO 2-	Negative terminal of digital output 2	4	DO 8-	Negative terminal of digital output 8
5	DO 3+	Positive terminal of digital output 3	5	DO 9+	Positive terminal of digital output 9
6	DO 3-	Negative terminal of digital output 3	6	DO 9-	Negative terminal of digital output 9
7	DO 4+	Positive terminal of digital output 4	7	DO 10+	Positive terminal of digital output 10
8	DO 4-	Negative terminal of digital output 4	8	DO 10-	Negative terminal of digital output 10
9	DO 5+	Positive terminal of digital output 5	9	DO 11+	Positive terminal of digital output 11
10	DO 5-	Negative terminal of digital output 5	10	DO 11-	Negative terminal of digital output 11
11	DO 6+	Positive terminal of digital output 6	11	DO 12+	Positive terminal of digital output 12
12	DO 6-	Negative terminal of digital output 6	12	DO 12-	Negative terminal of digital output 12
14	DI 1	Digital input 1	14	DI 13	Digital input 13
15	DI 2	Digital input 2	15	DI 14	Digital input 14
16	DI 3	Digital input 3	16	DI 15	Digital input 15
17	DI 4	Digital input 4	17	DI 16	Digital input 16
18	DI 5	Digital input 5	18	DI 17	Digital input 17
19	DI 6	Digital input 6	19	DI 18	Digital input 18
20	DI 7	Digital input 7	20	DI 19	Digital input 19
21	DI 8	Digital input 8	21	DI 20	Digital input 20
22	DI 9	Digital input 9	22	DI 21	Digital input 21
23	DI 10	Digital input 10	23	DI 22	Digital input 22
24	DI 11	Digital input 11	24	DI 23	Digital input 23
25	DI 12	Digital input 12	25	DI 24	Digital input 24
13	COM+/-	Input common point of (allowed for positive or negative)	13	COM+/-	Input common point (allowed for positive or negative)
26	COM+/-		26	COM+/-	

4.2 Drive accessories

■ Motor power cable

Table4.2.1

Part Name	Part No.	Description
Motor power cable	HVPS04AA□□MB	Suitable for 50 W - 750 W motor, without brake, flexible.
	HVPM04BA□□MB	Suitable for 1KW motor, without brake, straight connector, flexible.
	HVPM04BB□□MB	Suitable for 2KW motor, without brake, straight connector, flexible.
	HVPM04CA□□MB	Suitable for 1KW motor, without brake, L-type connector, flexible.
	HVPM04CB□□MB	Suitable for 2KW motor, without brake, L-type connector, flexible.
	HVPS06AA□□MB	Suitable for 50 W - 750 W motor, with brake, flexible.
	HVPM06BA□□MB	Suitable for 1KW motor, with brake, straight connector, flexible.
	HVPM06BB□□MB	Suitable for 2KW motor, with brake, straight connector, flexible.
	HVPM06CA□□MB	Suitable for 1KW motor, with brake, L-type connector, flexible.
	HVPM06CB□□MB	Suitable for 2KW motor, with brake, L-type connector, flexible.

□□ denotes the cable length as follows:

Table4.2.2

□□	03	05	07	10
Cable Length (m)	3	5	7	10

■ Encoder cable

Table4.2.3

Part Name	Part No.	Description
Encoder cable	HVE13IAB□□MB	Suitable for 50 W - 750 W motor, 13-bit incremental, flexible.
	HVE13IBB□□MB	Suitable for 1 KW - 2 KW motor, 13-bit incremental, straight connector, flexible.
	HVE13ICB□□MB	Suitable for 1 KW - 2 KW motor, 13-bit incremental, L-type connector, flexible.
	HVE17IAB□□MB	Suitable for 50 W - 750 W motor, 17-bit incremental, flexible.
	HVE17IBB□□MB	Suitable for 1 KW - 2 KW motor, 17-bit incremental, straight connector, flexible.
	HVE17ICB□□MB	Suitable for 1 KW - 2 KW motor, 17-bit incremental, L-type connector, flexible.
	HVE17AAB□□MB	Suitable for 50 W - 750 W motor, 17-bit absolute, flexible.
	HVE17ABB□□MB	Suitable for 1 KW - 2 KW motor, 17-bit absolute, straight connector, flexible.
	HVE17ACB□□MB	Suitable for 1 KW - 2 KW motor, 17-bit absolute, L-type connector, flexible.
	HE00817DR300	3 m in length, suitable for frame A-C models with the dual-loop encoder, flexible.

□□ denotes the cable length as follows:

Table4.2.4

□□	03	05	07	10
Wire Length (m)	3	5	7	10

Note:

The encoder cable shall be chosen to match with the motor encoder.

■ Control signal cable

Table4.2.5

Part Name	Part No.	Description
Control signal cable	LMACK02D	2 m in length. Connected to host controller. The cable at the controller terminal is free and can be soldered to make the connector based on the connector of host controller.
Extension I/O signal cable	HE00834S1200	3 m in length. Connected to host controller. The cable at the controller terminal is free and can be soldered to make the connector based on the connector of host controller.

■ Communication cable

Table4.2.6

Part Name	Part No.	Description
USB communication cable	051700800366	USB 2.0 Type A to mini-B 5 pin. 1.8 m in length. The cable at the drive terminal is the mini-B connector.
Modbus communication cable	HE00834S0800	0.3 m in length. Suitable for frame A-C models.
	HE00834S0900	1 m in length. Suitable for frame A-C models.
	HE00834S1000	2 m in length. Suitable for frame A-C models.
	HE00834S1100	3 m in length. Suitable for frame A-C models.
	HE00834S1300	0.3 m in length. Suitable for the frame D model.
	HE00834S1400	1 m in length. Suitable for the frame D model.
	HE00834S1500	2 m in length. Suitable for the frame D model.
	HE00834S1600	3 m in length. Suitable for the frame D model.

■ Connector kit

Table4.2.7

D2 Drive Model	Model No.	Description	Quantity
Frame A-C	D2-CK3	CN1: Connectors of AC power, motor power, regenerative resistor, and control power. 12 pins, pitch 5 mm, Wago 721-112/026-000.	1
		CN2: Brake connector. 4 pins, pitch 3.5 mm	1
		CN6: Control signal connector. 50 pins, welded type, EUMAX XDR-10350AS.	1
		CN1 connector fixture tool: Wago 231-131.	1
		CN2 connector fixture tool: Wago 734-230.	1
Frame D (with Modbus interface)	D2-CK4	CN1: Connectors of AC power, drive control power, regenerative resistor, and DC reactor. 11 pins, TE 1-2229794-1-PT1.	1
		CN2: Motor power connector. 3 pins, TE 3-22297894-1.	1
		CN4: Connector kit for serial communication. TE 2040008-1.	1
		CN5: Safety function connector. TE 1971153-1.	1
		CN6: Control signal connector. 50 pins, welded type, EUMAX XDR-10350AS.	1
		CN1 and CN2 connector fixture tools: TE 1981045-1.	2
Frame D	D2-CK5	CN1: Connectors of AC power, drive control power, regenerative resistor, and DC reactor. 11 pins, TE 1-2229794-1-PT1.	1
		CN2: Motor power connector. 3 pins, TE 3-22297894-1.	1
		CN5: Safety function connector. TE 1971153-1.	1
		CN6: Control signal connector. 50 pins welded type, EUMAX XDR-10350AS.	1
		CN1 and CN2 connector fixture tools: TE 1981045-1.	2

■ EMC accessory kit

Table4.2.8

Part Name	Model No.	Description	Quantity
D2 EMC accessory kit for single phase	D2-EMC1	Single-phase filter: FN2090-6-06 for 50 W to 400 W. (Rated current: 6 A, leakage current: 0.67 mA)	1
		EMI core KCF-130-B.	2
	D2-EMC3	Single-phase filter FN2090-10-06 for 750 W to 1 KW. (Rated current: 10 A, leakage current: 0.67 mA)	1
		EMI core KCF-130-B	2
D2 EMC accessory kit for three-phase	D2-EMC2	Three-phase filter: FN3025HL-20-71. (Rated current: 20 A, leakage current: 0.4 mA)	1
		EMI core KCF-130-B.	2
	D2-EMC4	Three-phase filter B84743C0035R166. (Rated current: 35 A, leakage current: < 0.5 mA)	1
		EMI core KCF-130-B	2

Note:

The EMI magnetic ring can reduce the noise interference, and can be applied on the main power cable, motor power cable, encoder cable, or pulse control cable based on demand.

■ Regenerative resistor

Table4.2.9

Part Name	Model No.	Resistance Value	Rated Power/Peak Power
Regenerative resistor	RG1	68 Ω	100W/500W
	RG2	120 Ω	300W/1500W

■ Connector specifications

Table4.2.10 Connector specifications for frame A-C models

Connector	Specifications	HIWIN Parts No.	Wire Diameter	Remarks
AC main power cable (CN1)	EU 12-pin 5.0 mm pluggable female connector	051500400269 WAGO: 2092-1112	12-24 AWG Recommended: 12 AWG/600 V	(Note 1)
Motor power cable (CN1)				
Regenerative resistor (CN1)				
Control power cable (CN1)				
Control signal cable (CN6)	50-pin, .050" Mini D Ribbon (MDR), standard solder connector	051500400272 SCSI 50 pin (male)	24-30 AWG	(Note 1)
Encoder cable (CN7)	HIWIN standard encoder cable			
Brake signal (CN2)	EU 3-pin 2.5 mm pluggable female connector	051500400251 WAGO: 733-103	20-28 AWG	Fixture tool: 733-130 (Note 1)
Mini USB communication (CN3)	USB 2.0 Type A to mini-B 5 pin (1.8 m) (Shielding)	051700800366		Optional

Note:

- (1) The accessory kit includes connectors of CN1, CN2, and CN6 (with 733-130 fixture tool). HIWIN P/N: 051800200070.
- (2) Turn off all power and use fixture tools to avoid electric shock at wiring.

Table4.2.11 Connector specifications for the frame D model

Connector	Specifications	HIWIN Parts No.	Wire Diameter
AC main power (CN1)	D3950/single-row 11 Port/ 7.5 mm/Line end/X key	051500400573 TE Connectivity 1-2229794-1	22-14 AWG Recommended: 14 AWG/600 V
Control power (CN1)			
Regenerative resistor (CN1)			
DC reactor (CN1)			
Motor power cable (CN2)	D3950/single-row 3 Port/ 7.5 mm/Line end/X key	051500400572 TE Connectivity 3-2229794-1	22-14 AWG Recommended: 14 AWG/600 V
RS485 communication (CN4)	Industrial mini I/O plug connector kit D-shape type 2	051500400544 TE Connectivity 2040008-1	24-14 AWG
Safety bypass (CN5)	Industrial mini I/O bypass connector type 1	051500400545 TE Connectivity 1971153-1	

4.3 Main power wiring

⚠ CAUTION

- ◆ Wiring and the related inspection must be done by the professional technician.
- ◆ Turn off the power before the wiring or inspection to avoid electric shock and other dangers.
- ◆ After the power is turned off, do not touch power terminals for a short time period (at least 5 minutes), since the power in the drive remains high.
- ◆ Perform wiring correctly and reliably; otherwise it may cause uncontrolled motor operation, personnel injury, machine malfunction, or other unexpected accidents.
- ◆ Do not make any modification to the drive.

4.3.1 AC power wiring (single-phase)

It is recommended to use the single-phase filter model of FN2090-6-06 for 50 W - 400 W motors, and FN2090-10-06 for 750 W - 1 KW motors.

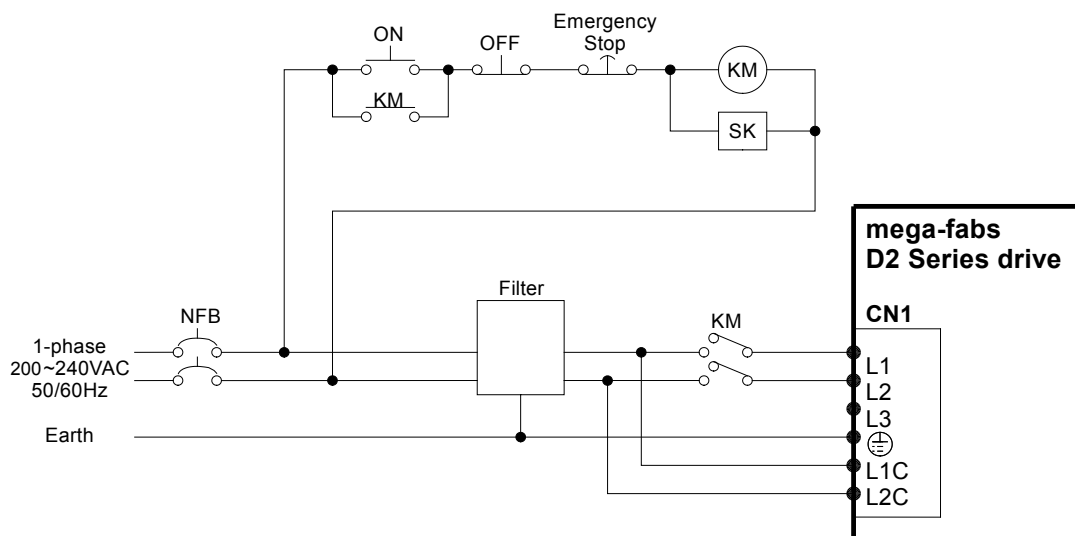


Figure4.3.1.1

Table4.3.1.1

FN2090-6-06 Filter	
Maximum continuous operation voltage	250 Vac, 50/60 Hz
Operation frequency	DC to 400 Hz
Rated current	1 to 30 A @40°C
Surge pulse protection	2 KV, IEC 61000-4-5

4.3.2 AC power wiring (three-phase)

It is recommended to use the three-phase filter of FN3025HL-20-7.

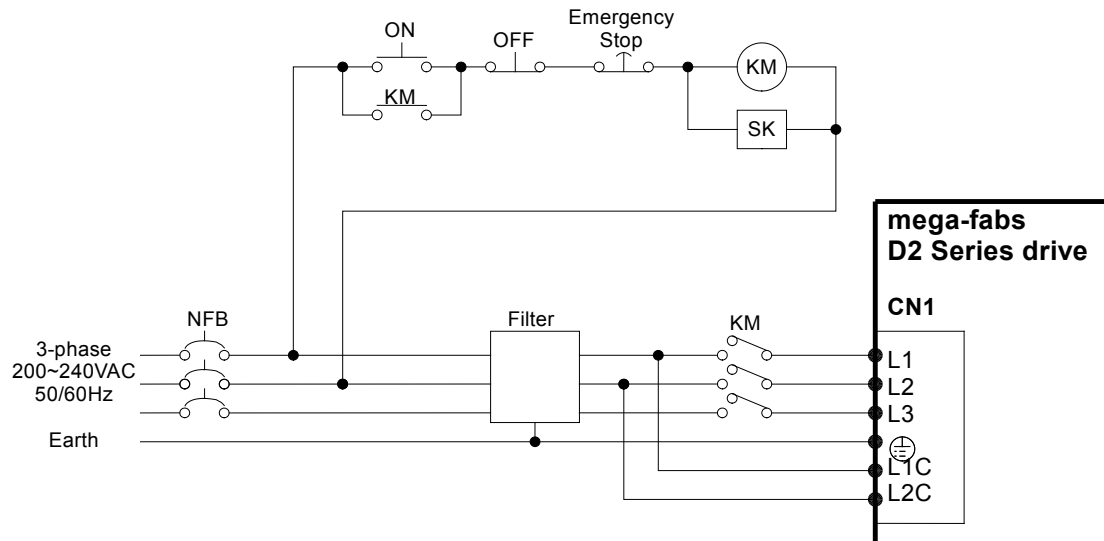


Figure4.3.2.1

Table4.3.2.1

FN3025HL-20-71 Filter	
Maximum continuous operation voltage	3 x 520/300 Vac
Operation frequency	DC to 60 Hz
Rated current	10 to 50 A @50°C

4.4 Multiple drives connection

Do not use the power connector on the drive to connect the power supply between drives in parallel.

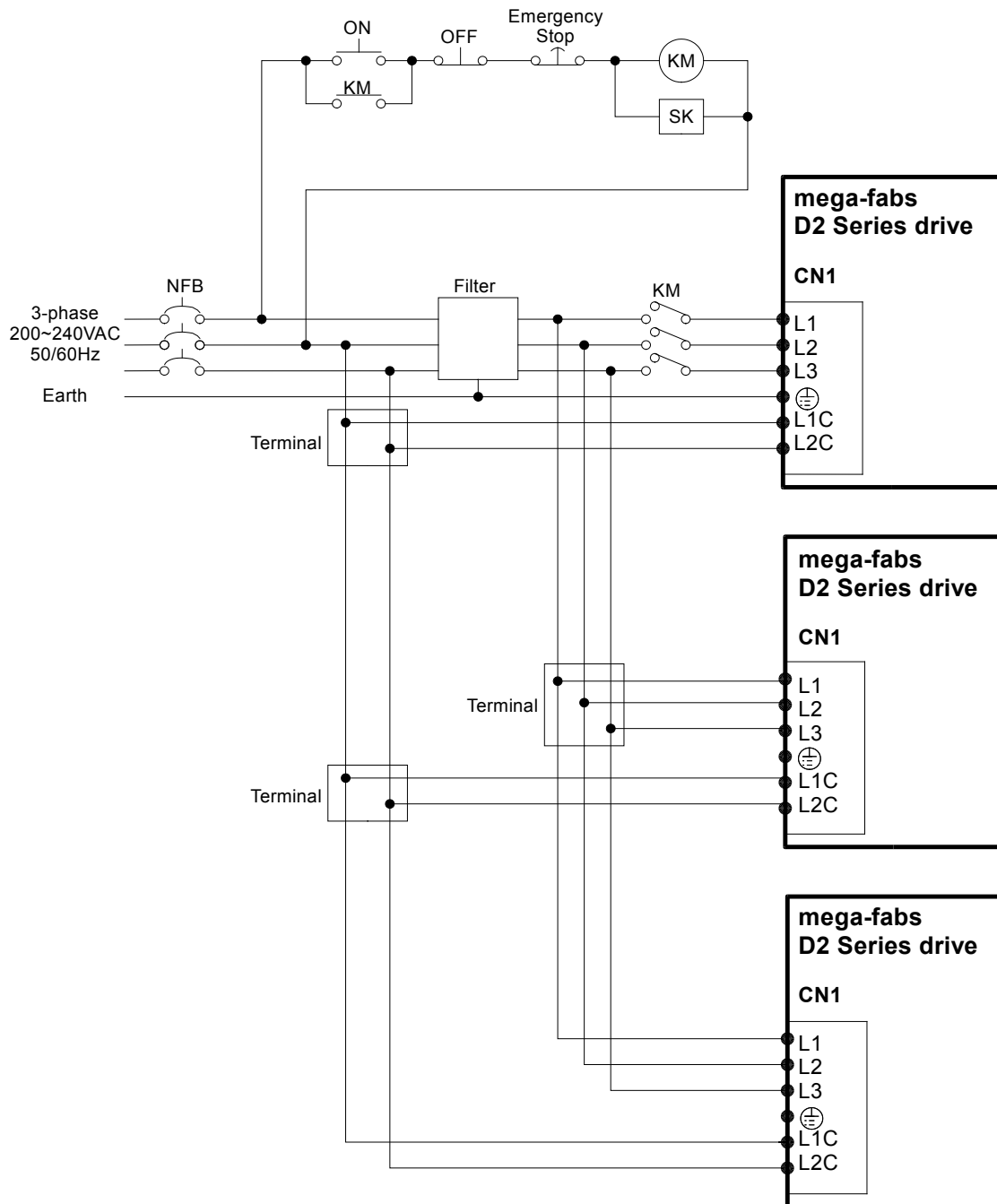


Figure4.4.1

■ Selection of no-fuse breakers (NFBs)

When NFB is used in the drive shunt, its rated capacity is usually 1.5 - 2.5 times the rated motor current in principle. The selection method is described as follows:

One drive: $I_B = C \times I_n$.

Two or more drives not started at the same time: $I_B = (\sum I_n - I_{nMAX}) \times K + C_{MAX} \times I_{nMAX}$.

Two or more drives started at the same time: $I_B = C_1 \times I_{n1} + C_2 \times I_{n2} + \dots + C_N \times I_{nN}$.

Note:

I_B : Rated NFB current;

I_n : Rated drive current;

I_{nMAX} : The maximum rated current among different drives;

C : Multiple of rated current, usually 1.5 - 2.5, or 1.5 if it cannot be determined;

C_{max} : Multiple of rated current for the maximum rated current among drives;

K : Demand rate; 1 if it cannot be determined.

Example:

If five D2-0123-◇-A◇ and one D2-0423-◇-B◇ drives are used,
(assuming that C and C_{MAX} are 2)

Not started at the same time: $I_B = (1.5 \times 5 + 4.1 - 4.1) \times 1 + 4.1 \times 2 = \underline{15.7} A_{rms}$.

Started at the same time: $I_B = 2 \times 1.5 + 2 \times 1.5 + 2 \times 1.5 + 2 \times 1.5 + 2 \times 1.5 + 2 \times 4.1 = \underline{23.2} A_{rms}$.

Table4.4.1 Rated current of D2-series drives

Drive Model Name	Rated Input Current
D2◇-0123-◇-A□	1.5 A_{rms}
D2◇-0423-◇-B□	4.1 A_{rms}
D2◇-1023-◇-C□	7.5 A_{rms}
D2T-2033-◇-D□	10.5 A_{rms}

4.5 I/O signal wiring

D2 model provides 9 general-purpose inputs and 4 general-purpose outputs on CN6 connector; while D2T model provides 10 general-purpose inputs and 5 general-purpose outputs on CN6 connector. Users can configure the function of each I/O by using the software. In this section, take D2 model as an example. The wiring method for D2T model is the same as that for D2 model.

4.5.1 Digital input wiring

General-purpose inputs of D2-series drives adopt the optical-coupler input interface suitable for the voltage system of 12 - 24 Vdc. D2 (D2T) model has the total of 9 (10) general-purpose inputs with one COM port and suitable for Sink or Source connection at the same time. The default function of I3 is "Axis Enable". Others can be set by using the human-machine interface (HMI) based on the user's requirement.

4.5.1.1 Sink input wiring examples

- Input wiring example via switches or relays

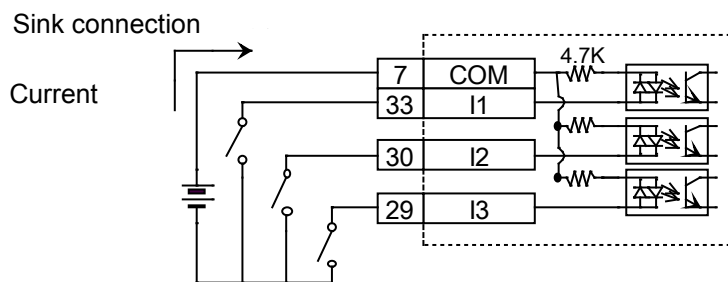


Figure4.5.1.1.1

- Input wiring example via transistors

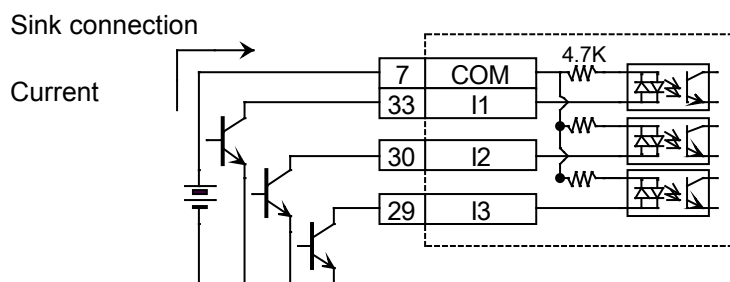


Figure4.5.1.1.2

4.5.1.2 Source input wiring examples

■ Input wiring example via switches or relays

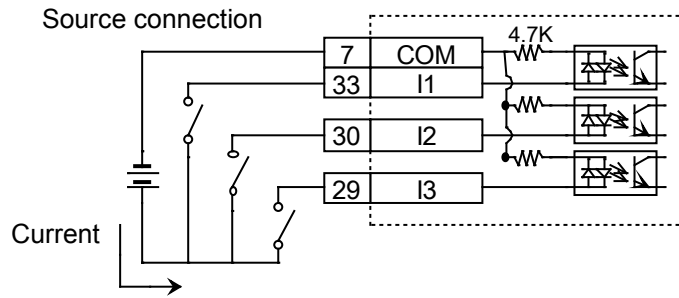


Figure4.5.1.2.1

■ Input wiring example via transistors

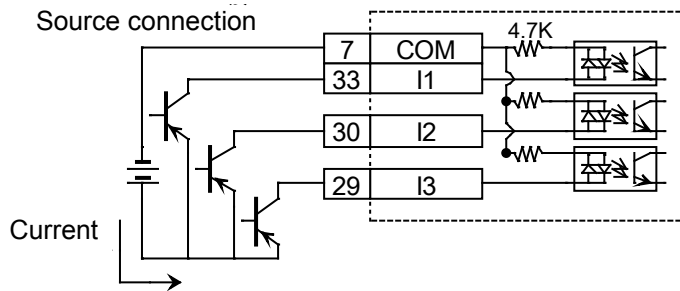


Figure4.5.1.2.2

4.5.2 Digital output wiring

General-purpose outputs of D2-series drive adopt the output interface of optical-coupler Darlington suitable for the voltage system of less than 24 Vdc. D2 (D2T) model has 4 (5) general-purpose outputs. Each output has an independent Darlington open-collector circuit. The maximum allowable current is 100 mA. Users can configure the function of each output by using the software.

Note:

When O5 of frame D model is set to brake signal output, it is necessary to connect to a relay to control the motor brake, since its maximum allowable current is 100 mA.

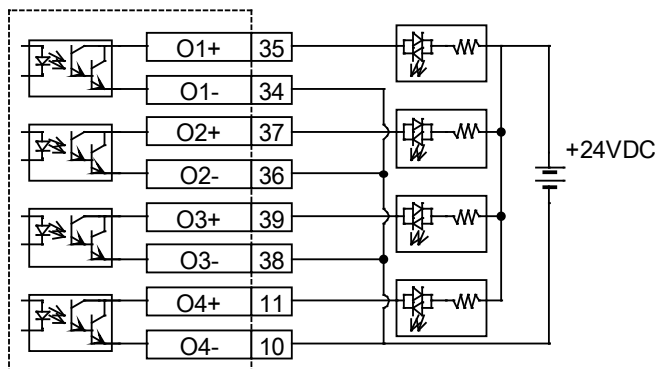


Figure4.5.2.1

■ Output wiring example via relays

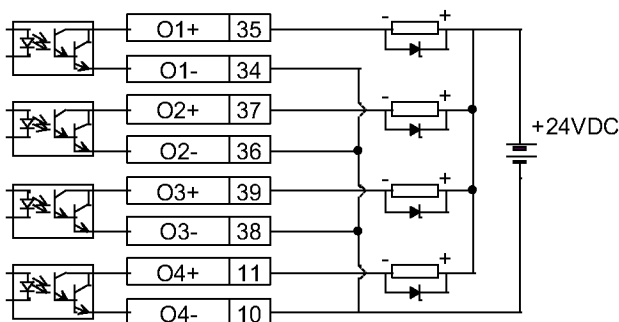


Figure4.5.2.2

■ Output wiring example via optical couplers

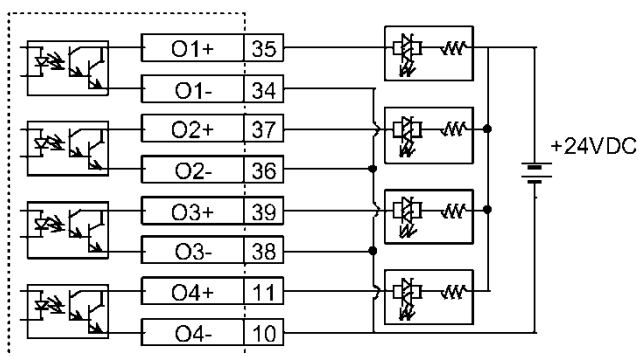


Figure4.5.2.3

4.6 Wiring examples for control commands

4.6.1 System wiring diagram for pulse command

The position mode can accept three formats of pulse command from the host controller. Refer to Section 3.1.1 for more information.

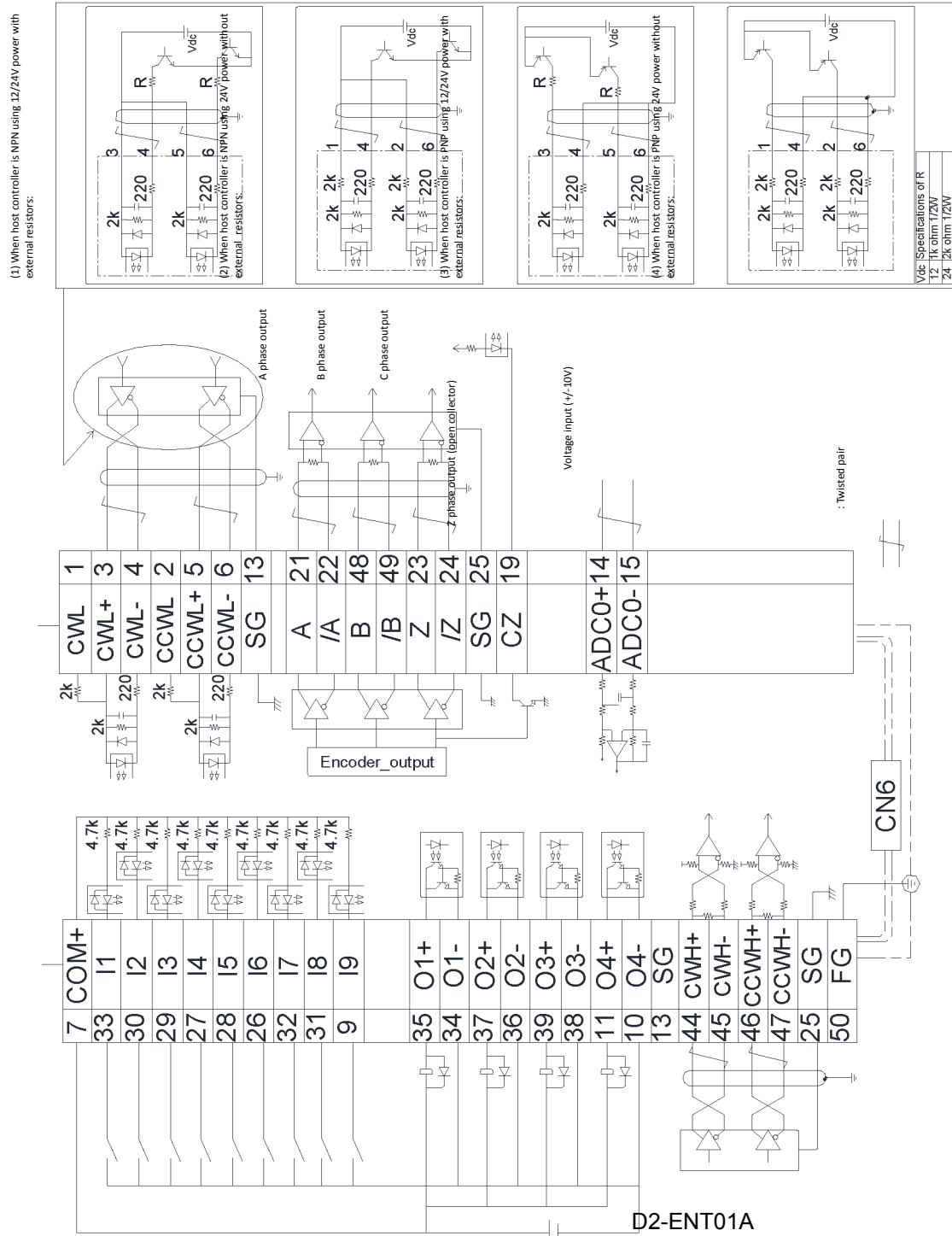


Figure 4.6.1.1

4.6.1.1 Differential interface for high-speed pulse

Wiring example for the host controller having the differential interface for high-speed pulse:

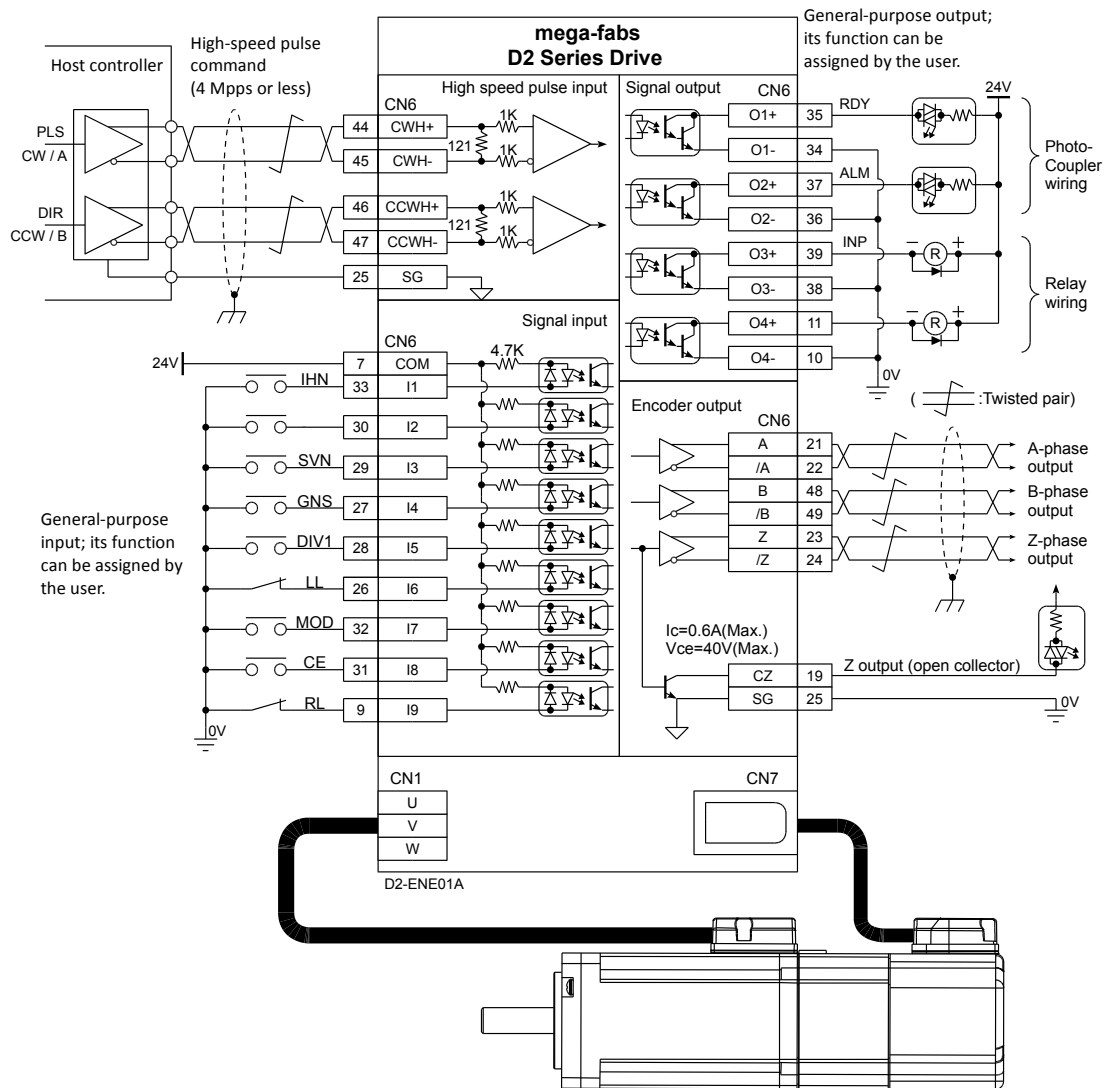


Figure4.6.1.1.1

4.6.1.2 Differential interface for low-speed pulse

Wiring example for the host controller having the differential interface for low-speed pulse:

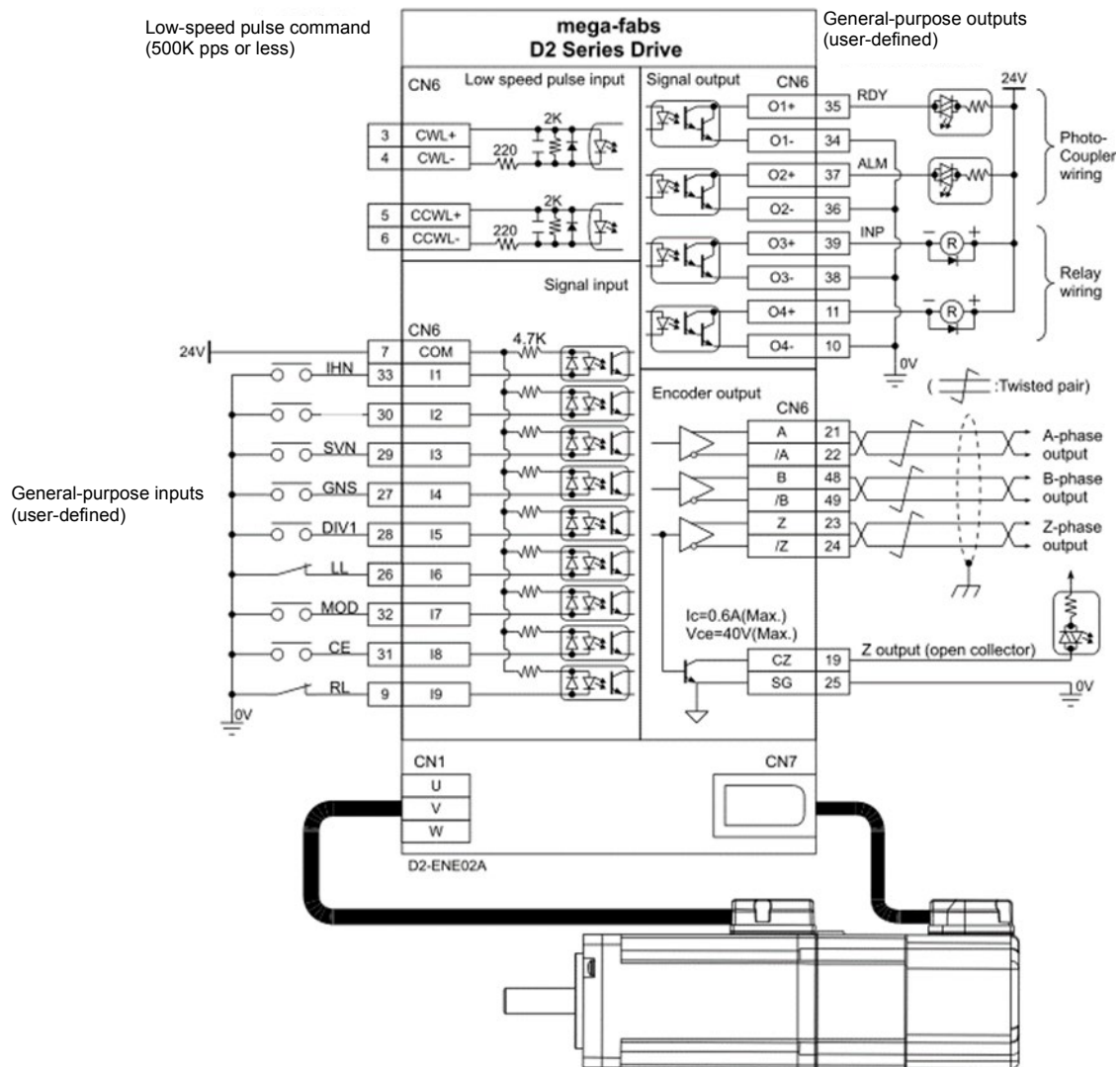


Figure4.6.1.2.1

4.6.1.3 Sink (NPN) interface with current-limit resistances

Wiring example for the host controller having the NPN interface with current-limit resistances:

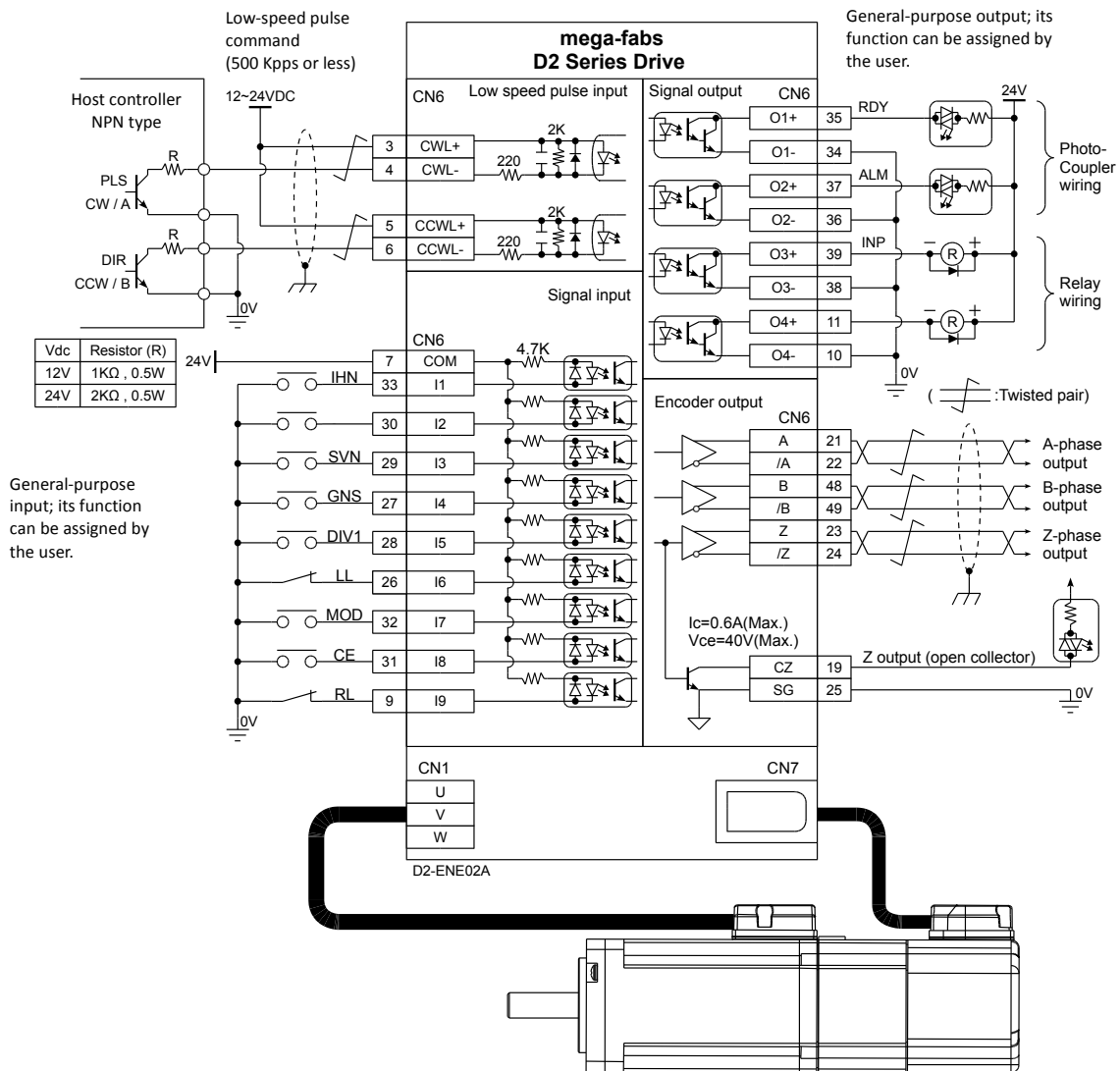


Figure4.6.1.3.1

4.6.1.4 Sink (NPN) interface without current-limit resistances

Wiring example for the host controller having the NPN interface without current-limit resistances:

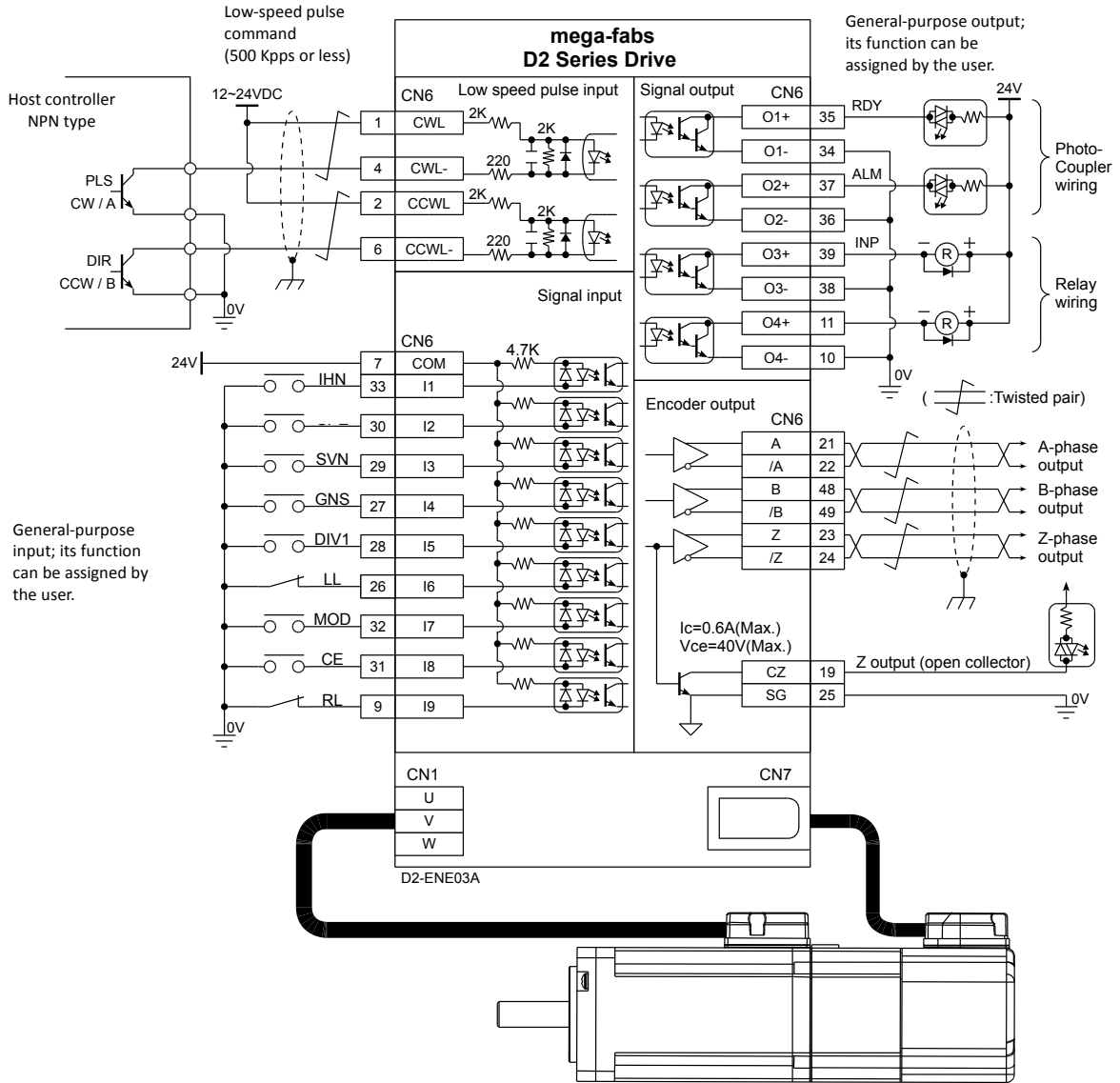


Figure4.6.1.4.1

4.6.1.5 Source (PNP) interface with current-limit resistances

Wiring example for the host controller having the PNP interface with current-limit resistances:

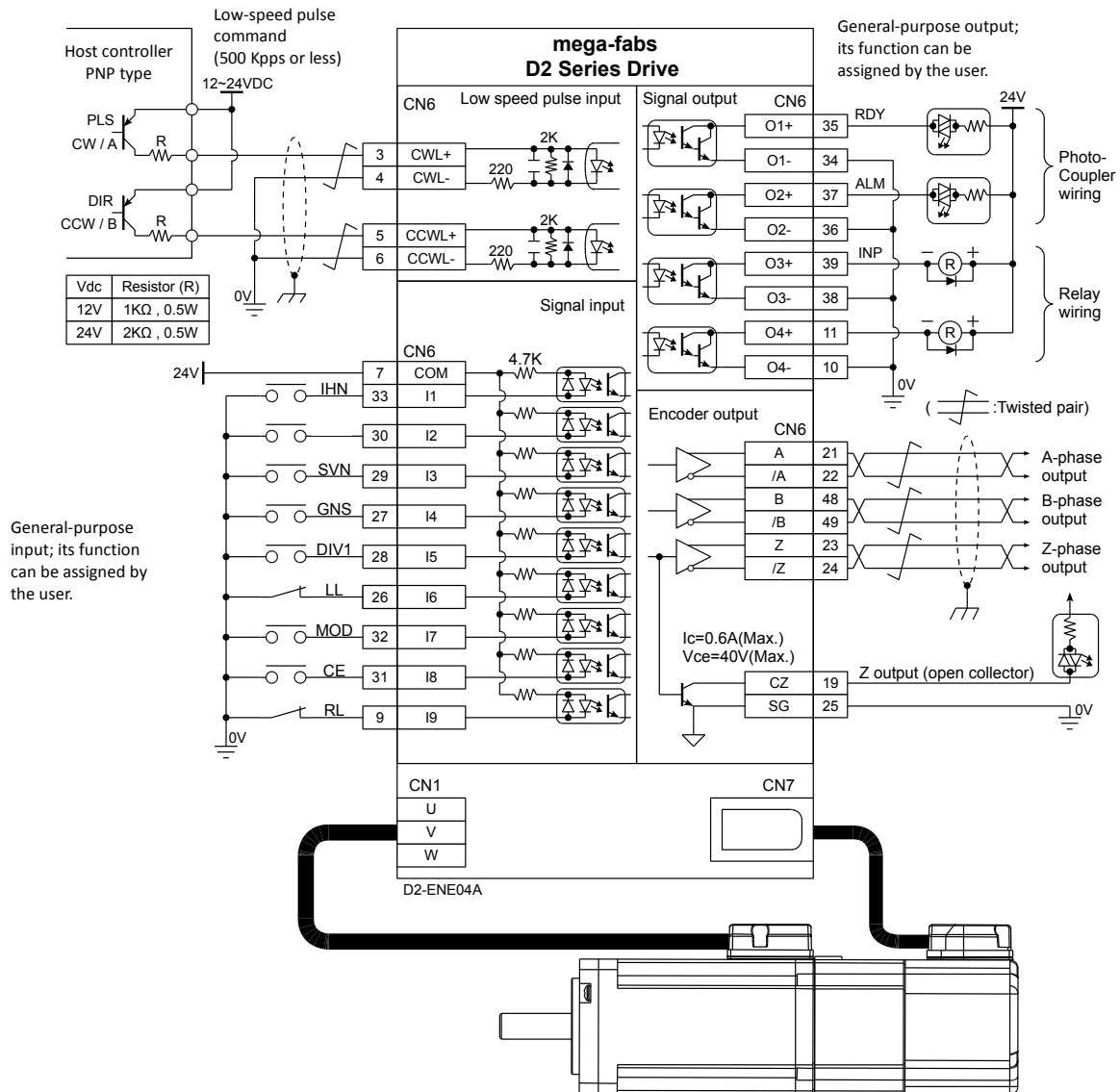


Figure4.6.1.5.1

4.6.1.6 Source (PNP) interface without current-limit resistances

Wiring example for the host controller having the PNP interface without current-limit resistances:

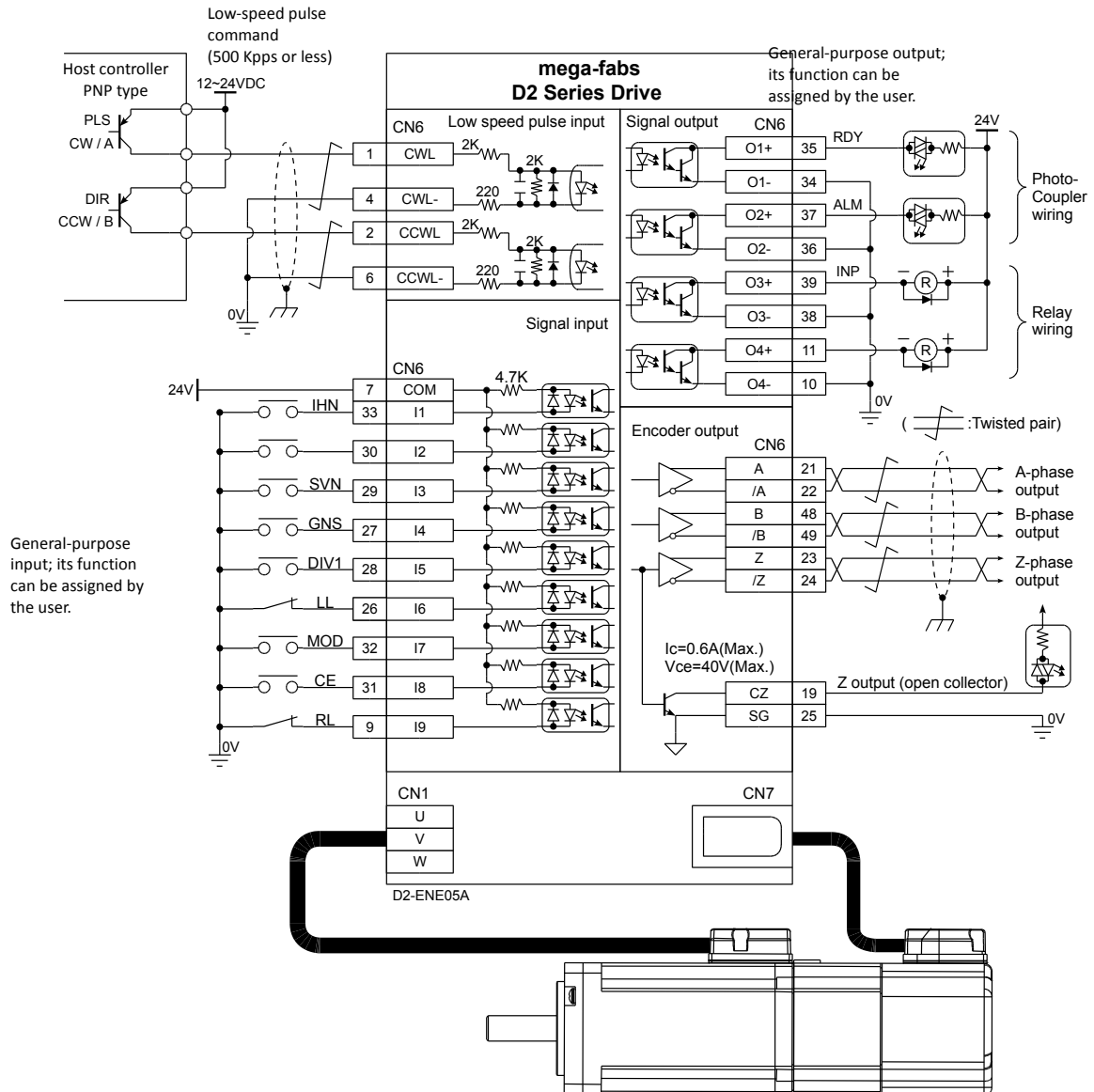


Figure4.6.1.6.1

4.6.1.7 5V TTL interface

Wiring example for the host controller having the 5V TTL interface:

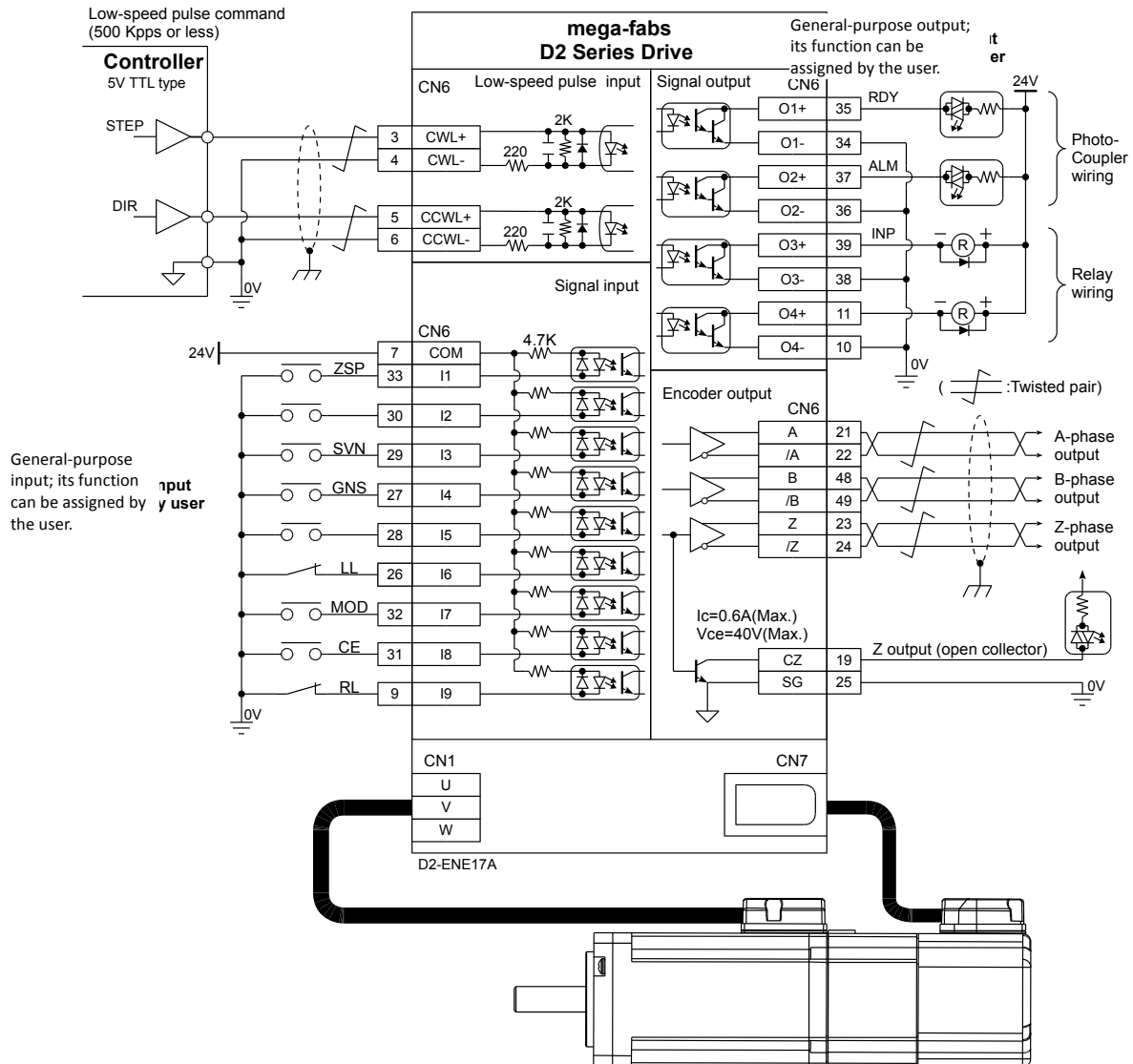
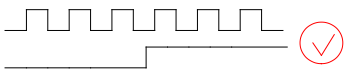
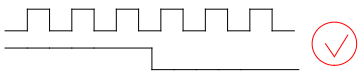
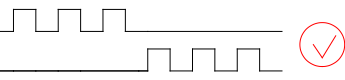
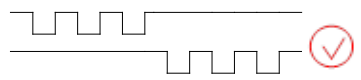
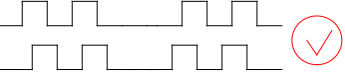
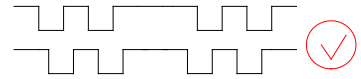


Figure 4.6.1.7.1

Note:

The signal logic of pulse command accepted by D2 drive is shown as follows.

Table4.6.1.7.1

Pulse Command	Positive Logic	Negative Logic
Pulse Dir		
CW CCW		
A B		

If the pulse command of host controller is the single-ended negative logic CW/CCW signal, it can be converted to the positive logic CW/CCW signal by using the following wiring.

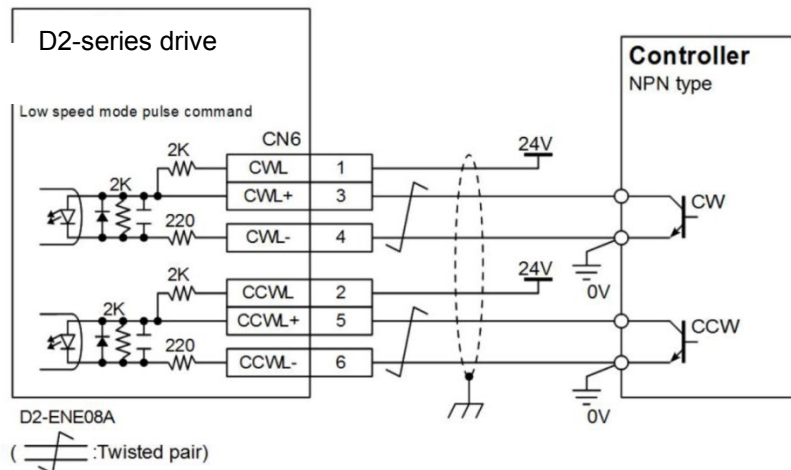


Figure4.6.1.7.2 Wiring for converting the single-ended negative logic to positive logic CW/CCW signal

4.6.2 System wiring diagram for voltage command

The drive can accept the voltage command form the host controller in the velocity and force/torque modes. Refer to Sections 3.1.2 and 3.1.3 for more information.

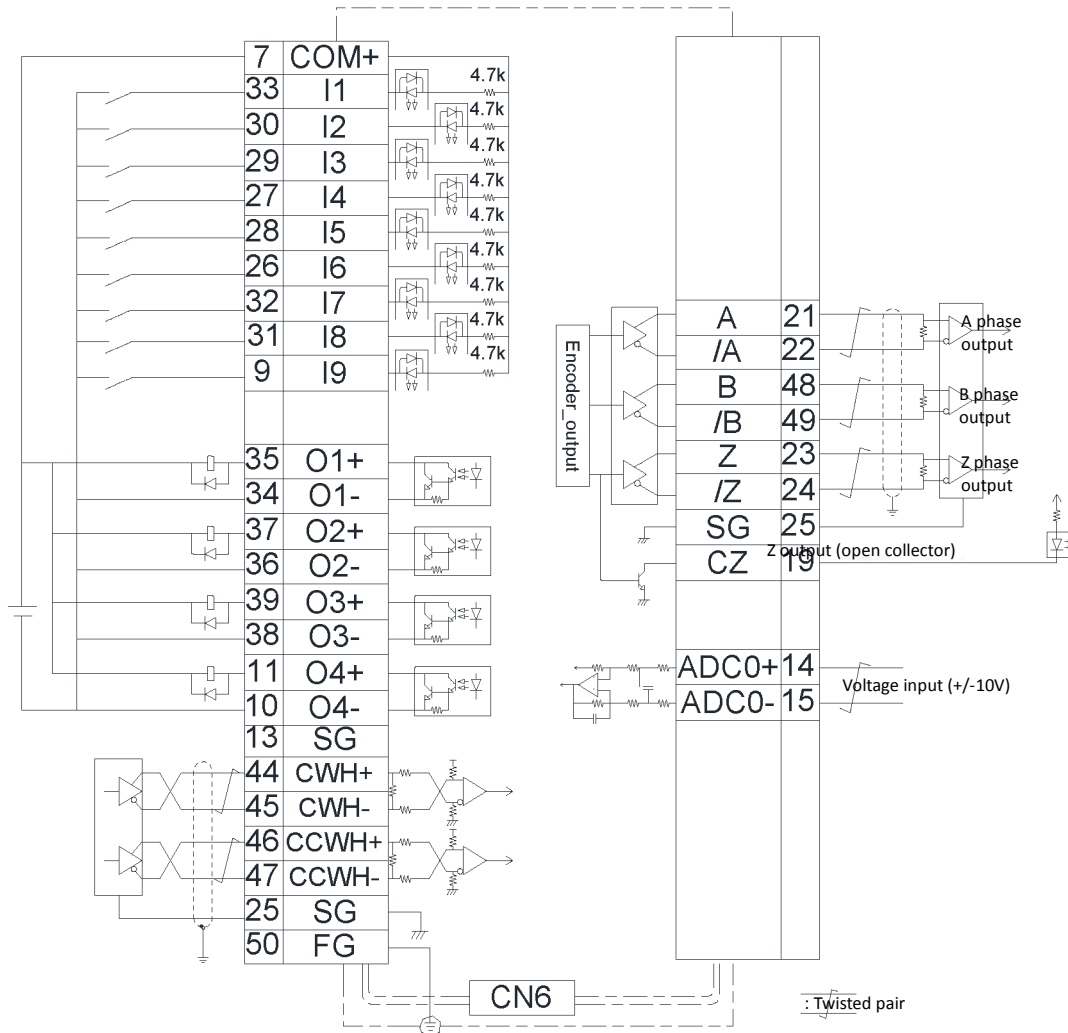


Figure4.6.2.1

Wiring example for the host controller having the interface of -10 V to +10 V:

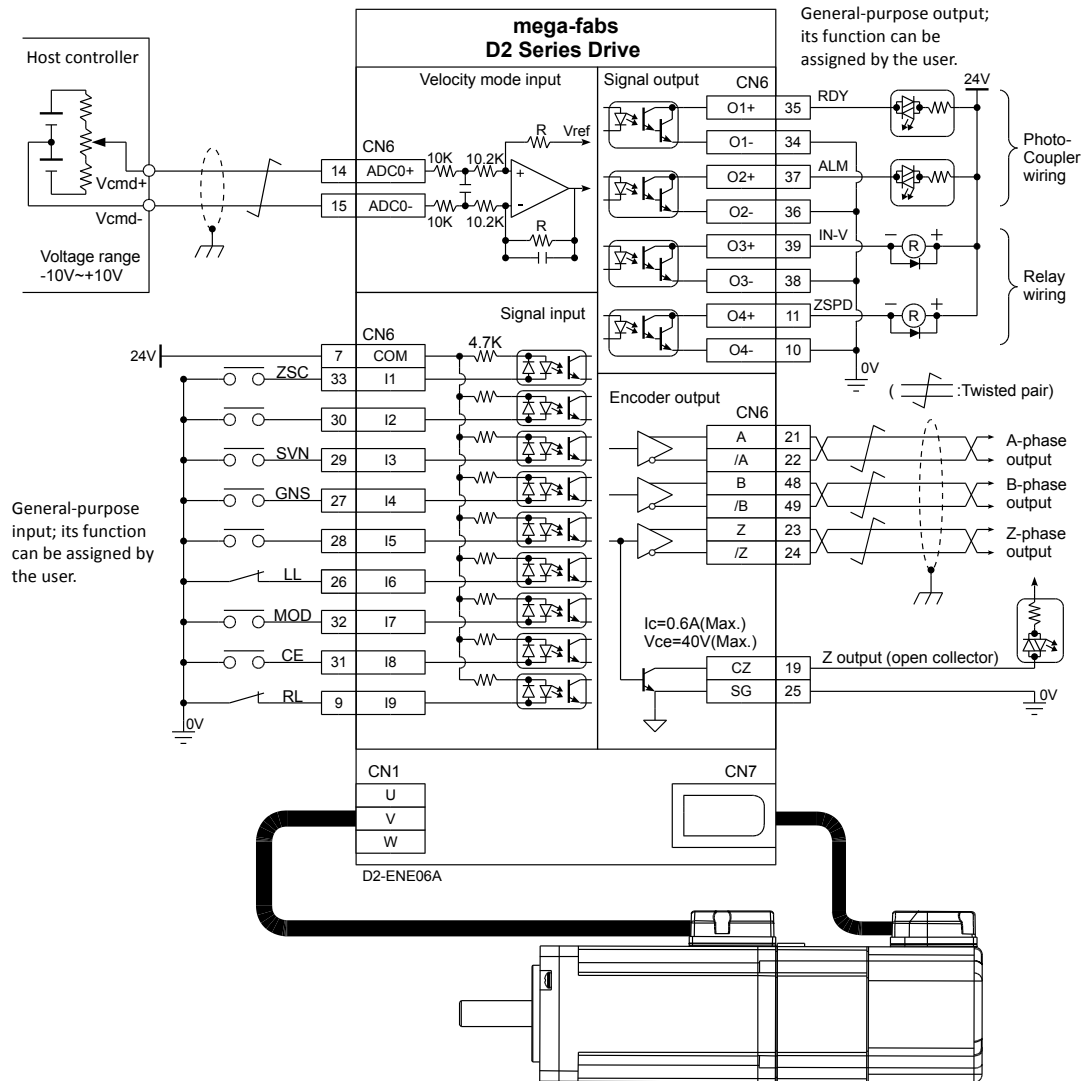


Figure4.6.2.2

4.6.3 System wiring diagram for PWM command

In addition to analog voltage command, D2-series drives can also accept the PWM command in the velocity and force/torque modes. The PWM command is classified into single-wire (PWM 50%) and two-wire (PWM 100%) types. Refer to Sections 3.1.2 and 3.1.3 for more information.

4.6.3.1 NPN interface with PWM 50%

Wiring example for the host controller having the NPN interface with PWM 50%:

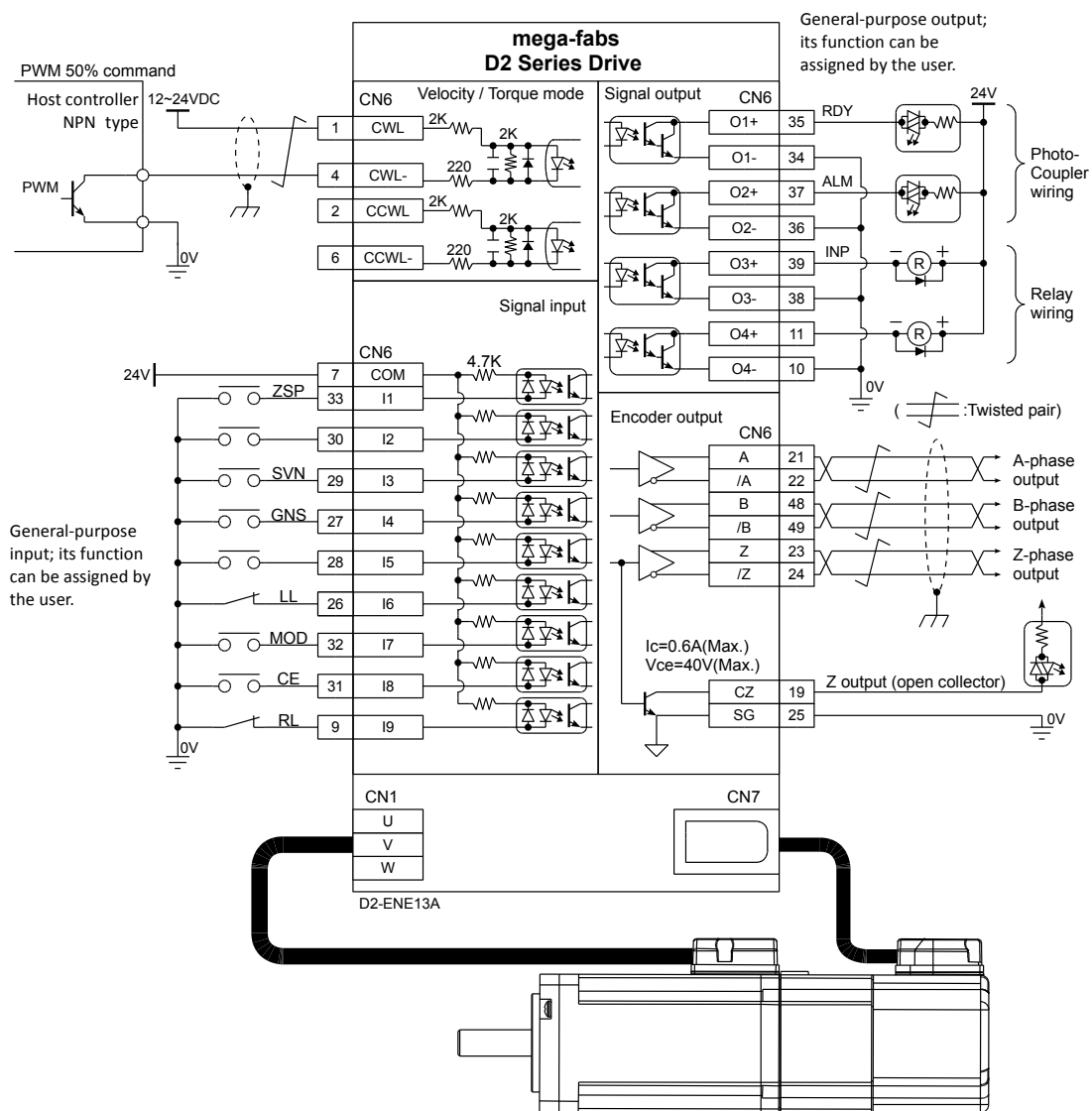


Figure4.6.3.1.1

4.6.3.2 NPN interface with PWM 100%

Wiring example for the host controller having the NPN interface with PWM 100%:

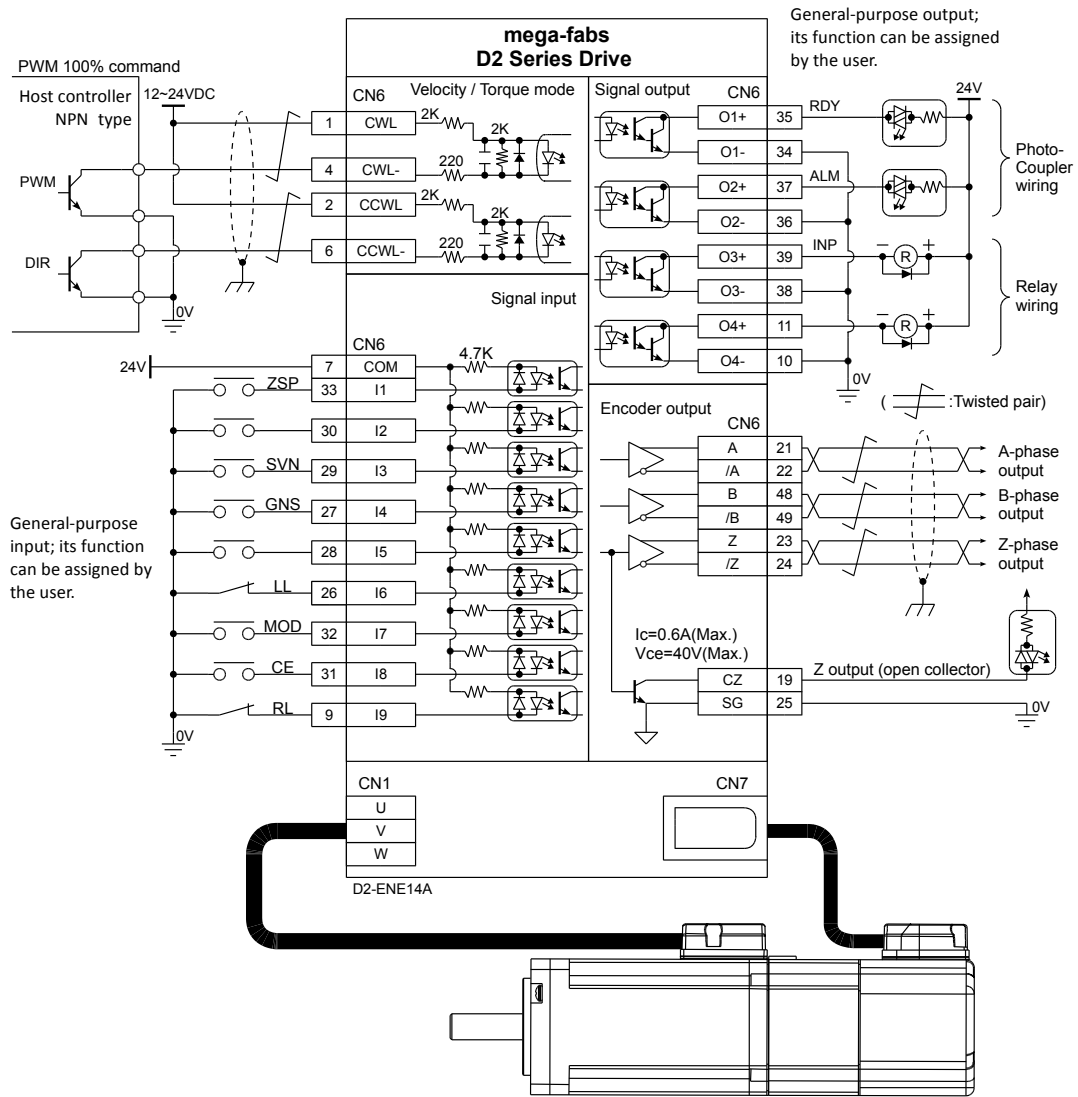


Figure4.6.3.2.1

4.6.3.3 5V TTL interface with PWM 50%

Wiring example for the host controller having the 5V TTL interface with PWM 50%:

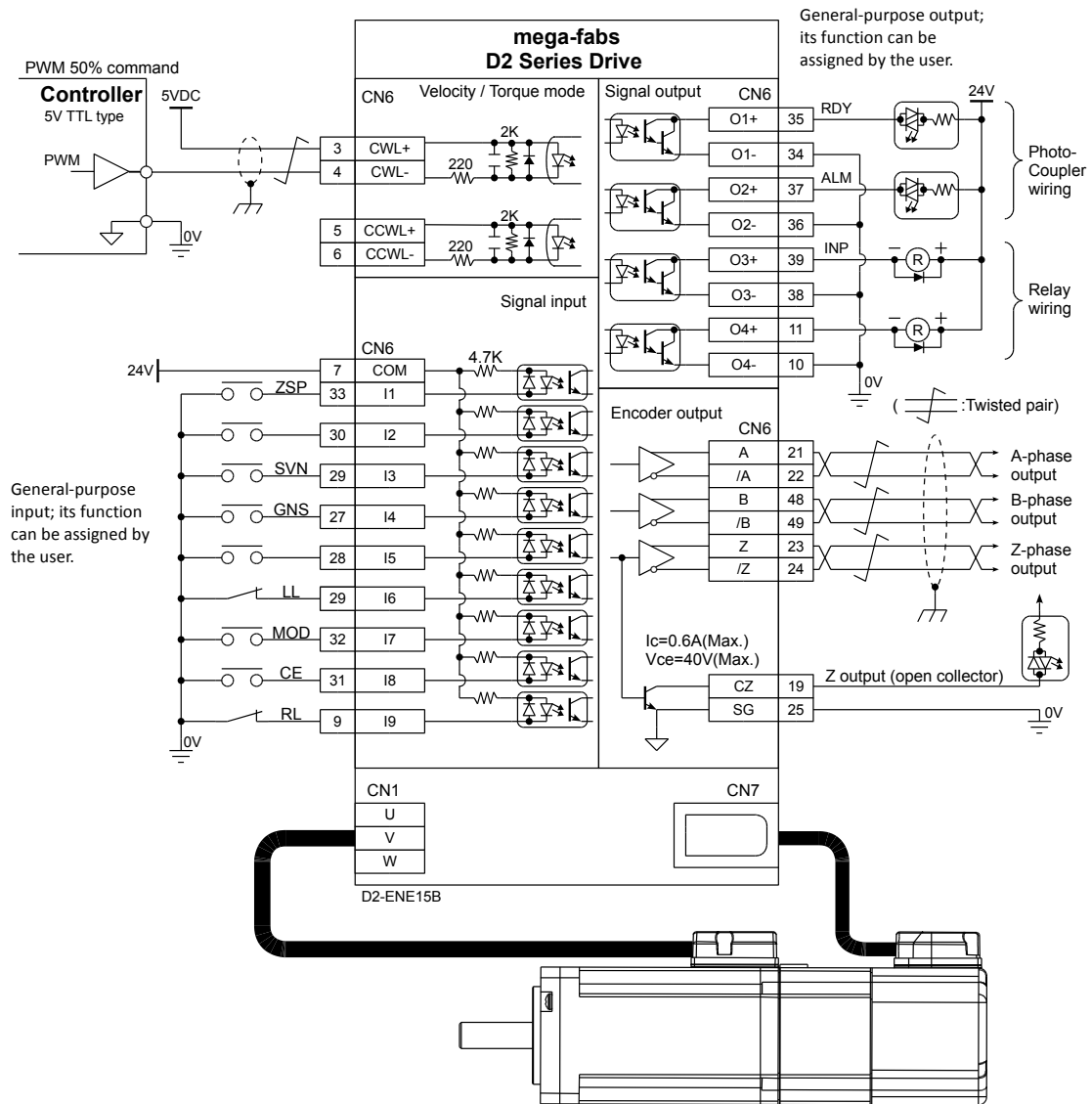


Figure4.6.3.3.1

4.6.3.4 5V TTL interface with PWM 100%

Wiring example for the host controller having the 5V TTL interface with PWM 100%:

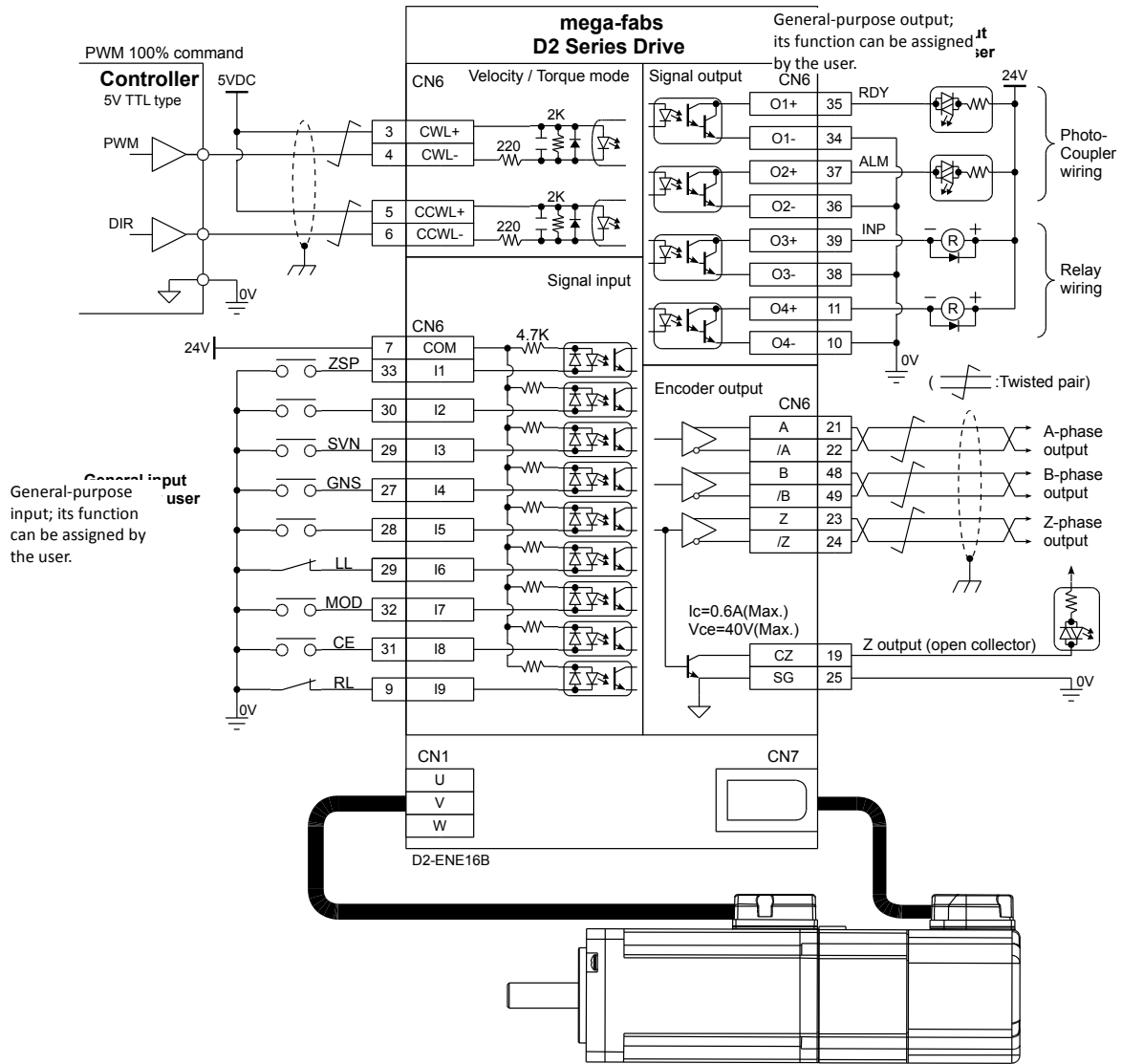


Figure4.6.3.4.1

5. Drive configuration

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5.1 Installation and communication

The human-machine interface (HMI) for D2-series drives is called Lightning. Through the connection between PC and the drive by using the mini USB, it can perform functions of initialization, configuration, operation, test runs, parameters saving, and so on. This section describes how to install Lightning and communicate with the drive.

5.1.1 Setup files

Files in the Lightning setup folder are shown in figure 5.1.1.1, included an auto execution file “setup.exe”, a firmware folder “dce”, and so on.

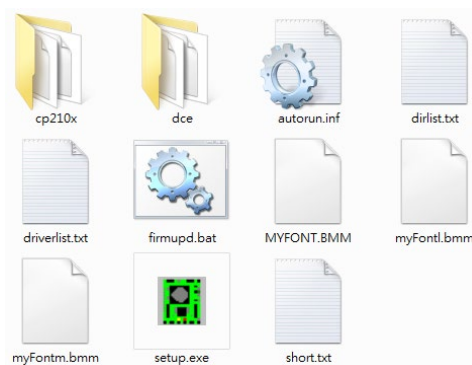


Figure5.1.1.1

If using the installation CD, simply wait for the setup program to run automatically. If using setup files downloaded from HIWIN website (after log in HIWIN website, the file path is “http://www.hiwinmikro.tw/hiwintree/Product_SubType.aspx?type=D2”), unzip the downloaded file and execute “setup.exe”. The default installation path is “C:\HIWIN”. Do not try to change this path. The installation window is given in figure 5.1.1.2. Click the “Start” button to run the automated installation procedure. After this procedure is completed, the message window of figure 5.1.1.3 appears to show that the software installation is ended successfully.

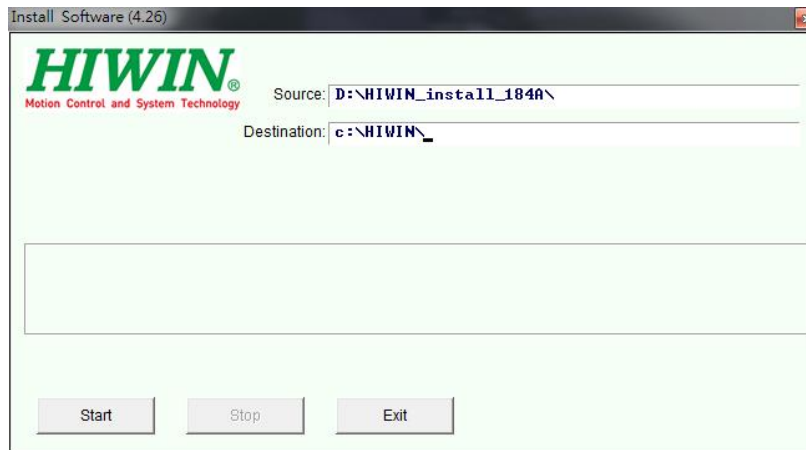


Figure5.1.1.2

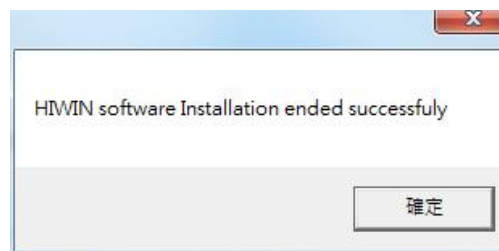


Figure5.1.1.3

The execution shortcut of Lightning will appear on the PC desktop after the installation procedure is completed, as shown in figure 5.1.1.4. The path for this shortcut is:

“C:\HIWIN\dce\toolswin\winkmi\lightening.exe”.



Figure5.1.1.4

5.1.2 Communication setup

There are three methods of communicating with the drive: (1) using USB communication, (2) using mega-ulink communication, and (3) using CoE communication. This section will introduce the former two methods. As for the last one, refer to the other HIWIN document: “HIWIN CoE Drive User Guide” (log in HIWIN website and download it. If the mega-ulink or CoE communication is used to connect with the drive, it is suggested to use network card with the network chip certified by Beckhoff.

Note:

- (1) The firmware for previous CoE model (firmware number 0.037) cannot support later EtherCAT model. The firmware must be updated.
- (2) The firmware for previous mega-ulink model (firmware number 0.037) cannot support later EtherCAT model. This can be solved by using PDL program, please contact HIWIN.

(1) Using USB communication

Before starting Lightening, connect to the drive via USB and turn on the control power. Normally, Lightening will automatically connect to the drive when it is opened. If not, click “Communication setup” in the “Tools” option to change the communication setup, as shown in the following figure.

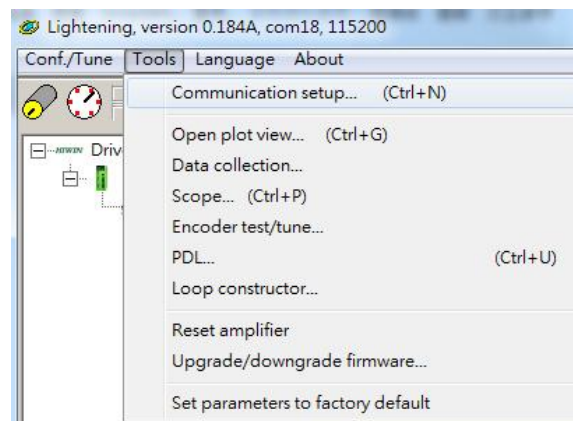


Figure5.1.2.1

The window for communication setup is shown in figure 5.1.2.2. D2 drive supports the USB communication method. Here, the “BPS” field shows the transmission rate and its default value is 115,200 bps. This value should not be changed. The “Port” field shows the communication port. It will display the existing PC ports. Select the port actually connected to the drive. Using default values in remaining fields, Lightening can successfully communicate with the drive.

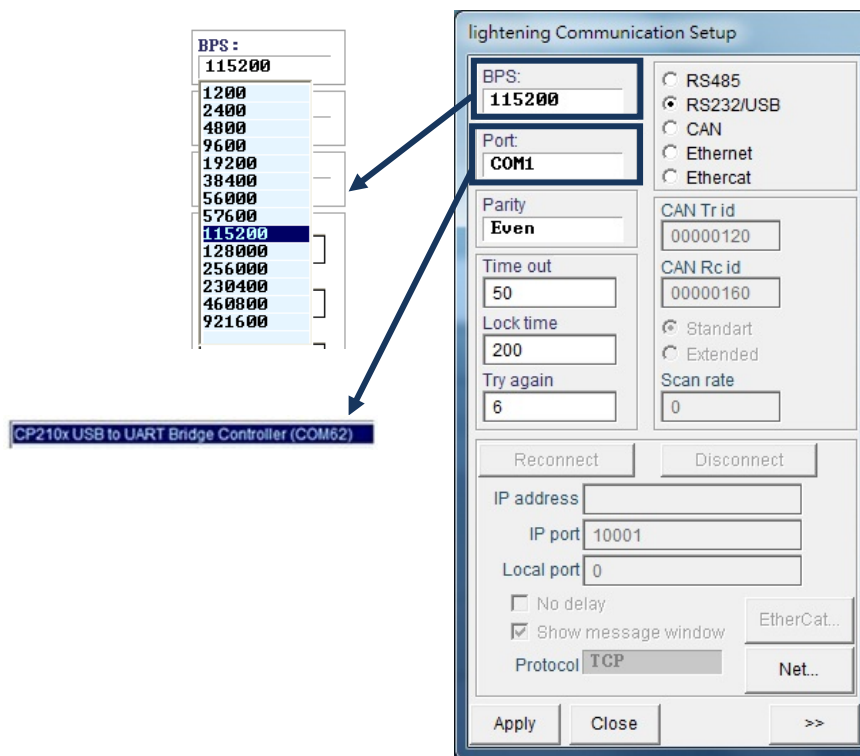


Figure5.1.2.2

(2) Using mega-ulink communication

At the first usage of mega-ulink communication, download and install WinPcap. After installing WinPcap is done, open the “lightening Communication Setup” window described in the previous subsection, as shown in figure 5.1.2.2. Select the radio button for “Ethercat” and click the “EtherCat” button, as shown in figure 5.1.2.3.

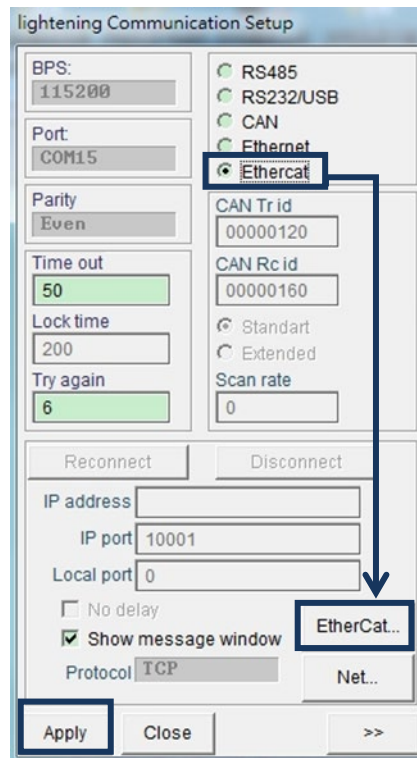


Figure5.1.2.3

The “EtherCat set up” window will appear to display all network cards in the computer, as shown in figure 5.1.2.4. Select the network card connected to the drive. After that, close the “EtherCat set up” window and click the “Apply” button in the “lightening Communication Setup” window.

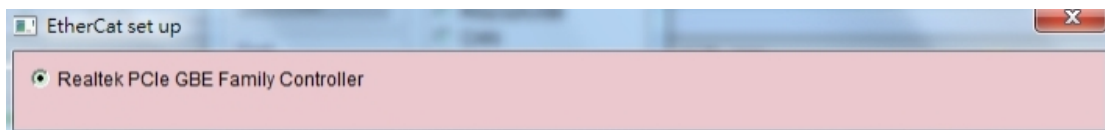


Figure5.1.2.4

After the setting is completed, the window of figure 5.1.2.5 will appear. The number of connected axes can be obtained from the information in the window. After going back to Lightning main window, the connection is established and “Ethercat” is shown in the title, as given in figure 5.1.2.6.

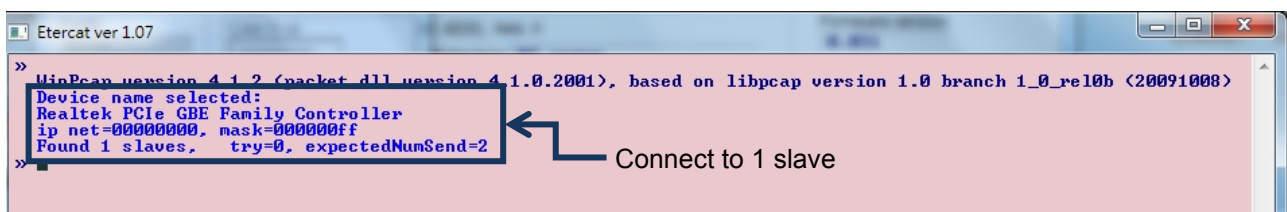


Figure5.1.2.5

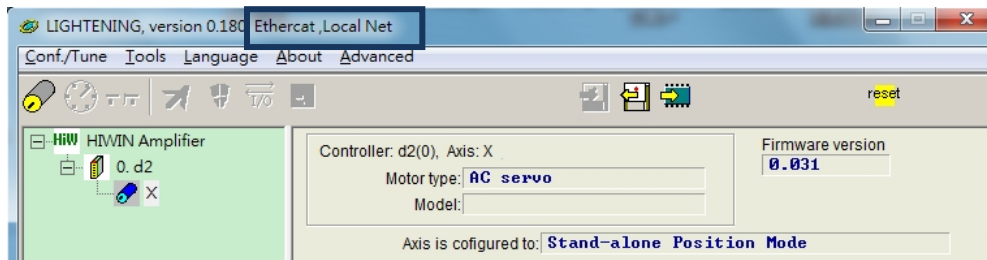


Figure5.1.2.6

5.1.3 HMI main window

The HMI main window after connecting is given in figure 5.1.3.1. The axis name can be modified by clicking the right mouse button at the axis name and choosing "Rename". It also can be modified directly by clicking the axis name.

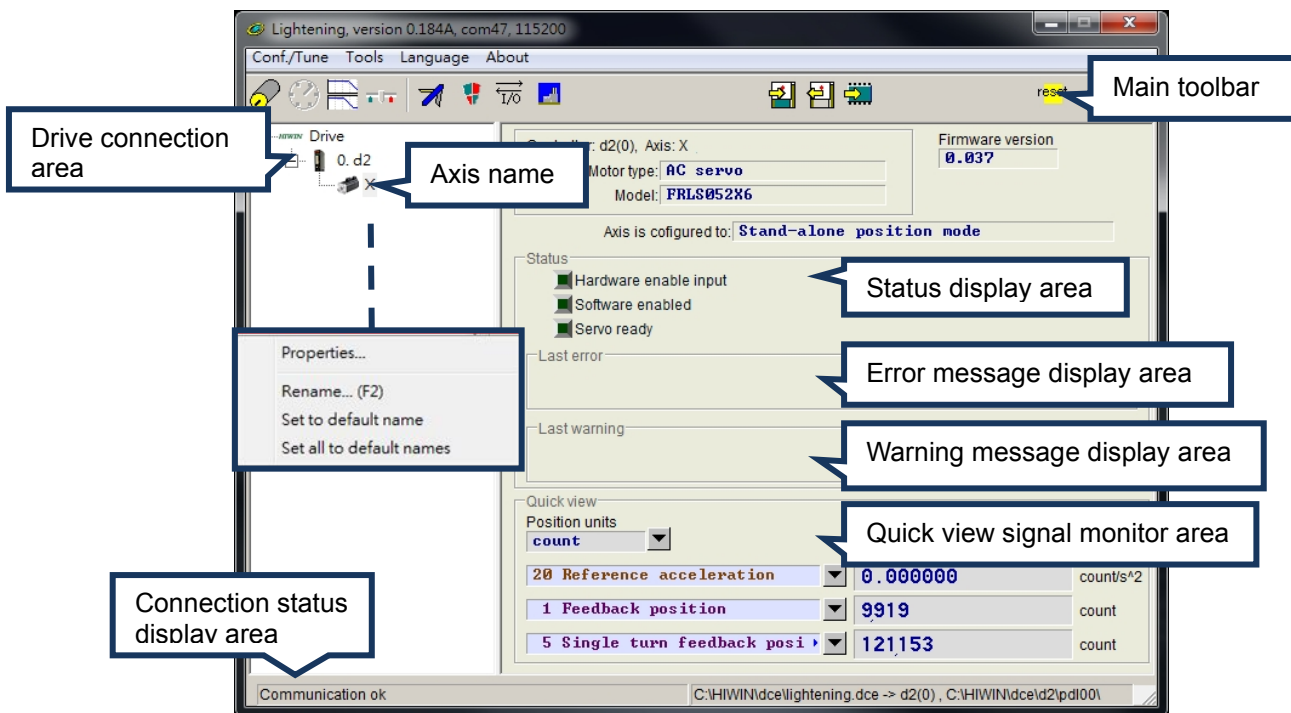







Figure5.1.3.1

■ Main toolbar

-  : Open the window of PDL program.
-  : Save current parameters in the drive RAM to file (PRM file).
-  : Load parameters in the file (PRM file) to drive RAM.
-  : Save current parameters in the drive RAM to Flash.
-  : Reset drive.

■ Status display light

There are three indicators for displaying statuses.

- **Servo ready** : The light will be off when the drive is at the disable status. It will become green when the drive is at the enable status.
- **Hardware Enable Input** : The light is green when the drive hardware is enabled. If the hardware is not enabled, the drive cannot enable the motor. The setting method of hardware enable via the external input refers to Section 5.5.1 and Appendix A.
- **Software Enabled** : The light is green when the drive software is enabled. Only when both hardware and software are enabled, the drive can enable the motor. Click the “Enable” button in the performance center to enable the software; while click the “Disable” button to cancel the software enable. If there is no connection between PC and the drive, the status of software enable is changed with the status of hardware enable. If there is the connection between PC and the drive, when Lightening HMI is closed, it will query whether the software is enabled or disabled after the window is closed.

■ Drive property

Properties of used drive can be obtained by clicking the right mouse button at the axis name and choosing “Properties”, as shown in figure 5.1.3.2.

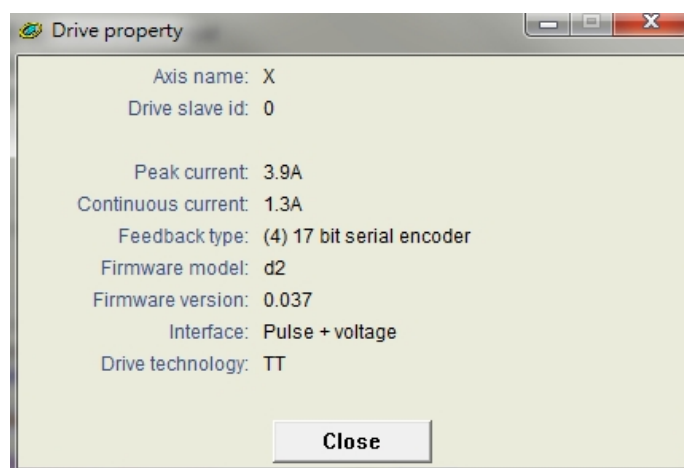


Figure5.1.3.2

Note:

When Lightening 0.144 (inclusive) or older version is used to connect with D2 model, or Lightening 0.180 (inclusive) or older version is used to connect with D2T model, the message for installation error will appear after connecting, as shown in figure 5.1.3.3. Since these HMI versions do not contain the firmware version for these drives, Lightening cannot identify them. Click the “Do nothing” button and download the latest version of Lightening from HIWIN website.

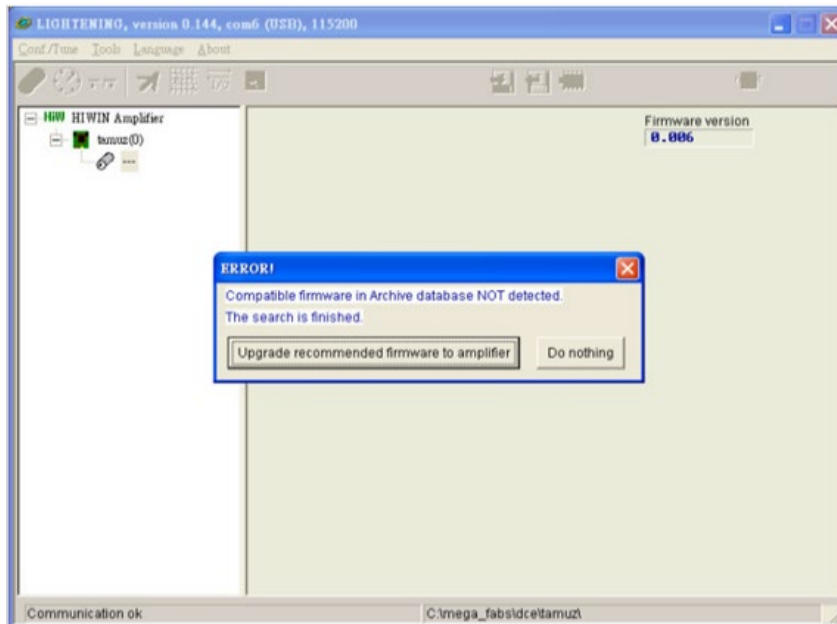



Figure5.1.3.3 Message for firmware version error

5.2 Configuration center

When using a new drive or a new motor, relevant parameters should be set based on the actual application via configuration center. The configuration center can be opened by clicking  in the main toolbar. The location of this button is shown in figure 5.2.1.

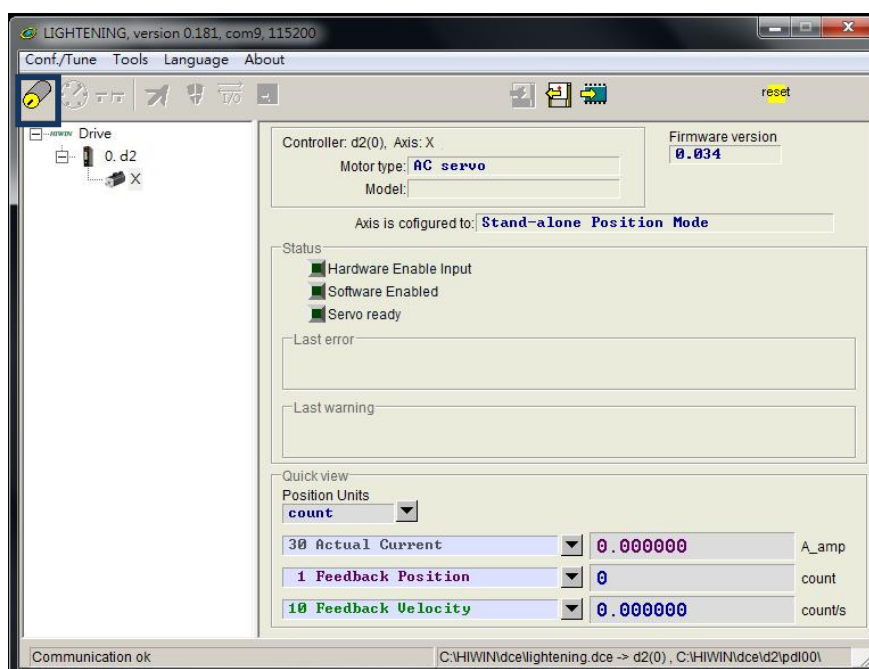

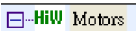


Figure5.2.1

Following setting steps must be done before using D2 drive to drive the motor successfully.

- (1) Motor type: Set the used motor type and the corresponding parameters for the motor hardware.
- (2) Encoder parameter: Set the used encoder type and its resolution.
- (3) Operation mode: Set the operation mode at the drive.

5.2.1 Motor configuration

The motor configuration is at the first page of configuration center. AC servo motors supported by D2 drive can be found under . For the motor with a serial encoder, it does not need to set motor parameters, since they are already saved in the encoder. Hence, there is no option of . For Lightening 0.177 (inclusive) or less, the motor configuration page is shown in figure 5.2.1.1; while for Lightening 0.178 (inclusive) or above, it is given in figure 5.2.1.2.

■ Setting for AC servo motor

(1) Motor parameters

By clicking the motor model name of HIWIN servo motor, motor parameters are displayed and can be set.

(2) Operation parameters

- Screw Moment of Inertia: the rotational inertia of used screw. Unit: Kg x m².
- Load Mass: the mass of load. Unit: Kg.
- Screw Pitch: the pitch of ball screw (i.e. the amount of linear movement when the screw moves one revolution). Unit: mm.
- Gear Ratio: the ratio of gear-teeth number at the load to that at the drive.

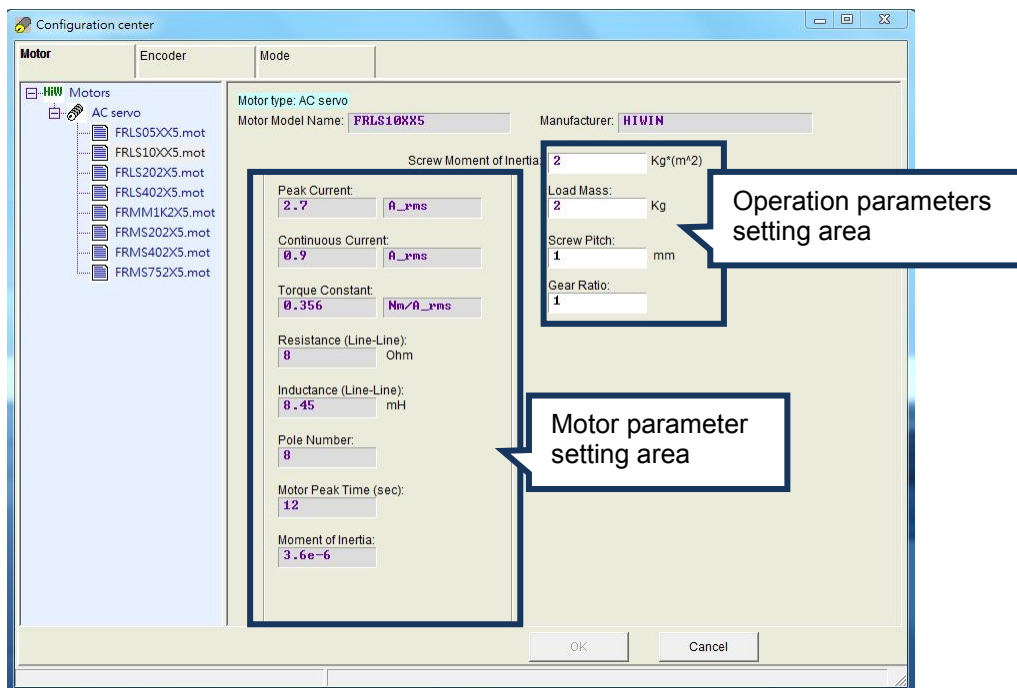


Figure5.2.1.1 Motor configuration page for Lightening 0.177 or less

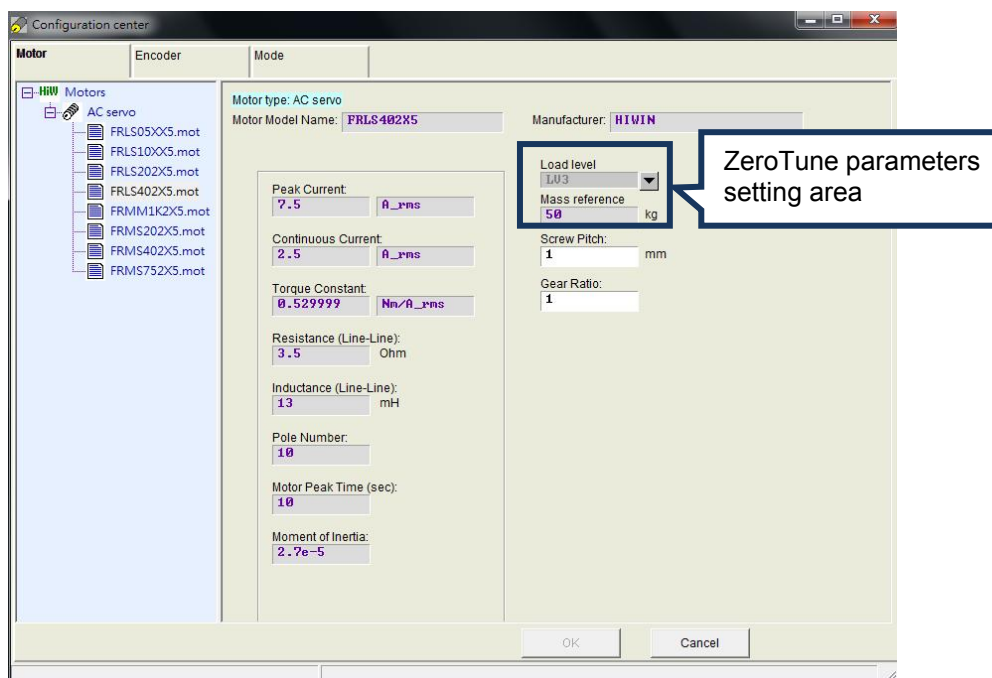


Figure5.2.1.2 Motor configuration page for Lightening 0.178 or above

(3) ZeroTune parameters

The tuneless feature of ZeroTune can avoid the complex procedure of gain tuning and can easily set gains. Only by selecting the load level of motor, the stable velocity response will be achieved. Even a beginner who has no knowledge about servo control can easily drive the motor. Required parameters to be set are given as follows.

- Load level: the level of load weight. There are five levels: LV1 - LV5. When this field shows "Tuned", it means that the gain is not set by ZeroTune, but is set by Auto tune or by manual.

- Mass reference: the maximum reference weight corresponding to the selected level. Unit: Kg. Table 5-1 shows the maximum reference weight at the different combination of motor power and load level.

Table5.2.1.1 Mass reference of ZeroTune

Motor power	LV1	LV2	LV3	LV4	LV5
50 W,100 W	5 kg	15 kg	30 kg	45 kg	60 kg
200 W,400 W	10 kg	25 kg	50 kg	75 kg	100 kg
750 W,1 KW	20 kg	50 kg	80 kg	110 kg	140 kg

Setting correct parameters for the motor operation can help to calculate suitable values for driving parameters, such that the drive can successfully drive the motor.

5.2.2 Encoder configuration

The drive normally receives a feedback signal from the position encoder to execute the servo control. The encoder configuration page is shown in figure 5.2.2.1. Select or set the correct type and parameters of encoder on this page. To work with the host controller, D2 drive can output encoder signals besides receiving encoder signals. It provides the buffered encoder output or emulated encoder output. When using the emulated encoder output, the output resolution can be modified by setting "Scaling".

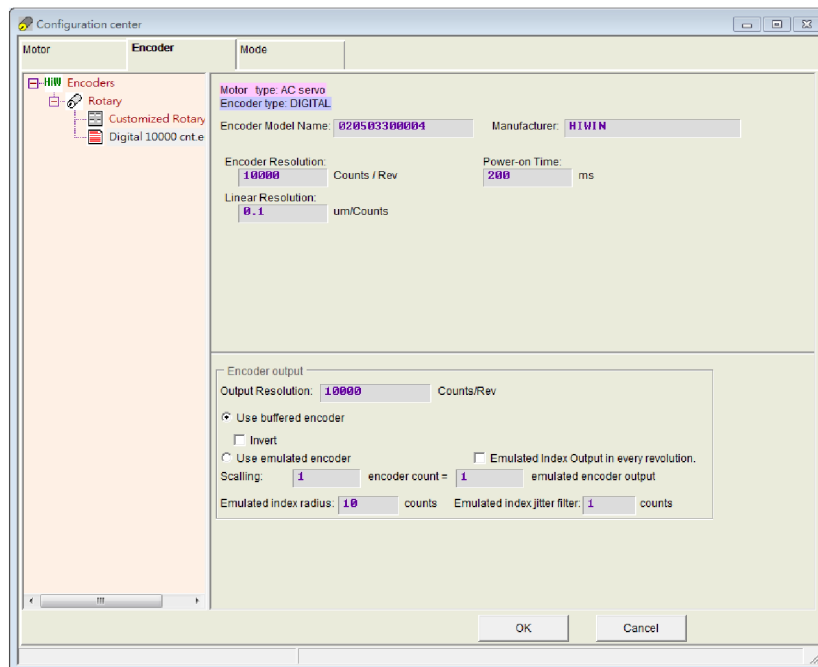


Figure5.2.2.1 Encoder configuration page for 13-bit encoder

5.2.2.1 HIWIN standard encoder

Specifications of rotary digital encoder used in HIWIN AC servo motor is given in table 5.2.2.1.1. The 9-th bit of motor model name being 5 uses the 13-bit digital incremental rotary encoder with the resolution of 10,000 counts/rev. The 9-th bit of motor model name being 6 uses the 17-bit serial incremental rotary encoder with the resolution of 131,072 counts/rev. The 9-th bit of motor model name being 4 uses the 17-bit serial multi-turn absolute rotary encoder with the resolution of 131,072 counts/rev.

Table5.2.2.1.1

AC servo motor model		counts/rev
FRLS series	FRLS05XX5, FRLS10XX5, FRLS202X5, FRLS402X5	13-bit Incremental (10,000 counts/rev)
FRMS series	FRMS052X5, FRMS102X5, FRMS4B2X5, FRMS752X5	
FRMM series	FRMM1K2X5	
FRLS series	FRLS052X6, FRLS102X6, FRLS202X6, FRLS402X6,	17-bit Incremental (131,072 counts/rev)
FRMS series	FRMS052X6, FRMS102X6, FRMS4B2X6,FRMS752X6	
FRMM series	FRMM1K2X6	
FRLS series	FRLS052X4, FRLS102X4, FRLS202X4, FRLS402X4,	17-bit Absolute (131,072 counts/rev)
FRMS series	FRMS052X4, FRMS102X4, FRMS4B2X4,FRMS752X4	
FRMM series	FRMM1K2X4	

(1) 13-bit incremental encoder

For HIWIN AC servo motor with the 13-bit incremental encoder, simply selecting the purchased motor model name, the program will automatically connect to encoder parameters suitable for this motor, as shown in figure 5.2.2.1. For example, for the 9-th bit of motor model name being 5, the program will automatically connect to the digital rotary encoder with the resolution being 10,000 counts/rev.

(2) 17-bit serial encoder

For HIWIN AC servo motor with the serial encoder, it does not need to set encoder parameters, since they are already saved in the encoder, as shown in figure 5.2.2.1.1. For example, for the 9-th bit of motor model name being 4 or 6, the program will automatically read encoder parameters and show the resolution being 131,072 counts/rev. When using the 9-th bit of motor model name being 4 (with multi-turn absolute encoder), it also shows “Multiturn range” of this encoder. The multi-turn range of HIWIN absolute encoder is -32,768 to 32,767.

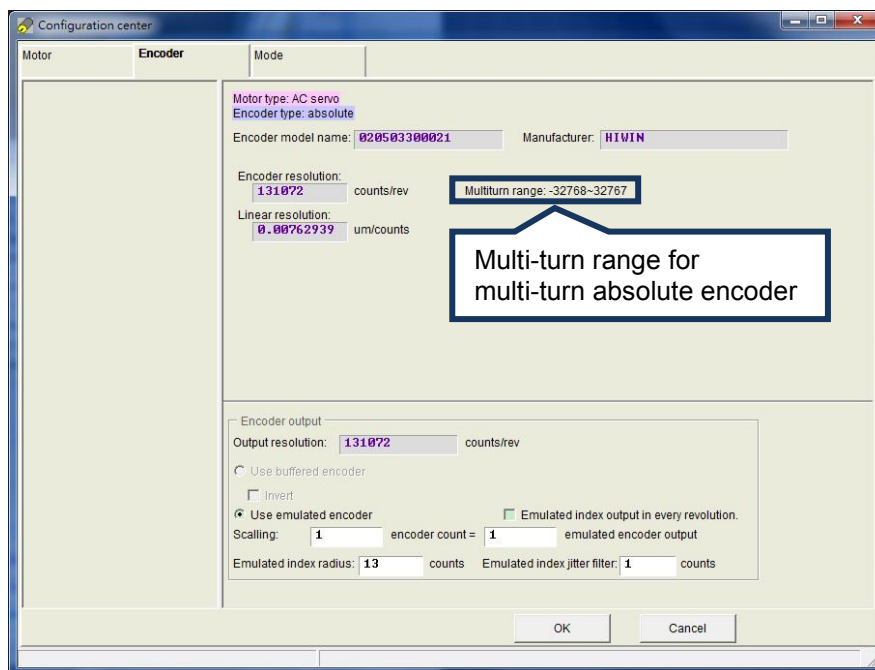


Figure 5.2.2.1.1 Encoder configuration page for 17-bit encoder

(3) Dual-loop encoder

HIWIN dual-loop model supports the 17-bit multi-turn absolute encoder (the 9-th bit of motor model name is 4) and the digital AqB linear encoder. Its encoder configuration page is given in figure 5.2.2.1.2.

- a When the option of “Dual loop” is not checked, the setting method for the serial encoder is adopted. The drive will read encoder parameters automatically, and users do not set them by manual. The option of “Use emulated encoder” only can be set in the “Encoder output” area. Users can decide whether to use the function of “Emulated index output in every revolution” by clicking this option. Details refer to Section 5.2.2.3.
- b When the option of “Dual loop” is checked, users must key in the resolution of linear encode, as shown in figure 5.2.2.1.3. If some encoders are powered on longer, the delay time should be set in the “Power-on time” field based on their specification to avoid occurring encoder error during the boot process. Moreover, there are two options of “Use buffered encoder” and “Use emulated encoder”, that can be chosen in the “Encoder output” area. These two output modes adopt the position signal of linear encoder. At this moment, the function of “Emulated index output in every revolution” is invalidated, and the option is anti-gray and cannot be checked.

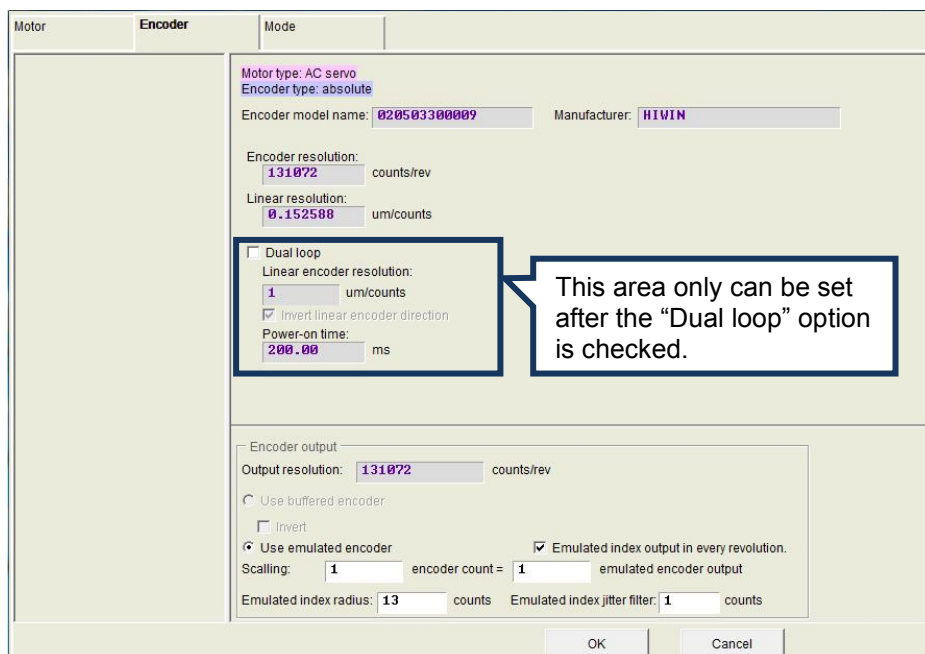


Figure 5.2.2.1.2 Encoder configuration page for dual-loop encoder (the “Dual loop” option is not checked)

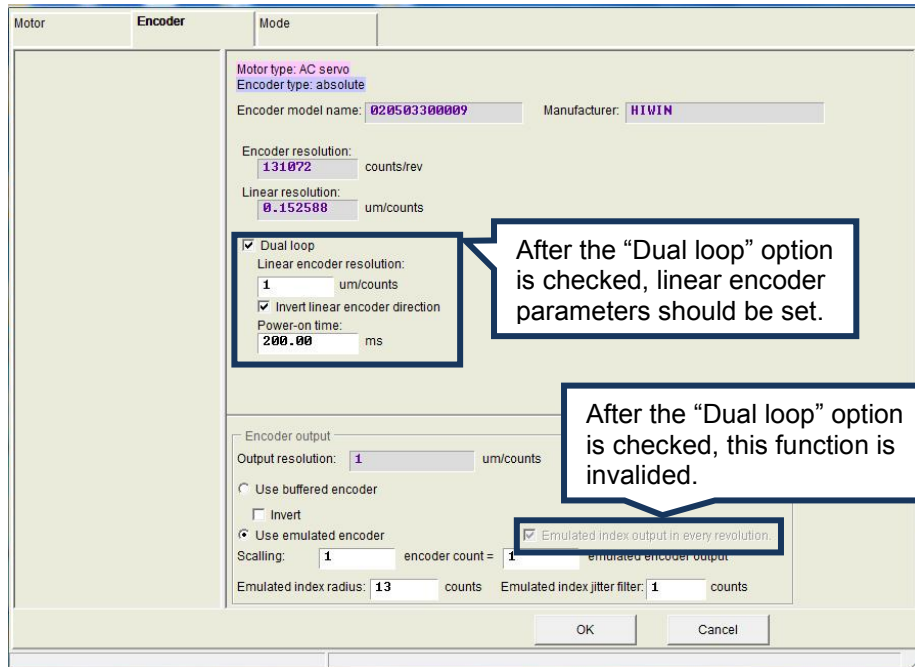


Figure 5.2.2.1.3 Encoder configuration page for dual-loop encoder (the "Dual loop" option is checked)

5.2.2.2 Customized digital incremental encoder

In the encoder configuration page, besides encoder parameters for HIWIN motor with common resolution can be chosen, parameters for various encoder brands can also be typed in the customized setting area. Opening "Rotary" and choosing "Customized Rotary Digital", the resolution parameter could be entered according to the encoder specification. In the "Encoder Resolutions" field, enter the total number of position signal for the encoder output as the motor rotating one revolution, where the unit is counts/rev. Based on the screw pitch and encoder resolution, the software automatically calculates the linear resolution and gives it in the "Linear Resolution" field. The unit is um/counts. After this setting is completed, the save function can be used to create encoder parameters. Users can load the created file for encoder parameters (*.enc) at any time.

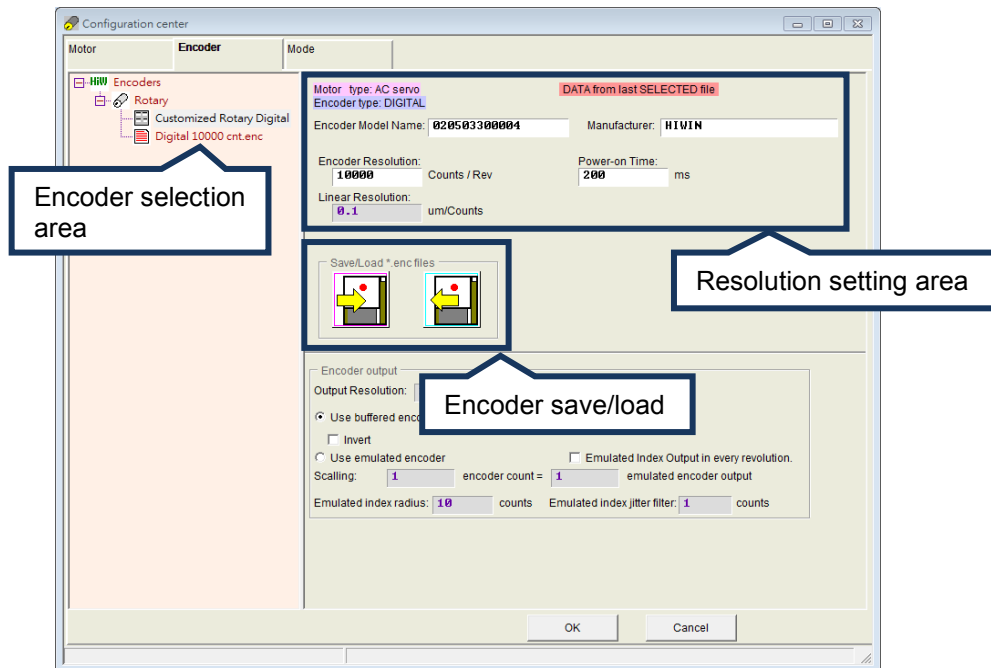


Figure 5.2.2.2.1 Encoder configuration page for customized encoder

5.2.2.3 Encoder output setting

D2 drive sends out the encoder signal with the AqB square wave via CN2. It can be connected to the host controller if needed. Checking “Use buffered encoder” or “Use emulated encoder” in the “Encoder output” area, as shown in figure 5.2.2.3.1, the value in the “Output Resolution” field will be updated according to the selected output mode.

Note:

For AC servo motor with the 17-bit encoder, the Z-phase signal can be sent out to the host controller by using the emulated encoder, as shown in figure 5.2.2.3.4.

(1) Buffered encoder output

When this option is selected, the drive will forward the signal from the motor’s encoder to the host controller. Moreover, the “Invert” function can be checked if needed. It allows the drive to inverse the received signal and then send out it. The resolution of output signal is also displayed on the page for reference.

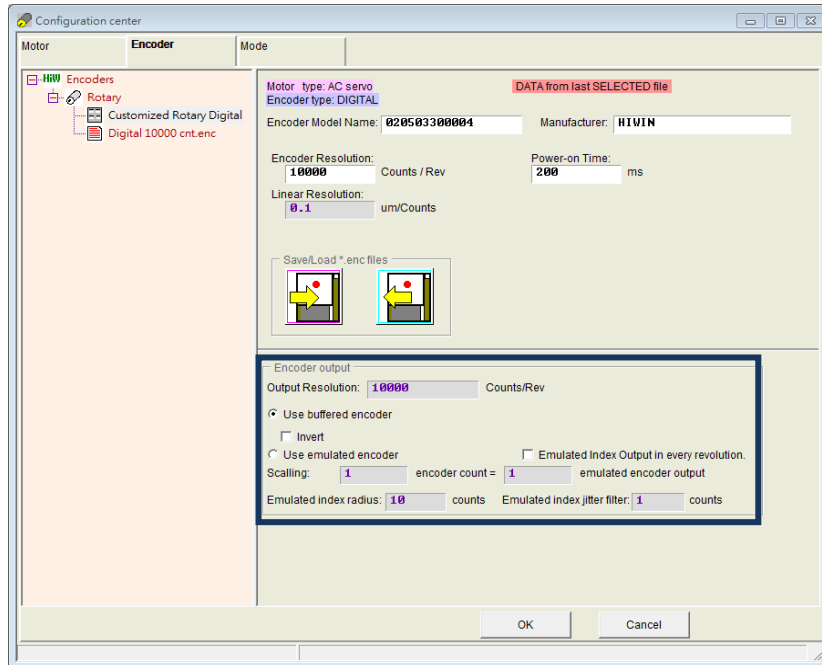


Figure5.2.2.3.1 Encoder output setting area

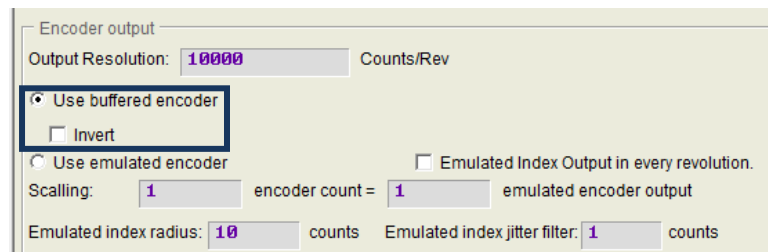


Figure5.2.2.3.2 Buffered encoder output

(2) Emulated encoder output

When this option is selected, the drive will multiply the received encoder position by “Scaling” and send the result to the host controller. If the ratio is 1:1, the drive will directly output the encoder signal based on the adopted encoder and the set resolution. At the some cases, the host controller cannot receive the encoder signal with a high frequency. Hence, a different ratio can be used, e.g., 5 encoder counts = 1 emulated encoder output. On the other hand, if the multiplier factor of analog encoder is set too small, “Scaling” might be needed to reduce the resolution of encoder output. The output direction can be changed by setting 1 encoder count = -1 emulated encoder output. Taking the emulated encoder output in figure 5.2.2.3.4 as an example, the encoder resolution is 10,000 counts/rev and the scaling for emulated encoder output is 5 encoder counts = 1 emulated encoder output. Therefore, “Output Resolution” is zoomed in to 2,000 counts/rev.

Note:

The function of emulated encoder output will temporarily loss efficacy when parameters are saved to Flash.

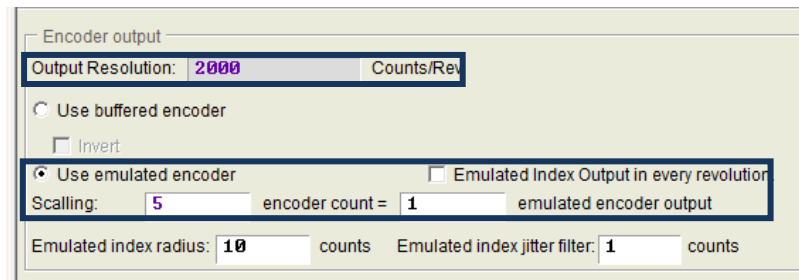


Figure5.2.2.3.3 Emulated encoder output

(3) Output Z-phase signal to host controller

For AC servo motor with the 17-bit encoder, the Z-phase signal can be sent out to the host controller by setting the encoder output to “Use emulated encoder”, as shown in figure 5.2.2.3.3. Before using this function, the encoder output must be set to “Use emulated encoder”, and following two parameters should be set:

- a Emulated index radius: the output range of emulated Z-phase signal, as shown in figure 5.2.2.3.4.
- b Emulated index jitter filter: reducing the bounce phenomenon of emulated Z-phase signal.

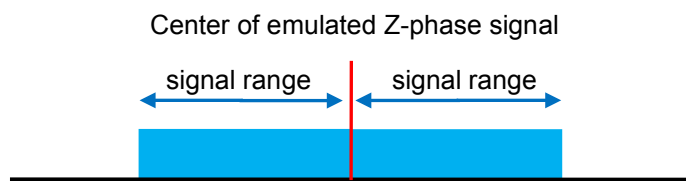


Figure5.2.2.3.4

When the home offset function is used for homing, the emulated Z-phase signal will move to the home position after home offset, as shown in the following figure.

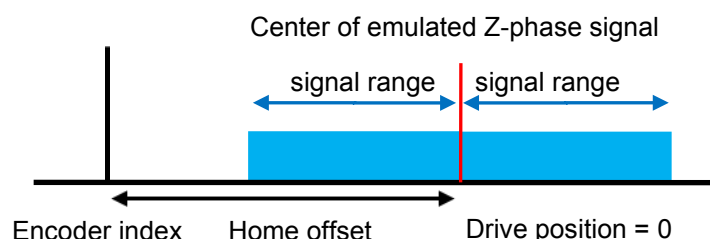


Figure5.2.2.3.5

- The output method of emulated Z-phase signal:
 - a If the option of “Emulated Index Output in every revolution” is not checked, the drive sends out the Z-phase signal only when it reaches the index position at the first time.
 - b If the option of “Emulated Index Output in every revolution” is checked, the drive sends out the Z-phase signal every time when it reaches the index position.

5.2.3 Operation mode configuration

The configuration page for the operation mode is shown in figure 5.2.3.1. After parameters of the previous two steps have been set, the last step is to set the operation mode for the drive.

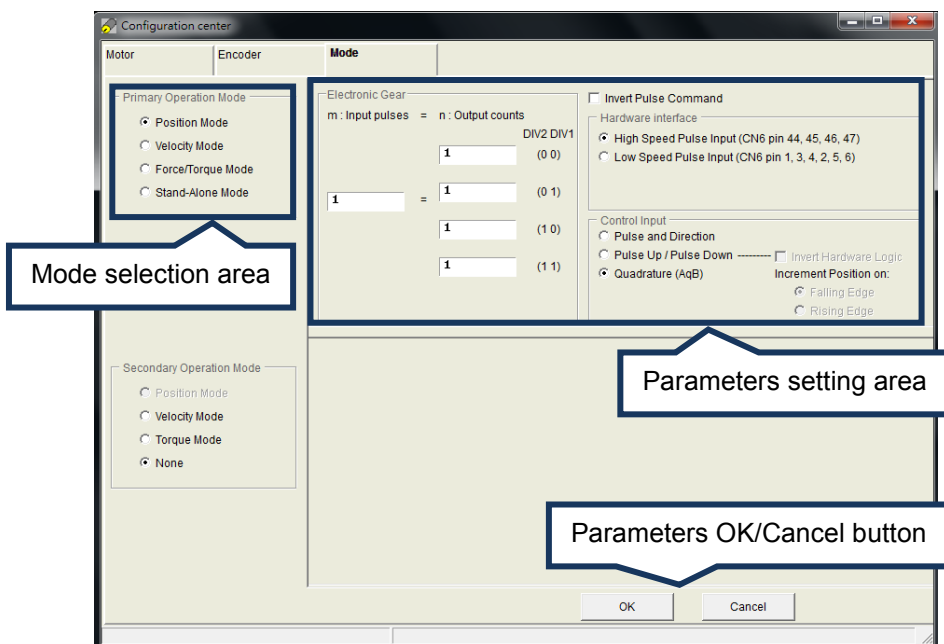


Figure5.2.3.1 Operation mode configuration page

■ Position mode

To work with the host controller only sending pulse commands, the position mode should be chosen to receive the external pulse command for the motion. The closed-loop control is done by the drive. D2 drive supports three formats of pulse command. Also, the electronic gear ratio is allowed to be set for the high-speed application.

Note:

- (1) Only at the status of servo ready, the drive accepts the pulse command sent by the host controller.
- (2) For the framework of dual-loop control, only the position mode and stand-alone mode can be selected.

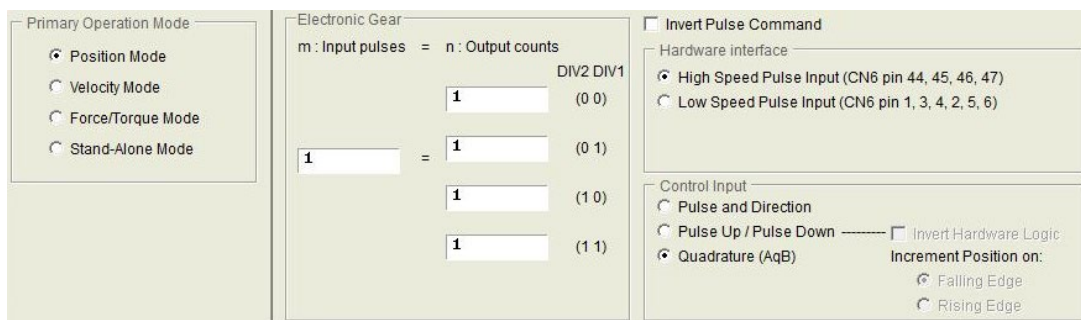
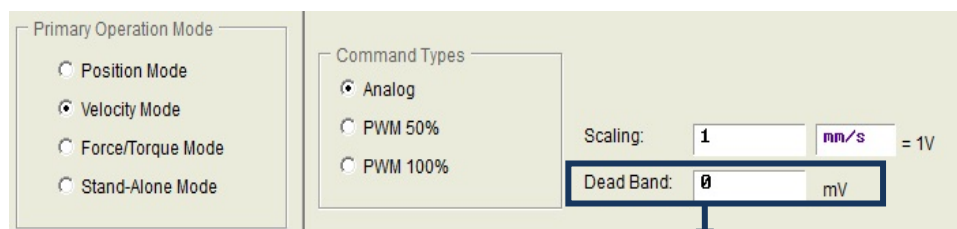


Figure5.2.3.2

■ Velocity mode

To work with the host controller sending analog commands or PWM commands, the drive can be set to the velocity mode. Only the ratio (“Scaling”) between the external command and velocity has to be set, where the unit is the corresponding relationship between 1V and mm/s or rpm, or between Full PWM and the maximum speed. If “Scaling” is set to a negative value, the motor will move in the reverse direction.



Dead band definition

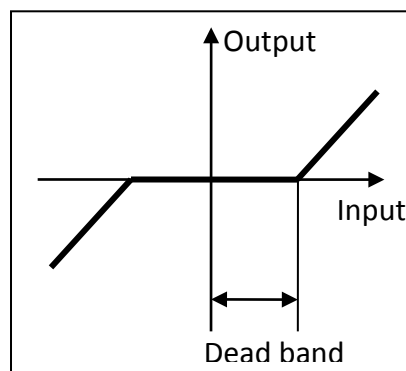


Figure5.2.3.3

■ Force/Torque mode

To work with the host controller sending analog commands or PWM commands, the other operation mode is the force/torque mode. Only the ratio (“Scaling”) between the external command and current has to be set, where the unit is the corresponding relationship between 1V and Ampere, or between Full PWM and the maximum current. If “Scaling” is set to a negative value, the motor will move in the reverse direction.

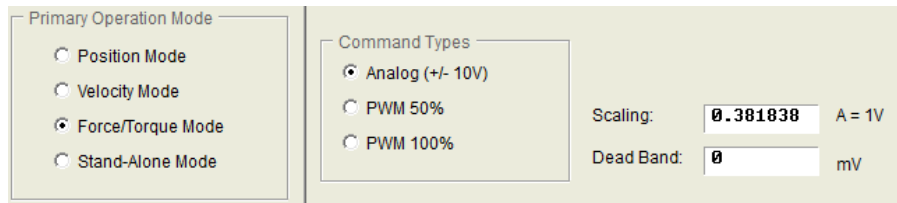


Figure5.2.3.4

■ Stand-Alone mode

If only test drive alone or without any host controller (such as only the servo side and drive side), the stand-alone mode can be selected. This mode let drive be responsible for all loop controls.

5.2.4 Modbus communication configuration

The configuration page for the Modbus communication is given in figure 5.2.4.1. Only the drive with the Modbus module has this configuration page.

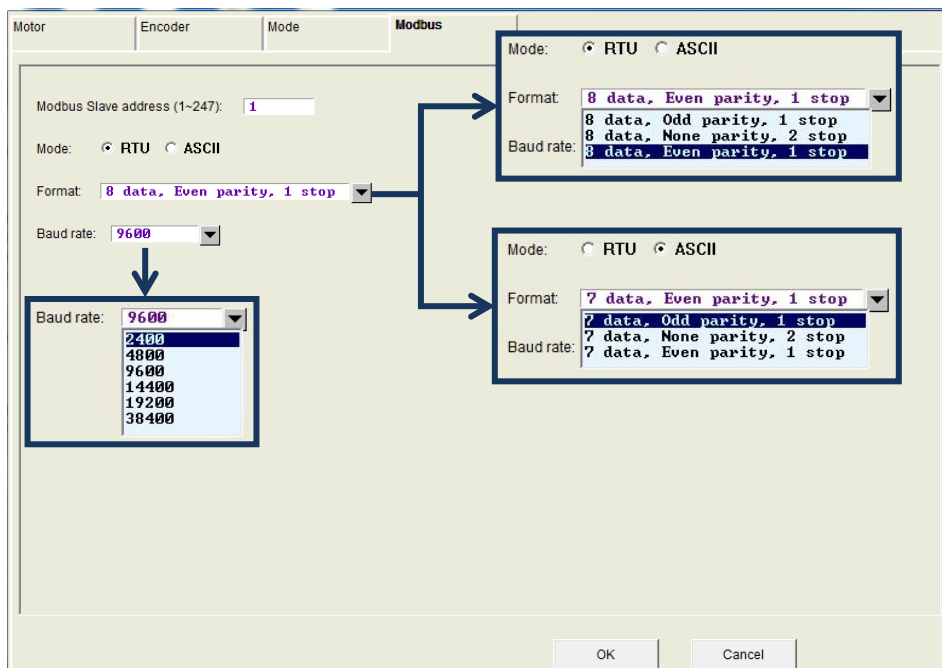


Figure5.2.4.1

(1) Modbus Slave address

Set the slave address of Modbus communication. Its value is between 1 and 247. Do not set different drives to the same slave address.

(2) Mode

Set the mode of Modbus communication. The default mode is RTU (remote terminal unit).

(3) Format

Set the data format for the used communication mode. The format information includes the data length, parity, and stop bits. The data length for the RTU mode is 7 bits; while that for the ASCII mode is 8 bits. The stop bit for odd parity and even parity is 1 bit; while that for none parity is 2 bits.

(4) Baud rate

Set the baud rate for the Modbus communication. It supports 2,400, 4,800, 9,600, 14,400, 19,200, and 38,400 bps. The default value is 9,600 bps.

5.2.5 Completing configuration procedure

After completing the motor, encoder, and operation mode configurations, click the “OK” button at the bottom of window to show figure 5.2.5.1. This window gives parameters before setting and after setting for the comparison. After confirming parameters, click the “Send to RAM” button to send parameters to the drive. If the “Cancel” button is clicked, the window returns to the configuration center.

Note:

For a new drive without initialization, after entering the configuration center, the “OK” button at the bottom of window is invalid and cannot be clicked. After parameter settings for the motor, encoder, and operation modes are confirmed, the “OK” button becomes valid.

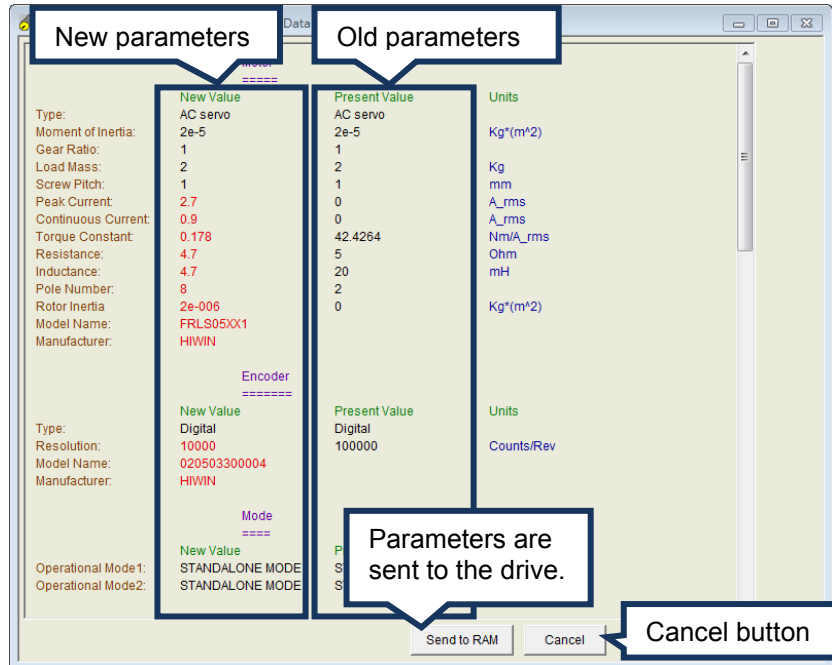


Figure5.2.5.1

If these parameters need to be kept, click (“Save to Flash”) on the HMI main window to save parameters to Flash. Parameters in Flash will not disappear even if the drive is turned off. If it is needed to save parameters to a file on the disc of PC, click (“Save Parameters from Amplifier RAM to File”) to save parameters to a file. The filename extension of saved file is *.prm. If it is needed to load parameters in the file to the drive, click (“Load parameters in the file to RAM”) to load parameters to the drive. After loading parameters, remember to click to save parameters to Flash.

5.3 Auto phase center

5.3.1 Function description

Click in the main toolbar on the HMI main window to open the auto phase center. The drive provides following two methods for phase initialization.

(1) STABS

This phase initialization method is for the 17-bit serial encoder. Without any tuning, the phase initialization can be done successfully, and the motor has no jitter phenomena in progress. This method is for the 9-th bit of drive model name being 4 or 5, and the 9-th bit of motor model name being 4 or 6. For example, the drive model name is D2T-0423-S-B4 and the motor model name is FRLS4020606A.

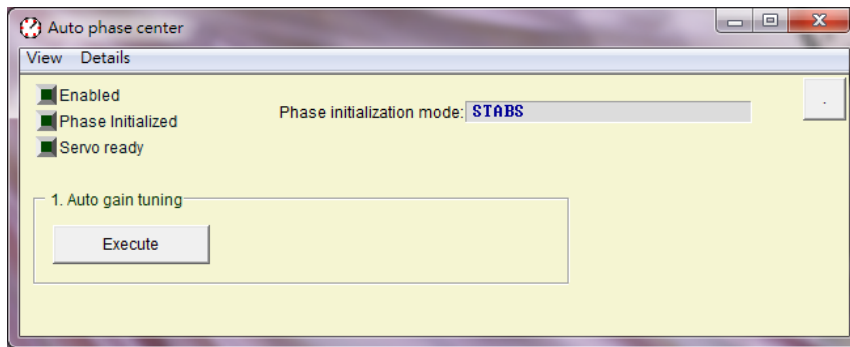


Figure5.3.1.1 For motors with HIWIN17 encoder and so on

(2) LSWIR

This method is for the less-wire incremental encoder, since it has a built-in hall sensor. Without any tuning and additional wiring, the phase initialization can be done successfully, and the motor has no jitter phenomenon in process. This method is for the 9-th bit of drive model name being 0, and the 9-th bit of motor model name being 5. For example, the drive model name is D2-0423-S-B4 and the motor model name is FRLS4020506A.

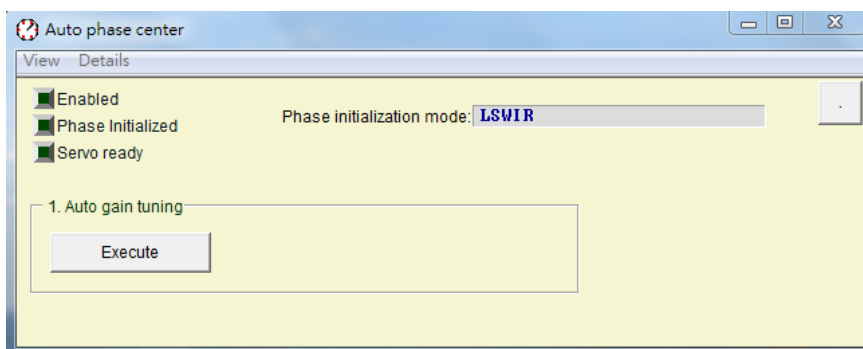


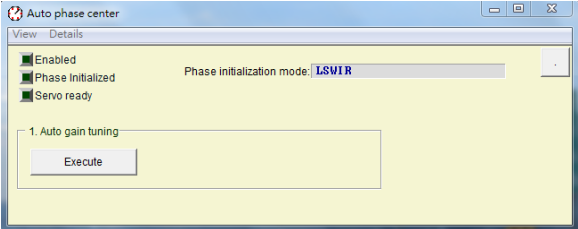
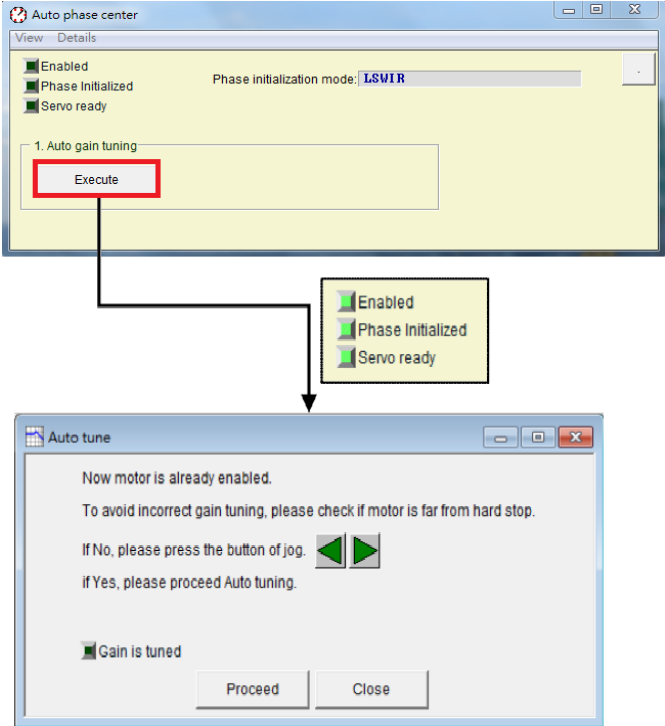



Figure5.3.1.2 For motors with wire-saving encoder

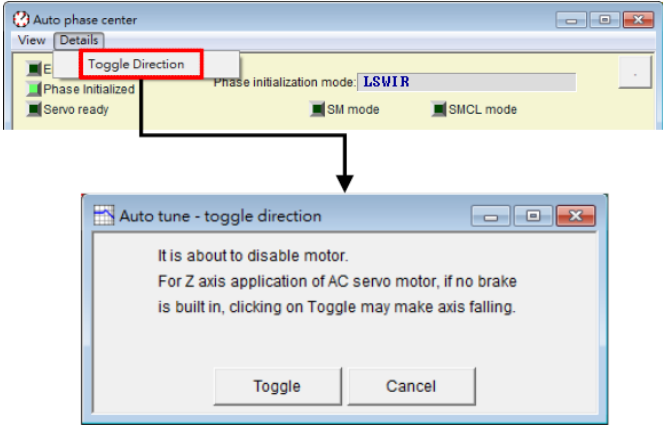
5.3.2 Pre-operation

- (1) Confirm that the connection to the motor is correct.
- (2) Confirm that the encoder signal is correct.
- (3) Confirm that the drive can receive the “Hardware enable” signal.
- (4) Confirm that the AC main power has been turned on.

5.3.3 Setting procedure

This section describes the procedure of auto phase initialization for LSWIR. As for STABS, it can use the same procedure for LSWIR.

Step	Graphical (HMI) description	Operation
1		<p>Setting phase initialization method: For the motor with the 9-th bit of motor model name being 5, the phase initialization method is automatically set to LSWIR.</p>
2		<p>Phase initialization and auto tune: Click the “Execute” button, as shown in the left figure, to start the phase initialization. The “Auto tune” window pops up after the phase initialization is completed. Use ◀ and ▶ to drive the motor to continue moving. Confirm that the motor moves far from the hard stop. After that, click the “Proceed” button to start auto tuning. Click the “Close” button to close the window after tuning has been completed. Now, the auto phase initialization is completed and the test-run function can be performed.</p> <p>Note:</p> <ol style="list-style-type: none"> (1) Observe whether status lights of  Phase Initialized and  Servo ready are green or not, to check if the phase initialization is done successfully and the servo close-loop control is ready. (2) The status light of  Gain is tuned flashes green during the process of auto gain tuning. After the auto tuning is completed, it keeps green. When the auto tuning is failed, it keeps red. In this case, close the “Auto tune” window and repeat Step 2.

3		<p>Confirming the movement direction and setting toggle direction: After performing jog in Step 2, if the motor moves in the direction opposite to the user-defined direction, close the “Auto tune” window and open the “toggle direction” window via steps in the left figure. Click the “Toggle” button in the window to complete the setting of reverse direction. Repeat Step 2 again.</p> <p>Note: When the motor is used in the vertical axis, if there is no mechanical braking mechanism, executing the toggle direction may cause a slipping phenomenon of motor, since the motor will be disabled at the toggle direction.</p>
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5.3.4 Troubleshooting

- (1) Confirm that the motor power cable and encoder feedback cable have been correctly connected.
- (2) Confirm that the parameter setting for the encoder or motor is correct, such as the encoder resolution or the number of motor pole pair.
- (3) Confirm that the grounding system is suitable.
- (4) Confirm that the enable signal of host controller in the drive has been triggered.
- (5) Confirm that the software enable signal in the drive has been triggered.
- (6) Confirm that there is no mechanical interference.
- (7) Confirm that the motor resistance is correct.

5.4 Auto tune center

5.4.1 Function description

The auto tune center can automatically find the better drive gain to save the time and cost of tuning by the engineer. When the auto gain tuning is performed, the motor will continue to vibrate at different frequencies and will perform functions of gain tuning (control-loop gains) and filter design in progress. The execution time approximates 25 seconds.

The auto tune center can be opened by clicking  in the Lightning main toolbar. Its location is shown in figure 5.4.1.1.

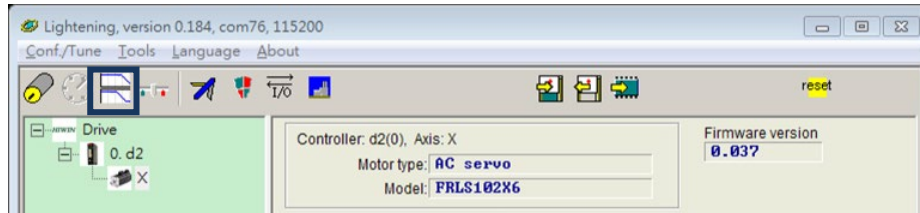




Figure5.4.1.1

Note:

The function of auto tune center only supports D2-serial drives (included D2T model). It is applicable to Lightening 0.184 and D2 MDP 0.037 (inclusive) or above, and D2COE MDP 0.113 (inclusive) or above. If the firmware version is not in the above version, the option of  in the Lightening main toolbar will be anti-gray and cannot be clicked. If it is in the above version, since it is no longer to execute the auto phase center, the option of  in the Lightening main toolbar will be anti-gray and cannot be clicked.

The window of auto tune center is given in figure 5.4.1.2. The window title is the version of auto tune center (Lightening 0.184 is 2.100). This window can be divided into two areas: enabling area and tuning area.

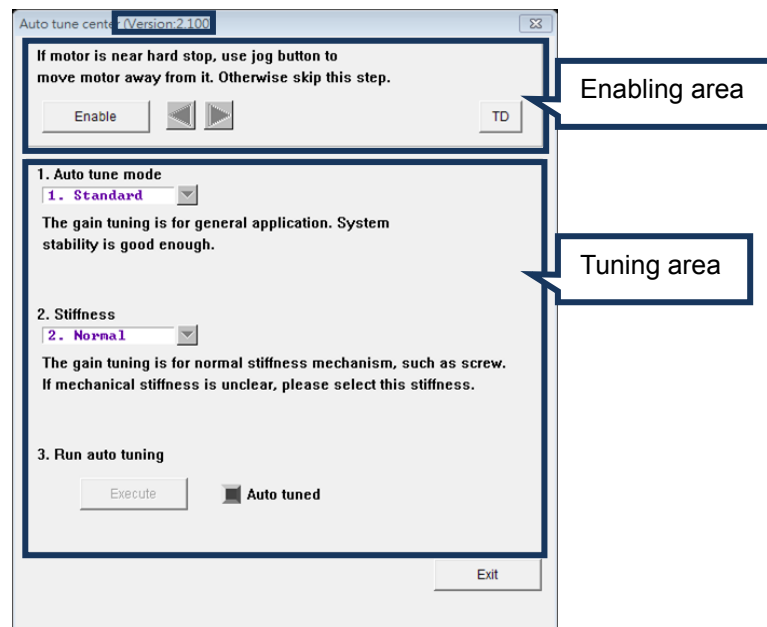






Figure5.4.1.2 Auto tune center - disable state

■ **Enabling area**

Clicking the “Enable” button in the enabling area, the drive will enable the motor. Click  or  to check the direction of motor movement, as shown in figure 5.4.1.3. If the motor is near the hard stop, click  or  to drive the motor far away from it. This can avoid failing in the process of auto gain tuning.

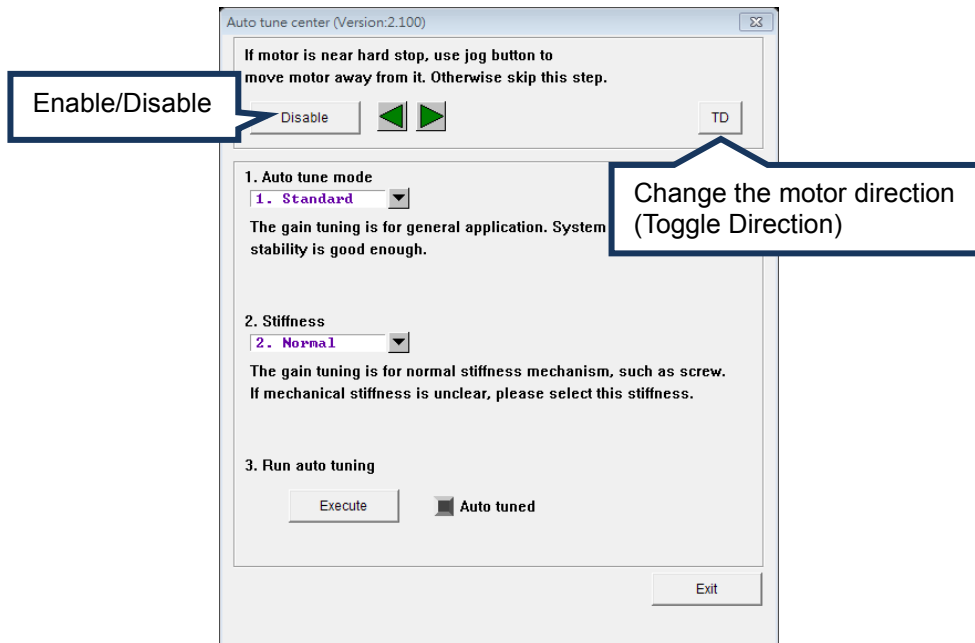


Figure5.4.1.3 Auto tune center - enable state

- A. If the motor is not enabled, all buttons in the tuning area are anti-gray. If the motor is enabled, the “Enable” button is changed to the “Disable” button, and all options in the tuning area are valid.
- B. There is one “TD” (toggle direction) button in the enabling area. The function of this button is to change the direction of motor movement, such that it is the same as the user-defined direction. If the direction is different, simply click the “TD” button to change the motor direction. After clicking the “TD” button, the drive will disable the motor. Users need to enable the motor again before continuing with the next step.

■ Tuning area

After setting “Auto tune mode” and “Stiffness” in the tuning area, click the “Execute” button, as shown in figure 5.4.1.4. After that, the “Execute” button will be changed to the “Stop” button. To stop the process of auto gain tuning, click the “Stop” button or close the window during the drive continuously sends the firing signal. When the firing signal is sent completely, the process of auto gain tuning cannot be stopped until the calculation of algorithm is completed.

A. Auto tune mode

Selectable auto tune modes are given in table 5.4.1.1. If the first tuning, the “Standard” mode is recommended.

Table5.4.1.1

Auto tune mode	Description
1. Standard (default)	Applicable to the most of mechanical applications. The system stability is high.
2. Advanced	Applicable to applications of emphasizing the positioning accuracy. The system performance is better.

B. Stiffness

Selectable stiffness is given in table 5.4.1.2. If the first tuning, the “Normal” stiffness is recommended.

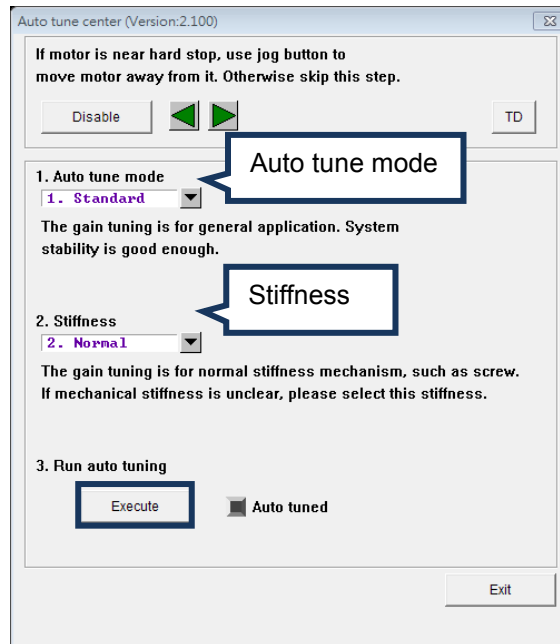


Figure5.4.1.4 Auto tune center - setting mode

Table5.4.1.2

Stiffness	Description
1. Soft	Stiffness is small. Suitable for the low rigidity, such as the belt and other mechanisms.
2. Normal (default)	Stiffness is normal. Suitable for the high rigidity, such as the ball screw and other mechanisms. If the mechanical stiffness is not clear, select this stiffness.
3. Rigid	Stiffness is high. Suitable for Harmonic drive, gear box, and other mechanisms close to the rigid-body system.

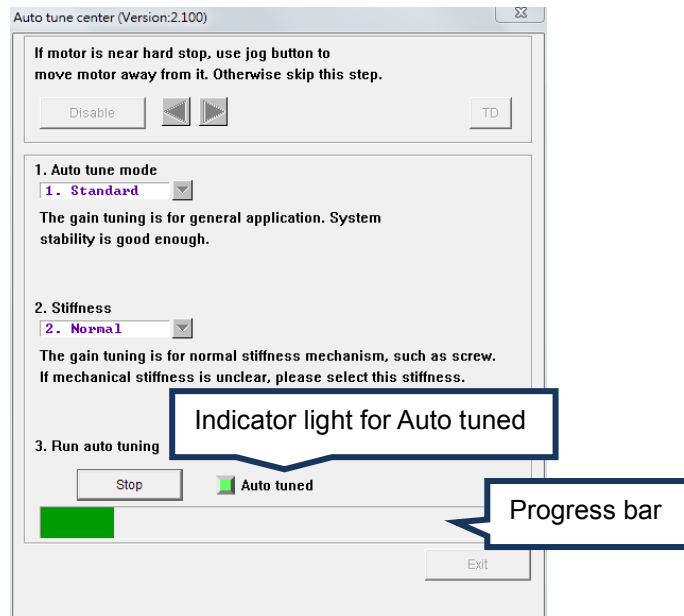


Figure5.4.1.5 Auto tune center – auto tuning

After clicking the “Execute” button, the drive will drive the motor to vibrate at different frequencies and the status light of “Auto tuned” will continue to flash. After the firing single is sent completely, the drive will disable the motor and perform the gain tuning algorithm. When the light stops flashing and the progress bar is full, it means that the process of auto gain tuning is finished (the execution time is about 25 seconds). After that, if the light keeps green, it indicates that the auto gain tuning is successful; while if the light keeps red, it indicates that the auto gain tuning is failed. The failed case and troubleshooting refer to Section 5.4.3. If the auto gain tuning is failed, the gain tuning and filter design will recover to the original setting.

5.4.2 Announcements

- If the mechanical system meets following conditions, the auto gain tuning easily fails:
 - (1) The stroke is not sufficient (for example, the motor running range is less than one revolution).
 - (2) The weight or inertial of load changes too much during the tuning process.
 - (3) The mechanical system touches the hard stop at tuning.
 - (4) The dynamic friction of mechanical system is too large.

- To avoid auto gain tuning failure, before performing it, be sure to confirm the following:
 - (1) Confirm that the motor power cable is connected well.
 - (2) Confirm that the encoder feedback cable is connected well.
 - (3) Confirm that the AC main power is turned on.
 - (4) Confirm that there is no warning or error in the drive (There is no warning or error in the Lightning main window).
 - (5) Confirm that the mechanical system can let the motor run at least 1 revolution.

Notes:

- (1) The auto gain tuning function can be applied to all operation modes. If the drive is set to the position mode, velocity mode, or force/torque mode, the drive cannot accept any external pulse command or analog voltage command.
- (2) After the auto tune center is opened, it cannot be switched back to the Lightning main window until the auto gain tuning process is completed.
- (3) The auto gain tuning function will disable the ZeroTune function. If the ZeroTune function is set again, gains obtained from the previous auto gain tuning will be disabled.

5.4.3 Troubleshooting

The following are causes and troubleshootings for auto gain tuning problems.

Table5.4.3.1



No.	Condition description	Troubleshooting
1	During the auto gain tuning, the AC main power is turned off, causing the drive to under voltage. (E09 Under voltage detected)	Restore the AC main power and reset the drive. After opening auto tune center, re-perform the auto gain tuning process.
2	During the auto gain tuning, the status light continues flashing for more than 3 minutes and cannot be stopped.	Power cycle drive. Move the motor to other position and re-perform the auto gain tuning process.
3	During the auto gain tuning, the drive occurs the position error too big. (E03 Position error too big)	Refer to Section 9. After troubleshooting, re-perform the auto gain tuning process.
4	After the auto gain tuning process is finished, the motor has a high-frequency resonance during motion.	<ul style="list-style-type: none"> • Stop the motor at the position occurring the high-frequency resonance, and re-perform the auto gain tuning process. • Decrease the auto tune mode or stiffness, and re-perform the auto gain tuning process. • Go to the performance center to decrease the CG value.
5	After the auto gain tuning process is finished, the motor has a low-frequency vibration during motion.	<ul style="list-style-type: none"> • Increase the auto tune mode or stiffness, and re-perform the auto gain tuning process. • Go to the performance center to increase the CG value.

If the motor still vibrates abnormally after performing the auto gain tuning process many times, please collect the following information and consult with the customer-service engineer to help troubleshooting the problem.

- (1) After performing the auto gain tuning process, go to “Message Windows” and click the left “S” button to save the file of plant.txt.
- (2) Perform “Frequency analyzer” and click the “Run” button in the “DCBL Plant” tab. Waiting for finish, click the “Loop Constructor” button. After the “Loop Constructor” window appears, click “File” -> “Save” -> “Save plant+gains to file...” to save the file of plant.lap.

5.5 I/O center

5.5.1 Digital input

Click  in the main toolbar on the main window to open the I/O center. Click the drop-down button () in the input function menu to select the digital input pin and its function, as shown in figure 5.5.1.1. D2 (D2T) model has 9 (10) digital inputs.

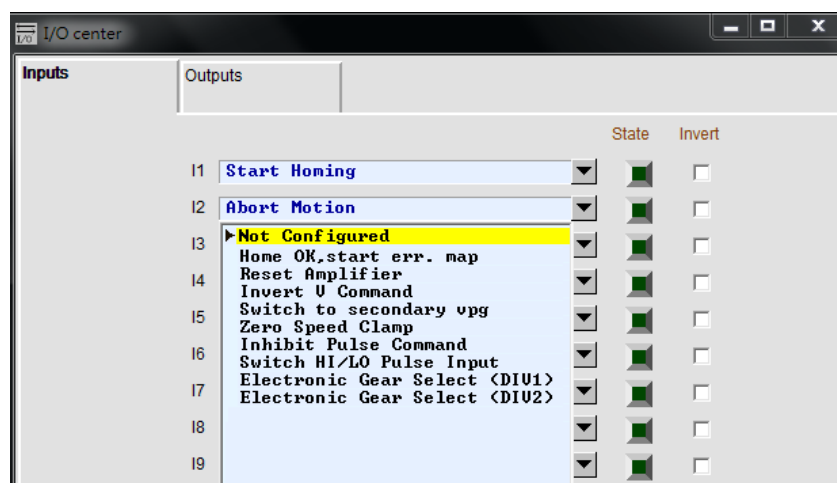


Figure 5.5.1.1 Input function menu

- (1) Status indicator light

If the status indicator light is green, it means that the corresponding input pin has been activated. If the light does not light, it means that the input pin is not activated.

- (2) Logic inverse setting (Invert)

When the “Invert” option is checked, the trigger condition will be reversed.

Table5.5.1.1

No.	Hardware Symbol	Input function	Description	Trigger
1	SVN	Axis Enable	Enable/Disable; the default used in I3.	Level trigger
2	LL	Left Limit Switch	Left hardware limit; the default used in I6.	Level trigger
3	RL	Right Limit Switch	Right hardware limit; the default used in I9.	Level trigger
4	MAP	Home OK, start err. map	The homing completed command from the host controller.	Edge trigger
5	RST	Reset amplifier	Reset the drive.	Edge trigger
6	DOG	Near home sensor	Near home sensor.	Level trigger
7	CE	Clear Error	Clear error.	Edge trigger
8	INVC	Invert V Command	Reversing the analog voltage command in the velocity or force/torque mode.	Level trigger
9	GNS	Switch to secondary CG	Switching to secondary common gain.	Level trigger
10	JSEL	Switch to secondary vpg	Switching to secondary vpg gain.	Level trigger
11	ZSC	Zero Speed Clamp	Zero speed clamp. In the velocity mode, the motor will be locked in a fixed position when the drive receives this signal and the motor speed is less than the set value.	Level trigger
12	INH	Inhibit Pulse Command	Inhibiting the pulse command.	Level trigger
13	PSEL	Switch HI/LO Pulse Input	Switching between the high-speed and low-speed pulse input channels.	Level trigger
14	EMG	Abort Motion	Emergency stop. The drive enters the emergency stop procedure after receiving this signal during motor motion.	Level trigger
15	MOD	Switch to secondary mode	Switching from the primary operation mode to the secondary operation mode.	Level trigger
16	HOM	Start Homing	Starting the built-in homing procedure of drive.	Edge trigger
17	DIV1	Electronic Gear Select (DIV1)	Selecting the electronic gear ratio in the position mode.	Level trigger
18	DIV2	Electronic Gear Select (DIV2)	Selecting the electronic gear ratio in the position mode.	Level trigger

Table5.5.1.2 Supported input functions for each operation mode

Input function \ Operation mode	Not CoE model				CoE model
	Position mode	Velocity mode	Force/torque mode	Stand-alone mode	Stand-alone mode
Axis Enable	V	V	V	V	V
Left (-) Limit Switch	V	-	-	V	V
Right (+) Limit Switch	V	-	-	V	V
Home OK, start err. map	V	V	V	V	-
Reset amplifier	V	V	V	V	V
Near home sensor	V	V	V	V	V
Clear error	V	V	V	V	-
Invert V command	-	V	V	-	-
Switch to secondary CG	V	V	V	V	-

Operation mode Input function	Not CoE model				CoE model
	Position mode	Velocity mode	Force/torque mode	Stand-alone mode	Stand-alone mode
Switch to secondary vpg	V	V	V	V	-
Zero speed clamp	-	V	-	-	-
Inhibit pulse command	V	-	-	-	-
Switch HI/LO pulse input	V	-	-	-	-
Abort motion	-	-	-	V	-
Switch to secondary mode	V	V	V	V	-
Start homing	V	V	V	V	-
Select electronic gear (DIV1)	V	-	-	-	-
Select electronic gear (DIV2)	V	-	-	-	--

Note:

“V” means that the input function has this function in the corresponding mode, and can be set to I1 - I10 at will.

Table5.5.1.3 Default input setting for D2 drive

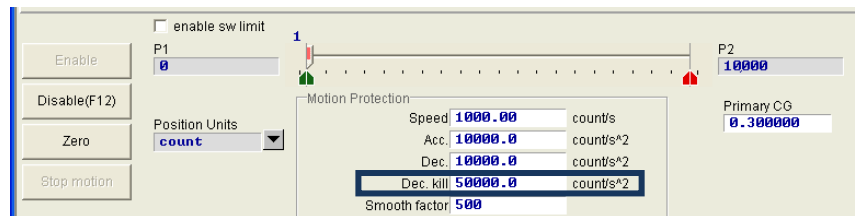
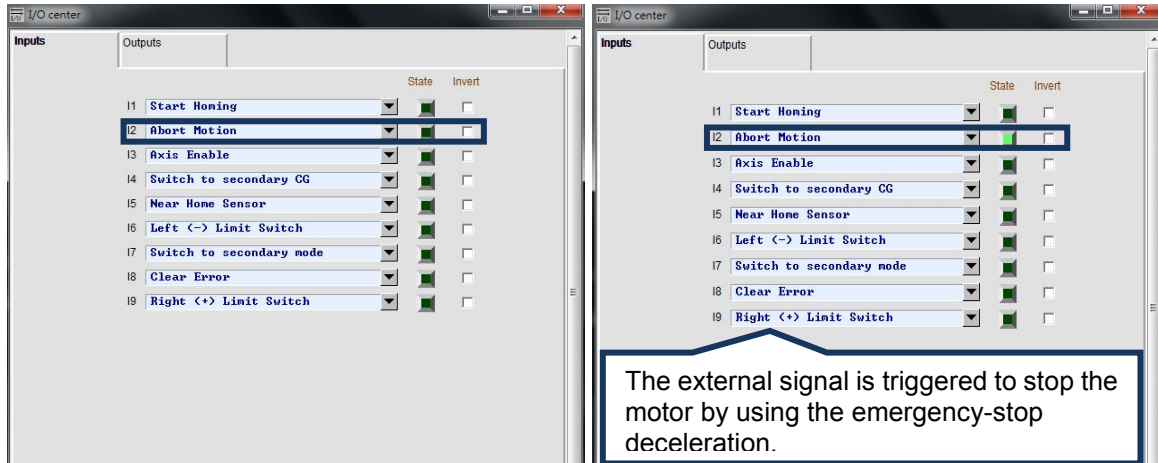
Pin	Signal	Not CoE model				CoE model	Inverse
		Position mode	Velocity mode	Force/torque mode	Stand-alone mode	Stand-alone mode	
33	I1	Inhibit Pulse Command	Zero Speed Clamp		Start Homing		No
30	I2				Abort Motion		No
29	I3	Axis Enable	Axis Enable	Axis Enable	Axis Enable	Axis Enable	No
27	I4	Switch to secondary CG	Switch to secondary CG	Switch to secondary CG	Switch to secondary CG	Left (-) Limit Switch	No
28	I5	Electronic Gear Select (DIV1)			Near Home Sensor	Right (+) Limit Switch	No
26	I6	Left (-) Limit Switch	Left (-) Limit Switch	Left (-) Limit Switch	Left (-) Limit Switch	Near Home Sensor	No
32	I7	Switch to secondary mode	Switch to secondary mode	Switch to secondary mode	Switch to secondary mode		No
31	I8	Clear Error	Clear Error	Clear Error	Clear Error		No
9	I9	Right (+) Limit Switch	Right (+) Limit Switch	Right (+) Limit Switch	Right (+) Limit Switch		No
8	I10*						No

Note:

Only for D2T model.

Input function	Abort Motion		Operation mode		Pos	Vel	Trq	Std
Symbol	EMG	Default input	I2	Circuit	Refer to 4.5.1			

- ◆ **Function description**
In the stand-alone mode, the drive will decelerate the motor to stop by using the emergency-stop deceleration (Dec. kill) when this input single is triggered by the button. The emergency-stop deceleration can be set in the performance center.
- ◆ **Instructions**
Select "Abort Motion" in the "Input" tab of I/O center (default is I2). Utilize the external trigger signal to stop the motor by using the emergency-stop deceleration.



When the input state of "Abort Motion" is True (the state light is green), the drive will decelerate the motor to stop by using the emergency-stop deceleration (Dec. kill).

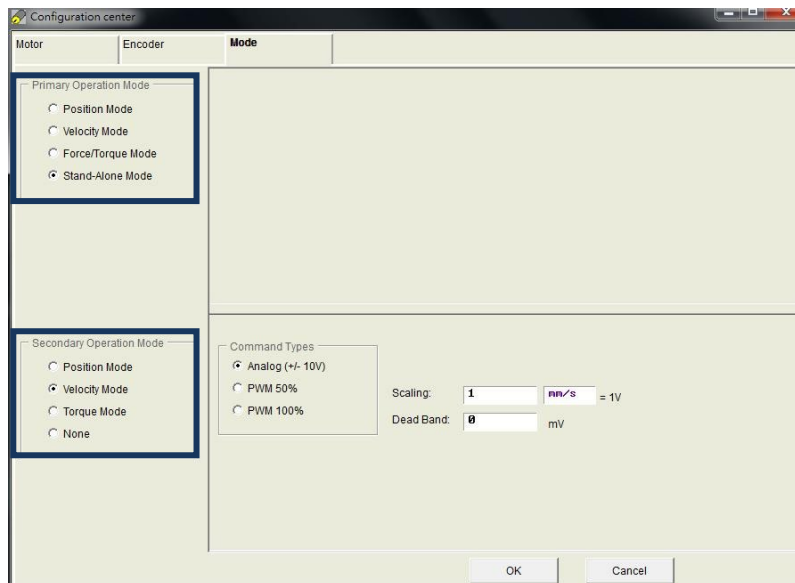
Input function	Invert V Command		Operation mode		Pos	Vel	Trq	Std
Symbol	INVC	Default input	None	Circuit	Refer to 4.5.1			

- ◆ **Function description**
Invert the voltage command sent by the host controller.
- ◆ **Instructions:**
Assign "Invert V Command" to the input function in the velocity or force/torque mode. When the input state of "Invert V Command" is False, the drive let the motor move in the forward direction at receiving the analog input voltage between 0 to +10 V, and in the reversal direction at receiving the voltage between -10 to 0 V. On the other hand, when the input state of "Invert V Command" is True, the drive let the motor move in the reversal direction at receiving the voltage between 0 to +10 V, and in the reversal direction at receiving the voltage between -10 to 0 V.

Input function	Invert V Command		Operation mode		Pos	Vel	Trq	Std
Symbol	INVC	Default input	None	Circuit	Refer to 4.5.1			

Input function	Switch to secondary mode		Operation mode		Pos	Vel	Trq	Std
Symbol	MOD	Default input	I7	Circuit	Refer to 4.5.1			

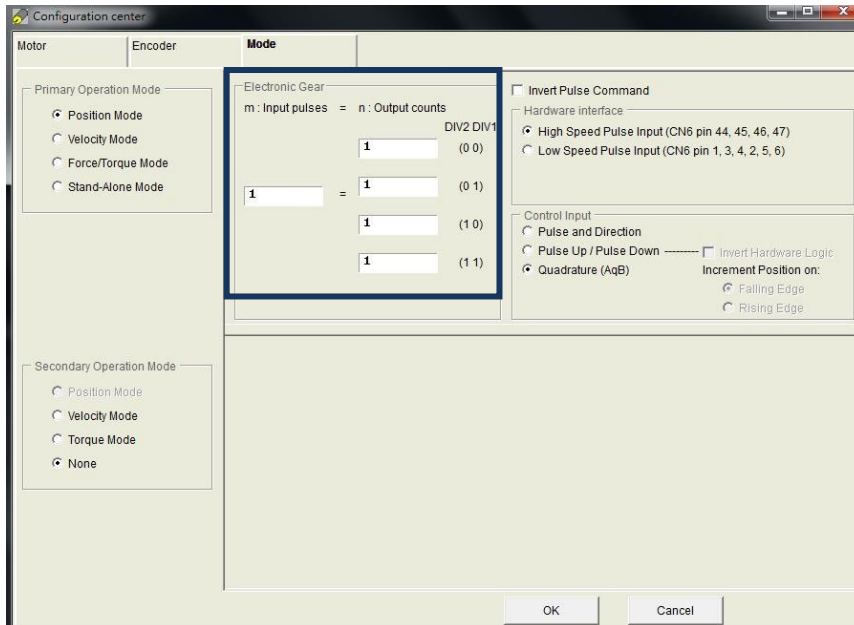
- ◆ **Function description**
Switch the operation mode via the I/O signal from the host controller.
- ◆ **Instructions**
Set the operation mode in the “Mode” tab of configuration center as shown in the following figure.



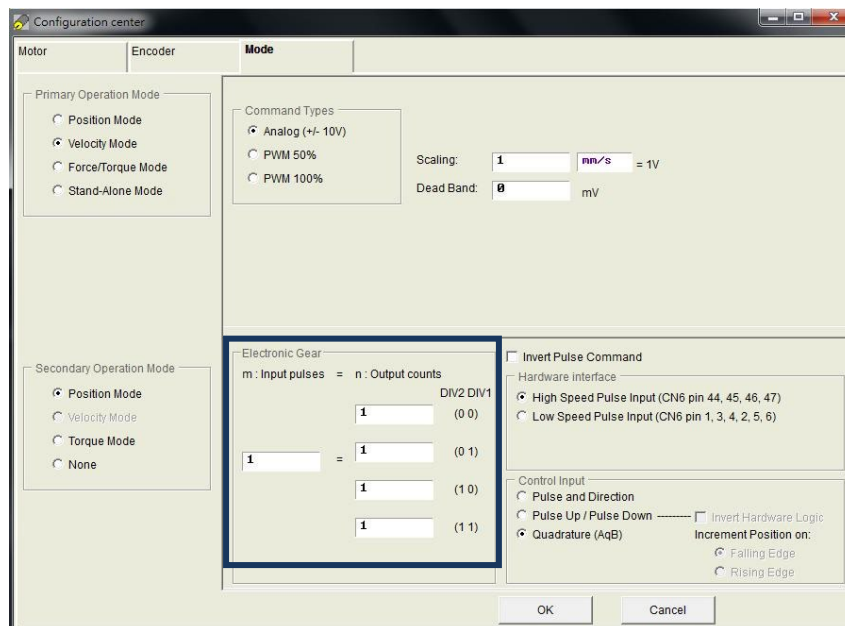
When the input state of “Switch to secondary mode” is False (the state light is off), the operation mode set in “Primary Operation Mode” is used. When the input state is True (the state light is on), the operation mode set in “Secondary Operation Mode” is used.

Input Function	Electronic Gear Select (DIV1, DIV2)		Operation mode		Pos	Vel	Trq	Std
Symbol	DIV1, DIV2	Default Input	I5	Circuit	Refer to 4.5.1			

- ◆ **Function description**
Switch among four sets of electronic gear ratio.
- ◆ **Instructions:**
Go to the “Mode” tab of configuration center, and select “Position Mode” in “Primary Operation Mode” or “Secondary Operation mode” to set four sets of electronic gear ratio, as shown in the following figure.



Configuration page for electronic gear ratio (Primary Operation Mode)



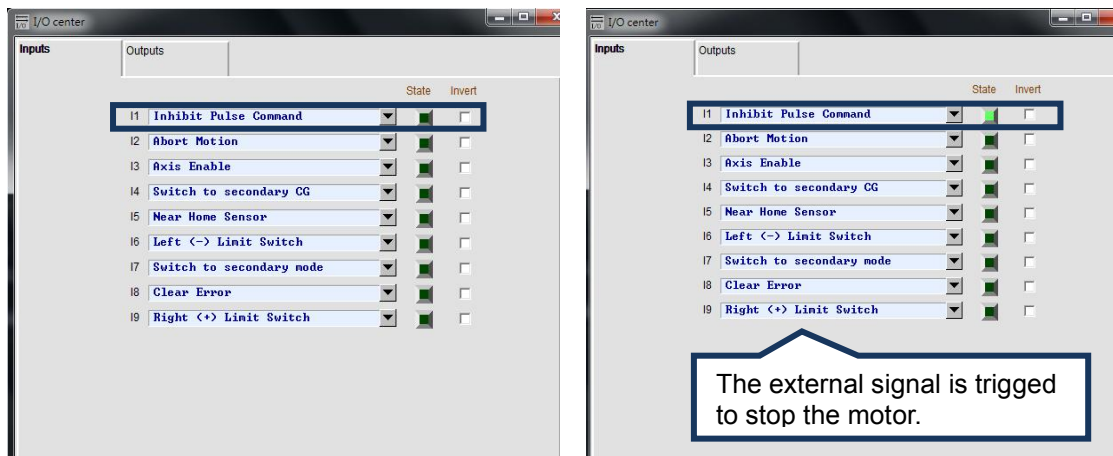
Configuration page for electronic gear ratio (Secondary Operation Mode)

Based on the different combination of DIV1 and DIV2, the required electronic gear ratio can be selected. The corresponding combination is shown in the following table. For example, the third electronic gear ratio is required, “Electronic Gear Select (DIV2)” is set to True and “Electronic Gear Select (DIV1)” is set to False.

DIV2	DIV1	Numerator
0	0	1 st
0	1	2 nd
1	0	3 rd
1	1	4 th

Input function	Inhibit Pulse Command		Operation mode		Pos	Vel	Trq	Std
Symbol	INH	Default input	I1	Circuit	Refer to 4.5.1			

- ◆ **Function description**
Inhibit to receive the pulse command sent by the host controller via triggering this input signal.
- ◆ **Instructions**
In the position mode, assign “Inhibit Pulse Command” to the input function. If this input single is True, the drive stops receiving the pulse command from the host controller; while if it is False, the drive receives the pulse command from the host controller to let the motor move.

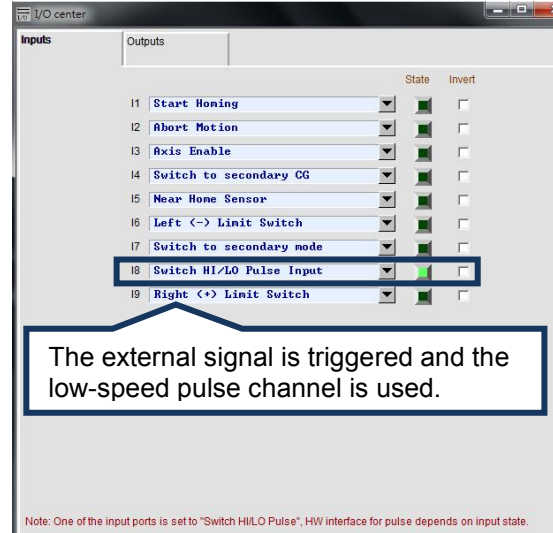
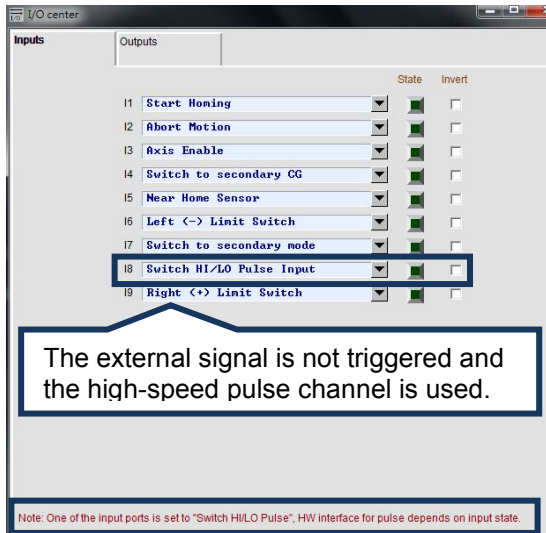


Input function	Start homing		Operation mode		Pos	Vel	Trq	Std
Symbol	HOM	Default input	I1	Circuit	Refer to 4.5.1			

- ◆ **Function description**
Execute the homing procedure.
- ◆ **Instructions**
When the state of “Start homing” is changed from False to True, the homing procedure will be executed based on the homing method set in the application center.

Input function	Switch HI/LO Pulse Input		Operation mode		Pos	Vel	Trq	Std
Symbol	PSEL	Default input	None	Circuit	Refer to 4.5.1			

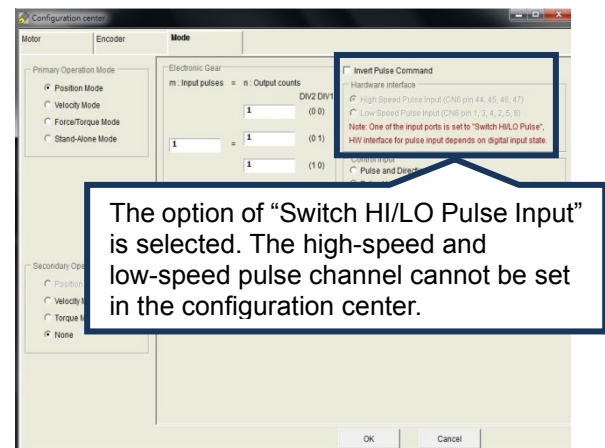
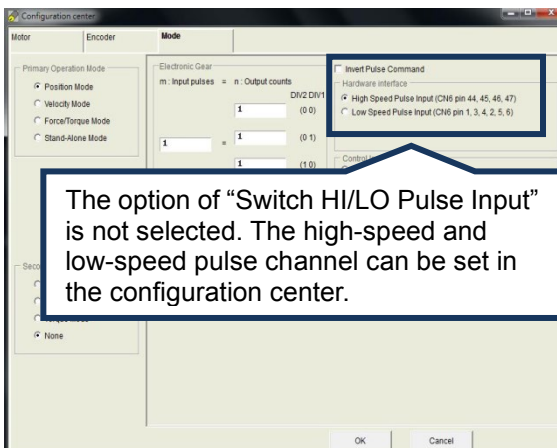
- ◆ **Function description**
In the position mode, trigger this input signal through the host controller to switch between the high-speed and low-speed pulse input channels.
- ◆ **Instructions**
Select "Switch HI/LO Pulse Input" in the "Inputs" tab of I/O center (as shown in the following figure). I1 to I9 are selectable. The following figure takes I8 as an example. Use an external trigger signal to switch between the high-speed and low-speed pulse input channels.



When the input state of "Switch HI/LO Pulse Input" is False (the state light is off), the high-speed pulse channel is used. When the input state is True (the state light is green), the low-speed pulse channel is used.

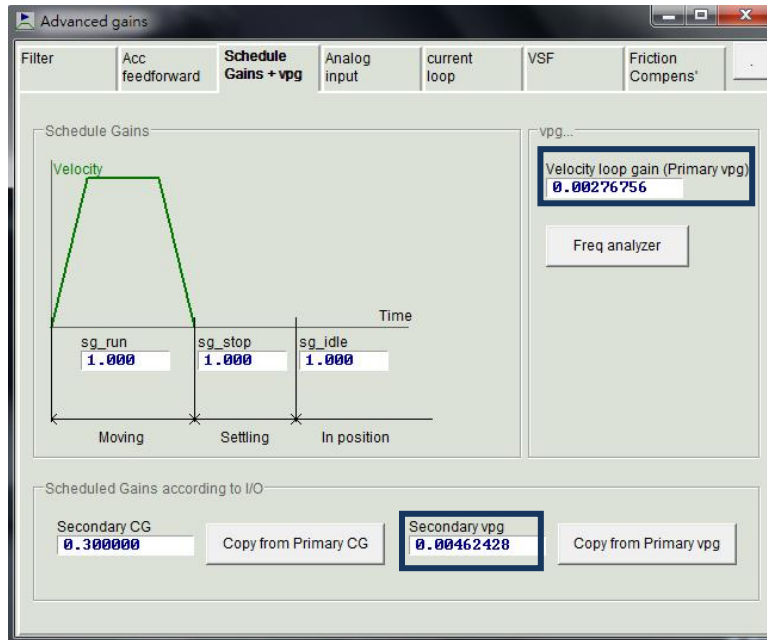
Note:

When any input (I1 - I9) is configured as "Switch HI/LO Pulse Input", the high-speed and low-speed pulse channels (hardware interface) cannot be set as selecting the position mode in the "Mode" tab of configuration center.



Input function	Switch to secondary vpg		Operation mode		Pos	Vel	Trq	Std
Symbol	JSEL	Default input	None	Circuit	Refer to 4.5.1			

- ◆ **Function description:**
Switch between velocity loop gains.
- ◆ **Instructions:**
Different velocity loop gains can be set in the “Schedule Gains + vpg” tab of “Advanced gains” window, as shown in the following figure.

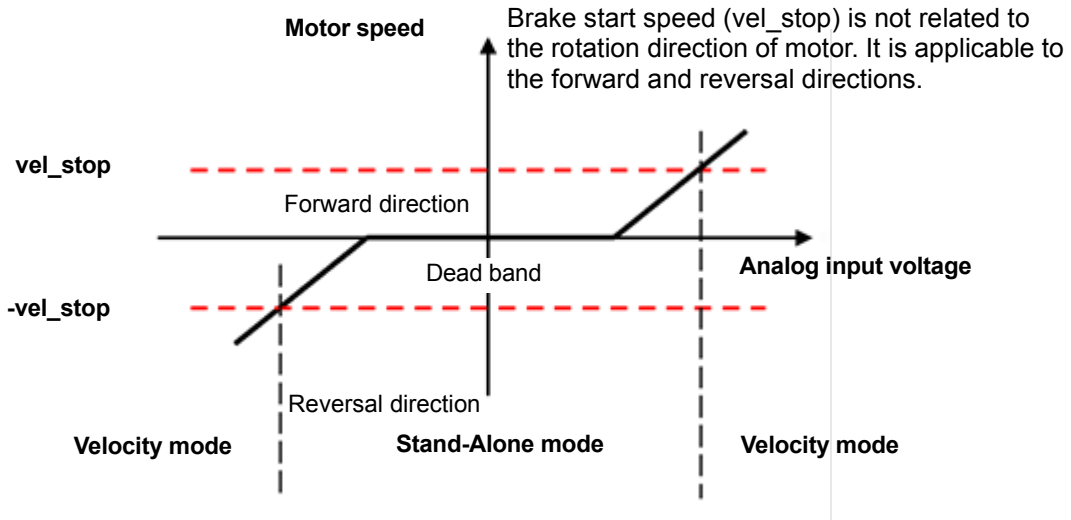


When the input state of “Switch to secondary vpg” is True (the light is on), “Secondary vpg” is used. When it is False (the light is off), “Primary vpg” is used.

Input function	Zero Speed Clamp		Operation mode		Pos	Vel	Trq	Std
Symbol	ZSC	Default input	I1	Circuit	Refer to 4.5.1			

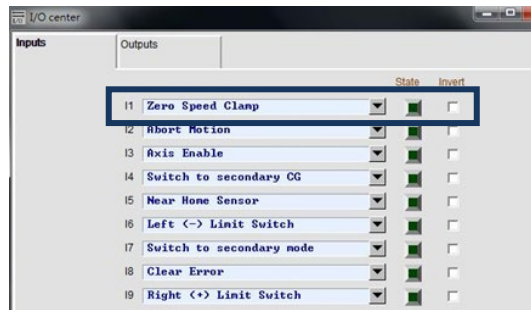
- ◆ **Function description**
This input function is only applicable to the velocity mode and is level triggered. When the input state of “Zero Speed Clamp” is True, if the motor speed corresponding to the analog input voltage command is equal to or less than the brake start speed, the operation mode will be switched to the stand-alone mode automatically, and the motor will be locked at the current position. Until the motor speed corresponding to the analog input voltage command is larger than the brake start speed, the operation mode will be switched to the velocity mode automatically to let the motor continue moving, as shown in the following figure.

Input function	Zero Speed Clamp		Operation mode		Pos	Vel	Trq	Std
Symbol	ZSC	Default input	I1	Circuit	Refer to 4.5.1			

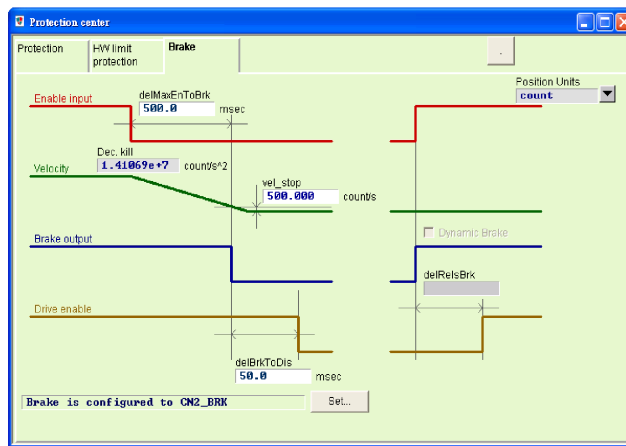


◆ Instructions

At the case of operation mode being set to the velocity mode, go to the I/O center and set “Zero Speed Clamp” as the input function. The following figure takes I1 as an example.

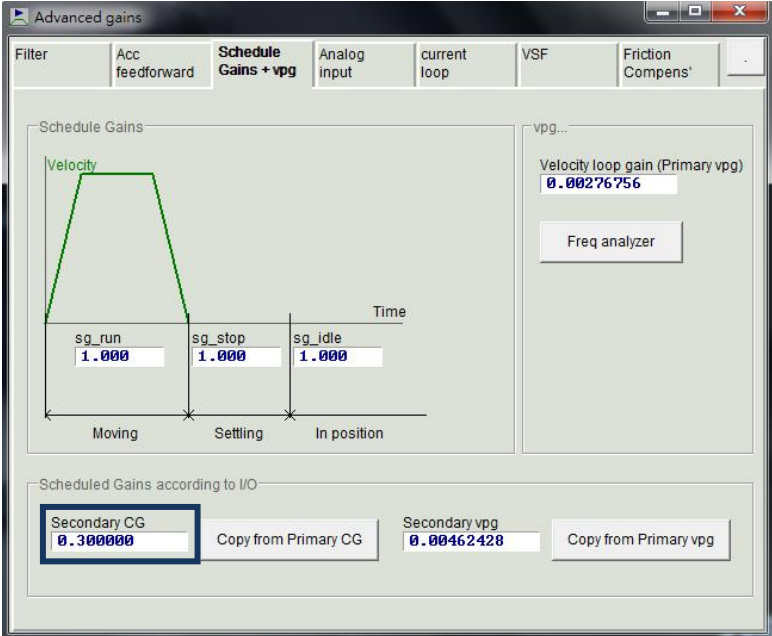


After that, go to the protection center and set the brake start speed (vel_stop) to a suitable value (the default value is 500 count/s), referring to the following figure.



The function of “Zero Speed Clamp” is activated when the input state of I1 is True.

Input function	Clear Error		Operation mode		Pos	Vel	Trq	Std
Symbol	CE	Default input	I8	Circuit	Refer to 4.5.1			
<p>◆ Function description Clear error message.</p> <p>◆ Instructions The error message will be cleared when the input state of “Clear Error” is changed from False to True.</p>								

Input function	Switch to secondary CG		Operation mode		Pos	Vel	Trq	Std
Symbol	GNS	Default input	None	Circuit	Refer to 4.5.1			
<p>◆ Function description: Switch between common gains.</p> <p>◆ Instructions: “Secondary CG” can be set in the “Schedule Gains + vpg” tab of “Advanced gains” window, as shown in the following figure.</p>								
								
<p>When the input state of “Switch to secondary CG” is True (the light is on), “Secondary CG” is used. When it is False (the light is off), “Primary CG” is used.</p>								

5.5.2 Digital output

D2 model provides 5 sets of programmable digital output. Here, 4 sets (O1 - O4) are general- purpose outputs located on the CN6 connector. The fifth set (CN2 BRK) is specially designed as the brake output and can also be used as the general-purpose output. D2T model has more than one general-purpose output (O5) located on the CN6 connector. In this section, take D2 model as an example to illustrate the digital output function.

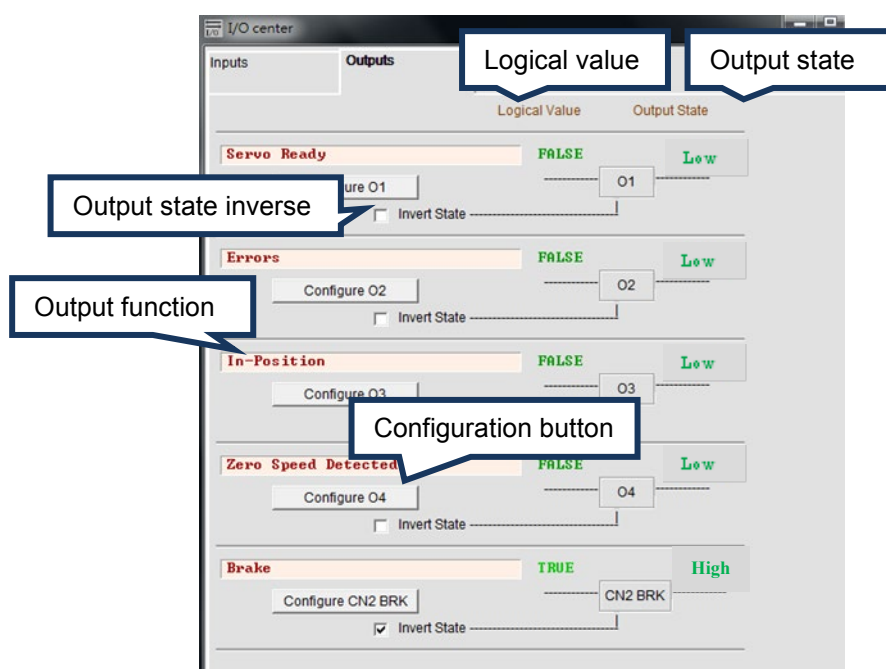


Figure 5.5.2.1 Digital output

(1) Logical value

The logical value of each output signal is displayed here. The displayed value is TRUE or FALSE.

(2) Output function

When any item in the function menu on “Configuration” window is checked, the item name is shown in the status display field. If two or more items are checked, it shows “Customized”. If all error items are checked, as shown in figure 5.5.2.1, it shows “Errors”. If no item is checked, it shows “PDL usage (General Purpose)” for the usage of general- purpose output. This means that the output function is controlled by the PDL program language.

(3) Output state

The current state of drive output pin is displayed here to be low or high (transistor is conducted or not conducted). This allows to know the state of hardware signal on the drive output to assist in wiring debugging.

(4) Invert state

If required, this option can be checked to reverse the polarity of output state to match the host controller.

Note:

The internal logic of drive is not affected by this “Invert State” setting at all.

(5) Output function setting

Each output pin has one corresponding “Configure” setting button. Taking O1 as an example, click the “Configure O1” button to open the “Configuration” window. This menu can be divided into three categories: “Statuses”, “Errors”, and “Warnings”, as shown in figure 5.5.2.2 two or more items are selected in the same configuration category, the output function works when one of these items is triggered. If all checked options need to be cancelled, click the “Not Configured” button. After selecting the desired function, click the “Apply” button to complete the setting. On the other hand, click the “Cancel” button to discard the setting. In the “Errors” category, there is one “Set all errors” button. It is recommended to use this button at selecting all errors in the “Errors” category. This is helpful to quickly complete the setting.

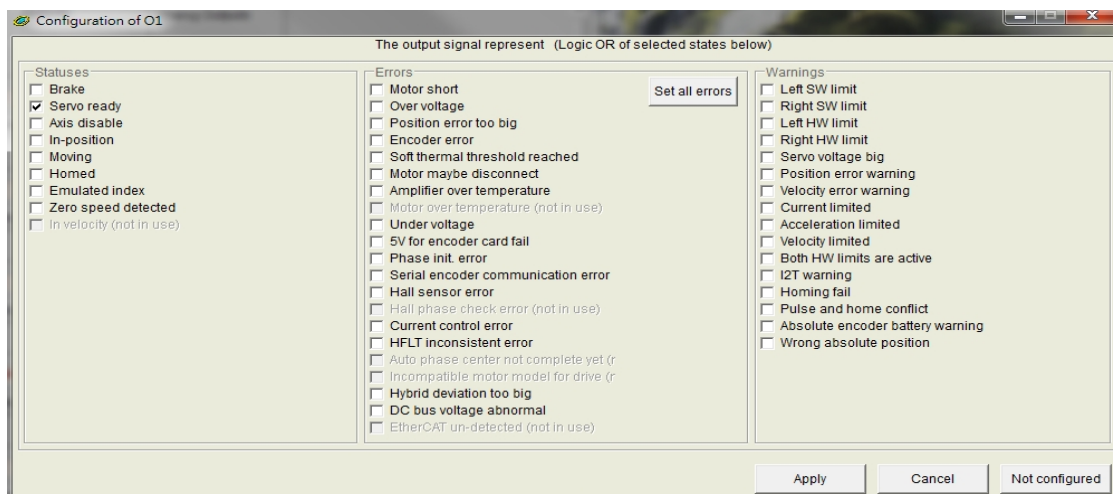


Figure 5.5.2.2 Output function setting

Table5.5.2.1

Item	Symbol	Output function	Description
Statuses			
1	BRK	Brake	Brake signal. (Checking the brake signal will no longer be possible to set other status, error, or warning.)
2	RDY	Servo Ready	Servo at the enable state.
3	DIS	Axis Disable	Servo at the disable state.
4	INP	In-Position	In-Position signal.
5	MOV	Moving	Moving.
6	HOMD	Homed	Homing completed.
7	EMI	Emulated Index	Emulated Z-phase signal.
8	ZSPD	Zero Speed Detected	Zero speed detection signal.
Errors			
1	ALM	Errors	All errors are normally checked (by clicking the “Set all error” button). Users can change the combination of errors to meet the requirement.
Warnings			
1	LS	Left Software Limit	Left software limit is triggered.
2	RS	Right Software Limit	Right software limit is triggered.
3	LH	Left Hardware Limit	Left hardware limit is triggered.
4	RH	Right Hardware Limit	Right hardware limit is triggered.
5	SVB	Servo Voltage Big	PWM command is greater than the set warning value.
6	PEW	Position Error Warning	Position error is greater than the set warning value.
7	VEW	Velocity Error Warning	Velocity error is greater than the set warning value.
8	CUL	Current Limited	Current has saturated. The specification of motor peak current is reached.
9	ACL	Acceleration Limited	When the motor is moving, the protection setting for the acceleration is reached.
10	VL	Velocity Limited	When the motor is moving, the protection setting for the velocity is reached.
11	BOHL	Both HW limits are active	Both left and right hardware limits are triggered.
12	HOMF	Homing fails	The homing process is failed.
13	PCHC	Pulse command and homing conflict	In the position mode, the pulse command and homing command are received at the same time.
14	AEBW	Absolute encoder battery warning	The encoder battery is no power. Replace the battery.
15	WAP	Wrong absolute position	The absolute encoder feedbacks an error absolute position. Reset the home position.

Table5.5.2.2 Default output setting for D2 drive

Pin	Signal	Not CoE model				CoE model	Inverse
		Position mode	Velocity mode	Force/torque mode	Stand-alone mode	Stand-alone mode	
34, 35	O1	Servo Ready	Servo Ready	Servo Ready	Servo Ready	Servo Ready	No
36, 37	O2	Errors	Errors	Errors	Errors	Errors	No
38, 39	O3	In-Position			In-Position	In-Position	No
10, 11	O4	Zero Speed Detected	Zero Speed Detected	Zero Speed Detected	Zero Speed Detected	Zero Speed Detected	No
40, 12	O5*						No
2	CN2 BRK	Brake	Brake	Brake	Brake	Brake	No

Note:

*Only for D2T model.

Table5.5.2.3 Supported output functions for each operation mode

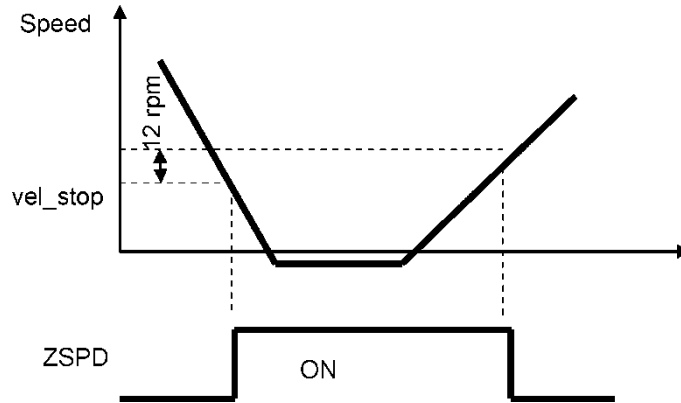
Output function \ Operation mode	Not CoE model				CoE model
	Position mode	Velocity mode	Force/torque mode	Stand-alone mode	Stand-alone mode
Brake	V	V	V	V	V
Servo ready	V	V	V	V	V
AXIS disable	V	V	V	V	V
In-position	V	--	--	V	V
Moving	V	--	--	V	V
Homed	V	V	V	V	V
Emulated index	V	V	V	V	--
Zero speed detected	V	V	V	V	--

Note:

“V” means that the output function has this function in the corresponding mode.

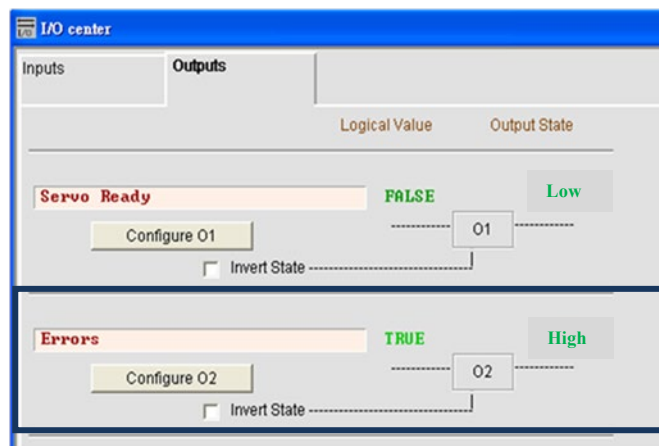
Output function	Zero Speed Detected		Operation mode		Pos	Vel	Trq	Std
Symbol	ZSPD	Default output	O4	Circuit	Refer to 4.5.2			

- ◆ **Function description**
The drive outputs this signal when the motor speed is close to zero.
- ◆ **Instructions:**
The so-called “speed closed to zero” means that the motor speed is less than the threshold set by the parameter “vel_stop”. In addition, this feature has the hysteresis of 12 rpm to avoid the bounce of ZSPD output signal. The parameter “vel_stop” refers to Section 8.3.

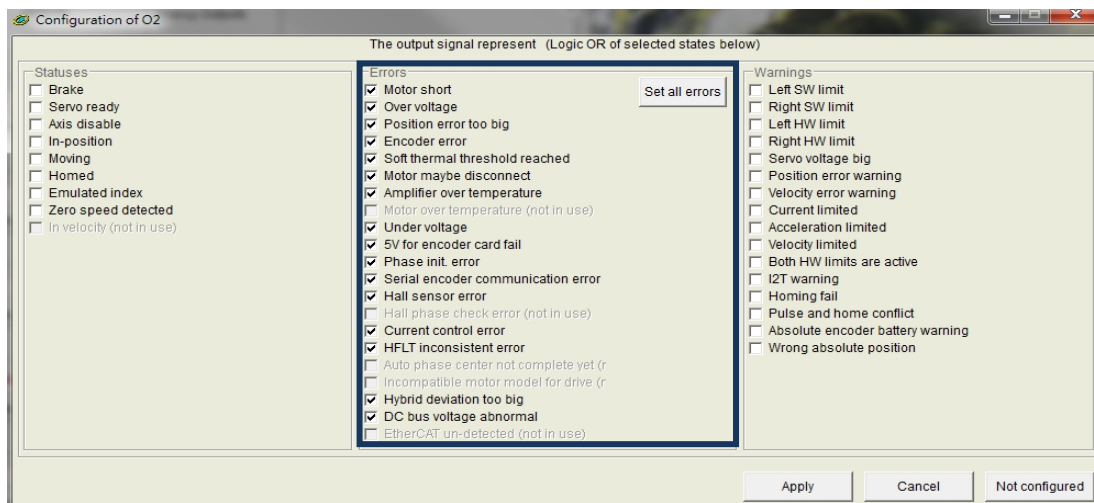


Output function	Errors		Operation mode		Pos	Vel	Trq	Std
Symbol	ALM	Default output	O2	Circuit	Refer to 4.5.2			

- ◆ Function description
Output the error status.
- ◆ Instructions:
“Errors” can be set in the “Outputs” tab of I/O center (The default is O2).



Click the “Configure O2” button to appear the “Configuration of O2” window. Click the “Set all errors” button to check all options in the “Errors” category, as shown in the red box of the following figure. The used output displays “Errors”. However, if a part of errors is selected, but not all errors, the used output displays “Customized”.



5.5.3 Analog output

D2T model has two analog outputs, located on the CN6 connector, which can be used to monitor the motor speed (pin 42) and motor torque (pin 43). The output voltage range is from -10 V to 10 V, and the output resolution is 16 bits. The configuration page for analog output is shown in figure 5.5.3.1.

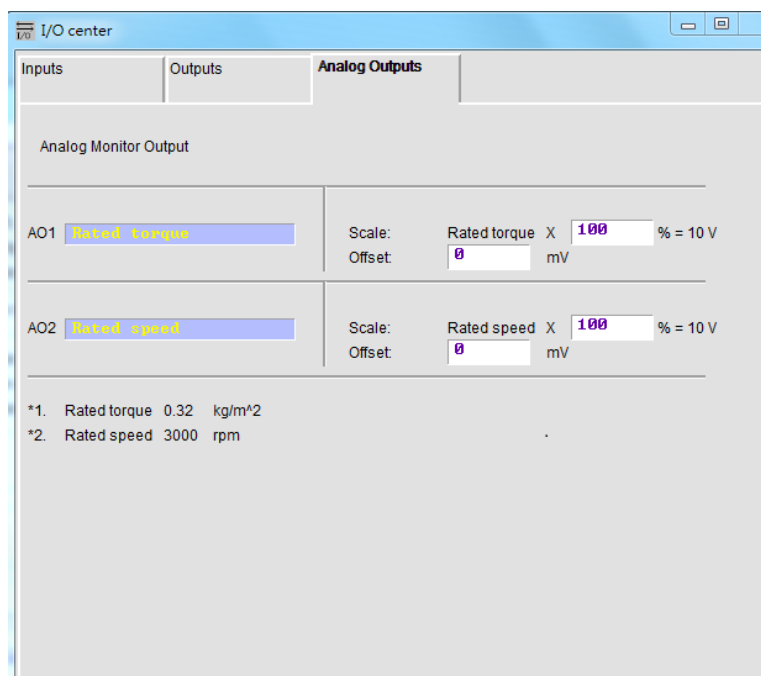


Figure5.5.3.1 Analog output

(1) AO1 Rated torque

Set the motor torque (Rated torque x □%) at the maximum output voltage of pin 43 on CN6 being 10 V, where “Rated torque” = “motor rated current” x “motor torque constant”. The value of □ is set by the user (the input range is from 1 to 300; the default value is 100). “Offset” is the offset of output voltage (the input range is from -10,000 mv to 10,000 mv; the default value is 0).

(2) AO2 Rated speed

Set the motor speed (Rated speed x □%) at the maximum output voltage of pin 42 on CN6 being 10 V, where “Rated speed” is the motor rated speed. The value of □ is set by the user (the input range is from 1 to 300; the default value is 100). “Offset” is the offset of output voltage (the input range is from -10,000 mv to 10,000 mv; the default value is 0).

5.5.4 Extension I/O

For D2 drive with the extension I/O module, parameters shown in table 5.5.4.1 can be used to set the voltage level for each extension I/O pin.

Table5.5.4.1 Extension I/O parameters

Parameter	Definition	Data Type	Maximum	Minimum
External_Input_1	Inputs on the extension I/O CN13	Uint16	4,095	0
External_Output_1	Outputs on the extension I/O CN13	Uint16	63	0
External_Input_2	Inputs on the extension I/O CN14	Uint16	4,095	0
External_Output_2	Outputs on the extension I/O CN14	Uint16	63	0

(1) Configured relationship between External_Input_1 and CN13

Table5.5.4.2

Bit No. of External_Input_1	15~12	11	10	9	8	7	6	5	4	3	2	1	0
Pin No. of CN13	-	25	24	23	22	21	20	19	18	17	16	15	14

(2) Configured relationship between External_Output_1 and CN13

Table5.5.4.3

Bit No. of External_output_1	15~6	5	4	3	2	1	0
Pin No. of CN13	-	12, 11	10, 9	8, 7	6, 5	4, 3	2, 1

(3) Configured relationship between External_Input_2 and CN14

Table5.5.4.4

Bit No. of External_output_2	15~12	11	10	9	8	7	6	5	4	3	2	1	0
Pin No. of CN14	-	25	24	23	22	21	20	19	18	17	16	15	14

(4) Configured relationship between External_Output_2 and CN14

Table5.5.4.5

Bit No. of External_output_2	15~6	5	4	3	2	1	0
Pin No. of CN14	-	12, 11	10, 9	8, 7	6, 5	4, 3	2, 1

Example:

When DI 9 of CN13 (pin 22) is at the high level, DO 2 of CN13 (pin 3 and pin 4) outputs a high-level signal.

```
#task/1;
```

```
_External_IOTest:
```

```
till(External_Input_1 & 0x0100 ); // Wait for DI 9 of CN13 to be high level.
```


```
External_Output_1 = 0x0002; // DO 2 of CN13 outputs a high-level signal.
```

```
ret;
```

5.6 In-position signal setting

In the servo system, the target position and the encoder feedback position have a certain following error. When the motor moves to the target position, there will be a small period of settling, called the settling time. Then, the motor enters the target radius. D2 drive provides the functional interface of in-position to observe whether the motor has reached the target position by setting “Target radius” and “Debounce time”. This function is supported only when the drive is operated in the position mode or stand-alone mode. The “In-Position” status can be sent to the host controller via the digital output signal.

■ Function setting

Click  to appear the window of performance center. The “In-Position” configuration page is displayed in the “Position” tab. Click the “Set scope...” button to open the “Scope” window if capturing the waveform is needed. The default of “In-Position” signal is O2. Refer to Section 5.5.2 for setting digital output.

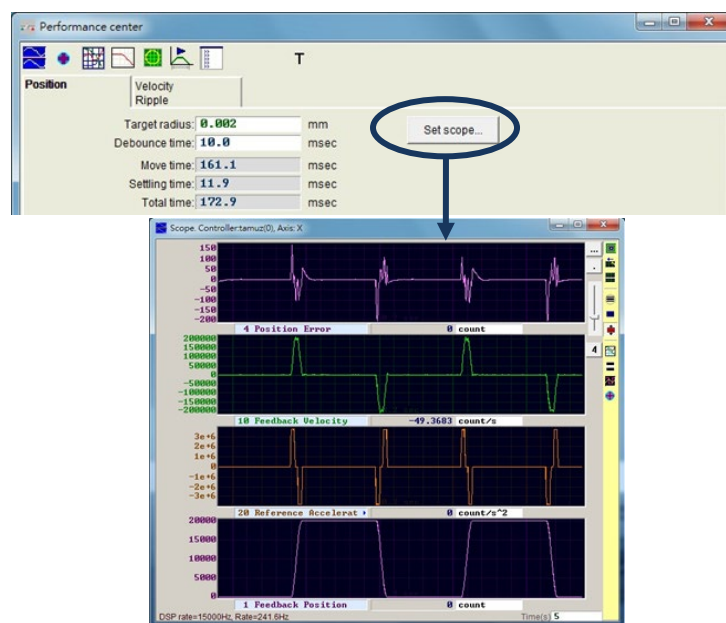


Figure5.6.1

Table5.6.1

Parameter	Description
Target radius	Target radius for the position error. After the position error is into "Target radius" and continues "Debounce time", "In-Position" is valid. The default value is 100 times the encoder resolution.
Debounce time	De-bounce time. After the position error is into "Target radius" for "In-Position" and continues this time, the in-position is valid.
Move time	Path planning time.
Settling time	Settling time.
Total	Total time (move time + settling time).

■ Debounce time setting

The motor positioning may have the overshoot phenomenon, resulting in that the "In-Position" signal will be instable before the motor reaches the target position. This can be resolved by setting "Debounce time". The "In-Position" signal will be sent when the position error enters "Target radius" and continues to a period of "Debounce time". The larger "Debounce time" is, the more stable the "In-Position" signal is, but the larger the time delay is. Through observing on the oscilloscope, the appropriate "Debounce time" can be set.

- (1) After fixing "Target radius" and setting "Debounce time" to 0 ms, let the motor move a distance and observe the "In-Position" signal on the oscilloscope, as shown in figure 5.6.2. When "In-Position" is achieved, the signal is a high level; while when it is not achieved, the signal is a low level. It can be observed from figure 5.6.2, when the motor moves to near the target position, there are six protruding pulses (the latter two are closer). Observing the high-level duration of each protruding pulse, the first one is about 1.5 ms, the second one is about 1.4 ms, the third one is about 1.4 ms, the fourth one is about 1.3 ms, and the fifth one and the sixth one are about 1 ms.

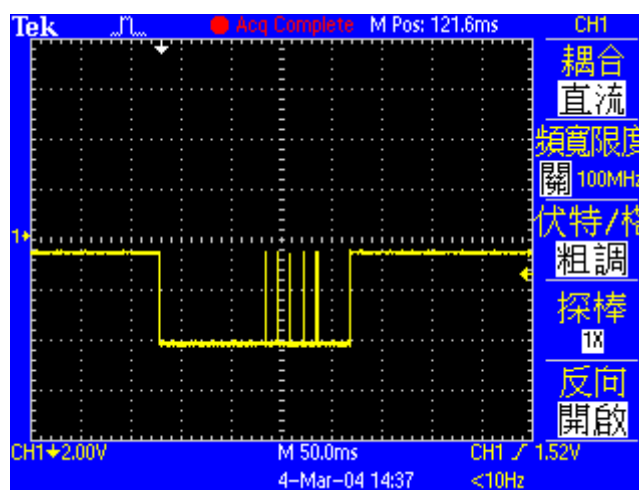


Figure5.6.2 In-position signal at "Debounce time" being 0 ms

(2) Observing in figure 5.6.2, the widest protruding pulse is 1.5 ms. So, “Debounce time” can be set to larger than this value. After considering the safety factor, set “Debounce time” to 3 ms. Let the motor move a distance, the “In-Position” signal is shown in figure 5.6.3. The instability of “In-Position” signal is improved.

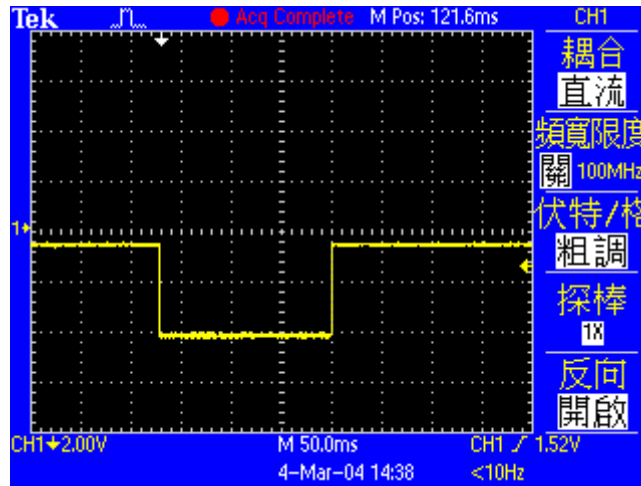



Figure5.6.3 In-position signal at “Debounce time” being 3 ms

5.7 Homing configuration

Click  to appear the window of application center, as shown in figure 5.6.2. The first tab is the homing configuration page of “Homing”.

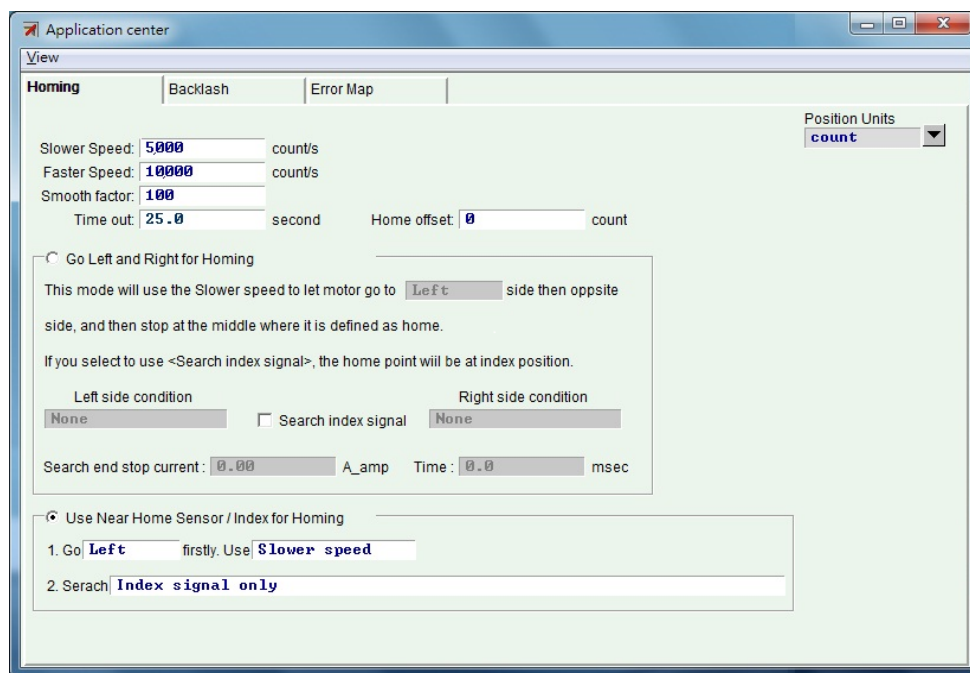


Figure5.7.1 Homing configuration page

There are 5 basic parameters for the homing configuration, as shown in the following table.



Table5.7.1

Parameter	Description
Slower Speed	Slower homing speed.
Faster Speed	Faster homing speed.
Smooth factor	The homing-specific parameter, smooth factor, can be set in the range of 1 to 500.
Time out	The maximum time of homing procedure.
Home offset	Home offset.

There are 4 modes of homing procedure:

- (1) Go left and right for homing, referring to Section 5.7.1.
- (2) Use near home sensor/index for homing, referring to Section 5.7.2.
- (3) Use multi-turn absolute encoder for homing, referring to Section 5.7.3.
- (4) Use homing methods in CiA 402 protocol, referring to Section 5.7.4.

The motor with the incremental encoder uses homing modes (1) and (2). The motor with the multi-turn absolute encoder uses the homing mode (3). However, in the case of CoE model, it uses the homing mode (4). This mode is only supported for the software version of Lightning 0.185 or above.

After setting homing mode, click the “Home” button at the bottom of performance center to start the homing procedure. The “Homed” status light on the performance center will continue flashing green when the homing is in progress. When the homing is completed, the “Homed” status light will be green () to indicate that the homing is successful. However, when the set “Time out” is reached and the home position is not found, the “Homed” status light will be red () to indicate that the homing is failed.

■ Home offset

- (1) Homing mode for incremental encoder

This method is only applicable to homing modes (1) and (2) described above. When “Home Offset” is set to a nonzero value, the home position found in the original condition is offset by a distance. This new position is taken as the coordinate origin, and the motor moves to this origin position. For example, if the left and right conditions are not “None”, the drive will take the position, which is the home position found in the original condition offset by a distance, as the new home position, as shown in figure 5.6.3. If “Home Offset” is positive, the coordinated origin is at the right side of home position found in the original condition; while if it is negative, the coordinated origin is at the left side of home position found in the original condition.

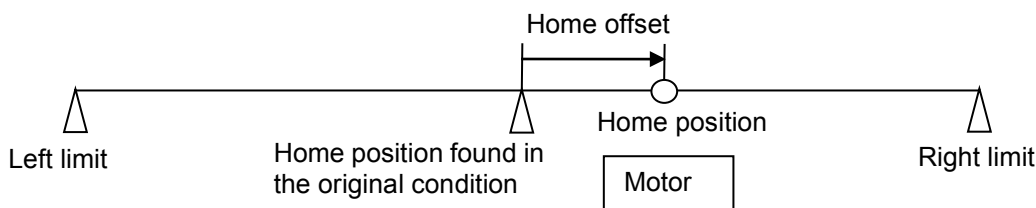


Figure5.7.2

(2) Homing mode for absolute encoder

This method is only applicable to the homing mode (3) described above. When “Home Offset” is set to a nonzero value, the drive sets the current position to the value of “Home Offset”, and the motor does not move, as shown in figure 5.7.1. If “Home Offset” is positive, the coordinated origin is at the left side of current motor position; while if it is negative, the coordinated origin is at the right side of current motor position.

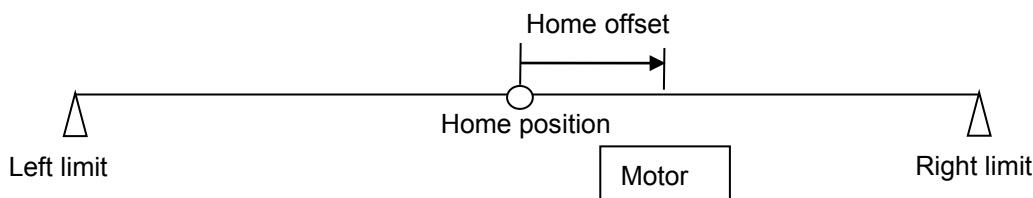


Figure5.7.3

(3) CiA 402 homing mode

This method is only applicable to the homing mode (4) described above. When “Home Offset” is set to a nonzero value, the drive sets the home position found in the original condition to the value of “Home Offset”, as shown in figure 5.7.3. If “Home Offset” is positive, the coordinated origin is at the left side of home position found in the original condition; while if it is negative, the coordinated origin is at the right side of home position found in the original condition.

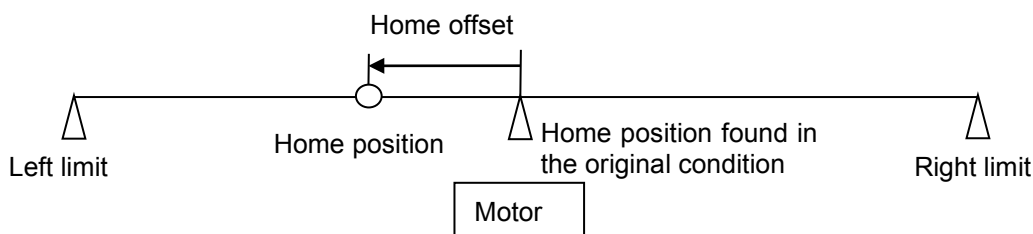


Figure5.7.4

5.7.1 Go left and right for homing

This function is a kind of multi-function homing mode built-in D2 drive. By searching the left and right conditions, the home position can be determined. The main method is to find the midpoint of two boundaries as the home position. The left and right conditions can choose the left and right limit switches. They also can be end stops. The current generated when the motor touches the mechanical stop is used to search the left and right conditions. If it is needed to search the single index of stroke for home position, click the option of “Search index signal” to achieve this requirement.

■ Homing procedure

The motor moves at the slower homing speed based on the set initial movement direction (parameter ①). Taking “Left” as an example, the motor first moves in the left direction to search the left side condition, and then moves in the right direction to search the right side condition. Finally, the motor stops at the middle of both sides, and takes this position as the home position. If the option of “Search index signal” is checked, the found index in progress is taken as the home position. Searching conditions for left side and right side are determined according to the setting (parameters ② and ③).

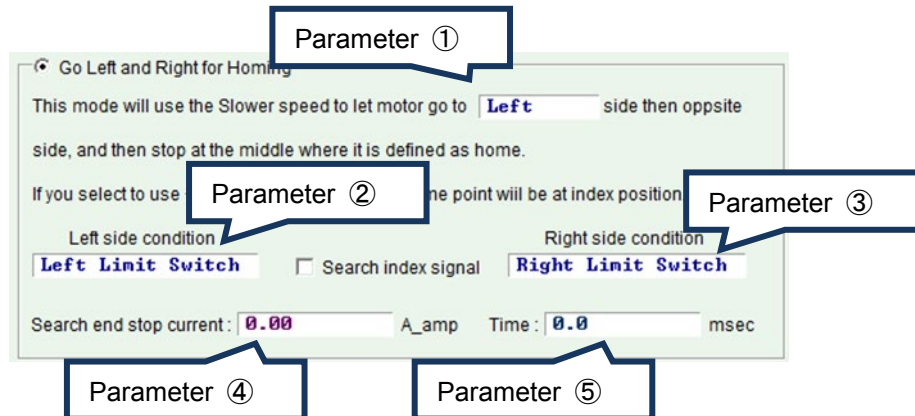


Figure5.7.1.1

Table5.7.1.1

No.	Parameter	Option	Description
①	Initial movement direction	Left	Search first in the left direction.
		Right	Search first in the right direction.
②	Left side condition	None	Not use the left side condition.
		End Stop	Search the left end stop.
		Left Limit Switch	Search the left limit switch.
③	Right side condition	None	Not use the right side condition.
		End Stop	Search the right end stop.
		Right Limit Switch	Search the right limit switch.
④	Current for searching End Stop		
⑤	Time for searching End Stop		

Select one of following items for the left or right side condition.

- (1) None: Non-search;
- (2) End Stop: Search the end stop;
- (3) Limit Switch: Search the limit switch.

Searching end stop should be carried out with parameters ④ and ⑤. Parameter ④ is used to set the force for searching end stop, and parameter ⑤ is used to set the duration of this force. If this time is too short, the drive may make a misjudgment of searching end stop before it is found. If this time is too long, the force on the end stop will increase, or the error of “Soft-thermal threshold reached” will occur. The current for searching end stop can be set by following steps.

- Step 1: Open the “Scope” window, as shown in figure 5.7.4, to set to observe the physical quantity of “Actual Current”.
- Step 2: Use the “Slower Speed” setting to move in the entire stroke.
- Step 3: Observe the change of “Actual Current”, and record the maximum value. As shown in figure 5.7.4, the maximum value of “Actual Current” is about 0.2 A. Therefore, “Search end stop current” could be set to be slightly more than 0.2 A. For example, it can be set to 0.23 A in this case.

To avoid the error of “Position error too big” occurring at searching the end stop, the slower speed and time for searching the end stop should meet the following condition:

$$\text{“Slower Speed”} \times \text{“Time”} < \text{“maximum pos error”}.$$

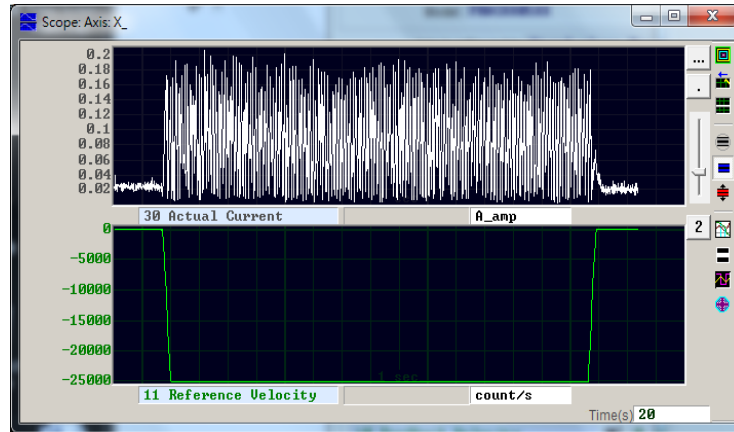


Figure5.7.1.2

➤ Exceptions:

- (1) Consider that “Left side condition” is set to “None” (i.e. not use the left side condition), “Right side condition” is set to “End Stop” or “Right Limit Switch”, and the initial movement direction (parameter ①) is set to “Left”, as shown in figure 5.7.1.1. When the homing is performed, the homing procedure is judged to be a failure, and the status light of “Homed” is red; and vice versa. (In this case, it is the unreasonable setting. Hence, the homing is failed.)

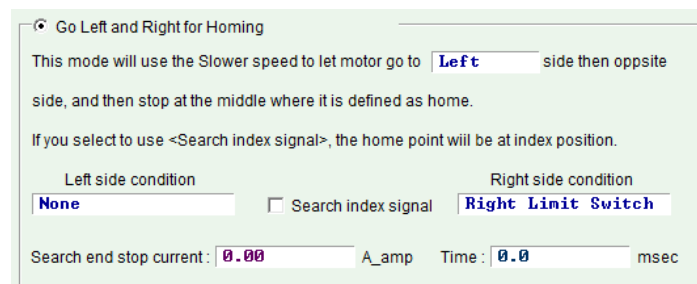


Figure5.7.1.3

- (2) If the option of “Search Index Signal” is checked and there are multiple indexes in the stroke, the drive will take the index closest to “End Stop” or “Right Limit Switch” as the home position.

➤ Homing example

According to the setting of figure 5.7.1.2, when starting the homing procedure, the motor moves at the slower homing speed in the negative direction to search the left limit switch. After it is found, the motor searches the first index signal at the slower homing speed in the positive direction. The action process is described in figure 5.7.1.3.

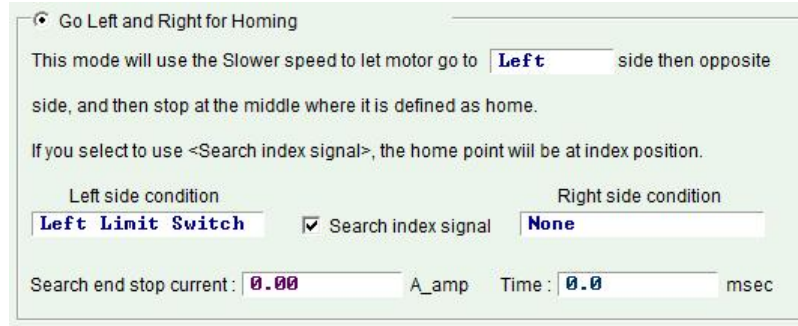


Figure5.7.1.4

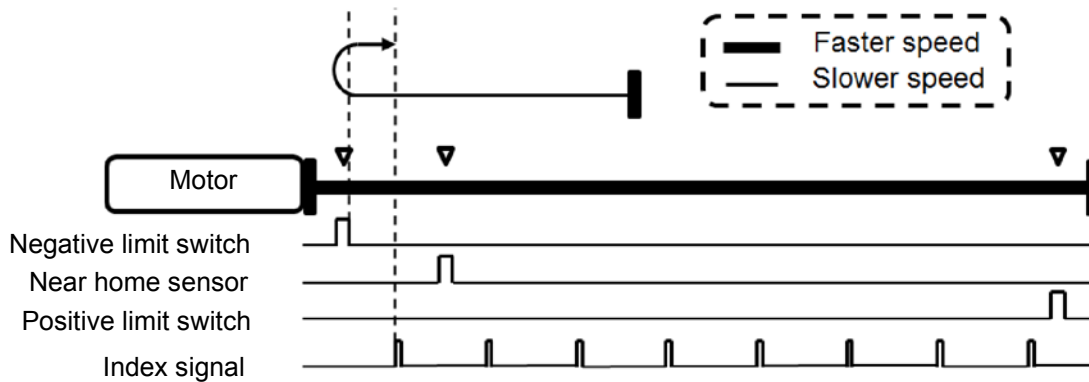


Figure5.7.1.5

5.7.2 Use near home sensor/index for homing

Another homing mode is to search “Near Home Sensor” or encoder index signal to determine the home position. “Near Home Sensor” is set to a digital input in the I/O center and is triggered via an external switch. After “Near Home Sensor” is found, the encoder index signal can be searched in the left or right direction for the home position to get the better accuracy.

■ Homing procedure

Use the setting of initial movement direction (parameter ⑥) and initial movement speed (parameter ⑦) to search “Near Home Sensor” or index signal.

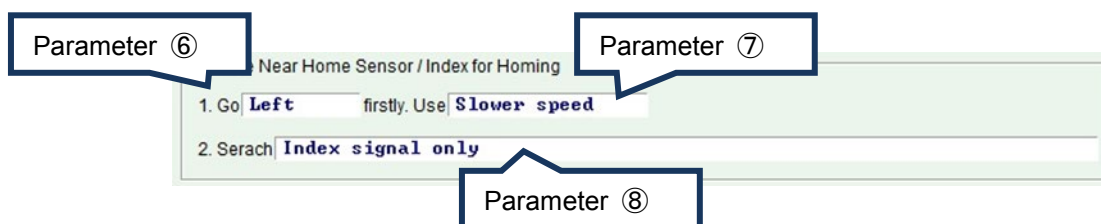


Figure5.7.2.1

Table5.7.2.1

No.	Parameter	Option	Description
⑥	Initial movement direction	Left	Search first in the left direction.
		Right	Search first in the right direction.
⑦	Initial movement speed	Slower speed	Search at the lower homing speed. Set it in the “Slower Speed” field given in figure 5.6.2.
		Faster speed	Search at the faster homing speed. Set it in the “Faster Speed” field given in figure 5.6.2.
⑧	Searching home position method	Index signal only	Search the encode index signal only.
		Near Home Sensor only	Search the near home sensor only.
		Near Home Sensor then change to lower speed, move left, search index	After the near home sensor is found, change to search the encoder index signal at the lower homing speed in the left direction.
		Near Home Sensor then change to lower speed, move right, search index	After the near home sensor is found, change to search the encoder index signal at a lower homing speed in the right direction.

When “Near Home Sensor” is used for homing, the photoelectric switch or mechanical switch can be connected to the digital input of drive. Taking I2 as an example, set I2 to be “Near Home Sensor” in the I/O center, as shown in figure 5.7.1.5.

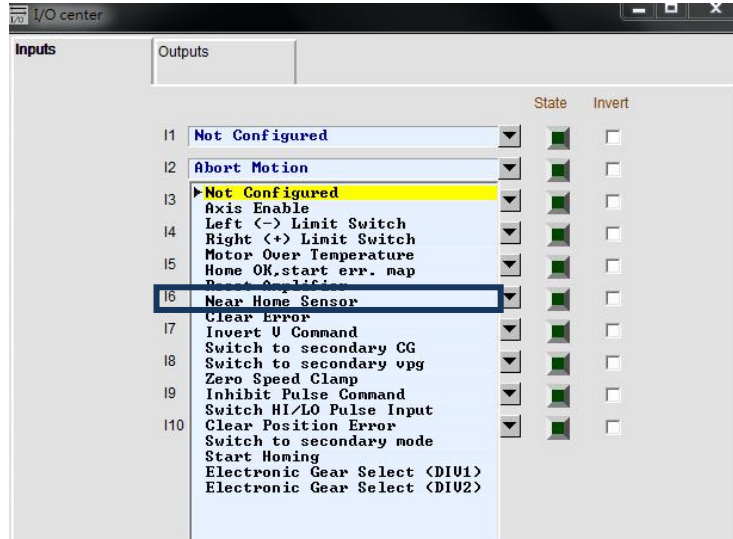


Figure5.7.2.2

➤ Homing example

According to the setting of figure 5.7.2.1, when starting the homing procedure, the motor moves at the faster homing speed in the negative direction to search “Near Home sensor”. After it is found, the motor searches the first index signal at the slower homing speed in the negative direction. The action process is described in figure 5.7.2.2.

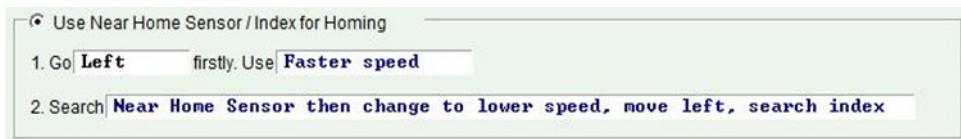


Figure5.7.2.3

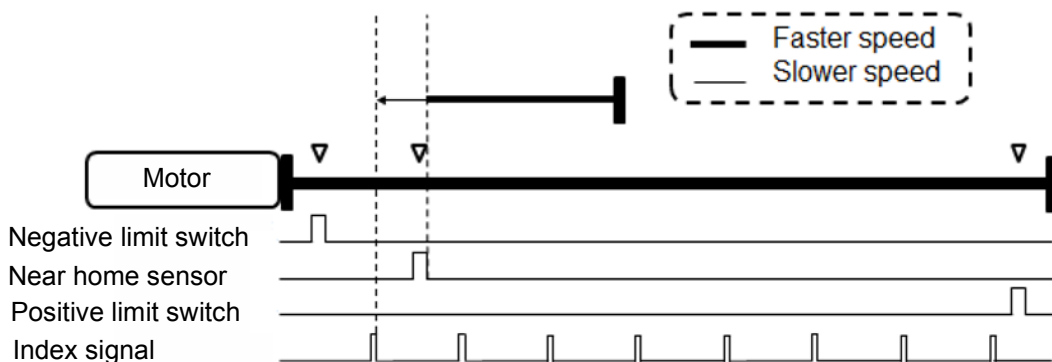


Figure5.7.2.4

5.7.3 Use multi-turn absolute encoder for homing

Due to the characteristic of multi-turn absolute encoder, the drive can obtain the absolute position of motor at any time. Therefore, this homing mode can know the home position without moving motor.

- Homing procedure

Take the current motor position as the home position.

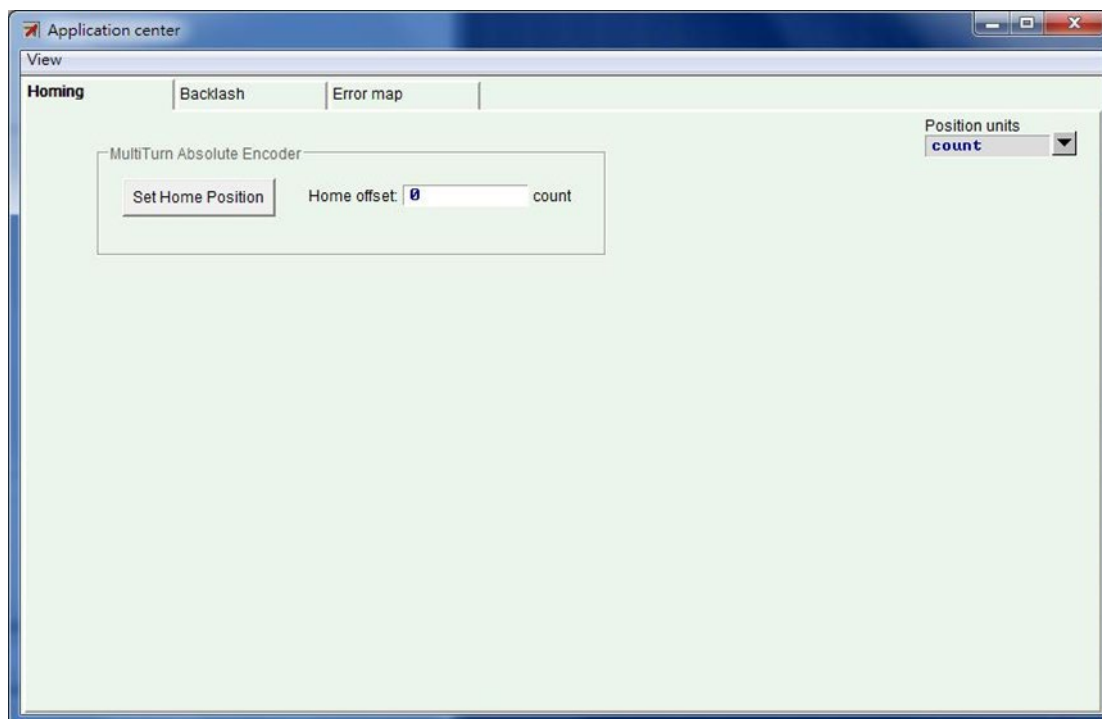


Figure5.7.3.1

5.7.4 Use homing methods in CiA 402 protocol

For the CoE model, the software version of Lightning 0.185 or above supports this homing mode. The configuration page is shown in figure 5.7.2.4, where the green line represents the faster homing speed, and the orange line represents the slower homing speed. Homing methods in this mode are summarized in table 5.7.4.1.

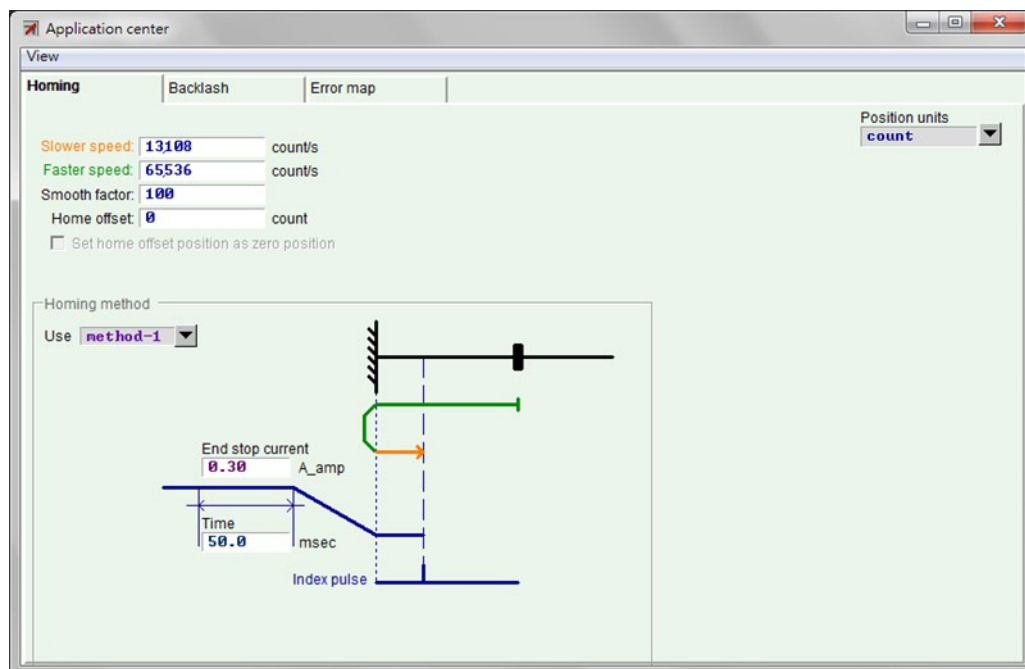
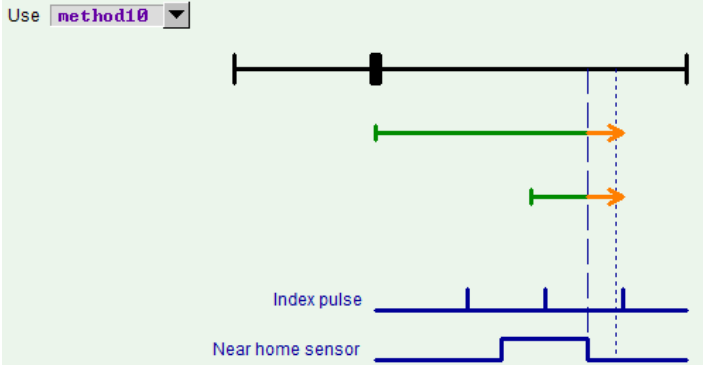
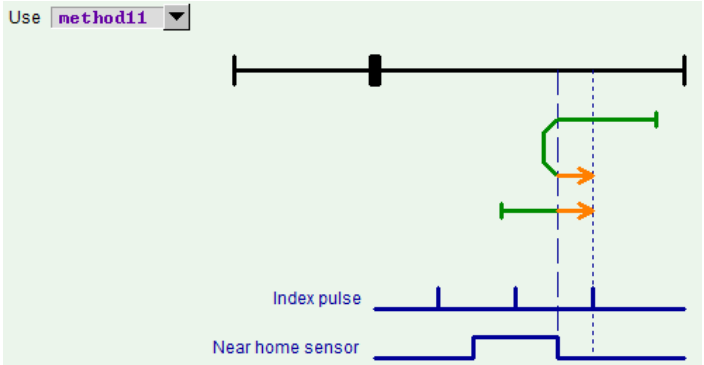
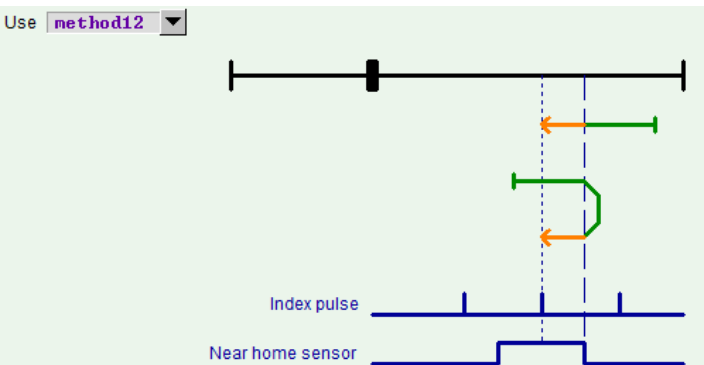


Figure5.7.4.1

Table5.7.4.1

No.	Description	Explanation
1	<p>Homing on negative limit switch and index pulse</p> <p>The motor searches the negative limit switch in the negative direction by using the faster speed. After searched, the motor searches the index in the positive direction by using the slower speed.</p>	
2	<p>Homing on positive limit switch and index pulse</p> <p>The motor searches the positive limit switch in the positive direction by using the faster speed. After searched, the motor searches the index in the negative direction by using the slower speed.</p>	

No.	Description	Explanation
7	<p>Homing on home switch and index pulse – positive initial motion, left edge of home switch, left-side index</p> <ul style="list-style-type: none"> Outside home switch The motor searches the left edge of home switch in the positive direction by using the faster speed. After searched, the motor searches the left-side index of this signal in the negative direction by using the slower speed. Inside home switch The motor searches the left edge of home switch in the negative direction by using the faster speed. After searched, the motor searches the left-side index of this signal in the negative direction by using the slower speed. 	<p>Use method7</p>
8	<p>Homing on home switch and index pulse – positive initial motion, left edge of home switch, right-side index</p> <ul style="list-style-type: none"> Outside home switch The motor searches the left edge of home switch in the positive direction by using the faster speed. After searched, the motor searches the right-side index of this signal in the positive direction by using the slower speed. Inside home switch The motor searches the left edge of home switch in the negative direction by using the faster speed. After searched, the motor searches the right-side index of this signal in the positive direction by using the slower speed. 	<p>Use method8</p>
9	<p>Homing on home switch and index pulse – positive initial motion, right edge of home switch, left-side index</p> <p>The motor searches the right edge of home switch in the positive direction by using the faster speed. After searched, the motor searches the left-side index of this signal in the negative direction by using the slower speed.</p>	<p>Use method9</p>

No.	Description	Explanation
10	<p>Homing on home switch and index pulse – positive initial motion, right edge of home switch, right-side index</p> <p>The motor searches the right edge of home switch in the positive direction by using the faster speed. After searched, the motor searches the right-side index of this signal in the positive direction by using the slower speed.</p>	 <p>The diagram for method10 shows a timeline for homing. A black bar at the top represents the home switch signal, with a vertical tick mark indicating its right edge. Below it, a green line with an orange arrow pointing right shows the motor's initial fast search for the home switch. A second green line with an orange arrow pointing right shows the motor's slower search for the right-side index pulse. At the bottom, two blue waveforms are shown: 'Index pulse' with three distinct pulses, and 'Near home sensor' which is high during the first pulse and low during the second. Vertical dashed lines indicate the timing of the fast and slow searches.</p>
11	<p>Homing on home switch and index pulse – negative initial motion, right edge of home switch, right-side index</p> <ul style="list-style-type: none"> • Outside home switch The motor searches the right edge of home switch in the negative direction by using the faster speed. After searched, the motor searches the right-side index of this signal in the positive direction by using the slower speed. • Inside home switch The motor searches the right edge of home switch in the positive direction by using the faster speed. After searched, the motor searches the right-side index of this signal in the positive direction by using the slower speed. 	 <p>The diagram for method11 shows a timeline for homing. A black bar at the top represents the home switch signal, with a vertical tick mark indicating its right edge. Below it, a green line with an orange arrow pointing left shows the motor's initial fast search for the home switch. A second green line with an orange arrow pointing right shows the motor's slower search for the right-side index pulse. At the bottom, two blue waveforms are shown: 'Index pulse' with three distinct pulses, and 'Near home sensor' which is high during the first pulse and low during the second. Vertical dashed lines indicate the timing of the fast and slow searches.</p>
12	<p>Homing on home switch and index pulse – negative initial motion, right edge of home switch, left-side index</p> <ul style="list-style-type: none"> • Outside home switch The motor searches the right edge of home switch in the negative direction by using the faster speed. After searched, the motor searches the left-side index of this signal in the negative direction by using the slower speed. • Inside home switch The motor searches the right edge of home switch in the positive direction by using the faster speed. After searched, the motor searches the left-side index of this signal in the negative direction by using the slower speed. 	 <p>The diagram for method12 shows a timeline for homing. A black bar at the top represents the home switch signal, with a vertical tick mark indicating its right edge. Below it, a green line with an orange arrow pointing left shows the motor's initial fast search for the home switch. A second green line with an orange arrow pointing left shows the motor's slower search for the left-side index pulse. At the bottom, two blue waveforms are shown: 'Index pulse' with three distinct pulses, and 'Near home sensor' which is high during the first pulse and low during the second. Vertical dashed lines indicate the timing of the fast and slow searches.</p>

No.	Description	Explanation
13	<p>Homing on home switch and index pulse – negative initial motion, left edge of home switch, right-side index</p> <p>The motor searches the left edge of home switch in the negative direction by using the faster speed. After searched, the motor searches the right-side index of this signal in the positive direction by using the slower speed.</p>	<p>Use <code>method13</code></p>
14	<p>Homing on home switch and index pulse – negative initial motion, left edge of home switch, left-side index</p> <p>The motor searches the left edge of home switch in the negative direction by using the faster speed. After searched, the motor searches the left-side index of this signal in the negative direction by using the slower speed.</p>	<p>Use <code>method14</code></p>
33	<p>Homing on index pulse – negative initial motion</p> <p>The motor searches the index pulse in the negative direction by using the slower speed.</p>	<p>Use <code>method33</code></p>
34	<p>Homing on index pulse – positive initial motion</p> <p>The motor searches the index pulse in the positive direction by using the slower speed.</p>	<p>Use <code>method34</code></p>
37	<p>Homing on current position</p> <p>Take the current position of motor as the home position.</p>	<p>Use <code>method37</code></p>


No.	Description	Explanation
-1	<p>Homing on hard stop and index pulse – negative initial motion</p> <p>The motor searches the hard stop in the negative direction by using the faster speed. After searched, the motor searches the index pulse in the positive direction by using the slower speed.</p> <p>(For the setting of searching the hard stop, refer to Section 5.7.1.)</p>	
-2	<p>Homing on hard stop and index pulse – positive initial motion</p> <p>The motor searches the hard stop in the positive direction by using the faster speed. After searched, the motor searches the index pulse in the negative direction by using the slower speed.</p> <p>(For the setting of searching the hard stop, refer to Section 5.7.1.)</p>	
-3	<p>Homing on absolute encoder</p> <p>This method is only available for the motor with the absolute encoder (the 9-th bit of motor model name is 4). Take the current position of motor as the absolute target position. The motor does not move in this method.</p>	
-4	<p>Homing on hard stop and home offset – positive initial motion</p> <p>The motor searches the hard stop in the positive direction by using the faster speed. After searched, the motor moves to the home offset (End stop offset) in the negative direction by using the slower speed. <small>(note)</small></p>	
-5	<p>Homing on hard stop and home offset – negative initial motion</p> <p>The motor searches the hard stop in the negative direction by using the faster speed. After searched, the motor moves to the home offset (End stop offset) in the positive direction by using the slower speed. <small>(note)</small></p>	

Note :

Homing methods -4 and -5 do not support the function of “Set home offset as zero position”. That is, whether this option is checked or unchecked, after the homing procedure is completed, the motor stops at the position of “home offset” and set this position to zero.

5.8 Save parameters to Flash and recover to factory default

5.8.1 Save parameters to Flash

Click  (“Save parameters from amplifier RAM to Flash”) in the HMI main window to save the current parameter in the memory. Parameters will not disappear even if the drive’s power is turned off. However, following two items should be noted.

- (1) The emulated encoder output is temporarily disabled during saving. Therefore, if the host controller is connected to the emulated encoder output, the received position information may be lost. Please pay attention to this.
- (2) Compensation values of “Error map” will not be saved via this function. Perform the “Save” procedure in the “Error map” window to save compensation values.

5.8.2 Recover to factory default

In the “Tools” menu of HMI main window, select “Set parameters to factory default” to restore drive’s parameters to factory settings, as shown in figure 5.7.3.1. Then, the window of figure 5.7.4.1 (for versions of Lightning 0.180 - 0.185A) appears to ask if users want to set the drive to factory default. If the error stable is needed to be cleared at the same time, check the option of “Clear error table in flash then reset drive”, and click the “Yes” button to automatically execute this function. When the option of “Clear error table in flash then reset drive” is checked, the program will display the “Notice” window to inform users that it will save default settings to the drive and then reset the drive before clearing “Error map”, as shown in figure 5.8.2.1. If the “Yes (Y)” button is clicked, the program executes the chosen function in the window of “Set parameters to factory default”. However, if the “No (N)” button is clicked, it will go back to the window of “Set parameters to factory default” to let users reselect functions needed to execute. After parameters are restored to factory settings, the drive will automatically execute the reset function.

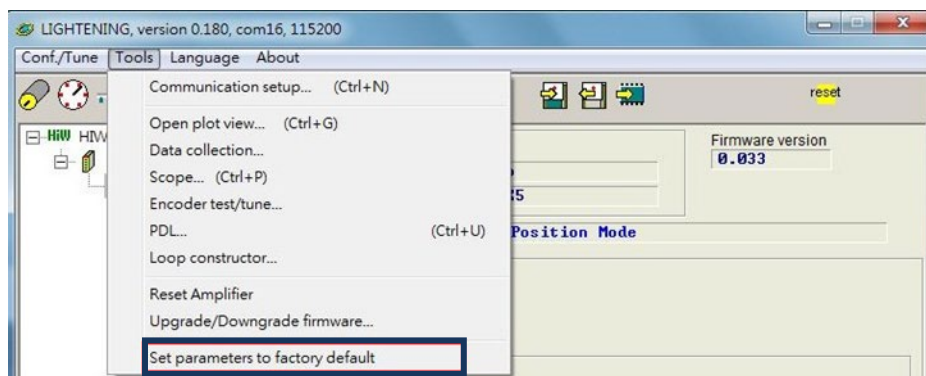


Figure5.8.2.1

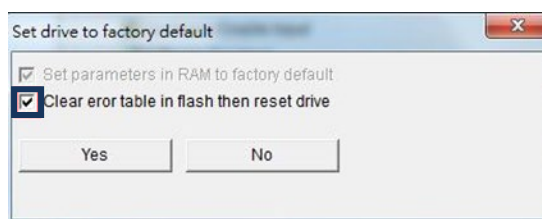


Figure5.8.2.2

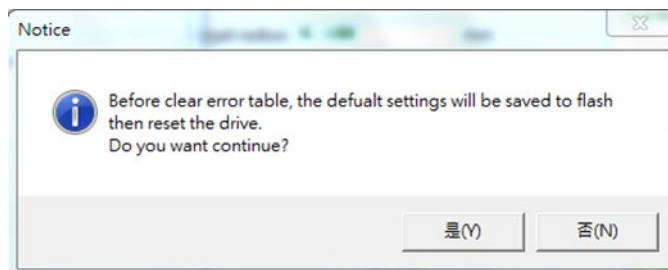


Figure5.8.2.3

For the version of Lightning 0.186 (inclusive) or above, select “Set amplifier to factory default” in the “Tools” menu of HMI main window. Then, the window of figure 5.8.2.2 appears to ask if users want to set the amplifier to factory default. Lightning is not only to restore drive parameters to factory settings, but also closes other windows exclusive of main window. If the error stable is needed to be cleared at the same time, check the option of “Clear error table in flash and reset drive”. If the content of “user.pdl” is needed to be cleared simultaneously, check the option of “Clear user PDL”. When the option of “Clear user PDL” is checked, the program will display the “Notice” window to inform users that “user.pdl” will be cleared, as shown in figure 5.8.2.4. If the “Yes (Y)” button is clicked, the program executes the chosen function in the window of “Set amplifier to factory default”. However, if the “No (N)” button is clicked, it will go back to the window of “Set amplifier to factory default” to let users reselect functions needed to execute. After parameters are restored to factory settings, the drive will automatically execute the “Reset” function.

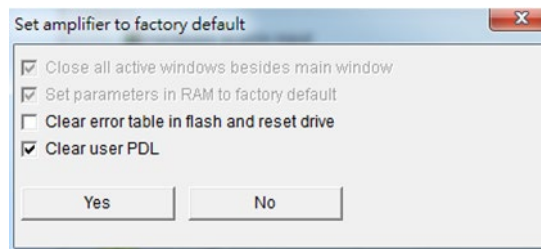


Figure5.8.2.4

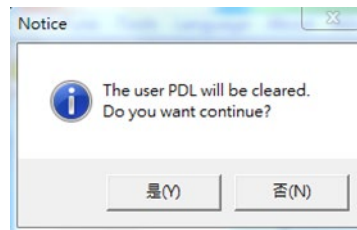


Figure5.8.2.5

5.9 Parameter setting examples via HMI


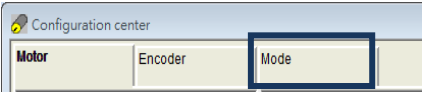
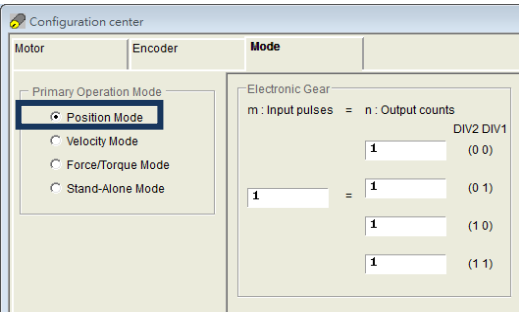
5.9.1 Position mode

In the position mode, the drive will move the corresponding distance when it receives the pulse command, referring to Section 3.1.1.

The position mode configuration includes: the mode selection, pulse format selection, electronic gear ratio setting, and smooth factor setting. After all parameters are set, refer to Section 5.8.1 to save parameters to flash.

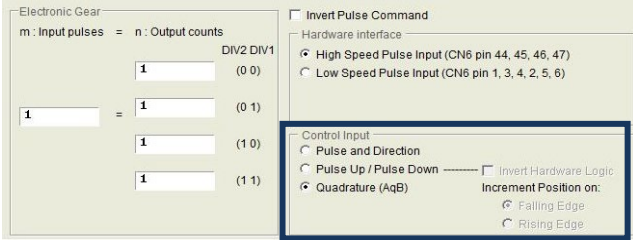
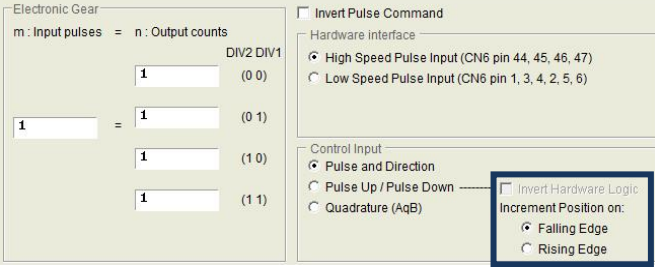
(1) Mode selection

Use following steps to select the position mode via HMI.

Step	Graphical (HMI) description	Operation
1		After executing Lightning, click the “configuration center” icon in the HMI main toolbar, as shown in the left figure, or select the “configuration center” option in “Conf/Tune”.
2		Select the “Mode” tab in the configuration center.
3		Select the “Position Mode” option in the “Mode” tab.

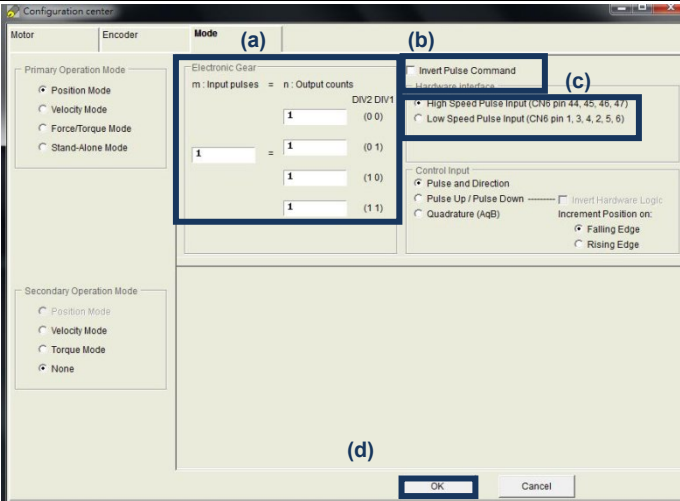
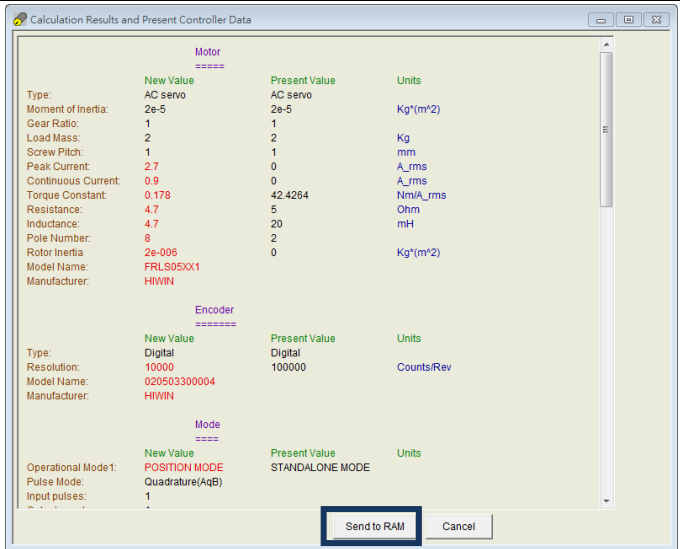
(2) Pulse format selection

D2 drive supports three types of command format, referring to Section 3.1.1. Use following steps to select the pulse format via HMI.

Step	Graphical (HMI) description	Operation
1		In the “Mode” tab, select the pulse format on the “Control Input” area as required.
2		Select the trigger method of pulse command on the “Increment Position On” area as required. Note: This setting is only needed at choosing “Pulse and Direction” or “Pulse Up/Pulse Down”.


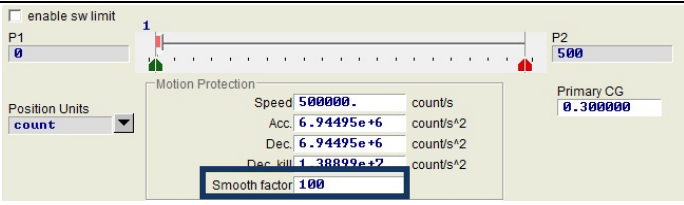
(3) Electronic gear ratio setting

D2 drive provides four sets of electronic gear ratio, referring to Section 5.5.1. Use following steps to set the electronic gear ratio via HMI.

Step	Graphical (HMI) description	Operation
1		Set the electronic gear ratio in the “Electronic Gear” area as required, as shown in the left figure (a).
2		Set to invert the pulse command in the “Invert Pulse Command” area as required, as shown in the left figure (b).
3		Set the high-speed/low-speed pulse command input in the “Hardware Interface” area as required, as shown in the left figure (c).
4		After all settings are completed, click the “OK” button, as shown in the left figure (d).
5		After the window for parameters confirmation appears, click the “Send to RAM” button to save parameters to drive RAM.

(4) Smooth factor setting

D2 drive provides the function of “Smooth factor”, referring to Section 3.4. Use following steps to set the smooth factor via HMI.

Step	Graphical (HMI) description	Operation
1		Click the “performance center” icon in the HMI main toolbar, as shown in the left figure, or select the “performance center” option in “Conf/Tune”.
2		Set “Smooth factor” in the performance center as required, as shown in the red box of left figure.


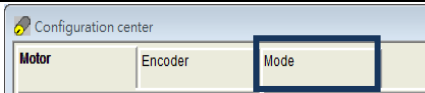
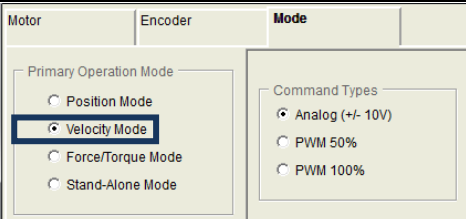
5.9.2 Velocity mode

D2 drive can transfer the voltage command and PWM command to the velocity command, referring to Section 3.1.2.

The velocity mode configuration includes: the mode selection and input command format setting. After all parameters are set, refer to Section 5.8.1 to save parameters to flash.

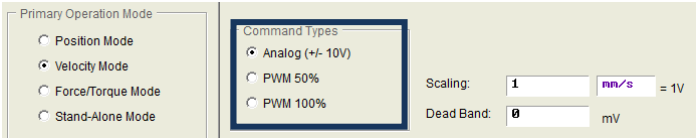
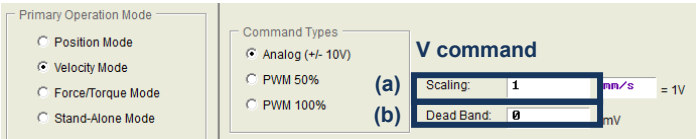
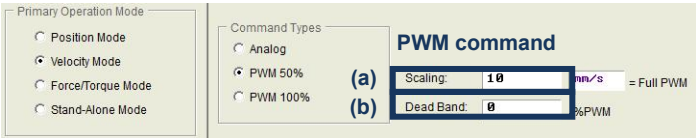
(1) Mode selection

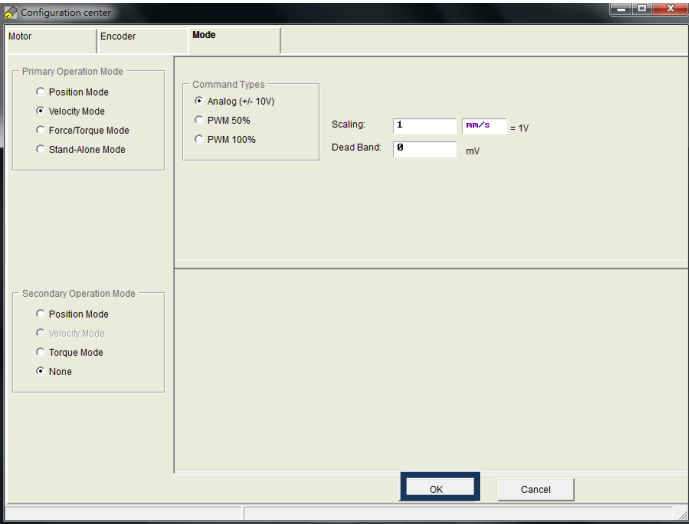
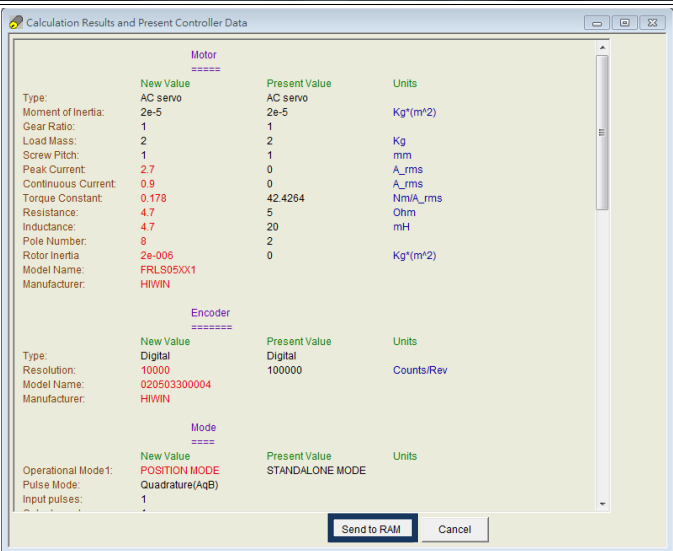
Use following steps to select the velocity mode via HMI.

Step	Graphical (HMI) description	Operation
1		After executing Lightning, click the “configuration center” icon in the HMI main toolbar, as shown in the left figure, or select the “configuration center” option in “Conf/Tune”.
2		Select the “Mode” tab in the configuration center.
3		Select the “Velocity Mode” option in the “Mode” tab.

(2) Input command format setting

Use following steps to set the input command format via HMI.

Step	Graphical (HMI) description	Operation
1		In the “Mode” tab, select the input command format on the “Command Types” area as required.
2		Set the ratio (Scaling) of external command to speed as required. The unit is 1 V equal to how many mm/s or rpm, or Full PWM equal to the maximum speed, as shown in the left figure (a).
3		Set “Dead Band” for the velocity command, as shown in the left figure (b). The definition of “Dead Band” refers to figure 5.2.3.3.

<p>4</p>		<p>After all settings are completed, click the “OK” button, as shown in the left figure.</p>
<p>5</p>		<p>After the window for parameters confirmation appears, click the “Send to RAM” button to save parameters to drive RAM.</p>


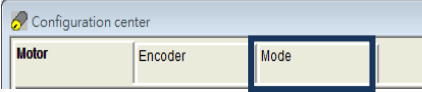
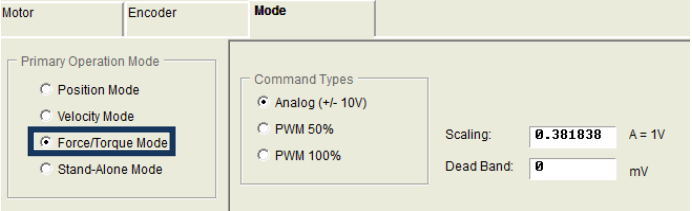
5.9.3 Force/Torque mode

D2 drive can transfer the voltage command and PWM command to the current command, referring to Section 3.1.2.

The force/torque mode configuration includes: the mode selection and input command format setting. After all parameters are set, refer to Section 5.8.1 to save parameters to flash.

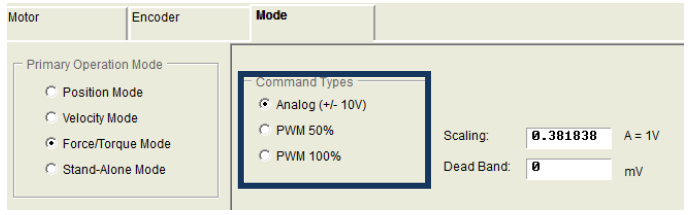
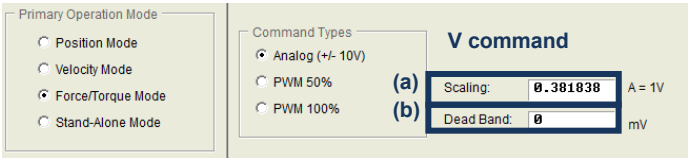
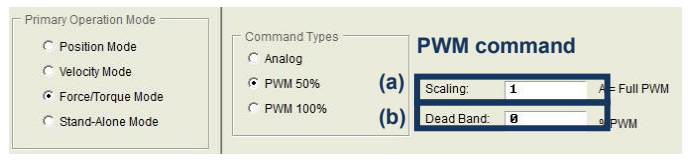
(3) Mode selection

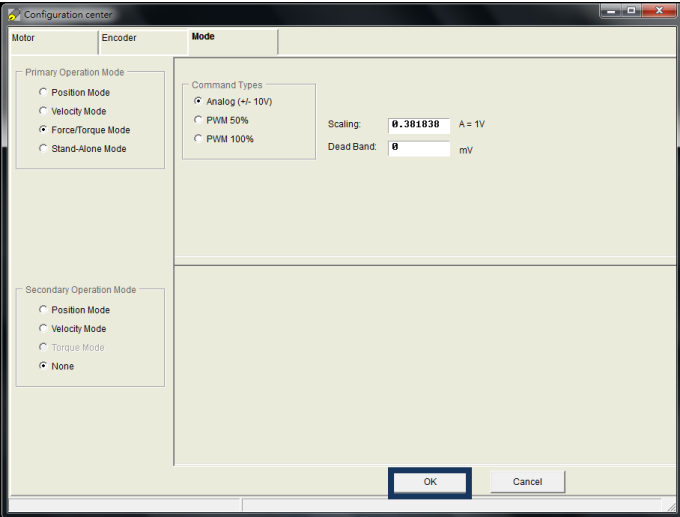
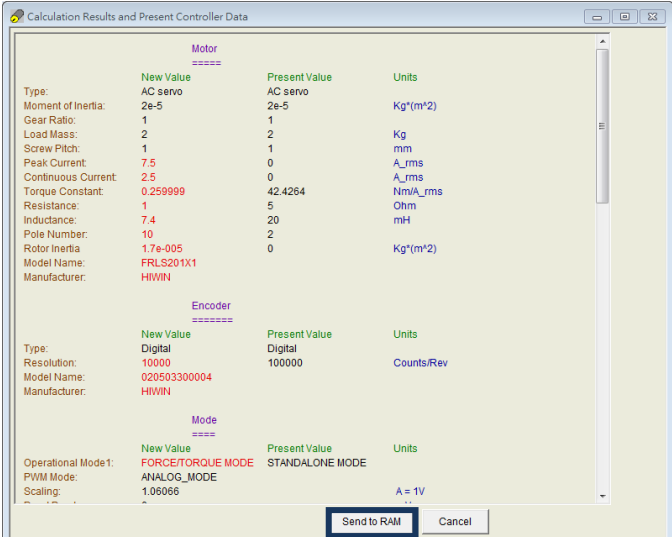
Use following steps to select the force/torque mode via HMI.

Step	Graphical (HMI) description	Operation
1		After executing Lightning, click the “configuration center” icon in the HMI main toolbar, as shown in the left figure, or select the “configuration center” option in “Conf/Tune”.
2		Select the “Mode” tab in the configuration center.
3		Select the “Velocity Mode” option in the “Mode” tab.

(4) Input command format setting

Use following steps to set the input command format via HMI.

Step	Graphical (HMI) description	Operation
1		In the “Mode” tab, select the input command format on the “Command Types” area as required.
2		Set the ratio (Scaling) of external command to current as required. The unit is 1 V equal to how many amperes, or Full PWM equal to the maximum ampere, as shown in the left figure (a).
3		Set “Dead Band” for the current command, as shown in the left figure (b). The definition of “Dead Band” refers to figure 5.2.3.3.

4		<p>After all settings are completed, click the “OK” button, as shown in the left figure.</p>																																																																																																												
5	 <table border="1" data-bbox="272 768 946 1303"> <thead> <tr> <th colspan="4">Motor</th> </tr> <tr> <th></th> <th>New Value</th> <th>Present Value</th> <th>Units</th> </tr> </thead> <tbody> <tr> <td>Type:</td> <td>AC servo</td> <td>AC servo</td> <td></td> </tr> <tr> <td>Moment of Inertia:</td> <td>2e-5</td> <td>2e-5</td> <td>Kg*(m²)</td> </tr> <tr> <td>Gear Ratio:</td> <td>1</td> <td>1</td> <td></td> </tr> <tr> <td>Load Mass:</td> <td>2</td> <td>2</td> <td>Kg</td> </tr> <tr> <td>Screw Pitch:</td> <td>1</td> <td>1</td> <td>mm</td> </tr> <tr> <td>Peak Current:</td> <td>7.5</td> <td>0</td> <td>A_rms</td> </tr> <tr> <td>Continuous Current:</td> <td>2.5</td> <td>0</td> <td>A_rms</td> </tr> <tr> <td>Torque Constant:</td> <td>0.259999</td> <td>42.4264</td> <td>Nm/A_rms</td> </tr> <tr> <td>Resistance:</td> <td>1</td> <td>5</td> <td>Ohm</td> </tr> <tr> <td>Inductance:</td> <td>7.4</td> <td>20</td> <td>mH</td> </tr> <tr> <td>Pole Number:</td> <td>10</td> <td>2</td> <td></td> </tr> <tr> <td>Rotor Inertia:</td> <td>1.7e-005</td> <td>0</td> <td>Kg*(m²)</td> </tr> <tr> <td>Model Name:</td> <td>FRLS201X1</td> <td></td> <td></td> </tr> <tr> <td>Manufacturer:</td> <td>HIWIN</td> <td></td> <td></td> </tr> </tbody> </table> <table border="1" data-bbox="272 1064 946 1176"> <thead> <tr> <th colspan="4">Encoder</th> </tr> <tr> <th></th> <th>New Value</th> <th>Present Value</th> <th>Units</th> </tr> </thead> <tbody> <tr> <td>Type:</td> <td>Digital</td> <td>Digital</td> <td></td> </tr> <tr> <td>Resolution:</td> <td>10000</td> <td>100000</td> <td>Counts/Rev</td> </tr> <tr> <td>Model Name:</td> <td>020503300004</td> <td></td> <td></td> </tr> <tr> <td>Manufacturer:</td> <td>HIWIN</td> <td></td> <td></td> </tr> </tbody> </table> <table border="1" data-bbox="272 1198 946 1303"> <thead> <tr> <th colspan="4">Mode</th> </tr> <tr> <th></th> <th>New Value</th> <th>Present Value</th> <th>Units</th> </tr> </thead> <tbody> <tr> <td>Operational Mode 1:</td> <td>FORCE/TORQUE MODE</td> <td>STANDALONE MODE</td> <td></td> </tr> <tr> <td>PWM Mode:</td> <td>ANALOG_MODE</td> <td></td> <td></td> </tr> <tr> <td>Scaling:</td> <td>1.06066</td> <td></td> <td>A = 1V</td> </tr> </tbody> </table>	Motor					New Value	Present Value	Units	Type:	AC servo	AC servo		Moment of Inertia:	2e-5	2e-5	Kg*(m ²)	Gear Ratio:	1	1		Load Mass:	2	2	Kg	Screw Pitch:	1	1	mm	Peak Current:	7.5	0	A_rms	Continuous Current:	2.5	0	A_rms	Torque Constant:	0.259999	42.4264	Nm/A_rms	Resistance:	1	5	Ohm	Inductance:	7.4	20	mH	Pole Number:	10	2		Rotor Inertia:	1.7e-005	0	Kg*(m ²)	Model Name:	FRLS201X1			Manufacturer:	HIWIN			Encoder					New Value	Present Value	Units	Type:	Digital	Digital		Resolution:	10000	100000	Counts/Rev	Model Name:	020503300004			Manufacturer:	HIWIN			Mode					New Value	Present Value	Units	Operational Mode 1:	FORCE/TORQUE MODE	STANDALONE MODE		PWM Mode:	ANALOG_MODE			Scaling:	1.06066		A = 1V	<p>After the window for parameters confirmation appears, click the “Send to RAM” button to save parameters to drive RAM.</p>
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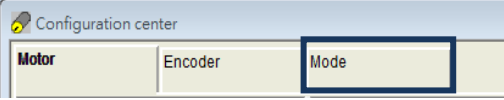
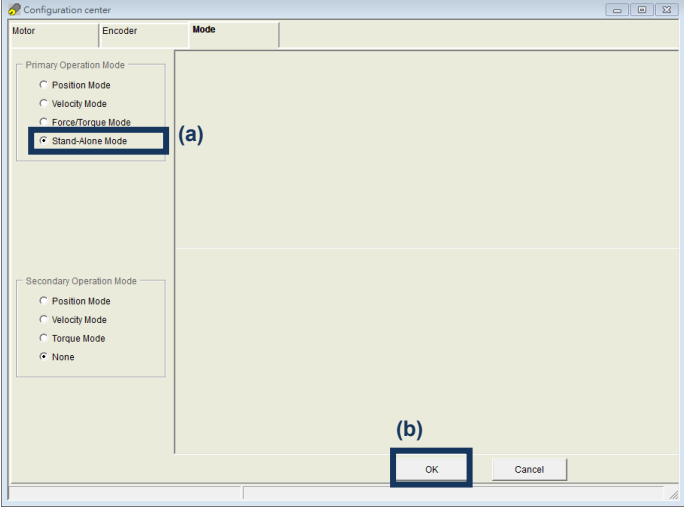
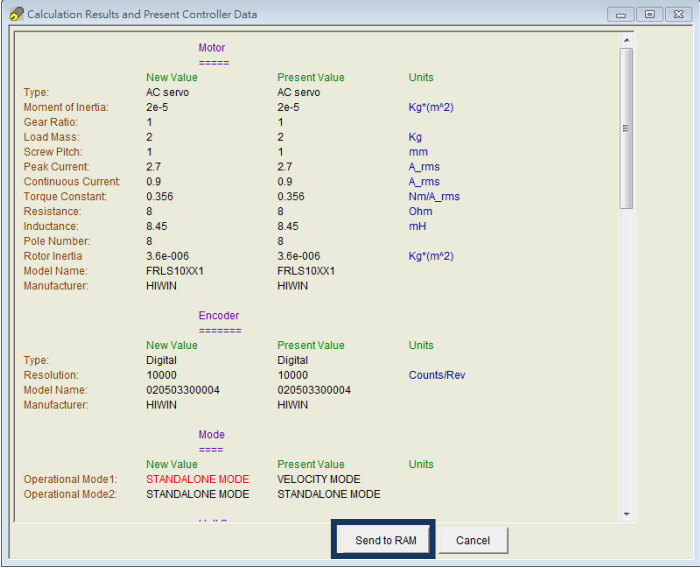
5.9.4 Stand-alone mode

In the stand-alone mode, the drive will execute the internal path planning to drive the motor, referring to Section 3.1.4.

The stand-alone mode configuration includes the mode selection. After all parameters are set, refer to Section 5.8.1 to save parameters to flash.

(1) Mode selection

Use following steps to select the stand-alone mode via HMI.

Step	Graphical (HMI) description	Operation
1		After executing Lightning, click the “configuration center” icon in the HMI main toolbar, as shown in the left figure, or select the “configuration center” option in “Conf/Tune”.
2		Select the “Mode” tab in the configuration center.
3		In the “Mode” tab, select the option of “Stand-Alone Mode”, as shown in the left figure (a).
4		After all settings are completed, click the “OK” button, as shown in the left figure (b).
5		After the window for parameters confirmation appears, click the “Send to RAM” button to save parameters to drive RAM.

6. Drive Tuning

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6.1 Status display and quick view

In Lightning HMI, the status display and “Quick view” are two auxiliary tools, which are indispensable in the tuning process. They can help to know the drive status at any time and present many important parameter values in the motion control.

6.1.1 Status display

There are 2 status display tools, as shown in figure 6.1.1.1. The left figure shows the “Status” area in the HMI main screen; while the right figure shows the “Status” area in the performance center. The status display provides the status and error/warning message for users to know the system status.

■ Status

- (1) Hardware Enable Input: To indicate whether the hardware enable signal is activated.
- (2) Software Enabled: To indicate whether the software enable is activated.
- (3) Servo Ready: To indicate whether the motor is enabled.
- (4) Phase Initialized: To indicate whether the motor completes the phase initialization.
- (5) Moving: To indicate whether the motor is in motion.
- (6) Homed: To indicate whether the motor completes the homing procedure.
- (7) SM mode: The motor is enabled in the SM mode.

■ Errors and warnings

- (1) Last error: Display the latest error message.
- (2) Last warning: Display the latest warning message.

Refer to Section 9 for more information.

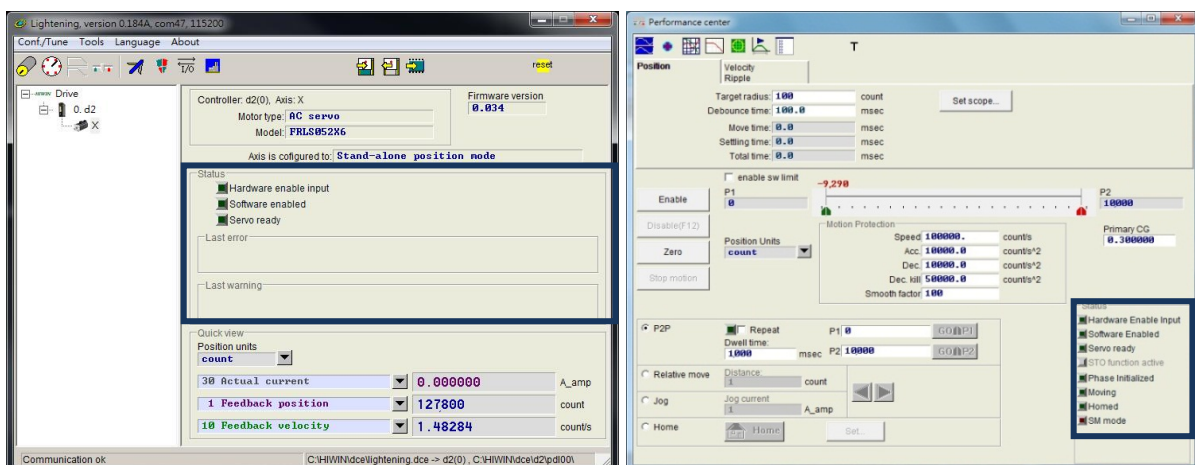


Figure 6.1.1.1 Status display

6.1.2 Quick view

The “Quick view” area is at the bottom of HMI main screen, and is used to help users to know more about the detail of drive’s current status. The interface provides 3 physical quantities to display. Users can select the physical quantity to be observed. These 3 physical quantities will update their display values at any time. This is convenient for users to observe and analyze the system status, as shown in figure 6.1.2.1. Refer to Section 3.11 for selectable physical quantities.

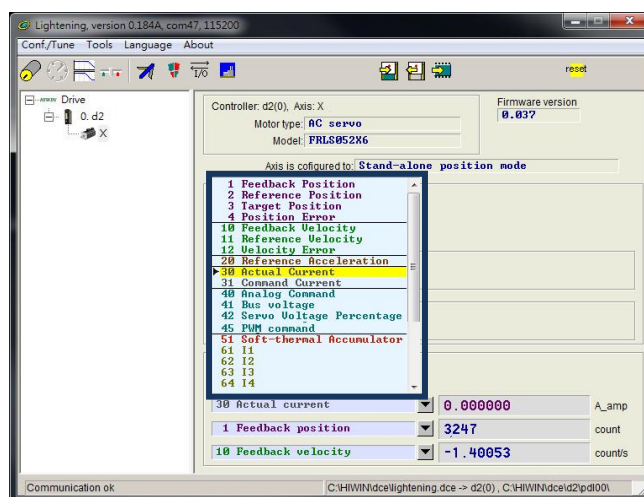


Figure6.1.2.1 Physical quantity menu in “Quick view”

■ Unit setting (Position Units)

For each display of physical quantity, if it is related with the distance, users can select the preferred unit to display (or set) the relevant physical quantity (position, speed, etc.), as shown in figure 6.1.2.2.

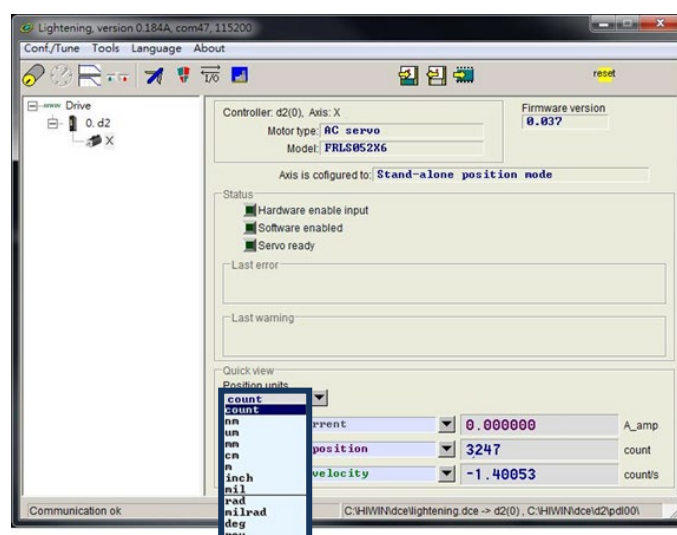


Figure6.1.2.2 Unit setting menu

6.1.3 Software shortcuts

There are two function shortcuts in HMI for D2 drive: **F6** and **F12**. They are only available if Lightening HMI is active for Windows operation system.

- (1) **F6**: Move the Lightening main window to the top level.
- (2) **F12**: This function is an emergency stop action. For example, clicking **F12** during the movement will perform the emergency stop action (refer to Section 3.4). The motor will be disabled after the stop.

6.2 Performance center

Most of tuning procedures are centered around the performance center. After completing the setting in Section 5.3 or Section 5.4, the motor is ready for test runs. The performance center is mainly used to provide users with the motion testing and tuning, and with the help of auxiliary tools to observe the motion performance. It provides three modes of motion: point-to-point (“P2P”) motion, relative motion, and continuous motion (“Jog”). Parameters related to these motions, such as speed, acceleration/deceleration, emergency stop deceleration, and smooth factor, are also set in this interface.

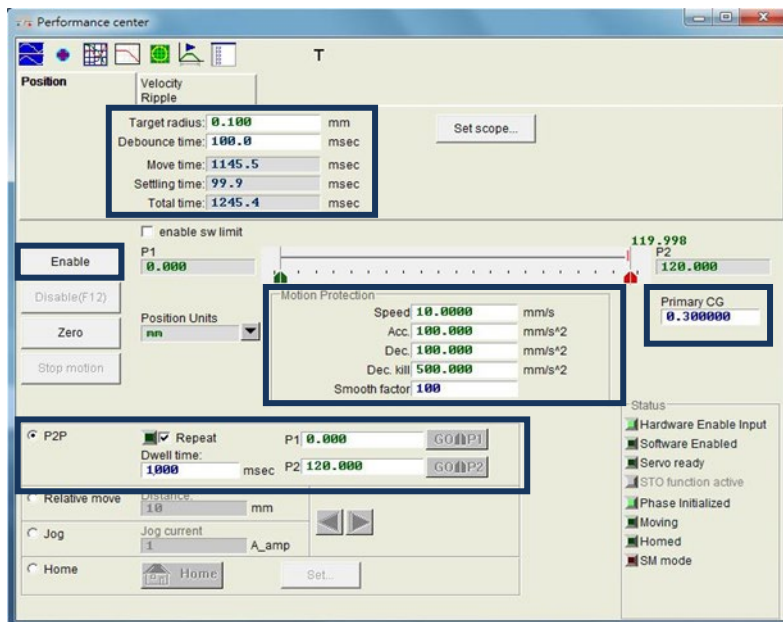


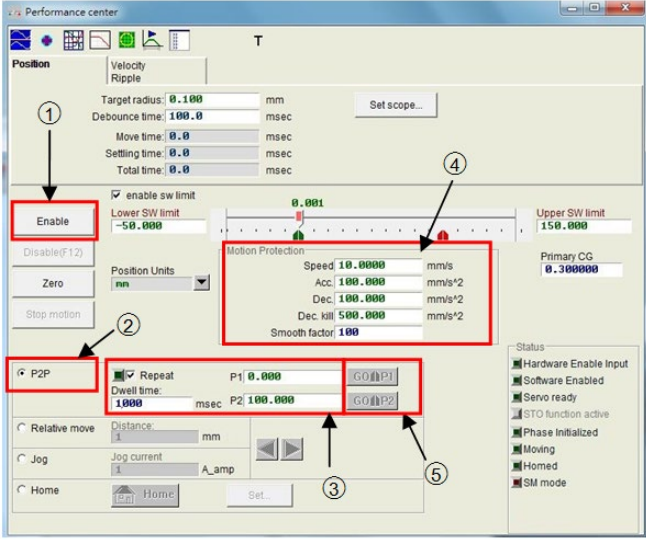
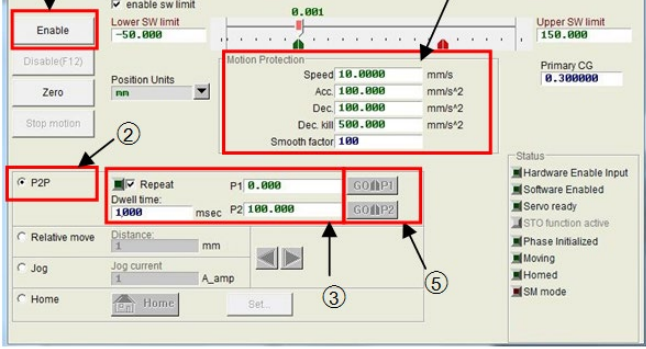
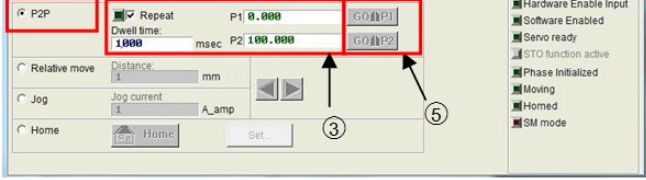






Figure6.2.1 Performance center

Take the point-to-point (P2P) motion as an operation example in the following:

Table6.2.1

Step	Graphical (HM) description	Operation
1		Click  to enable the motor.
2		Select  .
3		Set positions of P1 and P2 . (If software limits are used, set the position between “Lower SW limit” and “Upper SW limit”.)
4		Set the required speed, acceleration, deceleration, and smooth factor (refer to Section 3.4). If there are no special requirement, simply use default values.
5		Click  to move to the P1 position and click  to move to the P2 position. To perform a point-to-point back-and-forth motion, select the “Repeat” option and enter the break time (“Dwell time”). Then, click the button of  or  to perform the point-to-point motion.

The performance center has the function of measuring the settling time. The target radius of position error and debounce time for settling time can be set via “Target radius”, referring to Section 5.6. During motion, the servo gain (“Primary CG”) can be tuned to meet the requirement of settling time. The higher the servo gain is, the faster the response is and the shorter the settling time is. The required time from moving to in-position can be observed via “Move time”, “Settling time”, and “Total time” (refer to Section 3.7). Click “Set scope...” button to appear the graphical oscilloscope (“Scope”). This tool can be used to observe the motion waveform related to the settling time.

The performance center has the function of measuring the velocity ripple. The performance of velocity ripple can be observed via the point-to-point motion. Here, “V max”, “V min”, “V avg”, and “Velocity Ripple” are the maximum speed, minimum speed, average speed, and velocity ripple at the constant speed phase, respectively. Click the “Set scope...” button to appear the graphical oscilloscope (“Scope”). This tool can be used to observe the motion waveform related to the velocity ripple.

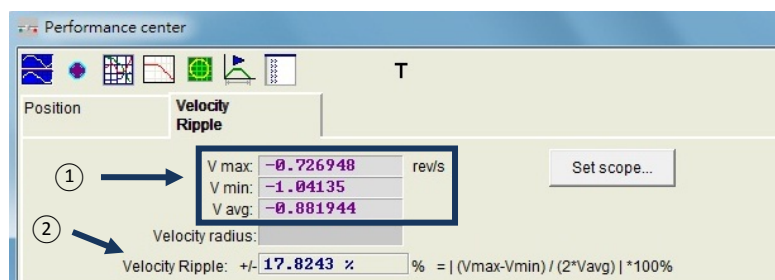


Figure6.2.1 Performance center – “Velocity Ripple” tab

- (1) V max: The maximum of velocity ripple.
- V min: The minimum of velocity ripple.
- V avg: The average of velocity ripple.
- (2) Velocity Ripple: Velocity ripple.

In addition to the P2P function, the relative motion (“Relative move”) can be set to move a distance; while the continuous motion (“Jog”) can continue moving in the positive or negative direction just by clicking the button of ◀ or ▶. The speed, acceleration/deceleration, and smooth factor in the “Motion Protection” area are also used as the function of motion protection. Hence, if these values are forgot to set to the value of motion protection after the test run is completed, the expected speed or acceleration may not be reached at receiving the motion command sent from the host controller. Please pay special attention to this.

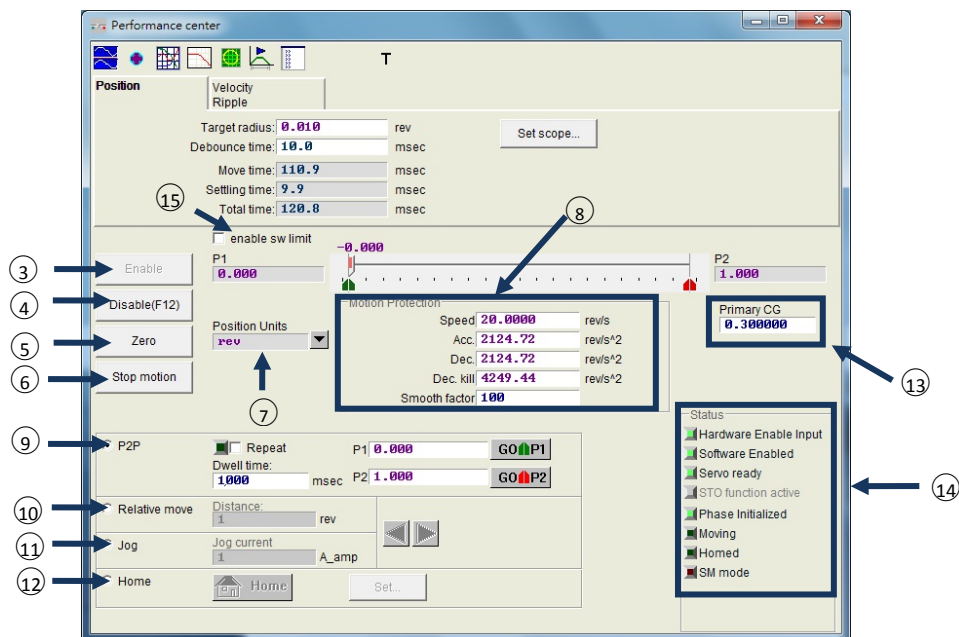



Figure6.2.2 Performance center – “Position” tab

- (3) Enable: Enable the motor.
- (4) Disable: Disable the motor.
- (5) Zero: Set the current position to the zero position.
- (6) Stop motion: Stop the motor.
- (7) Position Units: Unit setting. Set the preferred unit at the operation. This is the same as the unit setting in “Quick View” on the main window.
- (8) Motion Protection: Protection parameters for the motor motion, including the speed, acceleration, deceleration, emergency stop deceleration, and smooth factor at the test run. Users can use the smooth factor to plan the path trajectory as an S-type curve or T-type curve. The adjustment range is 1 - 500. The larger the value is, the closer to the S-type curve is; while the smaller the values is, the

closer to the T-type curve is. Refer to Section 3.4 for more information.

- (9) P2P: Execute the point-to-point motion.
- (10) Relative move: Execute the relative motion.
- (11) Jog: Execute the continuous movement. Set the current value for the continuous movement with the constant current.
- (12) Home: Execute the homing procedure.
- (13) Common Gain: Servo gain. The greater the gain is, the greater the servo rigidity is. Users can use this parameter to adjust the servo rigidity. But if the servo stiffness is too strong, it will lead to system instability, and cause the vibration and electrical noise. At this time, this value should be reduced.
- (14) Status Display: Display the status.
- (15) enable sw limit: Start the software limit protection, which restricts the travel of motor.

6.3 Scope

D2 drive provides a “Scope” graphics oscilloscope to help users to observe all significant physical quantities during the tuning process to judge the tuning result. In addition, this feature can be used to find the error clue when the drive cannot be operated. Click  or the “Set scope...” button in the performance center to open “Scope”. Clicking the “Set scope...” button in the “Position” tab and “Velocity Ripple” tab will display their respective physical quantities. As shown in figure 6.3.1, after selecting parameters, the real-time waveform of selected physical quantity can be observed.

Note:

The data shown in “Scope” is not fully real-time physical quantities. To observe more fine physical changes, use tools other than “Scope”, such as an oscilloscope or a data collection (refer to Section 6.4).

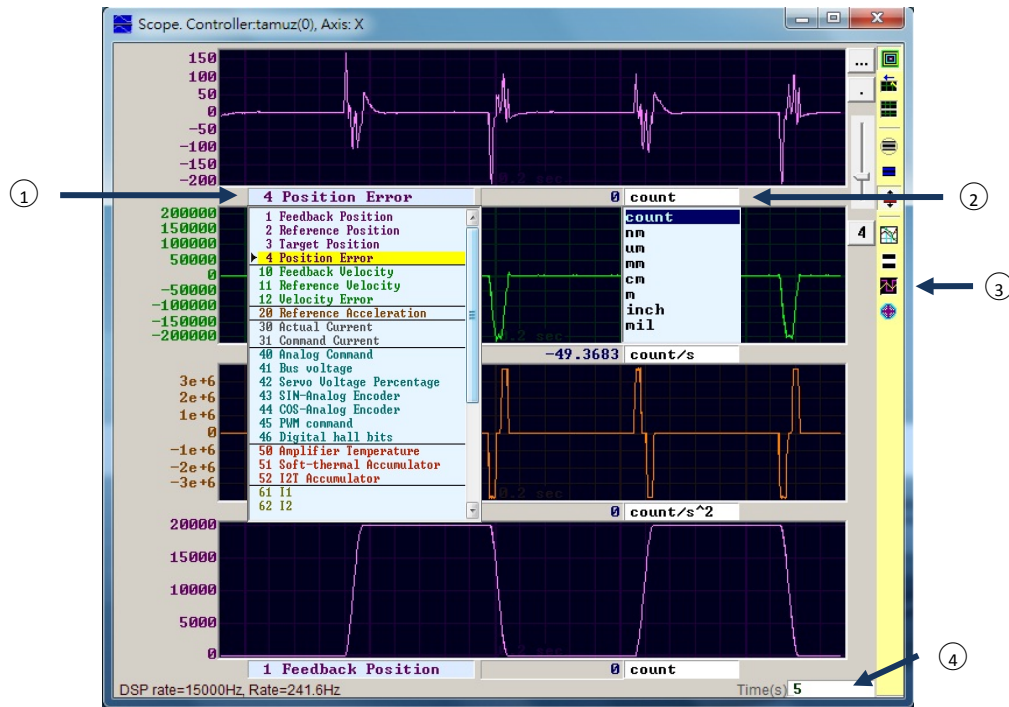


Figure6.3.1 Scope

- (1) Physical quantity: Select the physical quantity to be observed, referring to Section 3.11.
- (2) Unit: Select the unit of physical quantity.
- (3) Number of channel: Select the number of channels to be displayed simultaneously (1 - 8).
- (4) Time range of "Scope": Set the time length for one screen on the horizontal axis. Unit: seconds.

Table6.3.1

Symbol	Name	Description
	Scope On/Off (PageDown)	The switch of "Scope". When the switch is turned off and then turned on, the scope will re-capture the data.
	View in paper mode (Ctrl+T)	Change the display waveform mode. There are the "Normal" and "Paper" modes.
	Toggle scopes window (PageUp)	Display all selected physical quantities on a single screen. Each click to switch a physical quantity.
	Fit graph to window	Adjust all physical quantities to the appropriate scale.
	Fit graph to window dynamically	Adjust all physical quantities to the appropriate scale dynamically.
	Fit graph to window dynamically + clip	Same as above, but the range of vertical axis will only increase without reduction.
	Show last data with plot view tool	Use the "Plot view" tool to draw the data of "Scope".
	Reset scope	"Scope" will re-capture the data.
	Show all plots in same window	All physical quantities are drawn in the same screen and share one vertical axis.
	Open recorder window	Connect physical quantities currently set by "Scope" to the "Data collection" function.

6.4 Data collection

In addition to using “Scope” to observe physical quantities of each drive, there is a tool to provide more setting options for data capture, and more advanced graphical display and processing functions. The “Data collection” function allows users to set the sampling time, as well as conditional triggers to start and stop the data capture.

6.4.1 Function description

By using the “Scope” function of “Open recode window” shown in figure 6.3.1, the program will automatically set the selected physical quantity for the follow-up data capture. The main function is as follows.

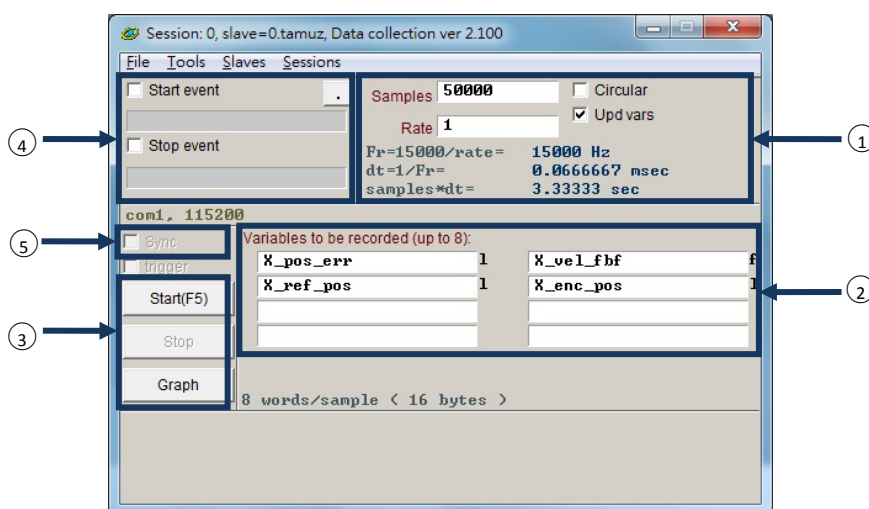


Figure6.4.1.1 Data collection

(1) Sampling frequency (“Rate”) and the number of samples (“Samples”):

- Samples: The number of samples.
- Rate: Determine the sampling frequency. For example, if “Rate” is set to 1, the sampling frequency is 15,000 Hz; while when it is set to 2, the sampling frequency is 7,500 Hz. The sampling frequency can only be up to 15,000 Hz. If too much data is collected, the data collection may be early completed due to the limit of communication bandwidth. Reducing the number of collected physical quantities can solve this phenomenon.
- Dt: Sampling time.
- Samples*dt: Total time of data collection. If users want to increase the total time of data collection, simply increase “Samples”.

- (2) It is the internal variable name of the physical quantity of collected data.
- (3) Manual collection button. Click the “Start” button to start the collection and click the “Stop” button to stop the collection. Click the “Graph” button to draw the collected data via “Plot view”.
- (4) Conditional auto collection. Set the start event and stop event for the data collection.
- (5) The auto collection option is triggered instantaneously.
 - Example 1: To capture the graph of one motion cycle
Check “Start event” and set it to “X_run”. Also, check “Stop event” and set it to “X_stop”. Click the “Start” button after the setting is completed. Now, “Data collection” is on standby. When the motor is moving, it will start to collect the data; while when the motor stops the motion, it will stop to collect the data. After the data collection is completed, click the “Graph” button to draw the graph of one motion cycle.
 - Example 2: To capture the graph of one speed period
Check “Start event” and set it to “X_vel_fb>0”. Also, check “Stop event” and set it to “X_vel_fb<0”. Click the “Start” button after the setting is completed. Now, “Data collection” is on standby. When the motor speed is greater than 0, it will start to collect the data; while when the motor speed is less than 0, it will stop to collect the data. After the data collection is completed, click the “Graph” button to draw the graph of one speed cycle.
 - Example 3: To capture the graph of drive from enable to disable
Check “Start event” and set it to “I3”. Also, check “Stop event” and set it to “~I3”. Click the “Start” button after the setting is completed. Now, this function will recognize the status of I3. When the drive is enabled (I3 = 1), it will start to collect the data; while when the drive is disabled (I3 = 0), it will stop to collect the data.

Note:

When “Upd vars” in ① is unchecked, the Lightning HMI stops updating variables. This can improve the bandwidth of data collection. However, if “Start event” is triggered by I3 (as in Example 3), the I/O pin of hardware is triggered via the external signal.

6.4.2 Data collection via PDL

In order to improve the accuracy of data collection, “Sync” (trigger the auto collection instantaneously) in figure 6.4.1.1 ⑤ provides more flexible and more real-time data capture than the conditional auto collection. The program fragment with the title labeled by “_RecordSync” should be added in the PDL program. Set the start event of data collection. Once this event is triggered, “Data collection” starts to collect the data. Operation steps are given as follows.

Step 1: An empty task is required to execute “_RecordSync”. Make sure that the task in PDL is less than four, i.e, whether one of task 0 to task 3 is available.

Step 2: Add the following content in the PDL program:

```
_RecordSync:
till( ); // Add to wait for the trigger event or status.
rtrs_act=1; // Start to record.
ret; // If this line is not added, the data collection cannot be triggered repeatedly.
```

Step 3: Add the interrupted condition or status in the parentheses of “till()” on the “_RecordSync” function. For example, it could be I4 (default for the right limit state) in the I/O center.

Step 4: Check “Sync” in figure 6.4.1.1 ⑤.

Step 5: Click the “Start” button in ③. The program starts to execute the “_RecordSync” function and waits for that the trigger event is satisfied. For example, when the status of I4 is changed from False to True, the data collection starts to capture the data. If I4 is triggered repeatedly, it will collect the record data of last trigger.

➤ Example

```
#task/1;
_RecordSync:
till(I4); // Wait for the status of I4 changing from False to True.
rtrs_act=1; // Start to collect.
ret;
```


6.5 Plot view

The “Plot view” function is built on the “Data collection” function. It draws the data collected by “Data collection” into graphics. “Plot view” has a powerful analysis function to provide the measurement and calculation. It is divided into five areas: function menu area, main toolbar area, physical quantity display area, graphic display area, and timeline scroll bar area, as shown in figure 6.5.1.

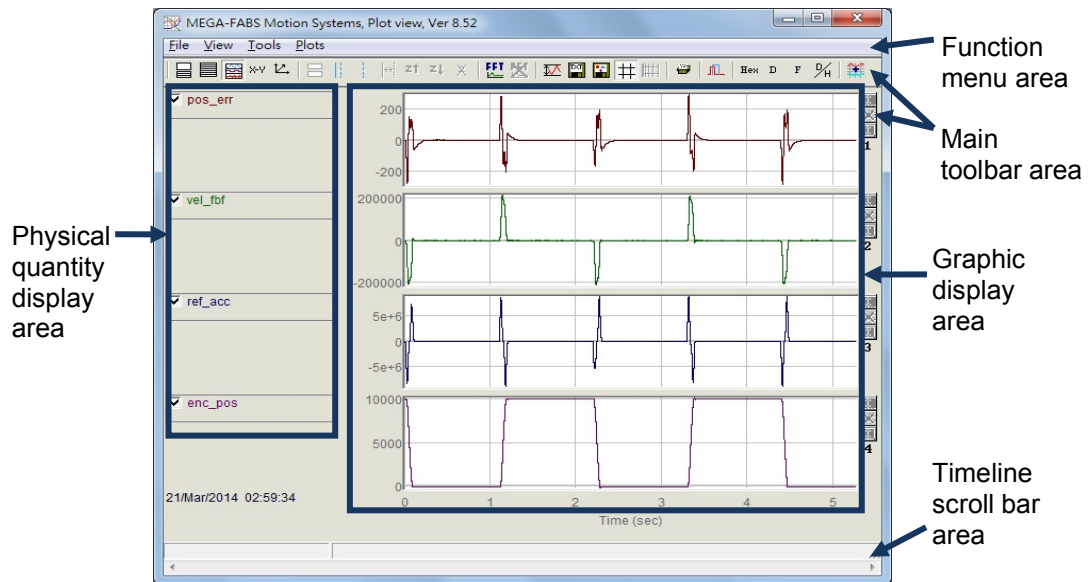






Figure6.5.1 Plot view

6.5.1 Graphic display mode

(1) Number of display channels

The graphic display area is mainly used to display the graph of physical quantity. When the graph of physical quantity is captured from “Scope” or “Data collection”, “Plot view” will display all physical quantities selected by “Scope”. “Plot view” can change the number of channels shown in the graphic display area. However, the maximum limit is not more than eight. The related icon on the main toolbar area is described as follows.

-  : Set the maximum number of display channels.
-  : Display a single channel.

To observe the graph of two physical quantities, click  and then select “Only graph 2” to change the number of channels into two. To observe the graph of one physical value, click  and then select “Only graph 1” to change the number of channels into one. As shown in figure 6.5.1.1, it gives an example that “Scope” or “Data collection” only collects two physical quantities.

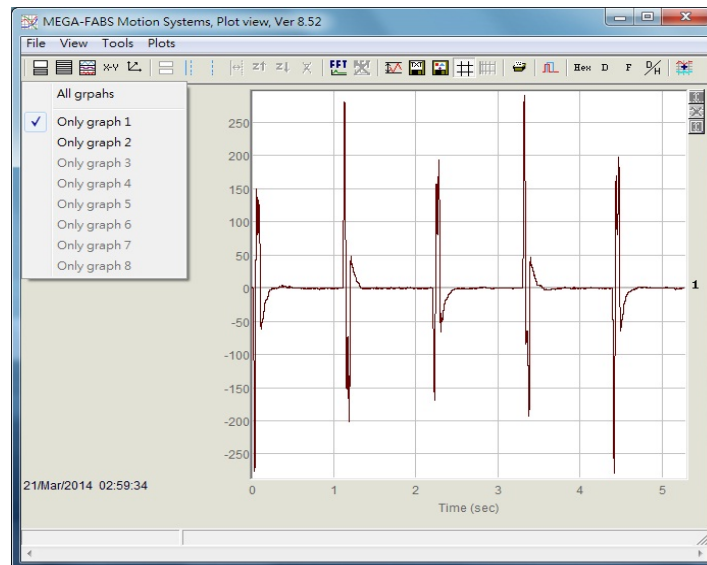


Figure6.5.1.1

(2) Show or hide physical quantities

If the physical quantity is unchecked, the graphic display area will hide the graph of this physical quantity. As shown in figure 6.5.1.2, it is the example of two physical quantities being unchecked. To uncheck all physical quantities, click the related icon on the main toolbar area as follows.

-  : Uncheck all physical quantities (or click the “Delete” button).

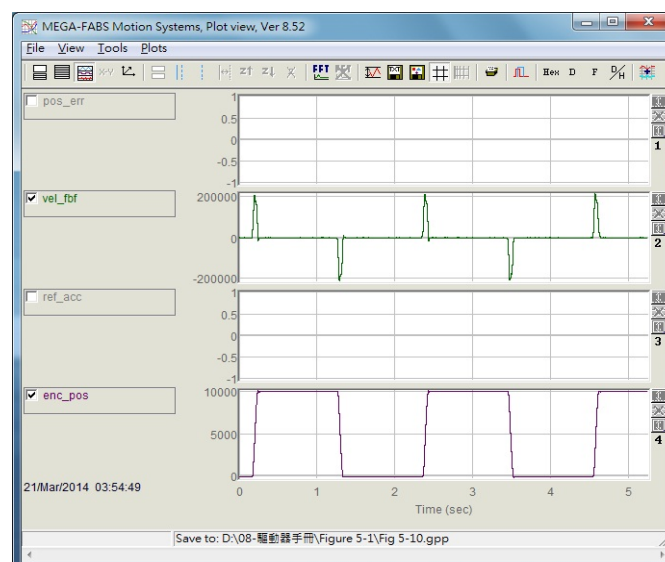












Figure6.5.1.2

(3) Zoom in/out

To observe a more subtle change in a certain interval, use the solid-line and dotted-line cursors to select the interval needed to zoom in. "Plot vies" provides the function of zoom in/out on the X and Y axes. The related icon and the operation method on the main toolbar area is described as follows.

-  : Zoom in on the graph between the blue solid-line and dotted-line cursors on the X axis.
-  : Undo zoom.
-  : Redo zoom.
-  : Cancel all zoom-in displays.
-  : Zoom in the graph between the red solid-line and dotted-line cursors on the Y axis.
-  : Cancel the zoom-in action on the Y axis.

(4) Zoom in/out on the X axis

To zoom in on the graph of physical quantity ranging from 2 to 4 seconds, as shown in figure 6.5.1.3, use the left mouse button to move the blue solid-line cursor or the right mouse button to move the dotted-line cursor to frame this interval. Then, click  to zoom in on this interval, as shown in figure 6.5.1.4. To zoom in a more subtle interval, such as 2 - 3 seconds, simply repeat above steps. To go back to zoom-in interval between 2 and 4 seconds, click . If  is clicked, the zoom-in interval between 2 and 3 seconds will be displayed again. Regardless of how many times users zoom in, use  to revert to the original graph, as shown in figure 6.5.1.3.

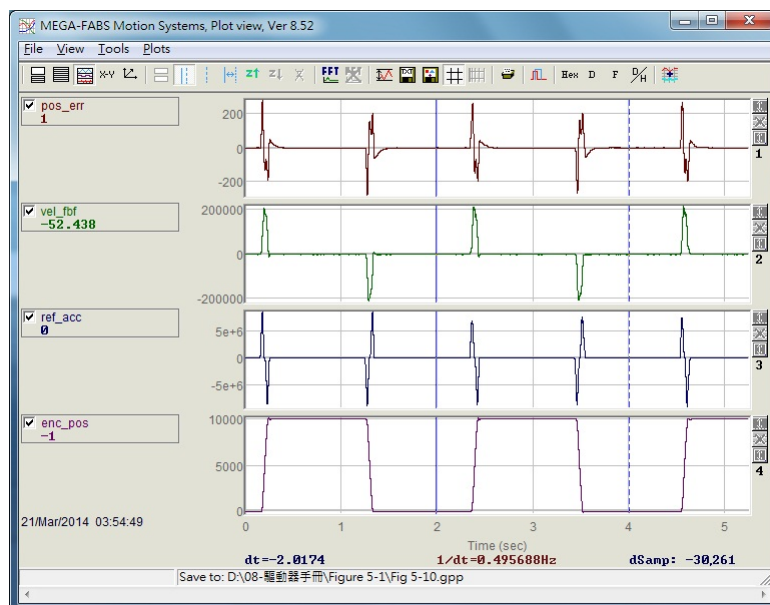


Figure6.5.1.3

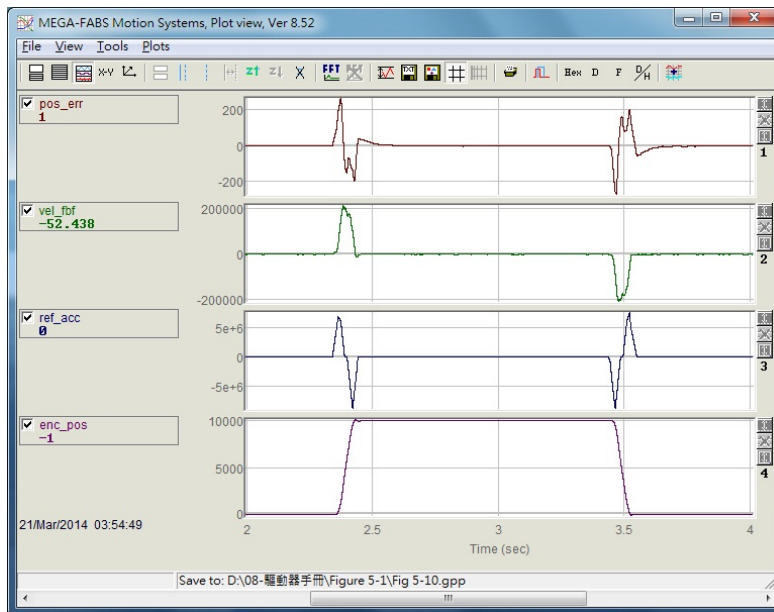




Figure6.5.1.4

(5) Zoom in/out on the Y axis

To zoom in on the Y axis, press and hold the “Ctrl” button and the left mouse button to move the red solid-line cursor or the right mouse button to move the dotted-line cursor to frame a suitable interval, as shown in figure 6.5.1.5. Then, click  at the upper right corner of window to zoom in on the graph within the selected interval on the Y axis, as shown in figure 6.5.1.6. At this time, the Y-axis value of graph is locked and shown in red. Dragging the horizontal scroll bar does not dynamically adjust the vertical display range, as shown in figure 6.5.1.7. Finally, if the icon of  is clicked, it will return to the original graph of Y axis before the zoom-in, as shown in figure 6.5.1.5.

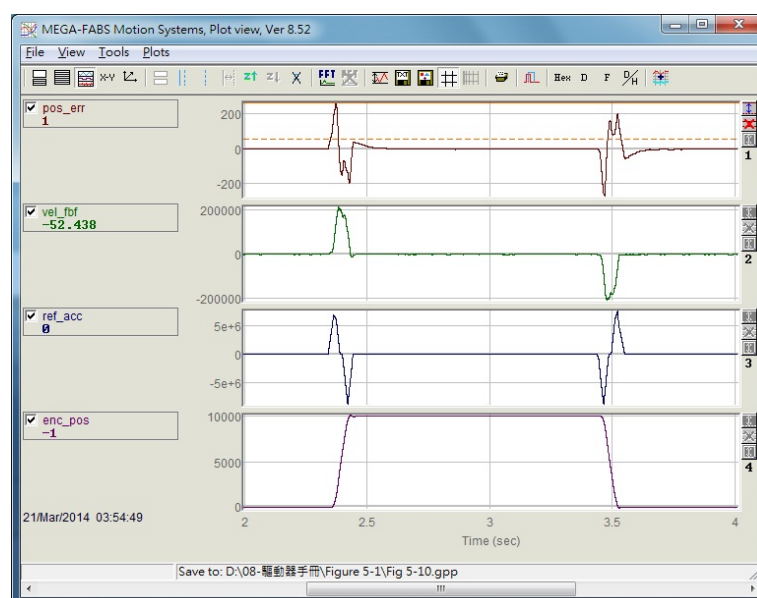


Figure6.5.1.5

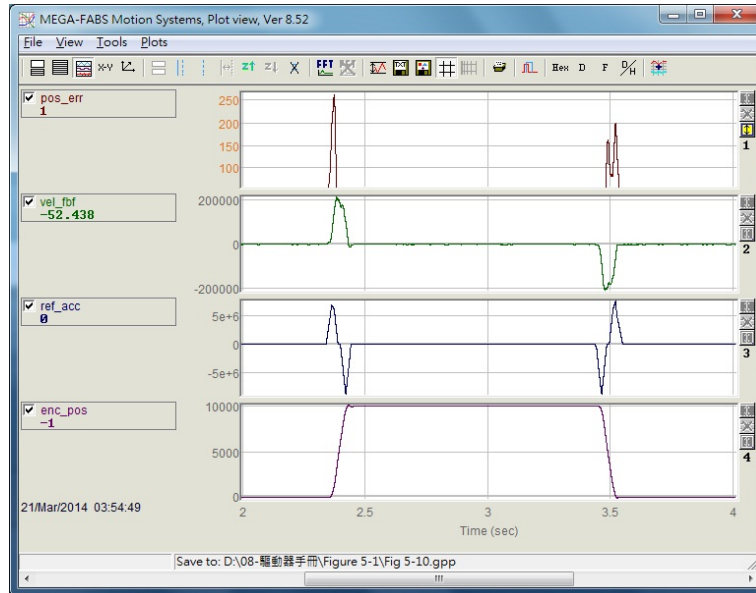


Figure6.5.1.6

Parameters are not automatically adjusted to fit the graph.

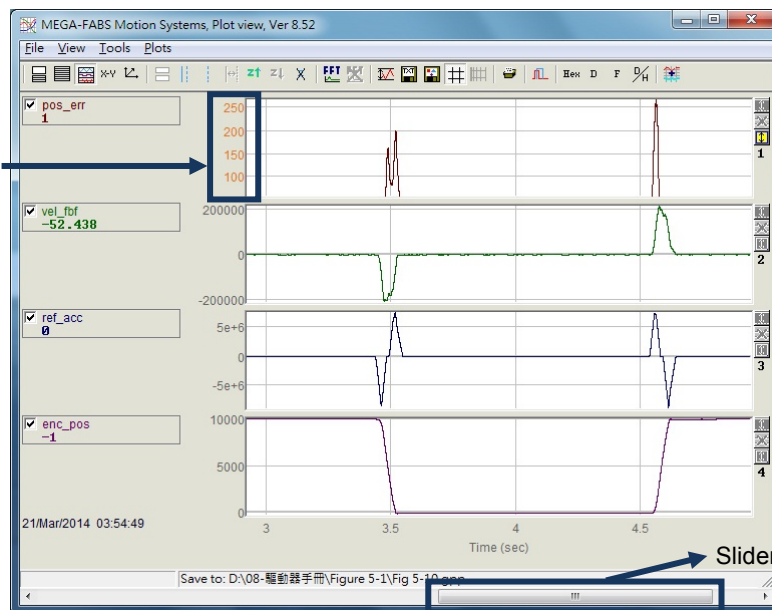


Figure6.5.1.7

(6) dt, 1/dt, dSamp



When the interval is framed by using the blue solid-line and dotted-line cursors, values of “dt”, “1/dt”, and “dSamp” will appear at the bottom of graphic display area. Here, “dt” is the time in the interval and “dSamp” is the sampling number in the interval, as shown in figure 6.5.1.5.

(7) Display a physical quantity on different channels

To move a physical quantity to another channel for display, click the physical quantity to present a dotted-line box, and then drag it to another channel.



(8) Display the value of physical quantity

When the blue solid-line cursor is moved to a specific point in time, the value of physical quantity at this time will be displayed at the bottom of this physical quantity. The value is displayed in decimal or hexadecimal, as shown in figure 6.5.1.5. The related icon on the main toolbar area is described as follows.

-  : Display the value in hexadecimal.
-  : Display the value in decimal.

6.5.2 Save/open file

In “Plot view”, the saved-file type can be divided into the text file (.txt), picture file (.bmp), and special “Plot view” file (.gpp). The .txt file saves the value of each physical quantity within the collection time; the .bmp file saves the graph of all physical quantities as a figure; while the .gpp file is the only file allowed to be opened in “Plot view”. Therefore, if the file will be re-opened via “Plot view” in the future, remember to save it as .gpp file. The related icon of saving as .txt file and .bmp file on the main toolbar area is described as follows.

-  : Save the value of physical quantities as a .txt text file.
-  : Save the graph of physical quantities as a .bmp figure file.

The .gpp file of “Plot view” is read or opened via the option of “Save” or “Open” in the function menu of “File”, as shown in figure 6.5.2.1.

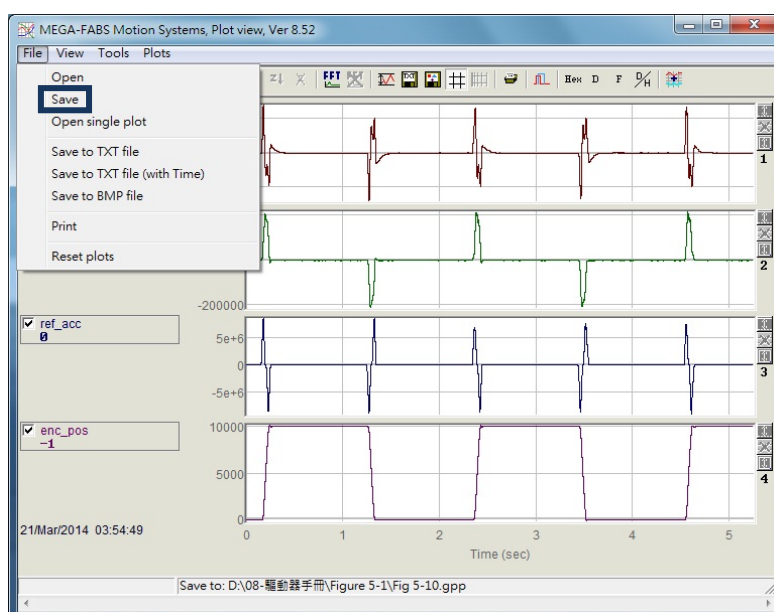



Figure6.5.2.1 Save as a .gpp file

6.5.3 Mathematical operation

“Plot view” also provides some math formulas for the operation of physical quantities, such as the integration, differentiation, addition, multiplication, ..., etc. This allows users to calculate and observe the calculated result directly in “Plot view”. In addition, it also provides the maximum, minimum, ripple calculation, and spectrum analysis of each physical quantity.


(1) Statistics table

Click  to display the table as shown in figure 6.5.3.1. It shows the maximum, minimum, average, root mean square (rms), Rip, and RipA of each physical quantity within the interval selected by cursors, as shown in figure 6.5.3.1. Here,

$$\text{Rip} = \text{standard deviation/average,}$$

$$\text{RipA} = (\text{maximum} - \text{minimum}) / \text{average.}$$

The related icon on the main toolbar area is described as follows.

-  : The maximum, minimum, root mean square (rms), and ripple calculation of physical quantity.




Plot	Maximum	Minimum	
pos_err Long(32 bit)	276 samp: 2,682	-274 samp: 19,126	Avr: 0 Rip: 15588.8% Rms: 42.2477 RipA: 202942%
vel_fbf Float(32 bit)	212750 samp: 68,641	-205755 samp: 19,310	Avr: 1918.87 Rip: 2038.56% Rms: 39117.4 RipA: 21809.9%
ref_acc Float(32 bit)	8.25189e+6 samp: 2,682	-8.68242e+6 samp: 69,199	Avr: -3433.88 Rip: -41396.7% Rms: 1.42151e+6 RipA: -493153%
enc_pos Long(32 bit)	10,077 samp: 36,510	-38 samp: 52,910	Avr: 5,445 Rip: 89.725% Rms: 4885.93 RipA: 185.752%

Range: 0...78866, delta=78867, total 78867 Ts=6.66667e-5

Figure6.5.3.1 Statistics table

(2) Mathematical operation method

Select “Math operation” of “Tools” in the function menu or click  to open the window of figure 6.5.3.2 to do a proper mathematical operation. Here, take the addition as an operation example. After clicking the option of “Linear”, choose “pos_err” and “vel_fbf” via the drop-down menu. Then, name the new physical quantity in the “New plot name” field and set its color. Finally, click the “Create” button to generate the physical quantity (“lin_1”) of “pos_err” plus “vel_fbf”, as shown in figure 6.5.3.3. Other mathematical operations are the same as that for addition. Not repeat them here. The related icon on the main toolbar area is described as follows.

-  : Mathematical operation.

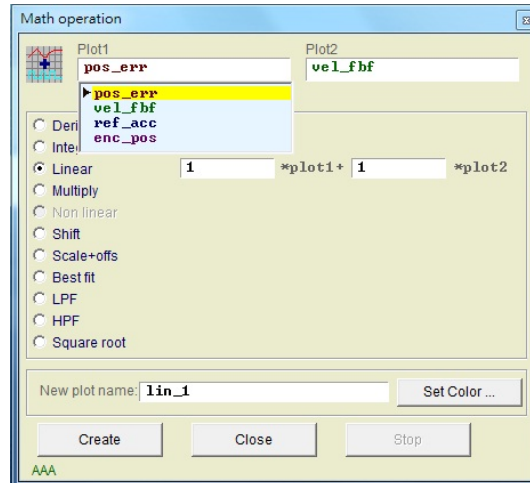


Figure6.5.3.2

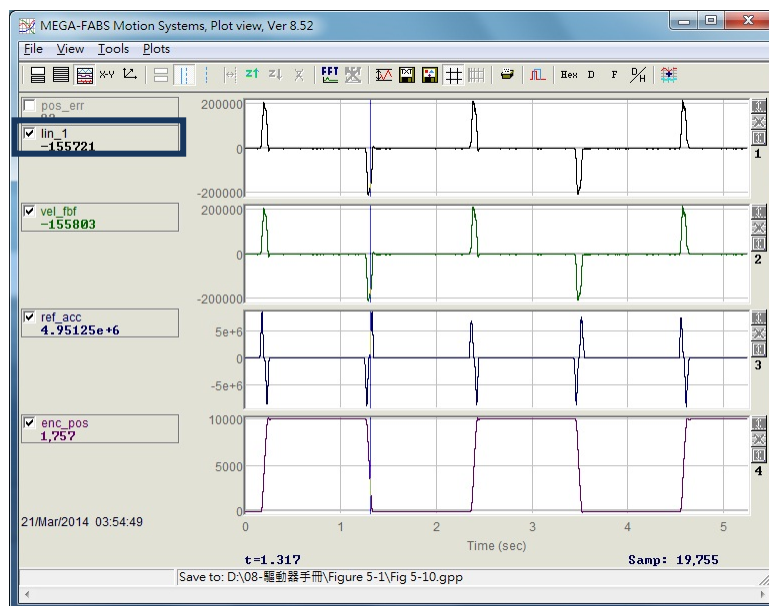






Figure6.5.3.3

(3) Fast Fourier transform (FFT)

Click  in the main toolbar area to appear the window of figure 6.5.3.4, and then choose the required physical quantity to do the Fourier transform. Here, take “pos_err” as an example. Finally, click the “Run FFT” button to generate the transformed graph, as shown in figure 6.5.3.5. To cancel the result of Fourier transform, click . The related icon on the main toolbar area is described as follows.

-  : Do the fast Fourier transform for physical quantity.
-  : Cancel the fast Fourier transform.

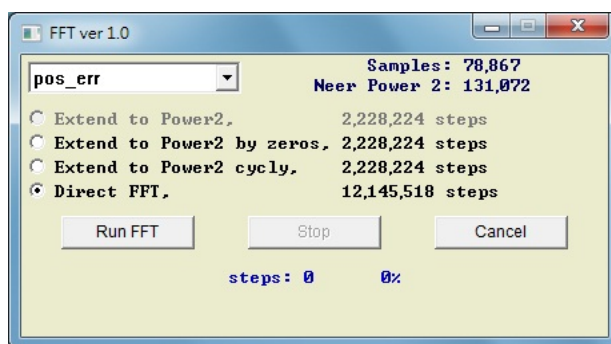


Figure6.5.3.4

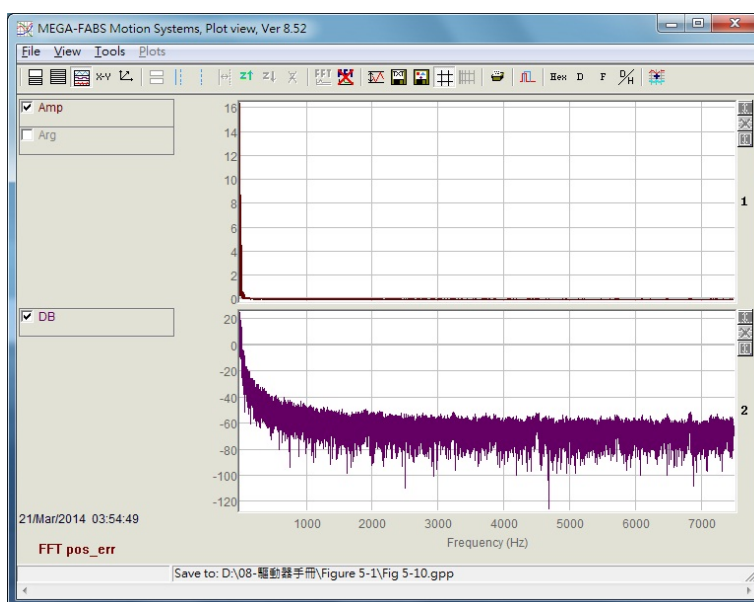


Figure6.5.3.5

(4) Natural logarithm

The natural logarithm function is to express the X axis in the logarithmic form. It is only applicable after the Fourier transform is completed. The related icon on the main toolbar area is described as follows.

-  : Express the X axis in the logarithmic form. It is only available after FFT is completed.

6.6 Advanced gains

Important tasks of servo drive include whether the time from the motor starting moving to arriving the position, i.e. “Move & Settle” (see Section 3.7), is very small, and whether the position error is very small and the velocity is very smooth during motion. These performance improvements can be achieved by tuning gains and parameters. The simplest way of D2 drive to adjust the performance of motor motion is to tune the common gain (“Primary CG”). The greater the common gain is, the stronger the servo rigidity is. However, if the servo rigidity is too strong, the system vibration or electrical noise may be generated. These phenomena are various with the mechanical status.

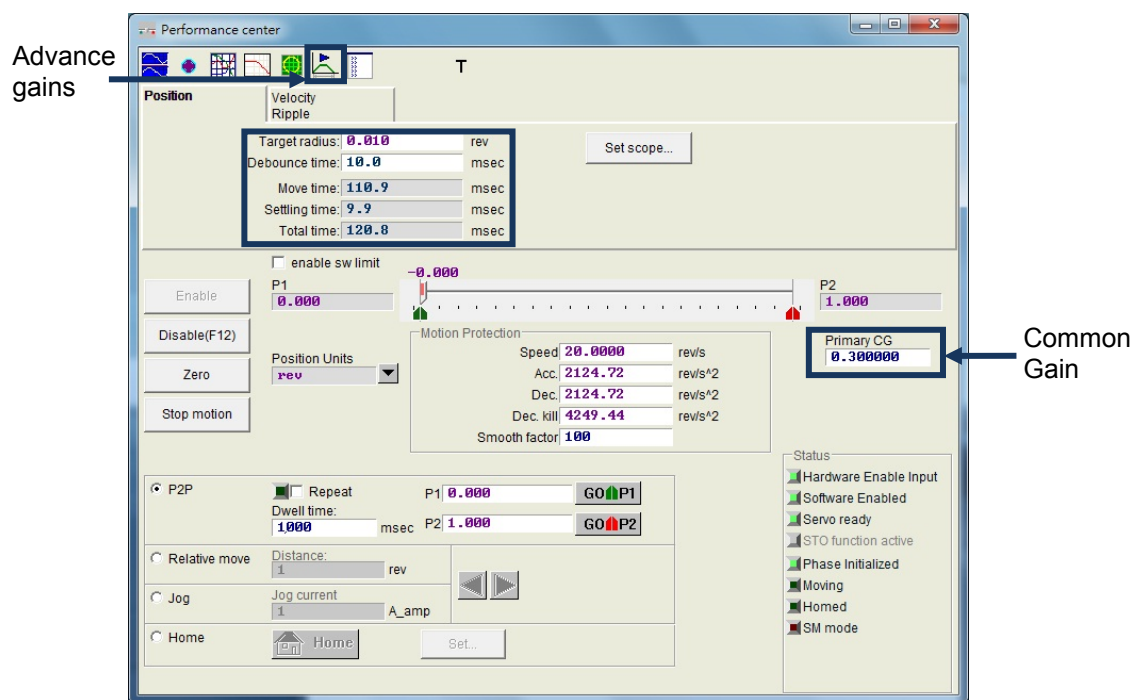


Figure6.6.1 Performance center

When using only common gain cannot fulfill the required performance, this system also provides “Advanced gains”, included functions of “Filter”, “Acc feedforward”, “Schedule Gains + vpg”, “Analog input”, “current loop”, and so on.

6.6.1 Filter

The filter is located in the servo control loop on the inside of drive. Its main purposes are to eliminate the control problem caused by the high-frequency vibration of system, and to deal with the resonant frequency of overall mechanical system. The performance of system control can be enhanced via the filter. D2 drive provides two filters that can be used simultaneously and set in the form of low pass filter or notch filter. To design a filter, the frequency analyzer is usually used to analyze the system characteristic. By clicking the “Bode...” button given in figure 6.6.1.1, the simulation interface of “Bode plot” is appeared for the filter design. Settings of two common used filters are described in the following.

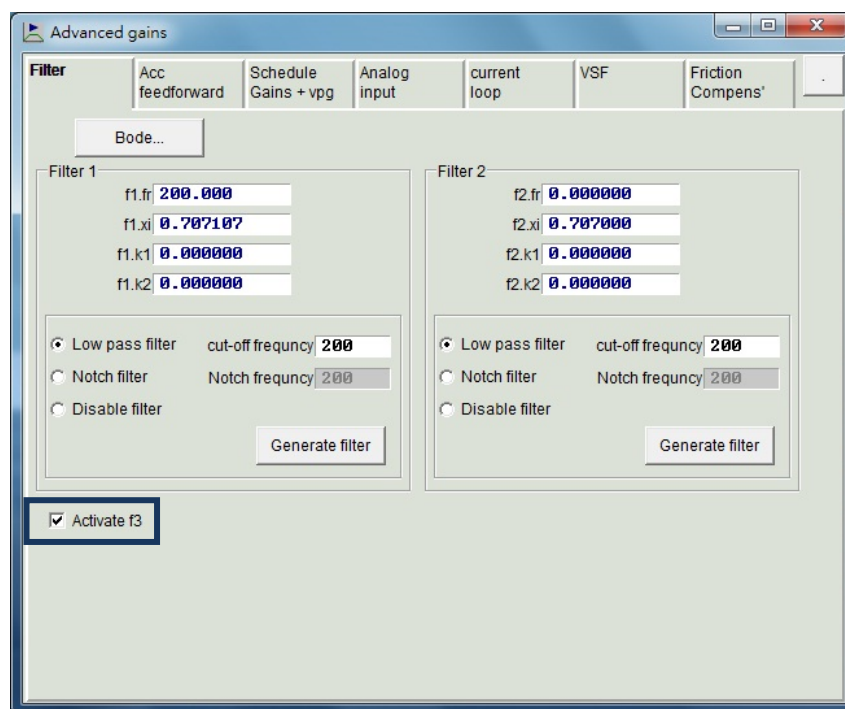


Figure6.6.1.1 Filter

■ Low pass filter

The setting of typical low pass filter is given as follows:

- (1) fr: The cutoff frequency of filter. The unit is Hz. For general applications, a good effect can be achieved at the setting of 500 Hz. Other cases can be considered to decrease this value. However, the control performance will be reduced if the cutoff frequency is too small.
- (2) xi: The damping ratio of filter. Its value ranges from 0 to 1.
- (3) k1: 0.
- (4) k2: 0.

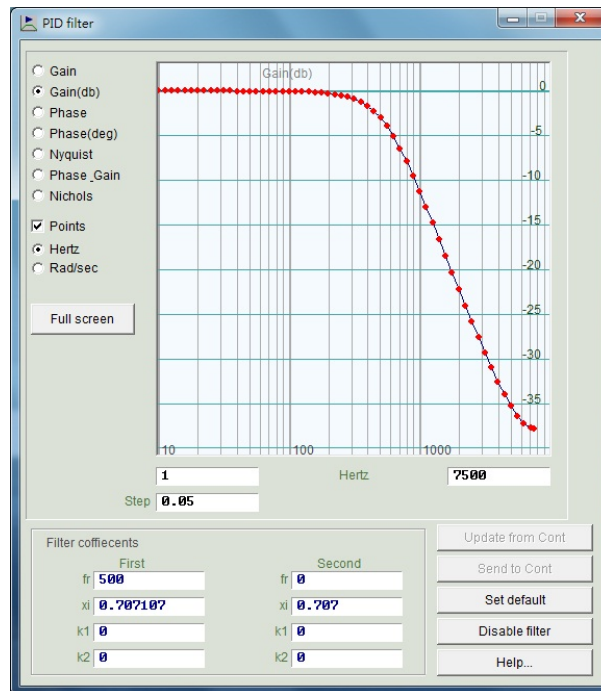


Figure6.6.1.2 Low pass filter

■ Notch Filter

When the system has an inappropriate resonance frequency (for example, between 10 and 250 Hz) that cannot be eliminated by the mechanism correction or design enhancement, the notch filter can be used to improve this problem. In general, the notch filter should be set according to the result of frequency analysis. Refer to Section 6.6.3.

The setting of typical notch filter is given as follows:

- (1) fr: The cutoff frequency of filter. The unit is Hz.
- (2) xi: The damping ratio of filter. Its value ranges from 0 to 1. The closer to 0 this value is, the narrower the filtering frequency band is; while the closer to 1 this value is, the wider the filtering frequency band is.
- (3) k1: 0.
- (4) k2: 1.

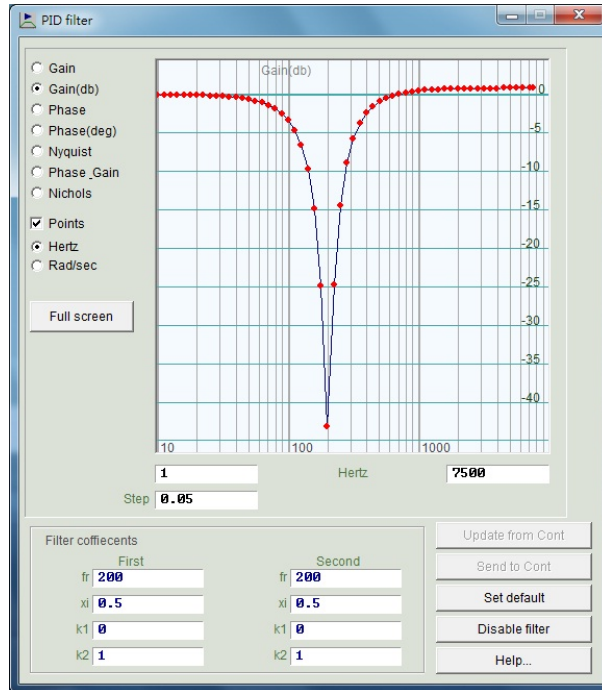


Figure 6.6.1.3 Notch filter

■ Automatic resonance suppression filter (f3)

After the auto gain tuning is successful, the automatic resonance suppression filter (f3) will be set and started automatically. However, after the auto gain tuning is completed, when the system vibration cannot be effectively suppressed by the f3 filter at driving the motor, cancel the check of “Activate f3” option in the “Filter” tab of “Advanced gains” window, as shown in the red box of figure 6.6.1.1. Then, modify “Filter 1” and “Filter 2” in manual to achieve an effective vibration suppression.

6.6.2 Acceleration feed-forward

The position error of servo control is usually large in the motion phase of acceleration or deceleration. Especially for applications with a large moving mass or moment of inertial, this problem is more likely to occur. By setting the parameter of acceleration feed-forward, the position error can be reduced effectively in the acceleration/deceleration phase.

Following steps are used to adjust the acceleration feed-forward.

- Step 1: Click the “Set scope...” button to display the “Scope” window.
- Step 2: Step 2. Set “Acc feedforward gain” in figure 6.6.2.1 to 0.
- Step 3: Set the maximum acceleration for path planning, and let the motor do the point-to-point motion.

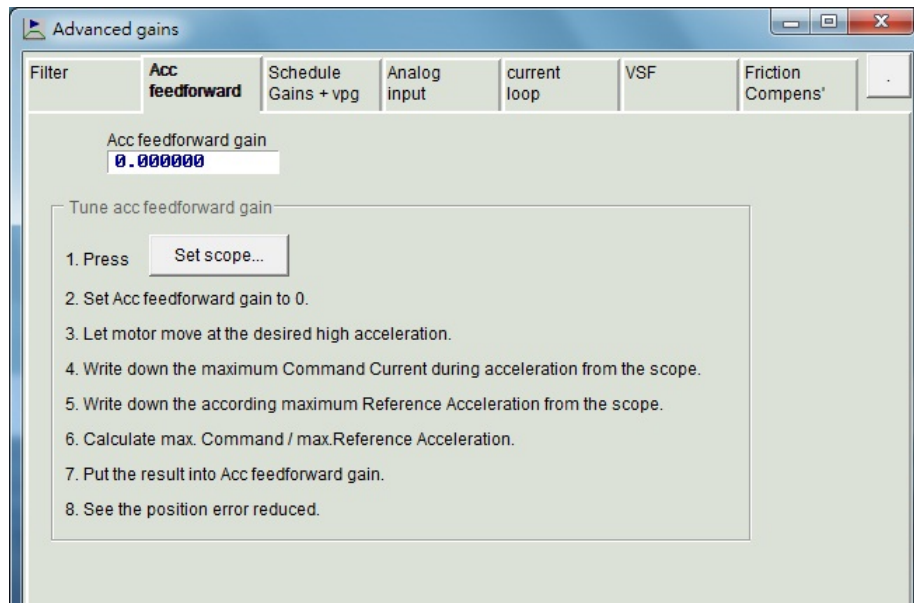


Figure6.6.2.1 Acceleration feed-forward

Step 4: Record the maximum of “Command Current” in the acceleration phase, as shown in figure 6.6.2.2. It can be observed from the figure that “Command Current” is 16 in the acceleration phase. When the motor starts moving, “Scope” will be shown as figure 6.6.2.2. Use the button of “Toggle scopes windows (Page UP)” to change to the graph with a single physical quantity. Repeatedly clicking this button will switch to the graph of “Command Current”, “Reference Acceleration”, or “Position Error” to facilitate the observation of graphic value.



Figure6.6.2.2Trajectory result of motor movement

- Step 5: Record the maximum of “Reference Acceleration” in the acceleration phase. In the example of figure6.6.2.2, the maximum of “Reference Acceleration is 950,000 count/s².
- Step 6: Dividing the value obtained in Step 4 by the value obtained in Step 5, Acc feedforward gain = Command Current/Reference Acceleration = 16/950,000 = 1.68421*10⁻⁵.
- Step 7: Enter the result obtained in Step 6 into the “Acc feed forward gain” field, as shown in figure 6.6.2.3.

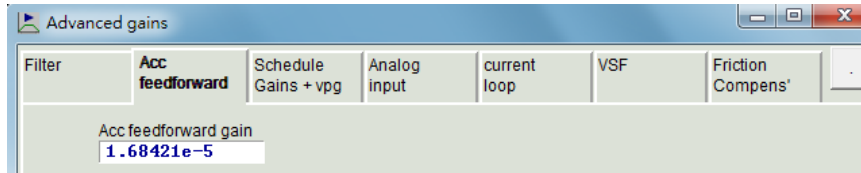


Figure6.6.2.3 Acceleration feed-forward gain

- Step 8: Observe whether “Position Error” is reduced. As shown in figure 6.6.2.4, the position error in the acceleration phase is decreased from 90 counts in figure 6.6.2.2 to 65 counts.



Figure6.6.2.4 Result of adding acceleration feed-forward

6.6.3 Schedule gains and velocity loop gain

■ Schedule gains

A complete motion can be roughly divided into three phases (see Section 3.7):

- (1) Move: From the start to the end of path planning.
- (2) Settling: From the end of path planning to the in-position phase.
- (3) In-position: Output an in-position signal.

The main purpose of “Schedule gain” is to adjust the output servo stiffness of each motion phase (“Move”, “Settling”, “In-position”) by changing the servo gain. The gain of each phase is adjusted in proportion. When it is set to 1, it means that the original servo gain is used. When it is less than 1, the gain of this phase is lowered. The corresponding parameter of each phase is given as follows.

- (1) Move: sg_run.
- (2) Settling: sg_stop.
- (3) In-position: sg_idle.

If “CG” = 0.5 and “sg_run” = 1.2, this means that the actual servo gain in the “Move” phase is changed to $0.5 \times 1.2 = 0.6$.

The “Settling” and “In-position” phases use the same setting method to change the originally fixed servo gain to the gain met the different requirement in each motion phase via “Schedule gains”.

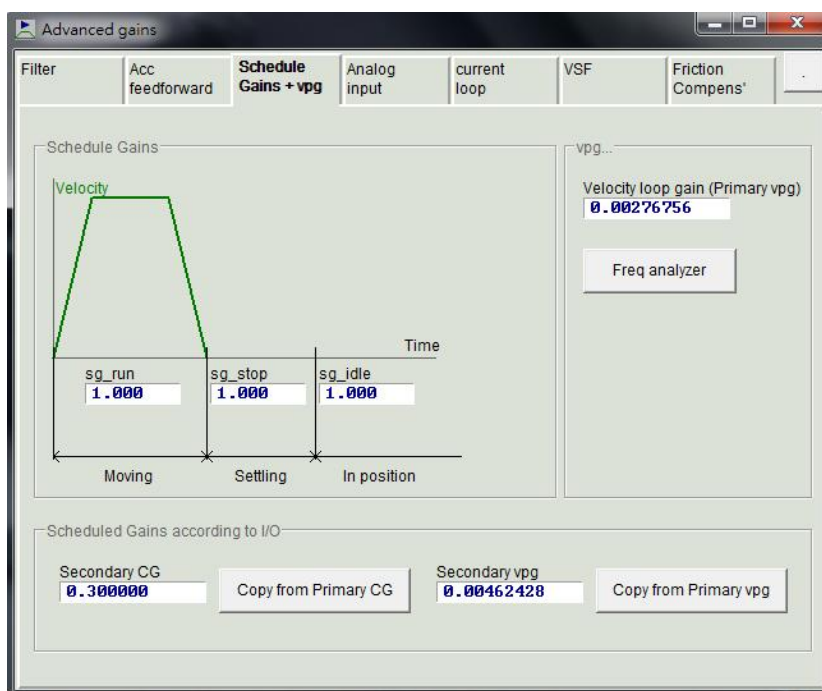


Figure6.6.3.1 Schedule gains

■ Velocity loop gain (vpg)

The velocity loop gain (vpg) is an internal control parameter of D2 drive. Normally, the initial value is calculated by parameters set in the configuration center. This value is not to be modified under the normal case. However, it can be re-adjusted by using “Freq analyzer”.

Step 1: Click the “Freq analyzer” button to appear the window of figure 6.6.3.2.

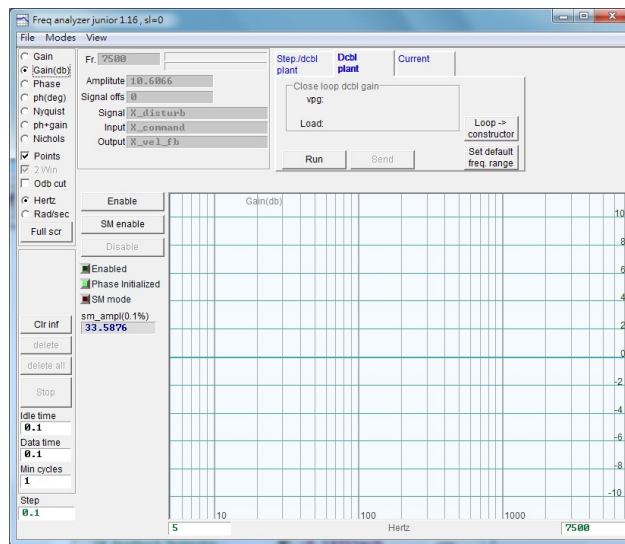


Figure6.6.3.2

Step 2: Click the “Enable” button.

Step 3: Click the “Run” button to start the frequency analyzer. The motor will be in the low-frequency vibration and then gradually issue a high-frequency sound. After it is completed, a frequency response will be drawn on the window, as shown in figure 6.6.3.3.

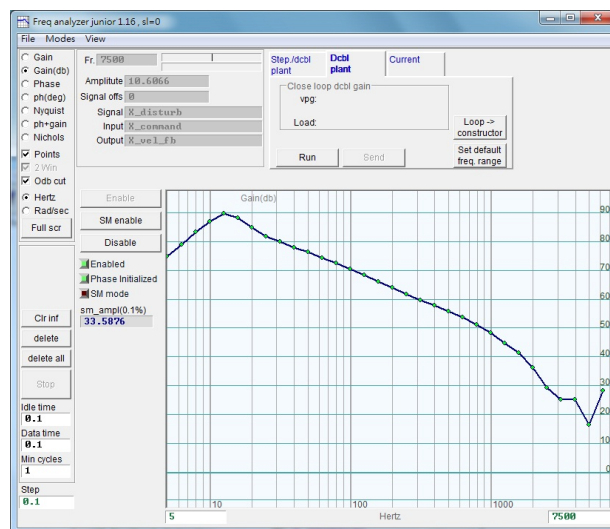


Figure6.6.3.3

- Step 4: Click the left mouse button on the frequency response diagram to appear the cursor line of -20 dB. Press and hold the left mouse button to drag the cursor line to close to the line of frequency response, as shown in figure 6.6.3.4. Dragging the line will re-calculate the gain and display the vpg value at any time. The gain is increased when the cursor line is dragged downward; while decreased when it is dragged upward.
- Step 5: Click the “Send” button to send the velocity loop gain to the drive. If the setting needs to be saved, do not forget to save it in the drive’s Flash.

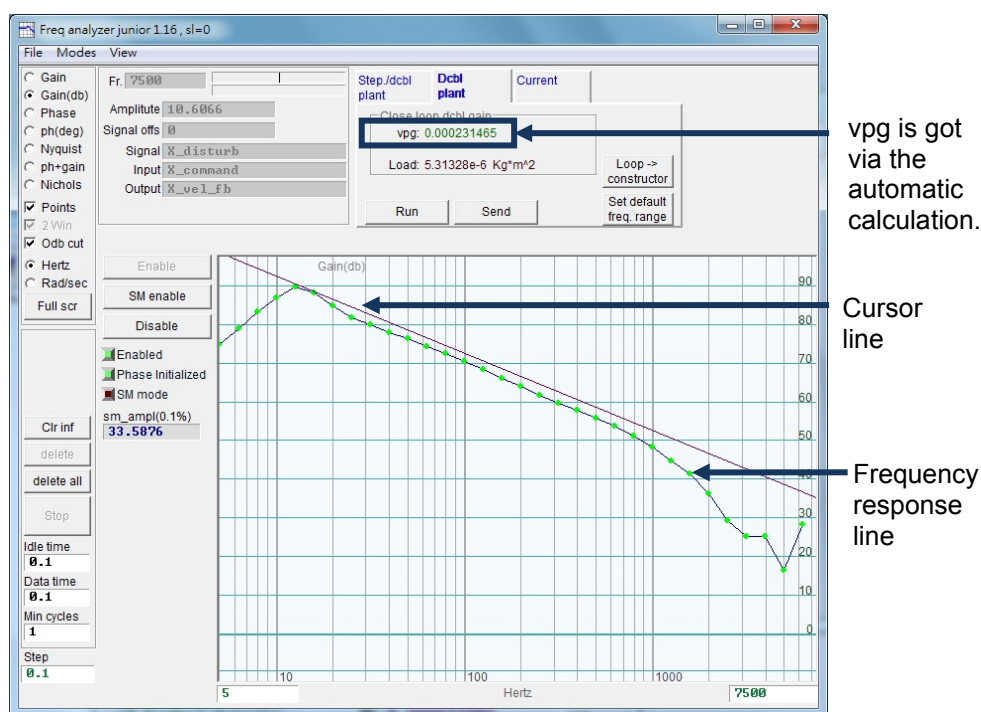


Figure6.6.3.4

6.6.4 Analog input

When the voltage mode is used, the voltage command sent by the host controller may contain the DC bias due to various factors. This will lead to the command distortion and affect the performance. In this case, this function can be used to compensate and correct the voltage. The compensation is very simple. As long as clicking the “Set Offset” button in the following figure, the measurement and offset correction will be executed automatically.

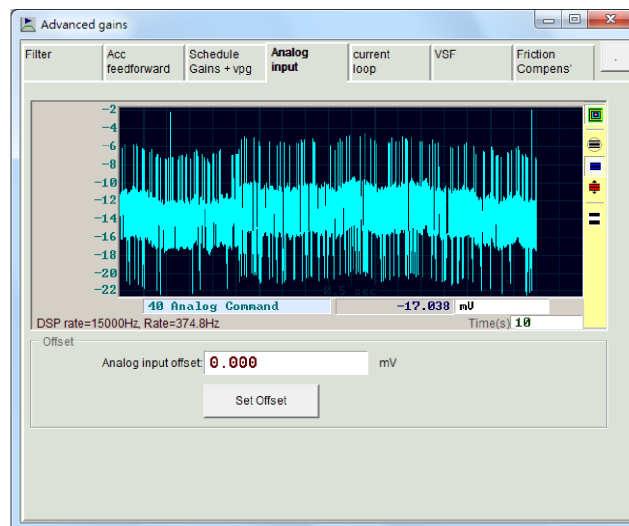


Figure6.6.4.1 Analog input

6.6.5 Current loop

Gain values of current loop, “Ki” and “Kp”, are basically calculated according to motor parameters when the motor model is selected in the configuration center. They are usually not required for further adjustment. However, if the motor parameter is not set correctly, this function can be used to adjust.

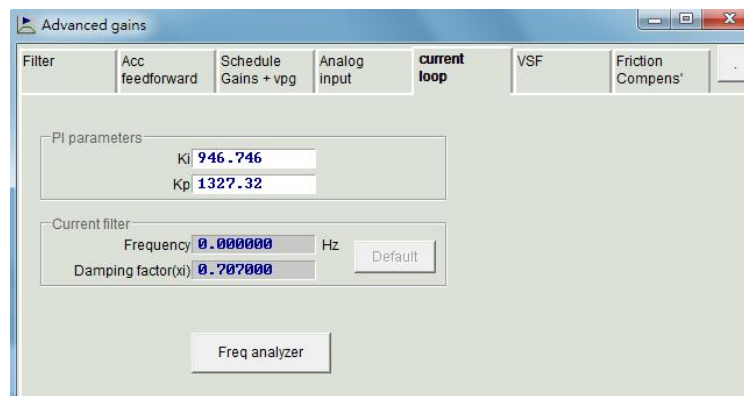


Figure6.6.5.1 Current loop

6.6.6 Vibration suppression feature

The vibration suppression feature (VSF) is used to suppress the vibration generated by the motor during the movement. Especially when the load of mechanism is the cantilever, the vibration is particularly evident. Through the “VSF” tab in the “Advanced gains” window, the effect of vibration suppression can be achieved by setting “Frequency” and “VSF factor”, and checking the “enable VSF” option. The setting range of “Frequency” is 0.1 - 200 Hz, and the range of “VSF factor” is 0.7 - 1.5. Generally, the value of “VSF factor” is recommended to be 1.0, same as the default value. Note that “enable VSF” cannot be checked or unchecked while the motor is moving; otherwise the motor will generate an unexpected vibration and error.

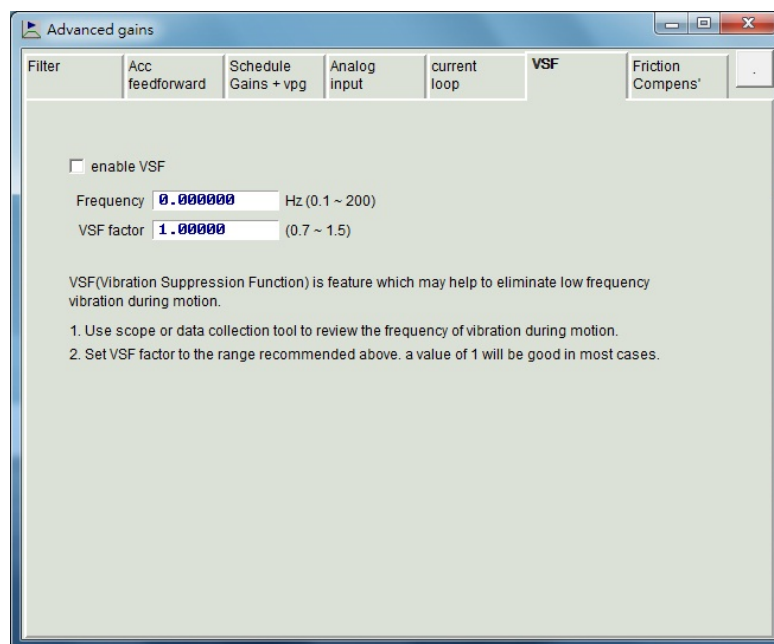



Figure6.6.6.1 Vibration suppression feature (VSF)

The following is the operation method for finding the vibration frequency and starting the vibration suppression feature.

- Step 1: Set the pre-planned acceleration, deceleration, speed, and travel. Then make the motor do the back-and-forth motion.
- Step 2: Open “Scope” to observe “Position Error” and “Reference Velocity”, as shown in figure6.6.6.2.
- Step 3: Click  (“Plot view”) at the right side of the “Scope” window to analyze captured graphs.

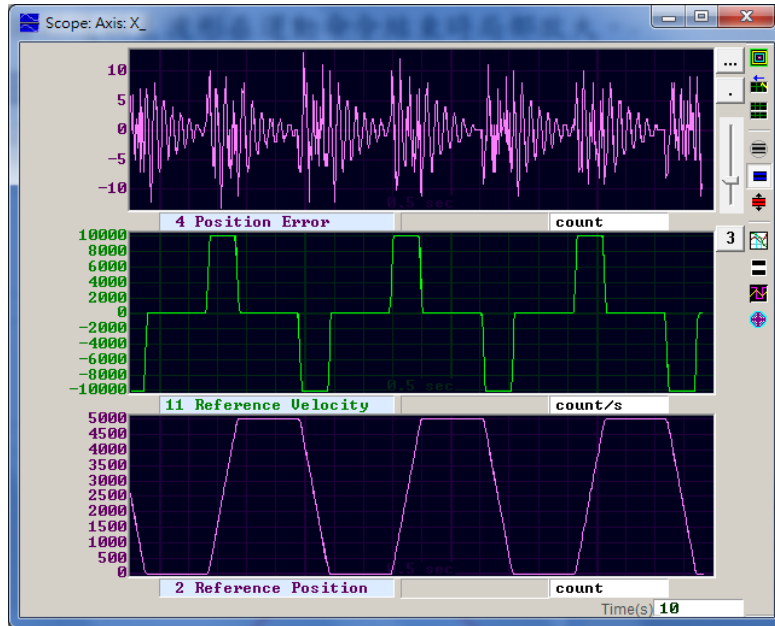



Figure6.6.6.2

Step 4: Enlarge the graph of “Position Error” at the end of motion command. Set the observed range in the window, as shown in figure 6.6.6.3, and then click  at the toolbar of window to enlarge the set range. Refer to Section 6.5 for related operations.

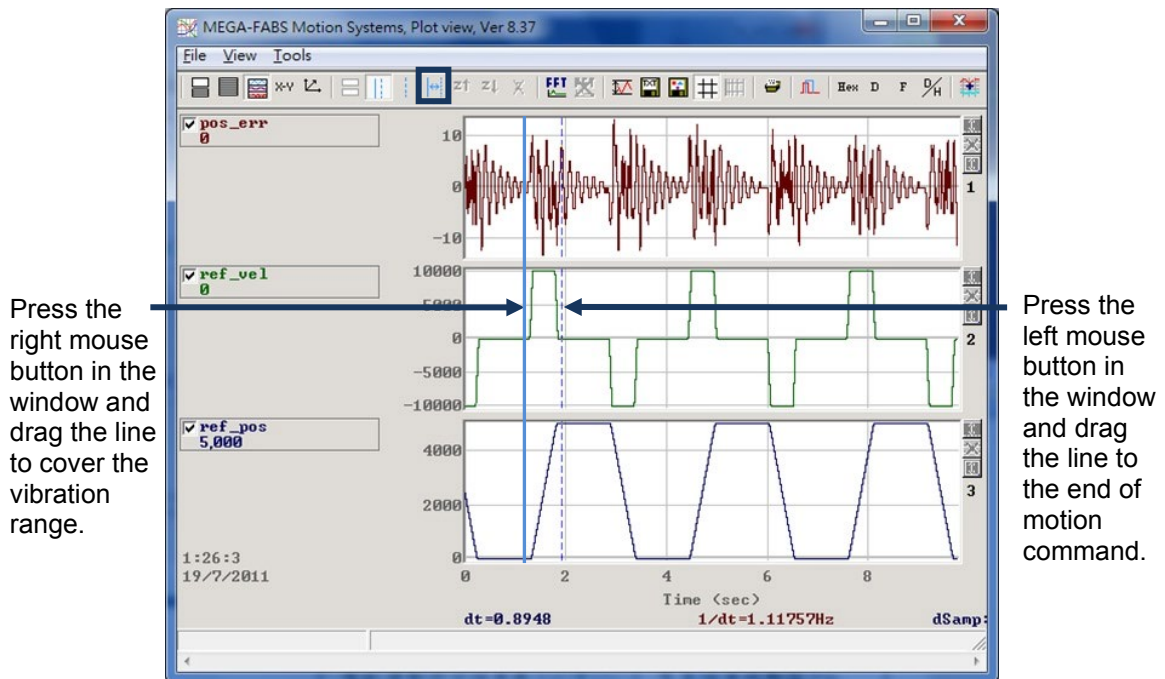



Figure6.6.6.3

Step 5: Click  at the toolbar of “Plot view” window to open the operation window for fast Fourier transform (FFT). Execute FFT on pos_err, as shown in figure 6.6.6.4.

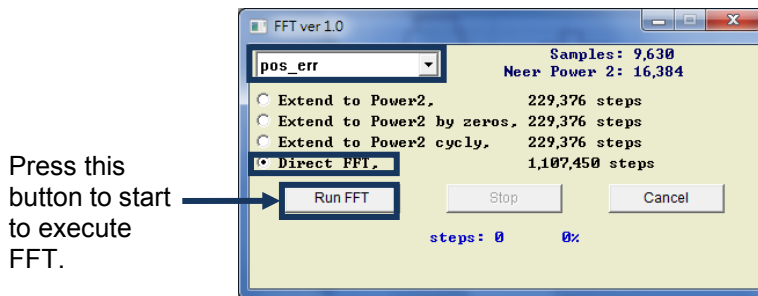


Figure 6.6.6.4

Step 6: After FFT is completed, the window of figure 6.6.6.5 appears.

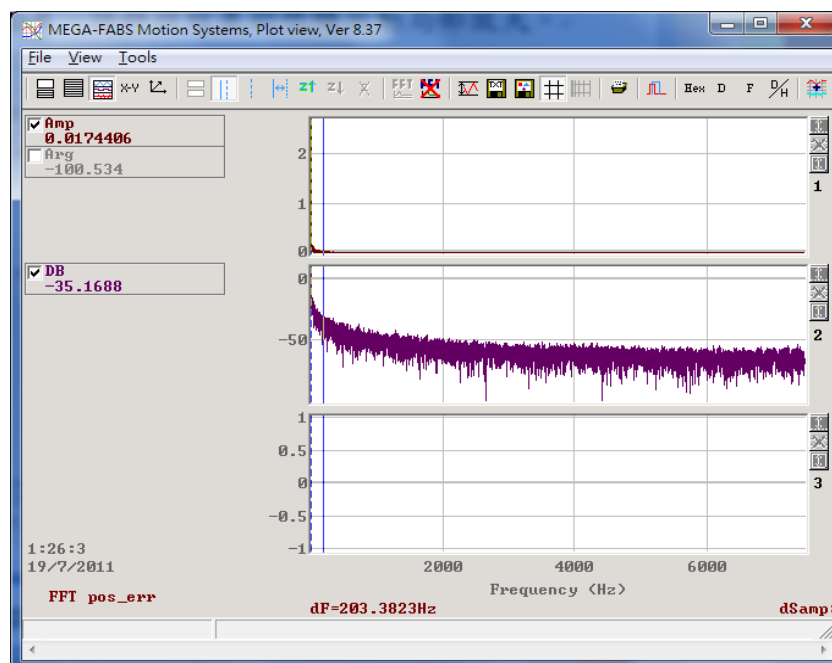


Figure 6.6.6.5

Step 7: Enlarge the low-frequency region to observe the maximum amplitude of vibration frequency, as shown in figure 6.6.6.6.

Step 8: Enter the value of low-frequency vibration frequency (this example is 6.7 Hz) into the “Frequency” field in the “VSF” tab of “Advanced gains” window.

Step 9: Check the “enable VSF” option to enable the vibration suppression feature, as shown in figure 6.6.6.7. Note that: Do not check or uncheck the “enable VSF” option during motor motion.

Step 10: After the vibration suppression feature is enabled, it is found from “Scope” that “Position Error” has become smaller when the motor is stopped, as shown in figure 6.6.6.8.

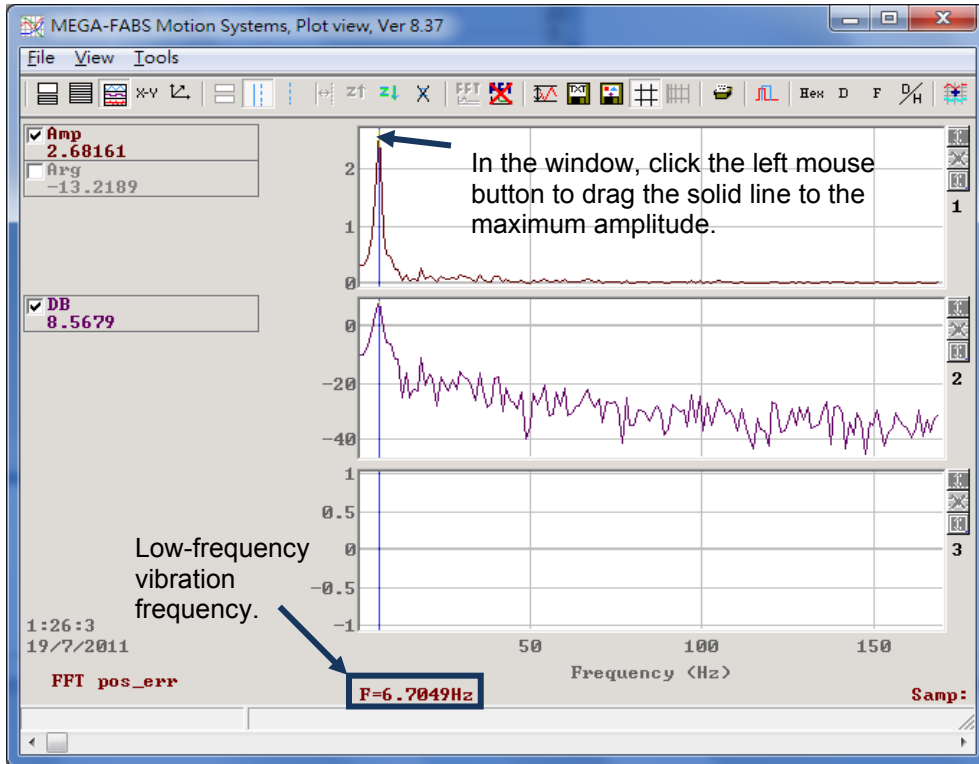


Figure6.6.6.6

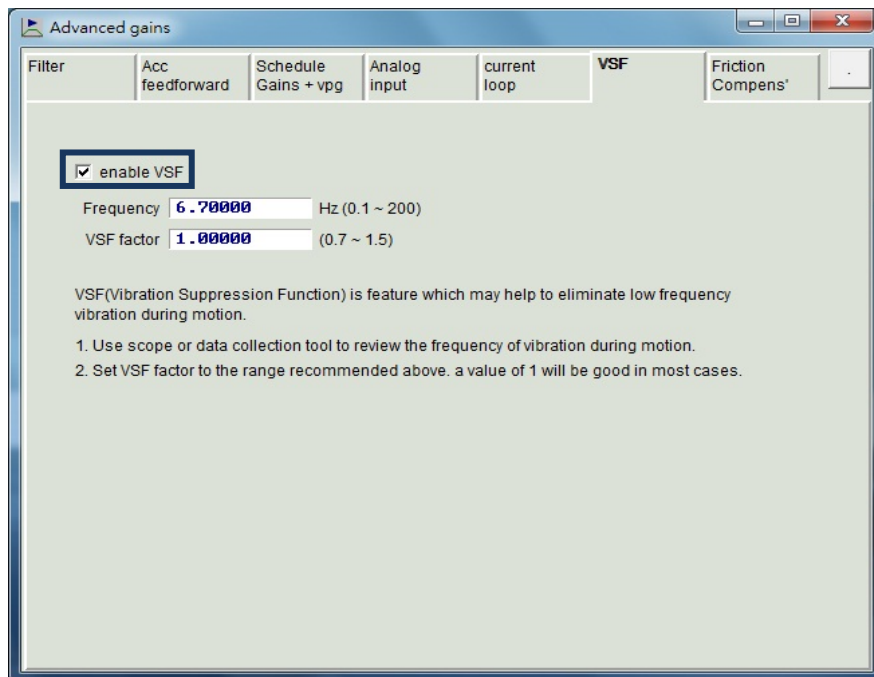


Figure6.6.6.7

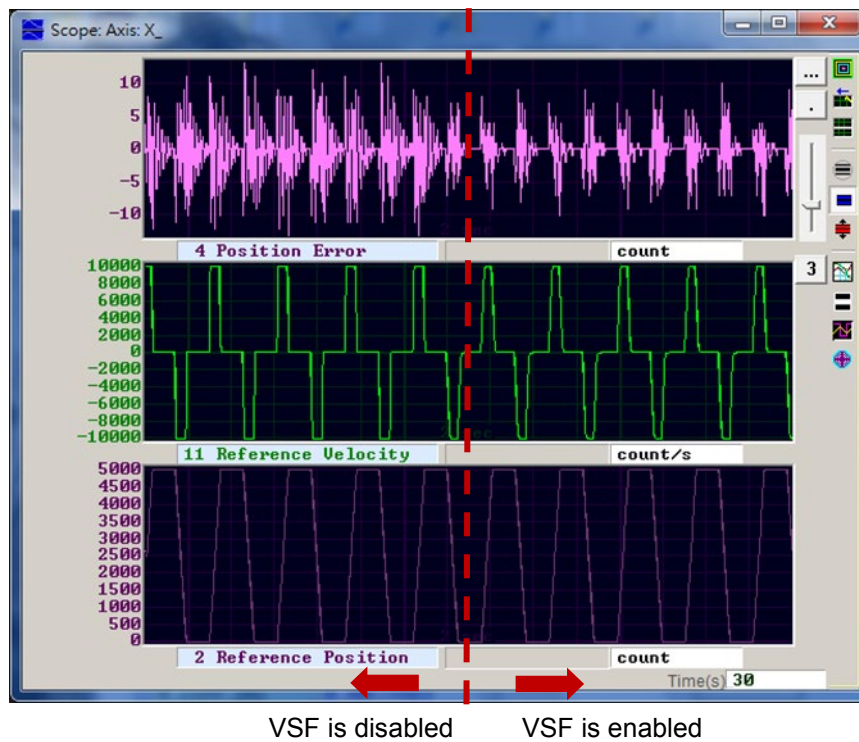


Figure6.6.6.8

6.6.7 Friction compensation

In the operation of drive element, there is always the mechanical friction to affect the efficiency and function of movement. D2-series drives provide a friction compensation method to reduce the effect of friction, as shown in figure 6.6.7.1.

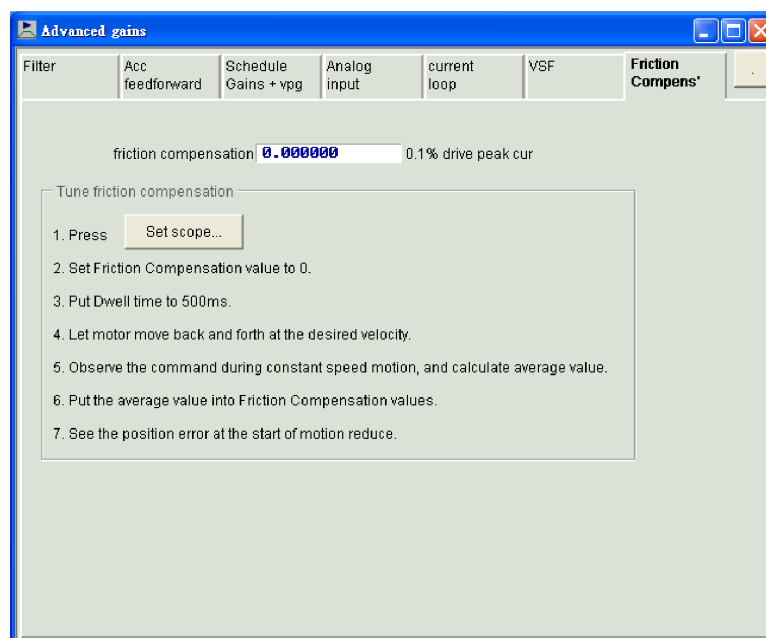


Figure6.6.7.1 Friction compensation

Before using the friction compensation function, the Lightning HMI provides a convenient set of steps. The friction compensation can be successfully added after completing each step.

- Step 1: Click the “Set scope” button to show the “Scope” window.
- Step 2: Set “friction compensation” in figure 6.6.7.1 to 0.
- Step 3: Set “Dwell time” to 500 ms.
- Step 4: Set the desired speed and make the motor to do the back-and-forth motion. Observing “Position Error” in “Scope” can determine whether the friction compensation is necessary to add or not. If the motor has a large position error at the start, as shown in the left side of figure 6.6.7.2, the friction compensation can be added to improve the position error.
- Step 5: Observe “Command Current” at the constant speed, and calculate the average value. In the example of figure 6.6.7.2, the average value of “Command Current” is 20.
- Step 6: Enter the average value obtained from Step 5 into the “friction compensation” field.
- Step 7: Observe whether “Position Error” is reduced at the start of motor movement. As shown in the right side of figure 6.6.7.2, it can be found that the friction compensation does reduce the position error.

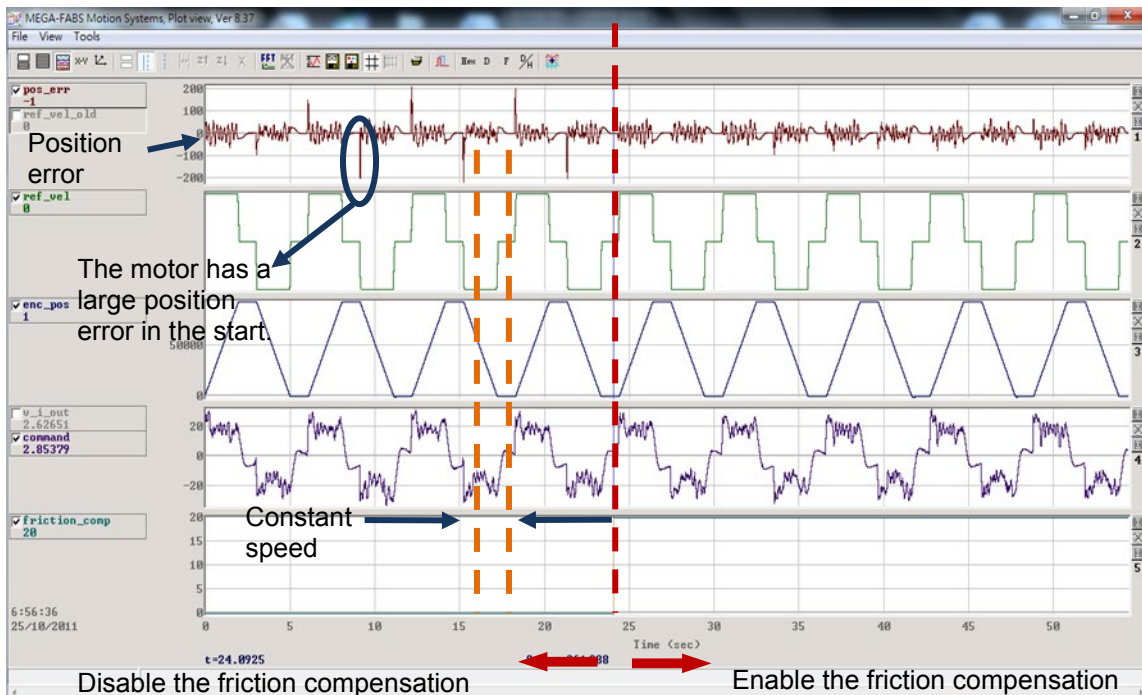


Figure6.6.7.2

6.7 Loop constructor

“Loop constructor” allows users to confirm the stability of control system. It has spectrum analysis tools, such as Nyquist, Nichols, and Bode, and provides users for adjusting filters and gain values (vpg, vig, ppg, and CG). This function can directly adjust parameters to observe the frequency response of control system. To open the “Loop constructor” window, click the “Loop constructor” option in the “Tools” menu of Lightning, as shown in figure 6.7.1. The “Loop constructor” window is given in figure 6.7.2.

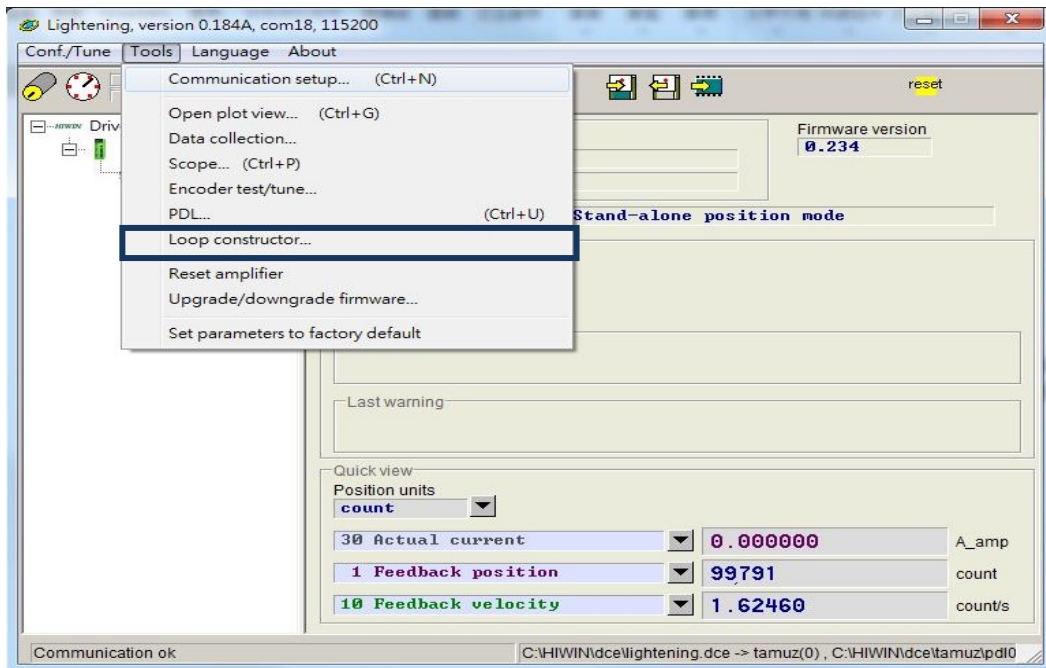


Figure6.7.1 Open “Loop constructor” from “Tools”

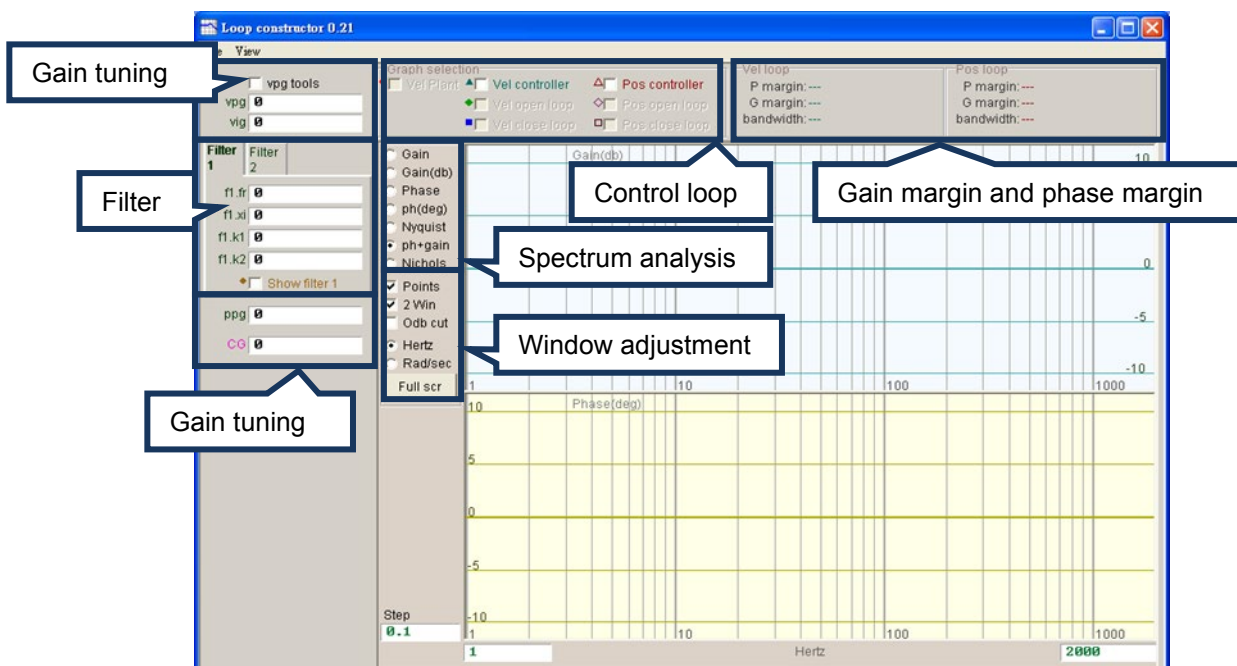


Figure6.7.2 Loop constructor interface

6.7.1 Load/Save file

Before using “Loop constructor” to analyze the control system, the control system and gains must be loaded by selecting the “Load” option in the “File” menu of “Loop constructor” window. There are three methods of loading file: (1) “Load plant + gains from file...”, (2) “Load plant from file...”, and (3) “Load gains from file...”, as shown in figure 6.7.1.1.

- (1) Load plant + gains from file...: Load the .lop file. This file contains the control system and gain parameters.
- (2) Load plant from file...: Load the .fgr file. This file contains the control system.
- (3) Load gains from file...: Load the .gns file. This file contains the control gain.

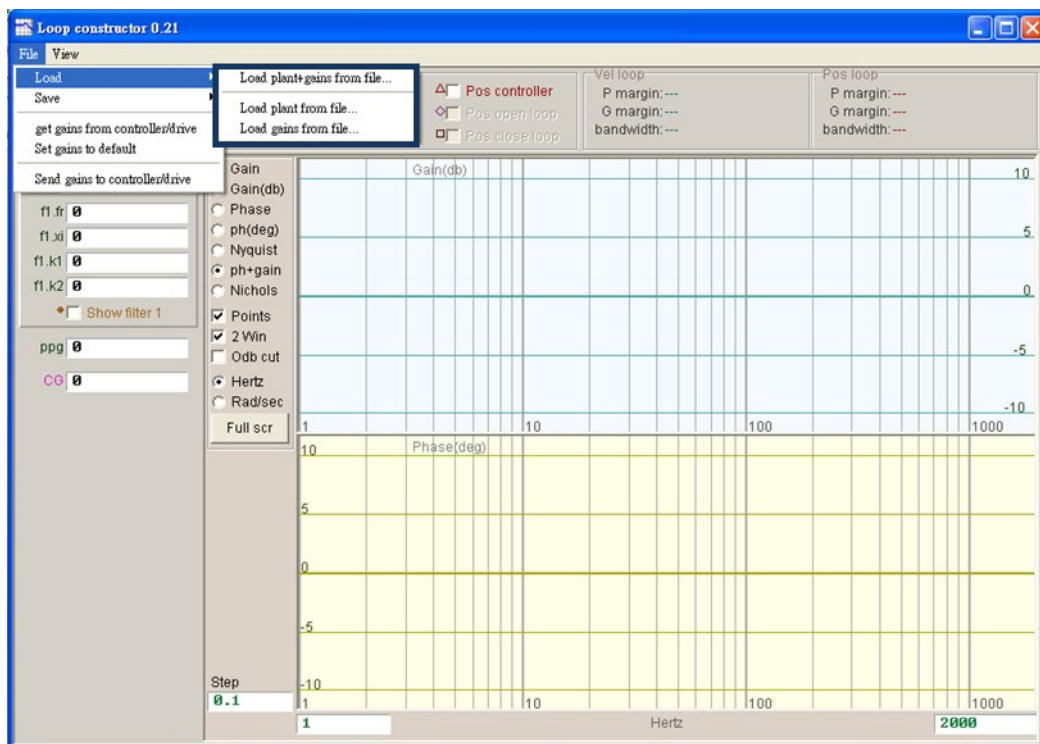


Figure6.7.1.1 Loop constructor - load data from file

After using “Loop constructor” to analyze the control system, if it is needed to save the control system and gain parameters, select the “Save” option in the “File” menu of “Loop constructor” window. There are three methods of saving file: (1) “Save plant + gains to file...”, (2) “Save plant to file...”, and (3) “Save gains to file...”, as shown in figure 6.7.1.2.

- (1) Save plant + gains to file...: Save as the .lop file. This file contains the control system and gain parameters.
- (2) Save plant to file...: Save as the .fgr file. This file contains the control system.
- (3) Save gains to file...: Save the .gns file. This file contains the control gain.

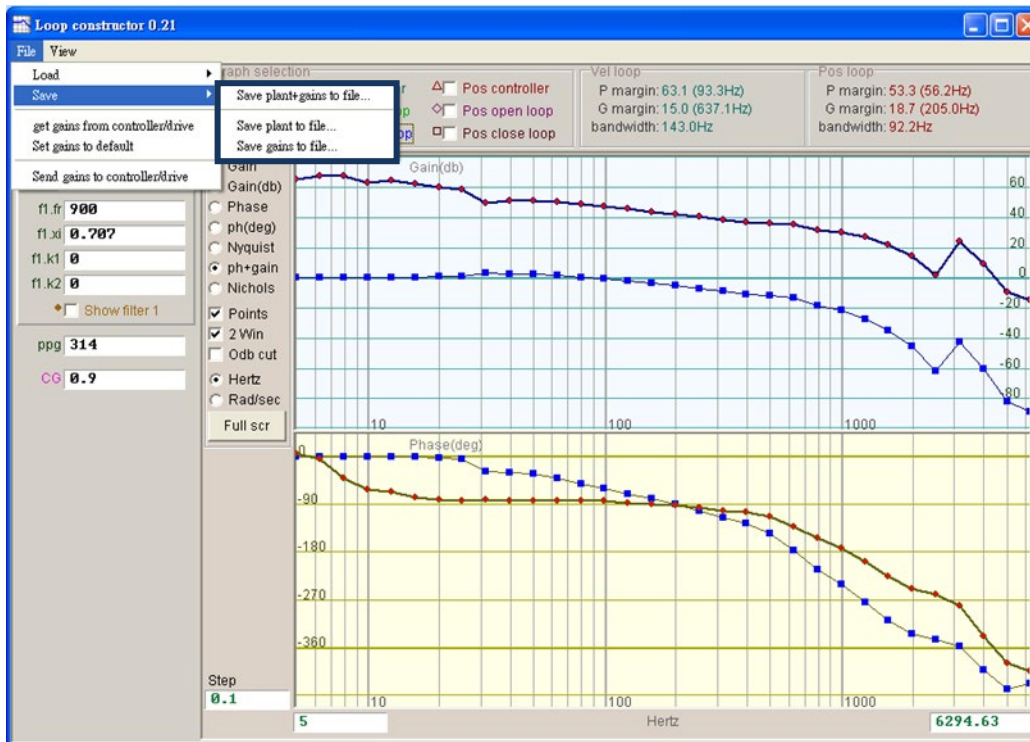


Figure6.7.1.2 Loop constructor - save data to file

6.7.2 Tool

Spectrum analysis tools of “Loop constructor” can analyze and simulate the Nyquist, Bode, and Nichols diagrams of control system. By using this function, the frequency response of control system can be obtained.

6.7.2.1 Frequency response function

The frequency response can be expressed by the transfer function of dynamic system, which indicates the relative relationship between the input signal and the output signal of dynamic system. The control architecture of drive is shown in figure 6.7.2.1.1.

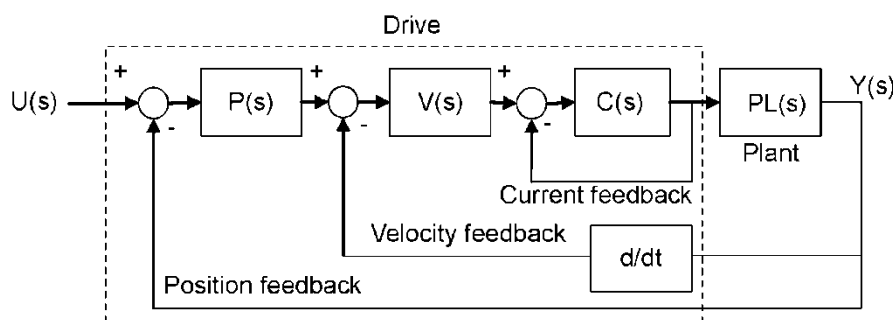


Figure6.7.2.1.1 Control structure of the drive

- (1) U (s): System input. It is the drive command.
- (2) Y (s): System output. It is the position feedback of encoder.
- (3) Plant: PL(s) is the relationship between the drive command and the feedback position. The plant contains the mechanical platform, motor, and feedback system.
- (4) Controller: P(s) is the position loop controller, V(s) is the velocity loop controller, and C(s) is the current loop controller.
- (5) Open loop: The transfer function of open loop system is “G(s) =P(s)*V(s)*C(s)*PL(s)”, meaning to ignore all feedback signals.
- (6) Close loop: The transfer function of close loop system is

$$T(s) = P(s)*V(s)*C(s)*PL(s)/((d/dt*P(s)*V(s)*C(s)*PL)+P(s)*V(s)*C(s)*PL(s)).$$

6.7.2.2 Nyquist

The “Nyquist” option of “Loop constructor” can analyze and simulate frequency responses of “Vel open loop” (velocity open loop) and “Pos open loop” (position open loop) of control system. Using the check method can select to analyze and simulate the Nyquist diagram of “Velocity open loop” or “Position open loop”. It can also select two loops to analyze and simulate at the same time. The Nyquist plot of “Pos open loop” is shown in figure 6.7.2.2.1. Clicking the curve on the Nyquist plot displays the value of frequency response for the analysis of control system.

- (1) Vel open loop: The frequency response of the velocity open loop of control system.
- (2) Pos open loop: The frequency response of the position open loop of control system.

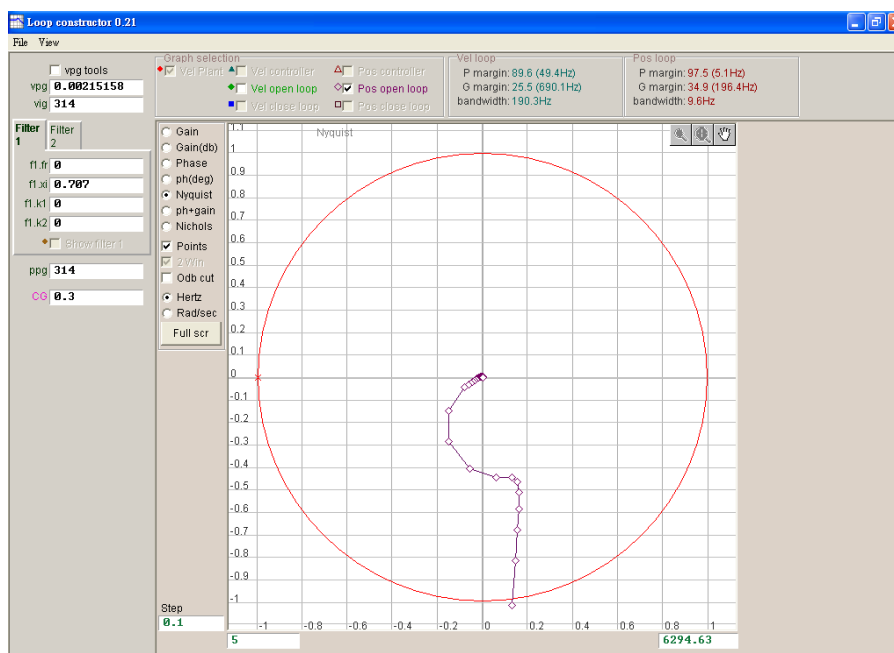


Figure6.7.2.2.1 Nyquist plot of position open loop

6.7.2.3 Bode

The “ph + gain” option of “Loop constructor” can analyze and simulate frequency responses of “Vel controller”, “Vel open loop”, “Vel close loop”, “Pos controller”, “Pos open loop”, and “Pos close loop” of control system. Using the check method can select to analyze and simulate the Bode diagram of velocity loop or position loop. It can also select six loops to analyze and simulate at the same time. Bode plots of “Vel close loop” and “Pos close loop” are shown in figure 6.7.2.3.1. Clicking the curve on the Bode plot displays the value of frequency response for the analysis of control system.

- (1) Vel controller (Velocity controller): The frequency response of velocity controller.
- (2) Vel open loop (Velocity open loop): The frequency response of the velocity open loop of control system.
- (3) Vel close loop (Velocity close loop): The frequency response of the velocity close loop of control system.
- (4) Pos controller (Position controller): The frequency response of position controller.
- (5) Pos open loop (Position open loop): The frequency response of the position open loop of control system.
- (6) Pos close loop (Position close loop): The frequency response of the position close loop of control system.

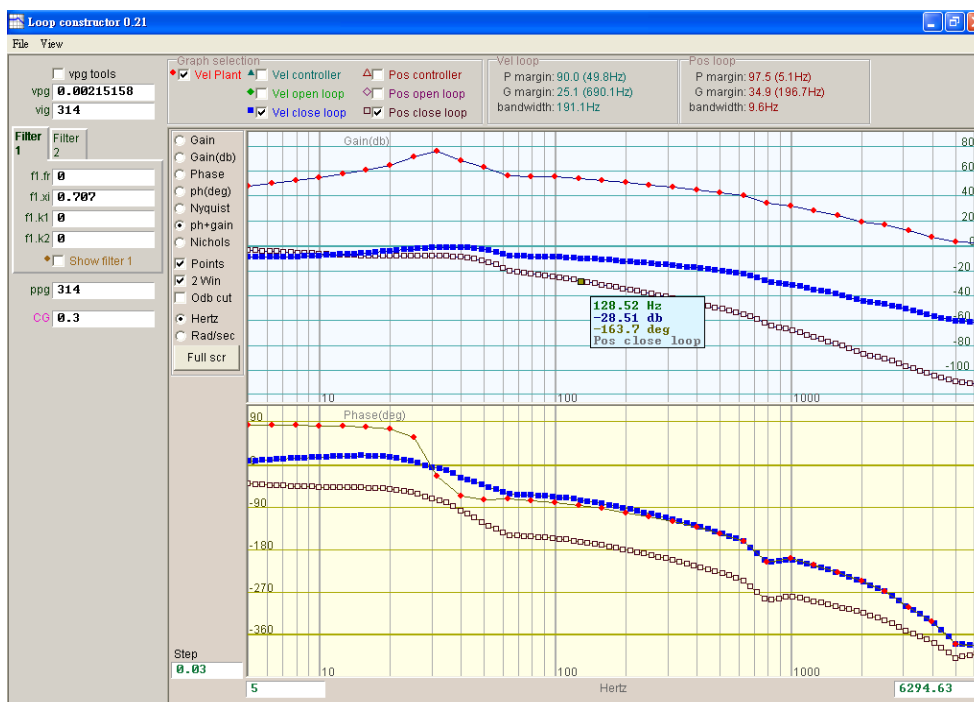


Figure 6.7.2.3.1 Bode plots of velocity close loop and position close loop

6.7.2.4 Nichols

The “Nichols” option of “Loop constructor” can analyze and simulate frequency responses of “Vel open loop” and “Pos open loop” of control system. Using the check method can select to analyze and simulate the Nichols diagram of “Vel open loop” or “Pos open loop”. It can also select two loops to analyze and simulate at the same time. Nichols plots of “Vel open loop” and “Pos open loop” are shown in figure 6.7.2.4.1. Clicking the curve on the Nichols plot displays the value of frequency response for the analysis of control system.

- (1) Vel open loop (Velocity open loop): The frequency response of the velocity open loop of control system
- (2) Pos open loop (Position open loop): The frequency response of the position open loop of control system

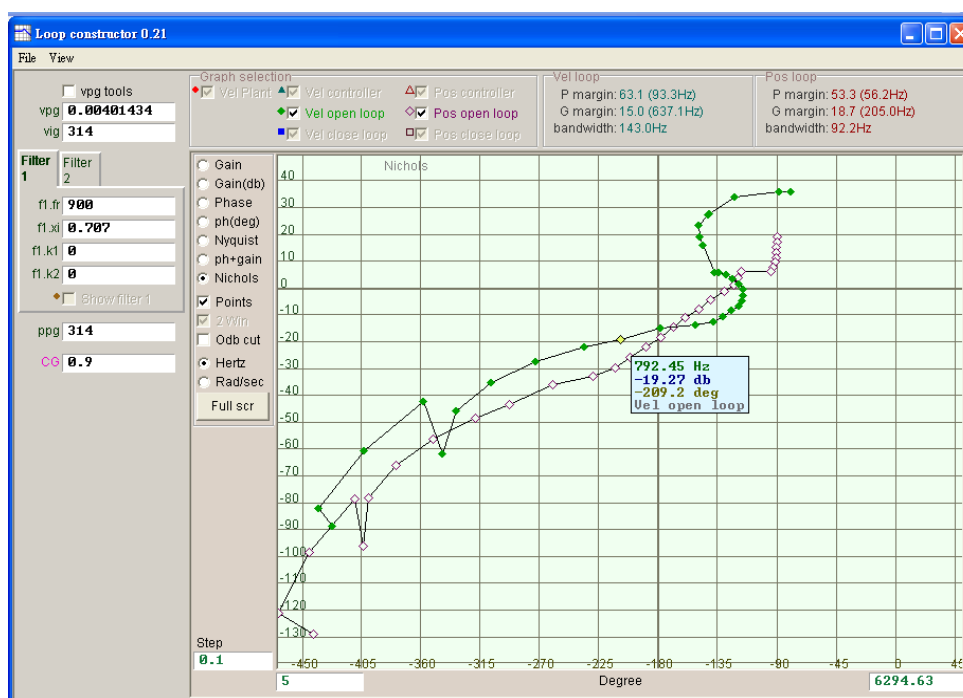


Figure 6.7.2.4.1 Nichols plots of velocity open loop and position open loop

6.7.3 Filter

The control loop of drive provides two filters, which can be used at the same time. They are designed to suppress the high-frequency noise, machine vibration, shortage structure rigidity, and so on.

6.7.3.1 Low pass filter

The low pass filter in the control system is used to suppress the high-frequency noise or machine vibration. The Bode plot of low pass filter is given in figure 6.7.3.1.1. Modifying the filter parameters (fr, xi) will affect the frequency response of various control loop analysis. This is used to simulate the frequency response of control system plus low pass filter to facilitate the actual adjustment.

- (1) fr: The cutoff frequency of filter. The unit is Hz. For general applications, a good effect can be achieved at the setting of 500 Hz. Other cases can be considered to decrease this value. However, the control performance will be reduced if the cutoff frequency is too small.
- (2) xi: The damping ratio of filter. Its value ranges from 0 to 1.
- (3) k1: Low pass filter = 0.
- (4) k2: Low pass filter = 0.

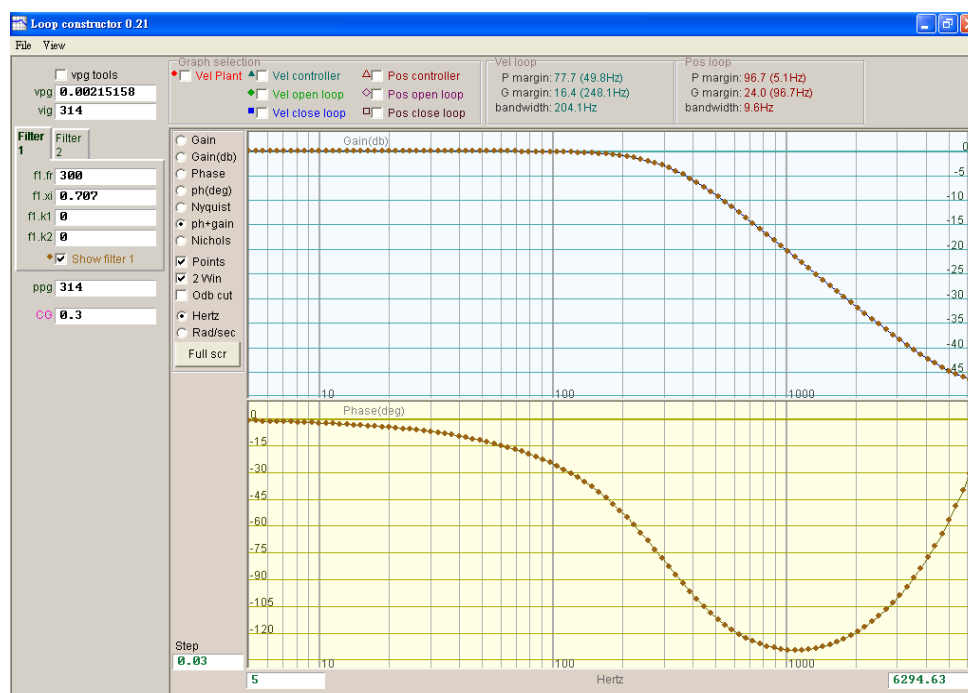


Figure 6.7.3.1.1 Low pass filter

6.7.3.2 Notch filter

When the mechanism system has an inappropriate resonance frequency and the resonance phenomenon cannot be eliminated by modifying the design of mechanism, this problem can be improved by using a notch filter. The Bode plot of notch filter is given in figure 6.7.3.2.1. Modifying the filter parameters (fr, xi) will affect the frequency response of various control loop analysis. This is used to simulate the frequency response of control system plus notch filter to facilitate the actual adjustment.

- (1) fr: The cutoff frequency of filter. The unit is Hz.
- (2) xi: The damping ratio of filter. Its value ranges from 0 to 1. The closer to 0 the narrower the filtering frequency band is, the closer to 1 the wider the filtering frequency band is.
- (3) k1: Notch filter = 0
- (4) k2: Notch filter = 1

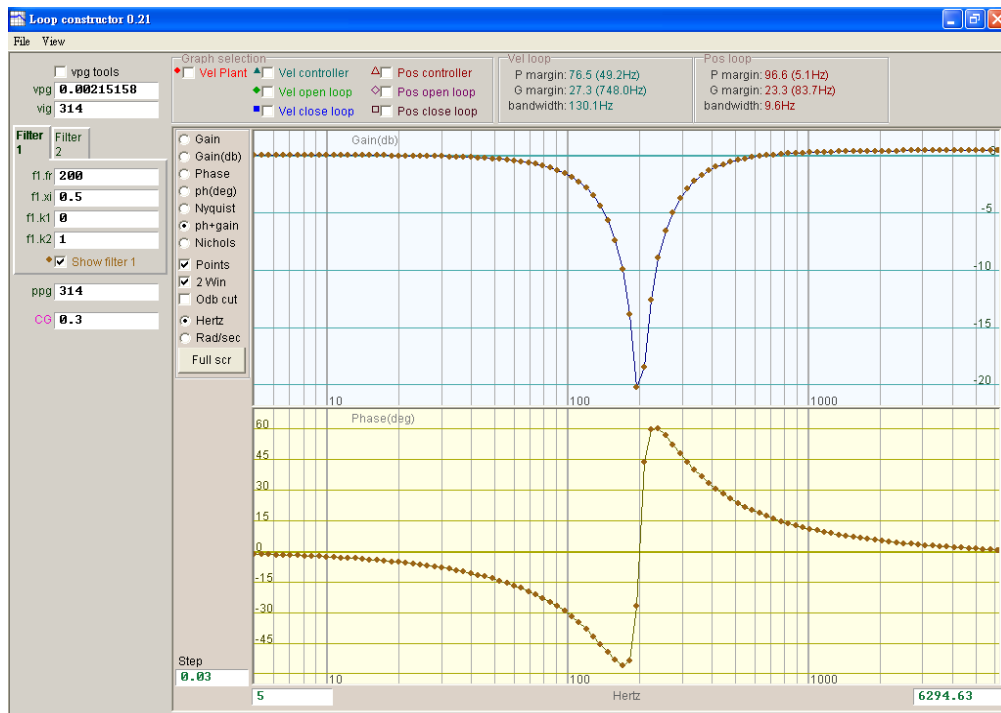


Figure 6.7.3.2.1 Notch filter

6.7.4 Gain tuning

“Loop constructor” provides gain values of velocity loop (vpg, vig) and position loop (ppg), and common gains (CG). Refer to Section 6.6 for more information. These parameters can be used to tune gains to simulate the stability of control system after gain tuning, as shown in figure 6.7.4.1.

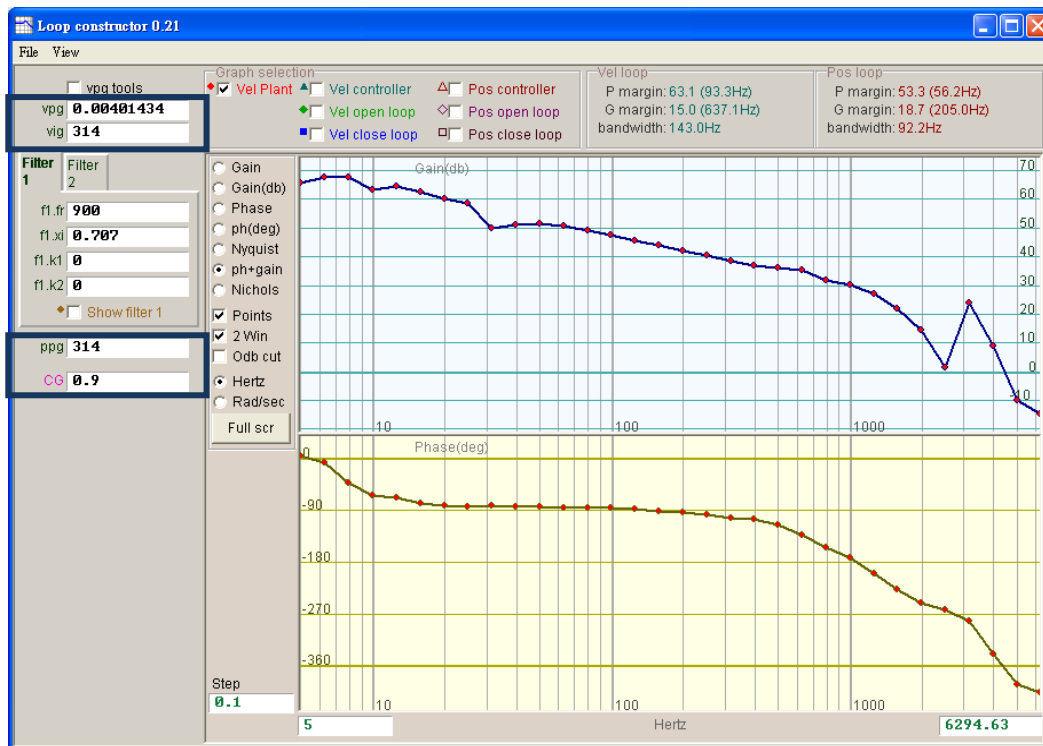


Figure 6.7.4.1 Loop constructor - gains

(1) Velocity loop

Gains of velocity loop are vpg and vig, where vpg is the proportional gain of velocity loop and vig is the integral gain of velocity loop.

- vpg: Tuning vpg affects the transient response of velocity loop and increase the bandwidth of velocity loop.
- vig: Tuning vig affects the steady-state error of velocity loop, but the excessive adjustment may cause the system instability.

(2) Position loop

The proportional gain of position loop is ppg.

- ppg: Tuning ppg affects the transient response of position loop and increase the bandwidth of position loop.

6.7.5 Spectrum analysis

“Loop constructor” provides the gain margin, phase margin, and bandwidth of velocity loop and position loop. This function can be used to tune gains to simulate the stability of control system after gain tuning, as shown in figure 6.7.5.1. Here, “P margin” is the phase margin, and “G margin” is the gain margin. Refer to Section 3.6 for more information.

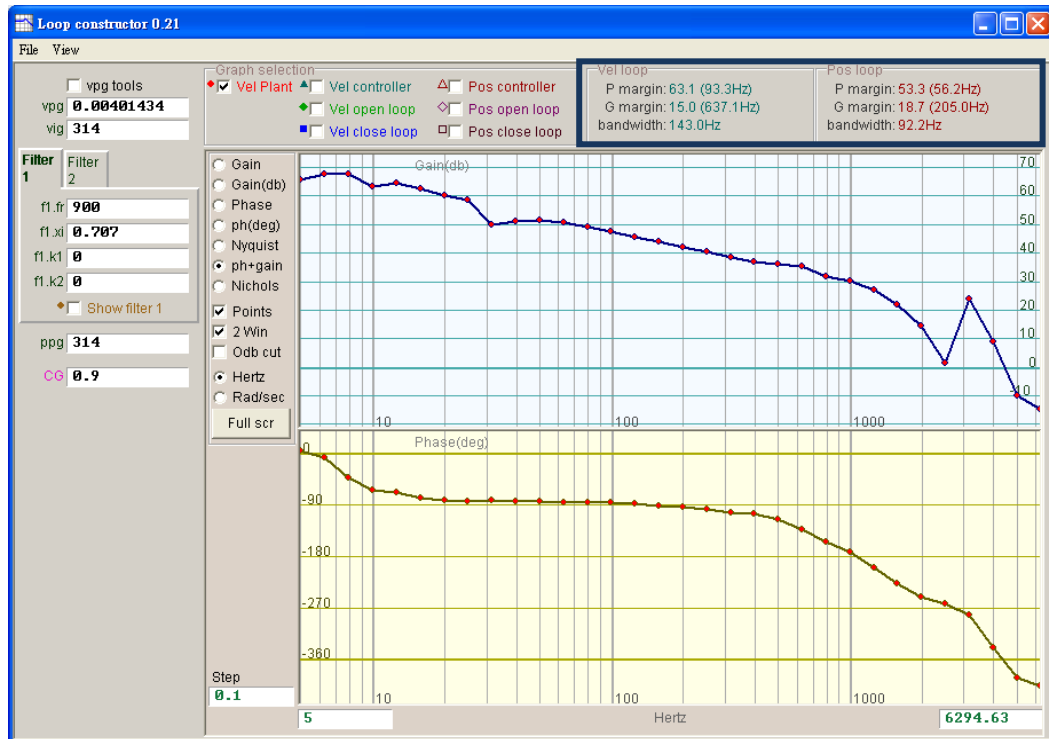



Figure6.7.5.1 Loop constructor - P margin and G margin

6.8 Encoder signal confirmation

The encoder plays an important role in the servo motor control, which provides the information about drive position or angle to achieve the servo loop control. For D2-series drives, the encoder output signal can be ensured via HMI.

(1) Encoder confirmation function

Click  in the window of performance center or select the “Encoder test/tune” option in the function menu of “Tools” to open this function window for observing whether the value or signal of encoder is normal. The function window for digital encoder is shown in figure 6.8.1.

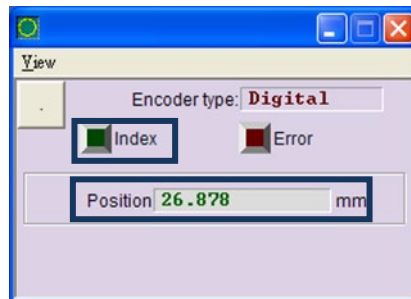


Figure6.8.1 Digital encoder

(2) Encoder value confirmation

The signal of digital encoder is comprised of two digital pulses with 90°-phase difference. For D2 drive, this function can be used to check whether the encoder value is correct. For example, move the motor with a known distance in manual to check whether the read “Position” is the same as the moved distance.

(3) Index signal confirmation

The Z-phase signal of encoder can be used to confirm whether the signal is normally received via the “Index” light in figure 6.8.1. When the drive gets the Z-phase signal, the “Index” light on the window flashes green.

6.9 Error map function

The motor accuracy is usually determined by the linear encoder used on the positioning platform. The positioning accuracy is usually measured and corrected by using a laser interferometer, so that the positioning error table can be obtained. D2 drive has an error map function. By inputting and saving the error table to the drive via HMI, the drive can use this information to calculate the compensation value at the fixed distance by using the linear interpolation manner to improve the positioning accuracy.

After measuring the positioning accuracy and obtaining the error table, set the compensation interval (“Interval”) and total compensation points (“Total points”) first, and then input the error compensation value into the table one by one.

Note:

- (1) “Error map” takes the home position as the start position, and compensates the position in the positive direction. Therefore, complete the homing procedure before enabling the error map function.
- (2) When the host controller needs to receive the feedback pulse outputted from the drive, and also to enable the error map function, set “Encoder output” in the “Encoder” tab to “Use emulated encoder”.

6.9.1 Set error map

The following describes steps of enabling the error map function for D2 drive.

Step 1: Go to the application center and select the “Error Map” tab to open the window of error map function, as shown in figure 6.9.1.1.

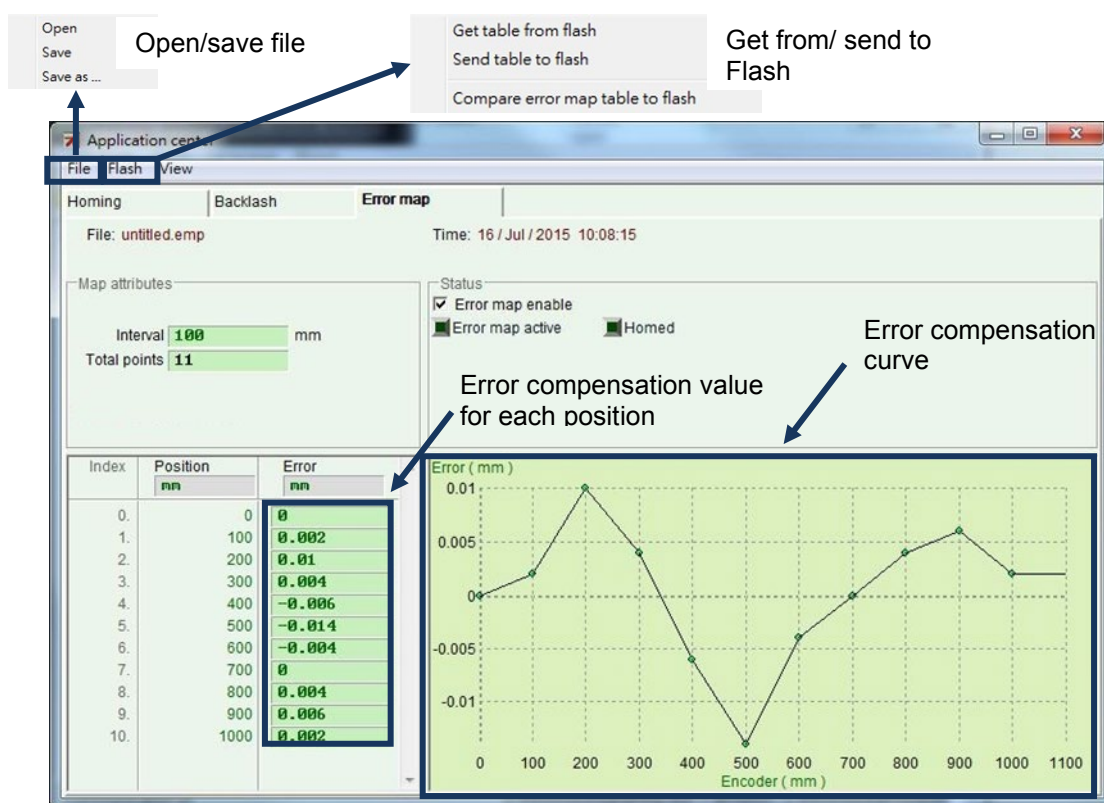


Figure 6.9.1.1 Error map window

Step 2: Set the compensation interval (“Interval”) and total compensation points (“Total points”), and then enter the error compensation value into the “Error” field. If a different custom unit is needed, click the unit field to set different unit. Taking the example of figure 6.9.1.2, the compensation range is from 0 to 1,000 mm, the compensation interval is 100 mm, and the total compensation point is 11 points. The value in the “Error” field is obtained from the error measurement of laser interferometer. For example, when the target position is 100 mm, the laser measurement returns to 100.002 mm.

The displayed reminder to inform that the modified compensation value has not been saved to the drive's Flash.

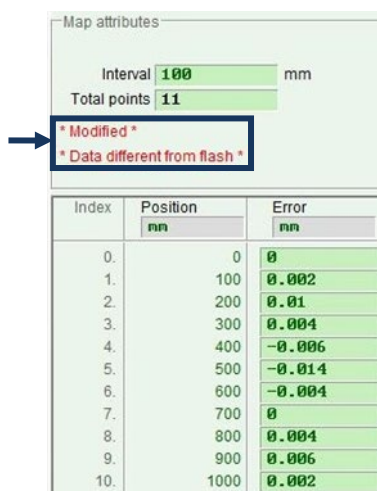


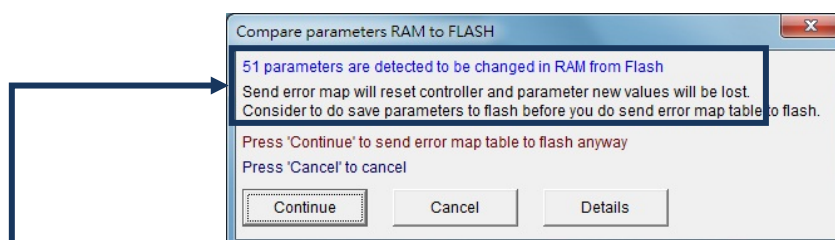
Figure6.9.1.2 Parameter setting of error map

Note:

- (1) When the error compensation value is entered into the table, the entered value is rounded to an integer multiple of encoder resolution. For example, if the encoder resolution is 2 um and the entered compensation value is 1 um, the program will forcibly convert it to 2 um. If the input is 0.5 um, it will be converted to 0 um.
- (2) Because the displayed accuracy is only to the third decimal, select the appropriate unit for "Position" and "Error".

Step 3: Check the option of "Error map enable" (Error map enable).

Step 4: Choose the "Send table to flash" option of "Flash" in the function menu. If there are other parameters modified except error map parameters, and not yet saved in Flash, the following window will be displayed. If there is no parameter needed to save except error map parameters, go to Step 6.



Current parameters except error map parameters are different from those in the drive's Flash. If click the "Continue" button to save error map parameters to Flash, servo parameters will be lost due to the forced "Reset" action of drive.

Figure6.9.1.3

Step 5: Click the “Cancel” button and go to the HMI main window to save servo parameters into Flash. After servo parameters are saved, redo Step 4.

Step 6: When the “confirm” window appears, click the “Confirm” button to save error map parameters into Flash. After error map parameters are saved, the drive will automatically execute the “Reset” action.

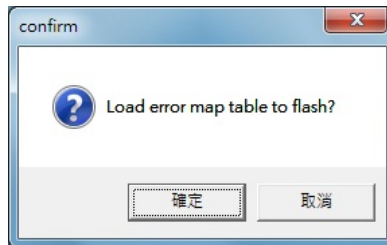


Figure6.9.1.4

6.9.2 Enable error map

After setting the related parameter of error map described above, the drive has the ability of error compensation. As soon as the motor completes the homing procedure, the drive starts the error map immediately. There are two ways for D2 drive to complete the homing procedure. Just choose one of them to use.

■ Homing with host controller

First, set the input function of “Home Ok, start err. map” in the I/O center (see Section 5.5). Assume that this function is set to I2, as shown in figure 6.9.2.1. The host controller sends the motion command to the drive via the pulse command or voltage command to let the motor move to the home position. Then, it stops to send the motion command. The host controller must send the signal to I2 through its digital control output. At this time, if the drive receives this signal, it thinks that the homing procedure is completed and starts the error map function.

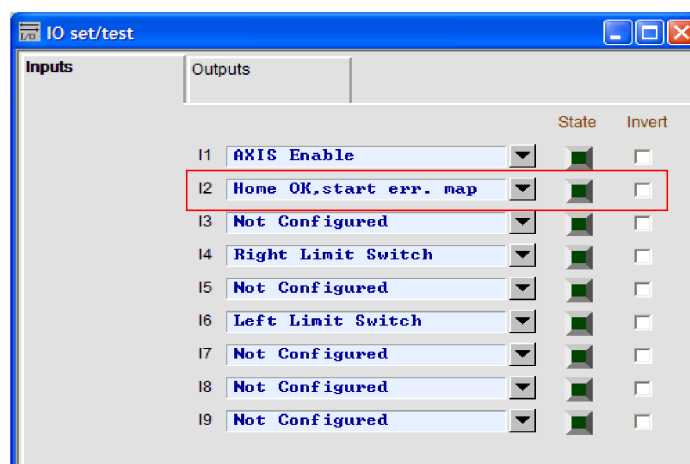



Figure6.9.2.1


■ Stand-Alone homing

Go to the performance center and click the “Home” button ( Home) to execute the homing procedure (see Section 6.2).

■ How to confirm whether the error map function is enabled

At any time, if users want to confirm whether the error map function is already in use, go to the “Status” area in the “Error map” window, and observe whether the “error map active” light is green. The green light indicates that the error map function is enabled.

6.9.3 Save/open error map

The established error compensation value can be directly saved into the disk, and can also be directly read from the disk. As shown in the following figure, click “File” in the function menu to do it. As described in Section 6.9.1, the “Send Table to Flash” option of “Files” in the function menu can save the error map table in the drive’s Flash. Note that, the “Save to Flash” button () in the main window cannot automatically save the error map table in the drive’s Flash (see Section 5.8.1).

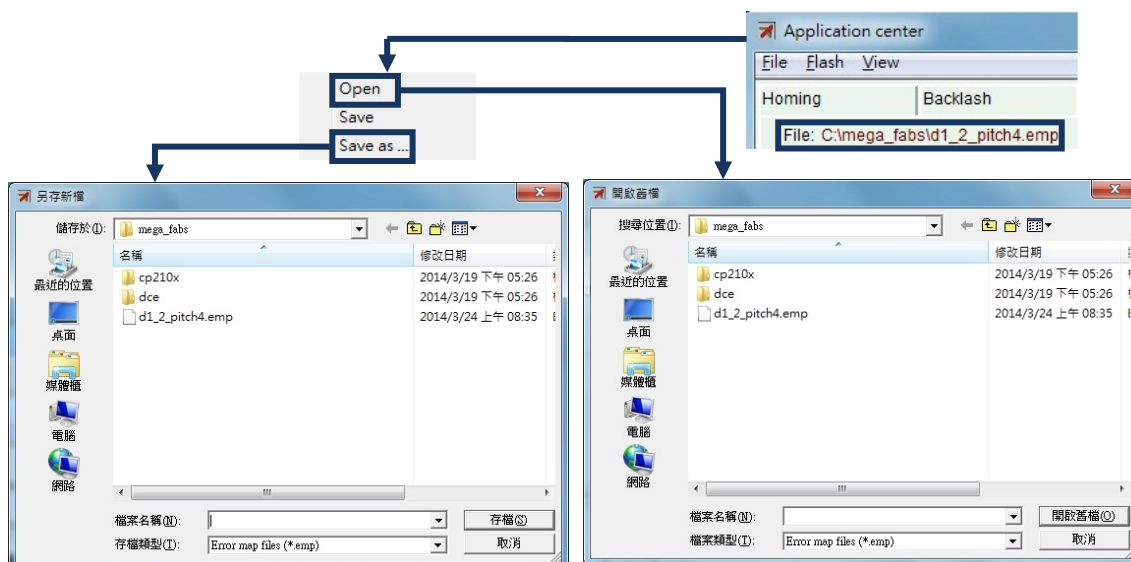


Figure6.9.3.1

6.9.4 Change start position

If it is needed to change the start position of error map, select the “Advanced” option of “View” in the function menu to appear the window of figure 6.9.4.1. Enter the required start position of compensation in the “Start position” field. In addition, pressing the “Next” button on the right side of window, the motor will move the distance of one “Interval” in the forward; while pressing the “Previous” button, the motor will move the distance of one “Interval” in the reversal. The “Error” value in the “Status” area is updated to the error compensation value corresponding to the current position. The red dot on the graph of “Error Map” is the “Encoder” value, and the “Feedback position” value is equal to the “Encoder” value plus the “Error” value.

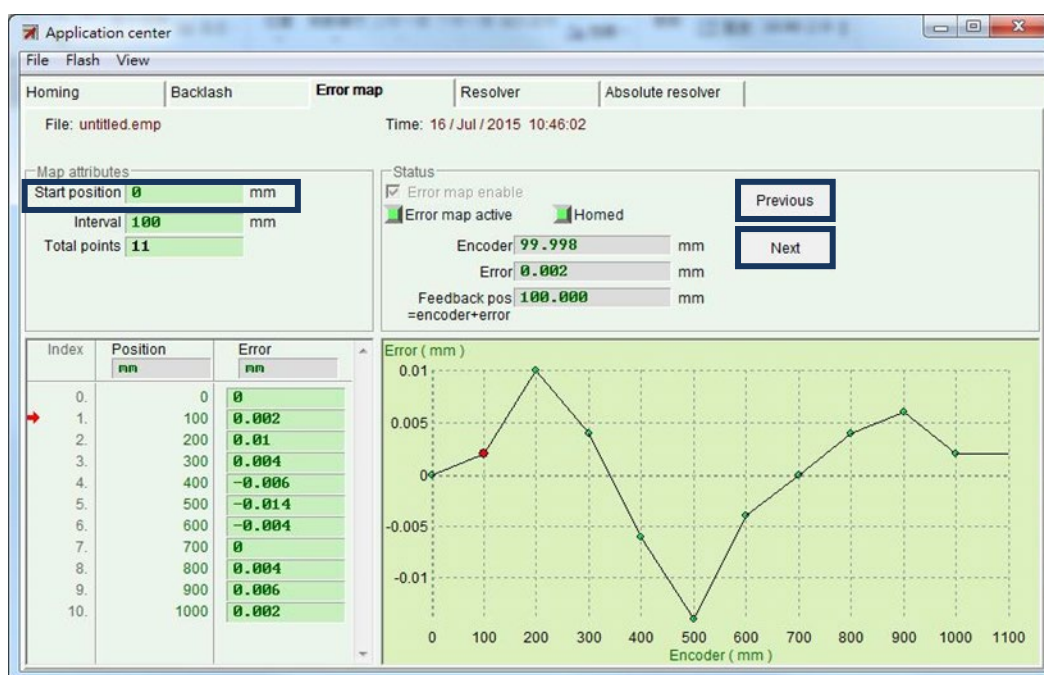


Figure6.9.4.1

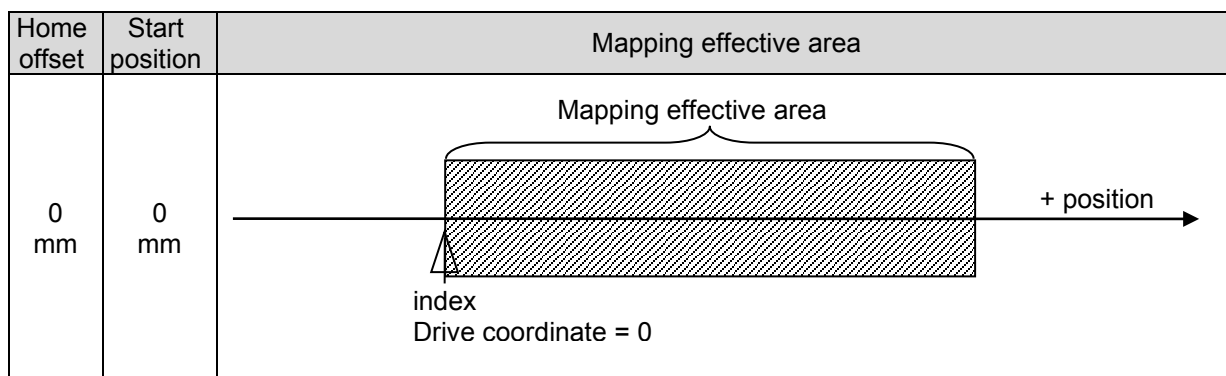
Note:

To compensate the errors in negative direction, input the stop point in Start position field and set the interval in Interval field. For instance, input -1000 in Start position field, 100 in Interval field and 11 in Total points field. Then the compensation positions will be -1000, -900, -800, ..., -100, 0, starting from index 0.

(1) “Home offset” = 0 and “Start position” = 0

For the setting of both “Home offset” and “Start position” being zero, the effective range of error map takes the index as the boundary. The area from the index towards positive direction is the mapping effective area; while the area from the index towards negative direction is the area without mapping.

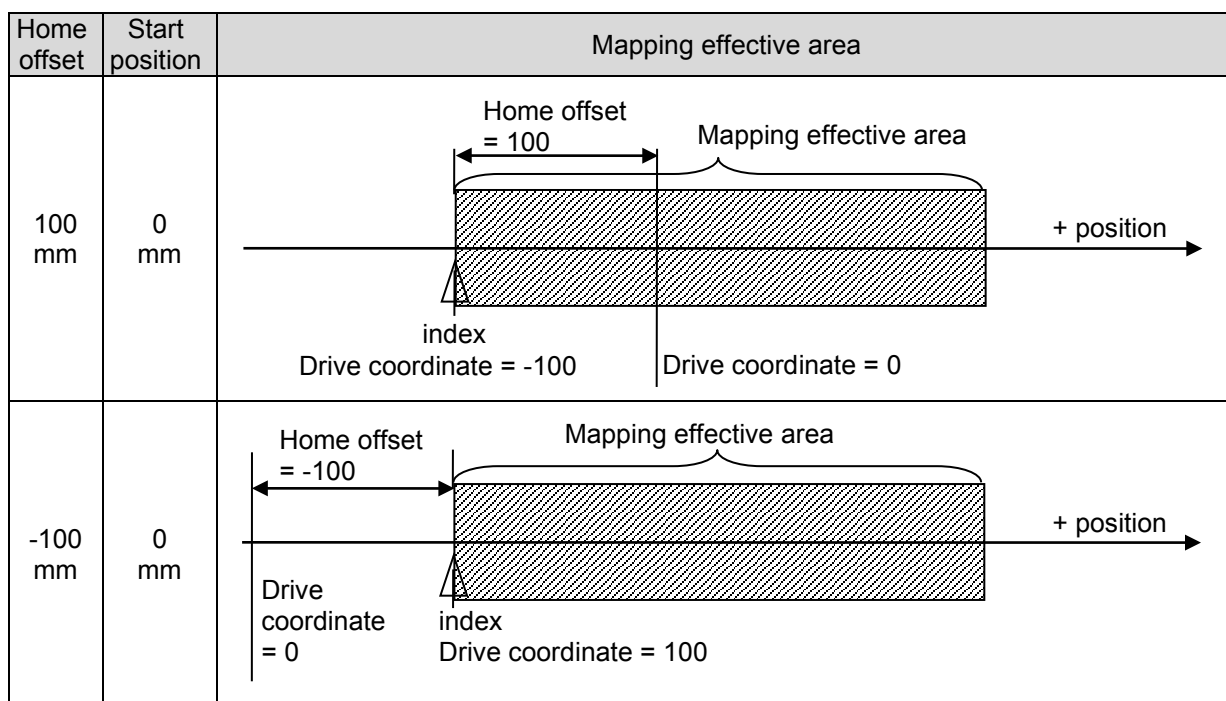
Table6.9.4.1



(2) “Home offset” ≠ 0 and “Start position” = 0

For the setting of “Home offset” being nonzero and “Start position” being zero, the mapping effective area is the same as that for the setting of both “Home offset” and “Start position” being zero.

Table6.9.4.2



(3) “Home offset” = 0 and “Start position” ≠ 0

For the setting of “Home offset” being zero and “Start position” being nonzero, the mapping effective area takes the index as the reference and will move corresponding to “Start position”.

Table6.9.4.3

Home offset	Start position	Mapping effective area
0 mm	100 mm	<p>Start position = 100</p> <p>index Drive coordinate = 0</p> <p>Mapping effective area</p> <p>+ position</p>
0 mm	-100 mm	<p>Start position = -100</p> <p>index Drive coordinate = 0</p> <p>Mapping effective area</p> <p>+ position</p>

(4) “Home offset” ≠ 0 and “Start position” ≠ 0

For the setting of both “Home offset” and “Start position” being nonzero, the mapping effective area does not change with “Home offset”, but moves with “Start position”.

Table6.9.4.4

Home offset	Start position	Mapping effective area
50 mm	100 mm	<p>Start position = 100</p> <p>Home offset = 50</p> <p>index Drive coordinate = -50</p> <p>Drive coordinate = 0</p> <p>Mapping effective area</p> <p>+ position</p>
100 mm	50 mm	<p>Home offset = 100</p> <p>Start position = 50</p> <p>index Drive coordinate = -100</p> <p>Drive coordinate = 0</p> <p>Mapping effective area</p> <p>+ position</p>

Home offset	Start position	Mapping effective area
50 mm	-100 mm	<p>Start position = -100 Home offset = 50</p> <p>Mapping effective area</p> <p>+ position</p> <p>index</p> <p>Drive coordinate = -50 Drive coordinate = 0</p>
100 mm	-50 mm	<p>Start position = -50 Home offset = 100</p> <p>Mapping effective area</p> <p>+ position</p> <p>index</p> <p>Drive coordinate = -100 Drive coordinate = 0</p>
-50 mm	100 mm	<p>Home offset = -50 Start position = 100</p> <p>Mapping effective area</p> <p>+ position</p> <p>index</p> <p>Drive coordinate = 0 Drive coordinate = 50</p>
-100 mm	50 mm	<p>Home offset = -100 Start position = 50</p> <p>Mapping effective area</p> <p>+ position</p> <p>index</p> <p>Drive coordinate = 0 Drive coordinate = 100</p>

Home offset	Start position	Mapping effective area
-50 mm	-100 mm	<p>Start position = -100</p> <p>Home offset = -50</p> <p>Mapping effective area</p> <p>Drive coordinate = 0</p> <p>index Drive coordinate = 50</p> <p>+ position</p>
-100 mm	-50 mm	<p>Home offset = -100</p> <p>Start position = -50</p> <p>Mapping effective area</p> <p>Drive coordinate = 0</p> <p>index Drive coordinate = 100</p> <p>+ position</p>
100 mm	100 mm	<p>Home offset = Start position = 100</p> <p>Mapping effective area</p> <p>index Drive coordinate = -100</p> <p>Drive coordinate = 0</p> <p>+ position</p>
-100 mm	-100 mm	<p>Home offset = Start position = -100</p> <p>Mapping effective area</p> <p>Drive coordinate = 0</p> <p>index Drive coordinate = 100</p> <p>+ position</p>

6.10 Backlash compensation

If the platform moves in a fixed direction and stops, it does not move immediately when it needs to move in the opposite direction. The platform stays at the original position until the motion command is accumulated to a certain amount to start moving. This is called the backlash error. Go to the “Backlash” tab. The backlash compensation setting is given in figure 6.10.1. This setting can be used for backlash compensation to improve the bi-direction reproducibility.

- Backlash function setting

Enter the measured backlash value into this field to complete the backlash compensation setting.

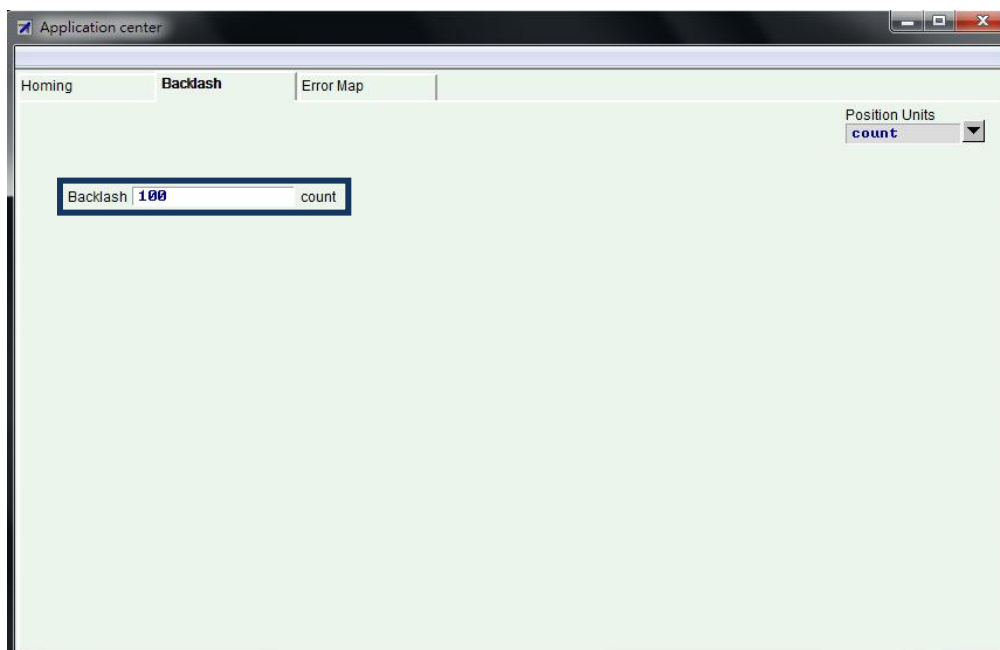


Figure6.10.1 Backlash compensation window

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7. LCD Operation

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7.1 LCD function

7.1.1 Panel description

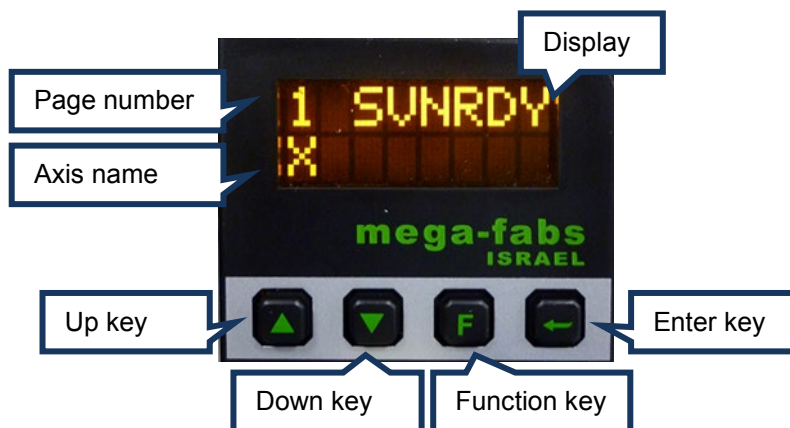


Figure7.1.1.1 LCD panel

Table7.1.1.1 Panel function description

Name	Function
Display	Display change parameter values, statuses, parameters, actions, and so on.
Page number	LCD display is divided into four pages. The current page number is shown in the upper left corner.
Axis name	The axis name is displayed on the first page - home page, and can be modified on the HMI main window. Refer to Section 5.1.3. Messages will also be displayed if there are errors or warnings.
Cursor	<ul style="list-style-type: none"> - Static cursor: Flashing underscore. The parameter can be edited. - Dynamic cursor: Solid flashing box cursor. The parameter is editing or the continuous motion is in progress (jogging). - No cursor: Parameters can only be displayed, but not edited.
Up key	Select options, set parameter values, and do "Jog" action.
Down key	Select options, set parameter values, and do "Jog" action.
Function key (F key)	Switch among four modes, and switch between actions of edit mode at setting the parameter value.
Enter key	Enter the option of status display, save the setting parameter value, and confirm the action input.

7.1.2 Operation page description

There are four modes on the display panel: home page, display parameters page, change parameters page, and actions page. Press the F key to switch to other mode. The overall structure of LCD is shown in figure 7.1.2.1.

(1) Home page

It mainly shows the servo enable state of drive, error message or warning message, and the axis name of servo axis.

(2) Display parameters page

It mainly shows the motor feedback position, reference position, position error, feedback velocity, reference velocity, I/O statuses, motor statuses (phase initialization, motor movement, homing, error map), and other parameters.

(3) Change parameters page

It mainly is used to change the common gain, velocity loop gain, phase initialization gain, operation mode, pulse format, and other parameters, and to save parameters in the memory to Flash. More than 200 advanced parameters can be set.

(4) Actions page

It is mainly for the servo enable or disable, continuous motion (Jog), moving to the absolute target position, setting the current position to zero, "Auto Tune", selecting the motor model name, and other actions.

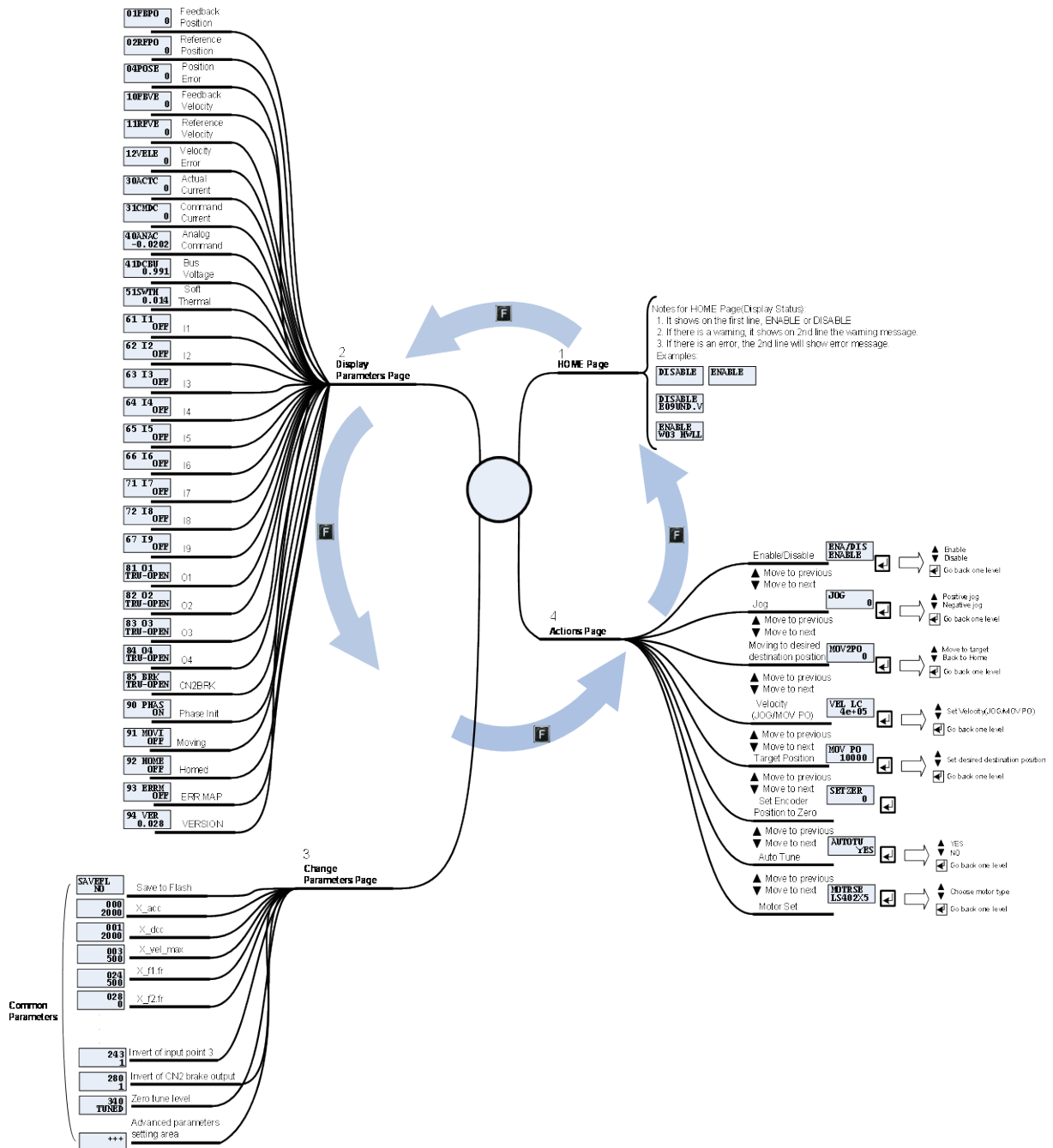


Figure 7.1.2.1 Overall LCD operation structure

7.2 Parameter initialization via LCD

When taking an uninitialized new drive, follow steps below to select the motor model name, perform the initialization procedure, and drive the motor via the LCD panel. The example of operation procedure is that the motor model name is FRLS402XX5 and the operation mode is the stand-alone mode (“STNDALON”).

- (1) Press the Enter key to set motor model (“MOTRSE”), and then press the Up key or Down key to select the motor model name connected to the drive. This example is “LS402XX5”. If the 9-th bit of motor model name is 4 or 6, it uses the serial encoder and the motor model name is unnecessary to be selected. Press the Enter key to confirm the motor model name.
- (2) The LCD screen changes to the gain setting page of “ZeroTune” (“ZT”). Servo loop gains can be easily set without complex procedures via “ZeroTune”. Only by selecting the load level of motor, the well stable velocity response can be achieved. Even a beginner who has no knowledge about the servo control can easily drive a motor. Press the Enter key to enter the “ZT” setting, and then press the Up key or Down key to select the load level (“LV”). Figure 7.1.2.1 shows the reference weight corresponded to the load level. After selecting the appropriate load level, press the Enter key to confirm it.
- (3) The LCD screen moves to the setting page of operation mode (“MODE”). Press the Enter key to enter the “MODE” setting. Press the Up key or Down key to select “STNDALON”, and then press the Enter key to confirm the change of operation mode.
- (4) The LCD screen moves to the “SAVE TO FLASH” page (“SAVEFL”). Press the Enter key to enter the setting page of saving parameters to Flash, and then press the Up key or Down key to select “NO”. Press the Enter key to confirm that parameters do not be saved to Flash. Refer to Section 7.5.1 for more information.
- (5) The LCD screen moves to the home page. At this time, “SVNRDY” is displayed to indicate that the motor is not enabled yet. Now, the setting of motor parameter initialization is completed.

Table7.2.1 Reference weight of “ZeroTune”

Motor Power	LV1	LV2	LV3	LV4	LV5
50 W, 100 W	5 Kg	15 Kg	30 Kg	45 Kg	60 Kg
200 W, 400 W	10 Kg	25 Kg	50 Kg	75 Kg	100 Kg
750 W, 1 KW	20 Kg	50 Kg	80 Kg	110 Kg	140 Kg

Note:

LV1 - LV5 mean the load level. For different motor power and load level, the corresponding reference weight will be displayed.

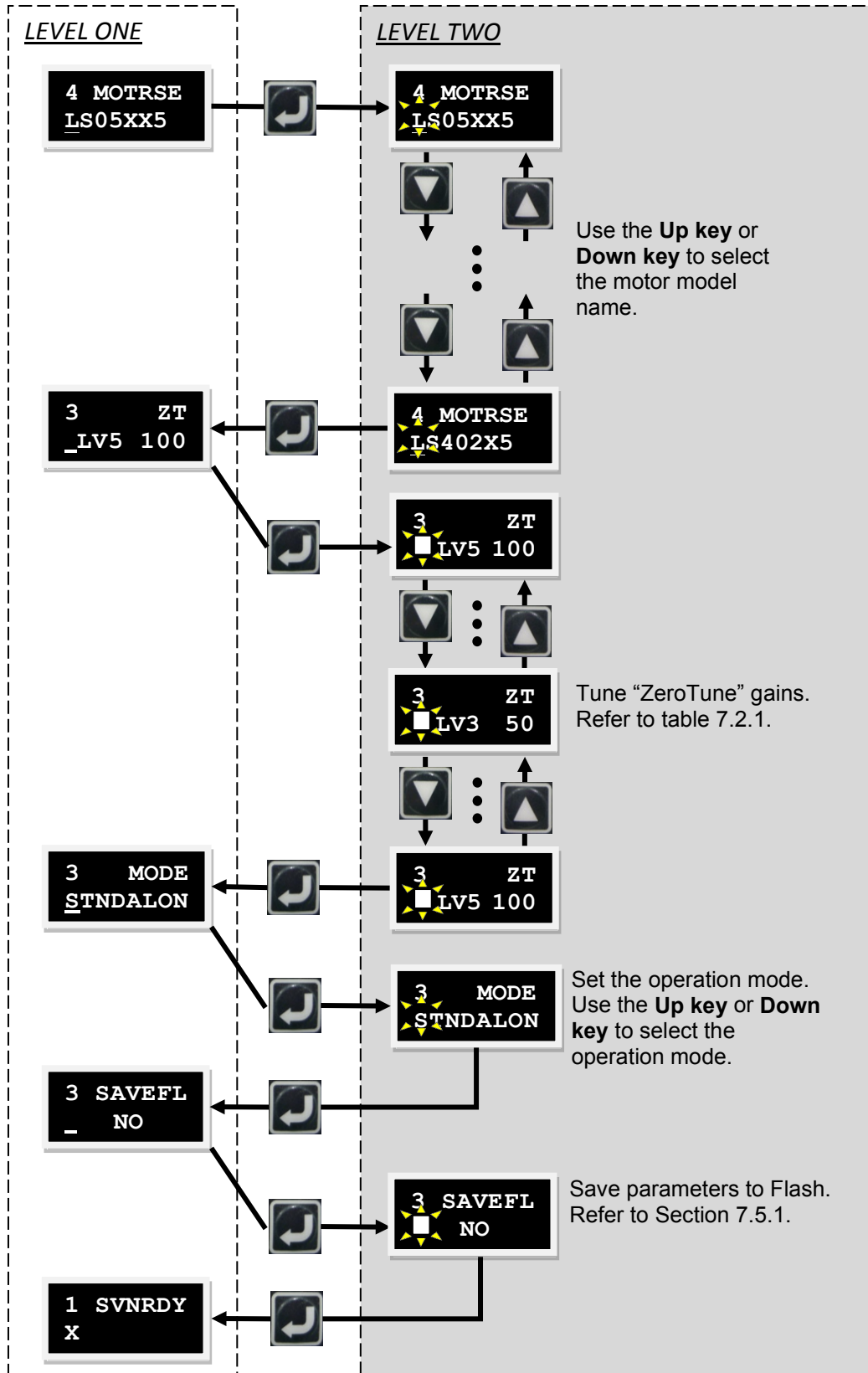


Figure 7.2.1 Setting procedure of motor parameter initialization

7.3 Home page

When the drive is power-on, the display will show the status of servo ready first. The symbol of this status is given in table 7.3.1.

Table7.3.1 LCD displayed symbols for servo ready

LCD Symbol	Description
SV RDY	Servo is ready.
SVNRDY	Servo is not ready.

When D2 drive detects the occurrence of error or warning, the error or warning message will be displayed on the second line, as shown in figure 7.3.1. Displayed symbols of error and warning are described in table 7.3.1 and table 7.3.2, respectively. There are two designs for LCD display. Before firmware versions of D2 MDP 0.037 (inclusive) and D2COE MDP 0.113 (inclusive), the LCD display adopts the abbreviated design for LCD displayed symbols. On the other hand, after firmware versions of D2 MDP 0.038 (inclusive) and D2COE MDP 0.114 (inclusive), the LCD display adopts the numbered design for LCD displayed symbols.

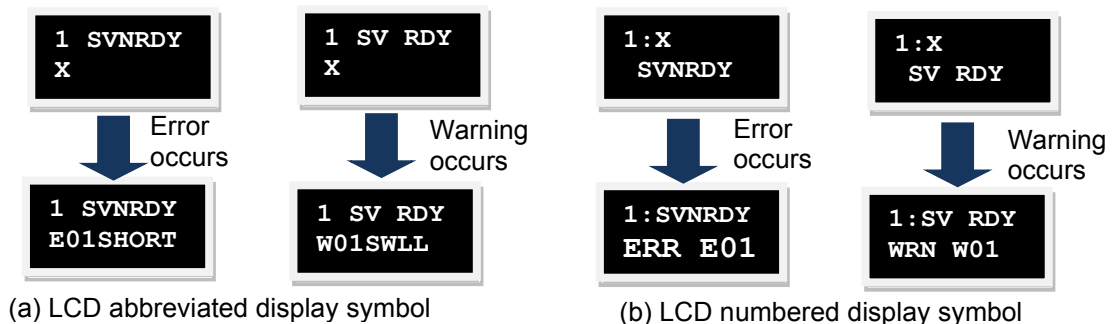


Figure7.3.1 Error and warning display

Table7.3.2 LCD displayed symbols for error message

No.	LCD Symbol (Abbreviated)	LCD Symbol (Numbered)	Error Message Displayed On Lightening
1	E01SHORT	ERR E01	Motor short (over current) detected
2	E02OVERV	ERR E02	Over voltage detected
3	E03PEBIG	ERR E03	Position error too big
4	E04ENCOD	ERR E04	Encoder error
5	E05SWHOT	ERR E05	Soft-thermal threshold reached
6	E06UVWCN	ERR E06	Motor maybe disconnected
7	E07D.HOT	ERR E07	Amplifier over temperature
9	E09UND.V	ERR E09	Under voltage detected
10	E10V5ERR	ERR E10	5V for encoder card fail
11	E11PHINI	ERR E11	Phase initialization error
12	E12SER.E	ERR E12	Serial encoder communication error
13	E13HAL.E	ERR E13	Hall Sensor Error

No.	LCD Symbol (Abbreviated)	LCD Symbol (Numbered)	Error Message Displayed On Lightening
15	E15CURER	ERR E15	Current Control Error
17	E17HYBDV	ERR E17	Hybrid deviation too big
18	E18STO	ERR E18	STO active
19	E19HFLT	ERR E19	HFLT inconsistent error
21	E21WRGMT	ERR E21	Incompatible motor model and drive
22	E22BUS.E	ERR E22	DC bus voltage abnormal
23	E23NOET	ERR E23	EtherCAT interface is not detected
24	E24HOM.E	ERR E24	CiA-402 homing error
25	E25FAN.E	ERR E25	Fan fault error
26		ERR E26	Drive overload error

Note:

- (1) Before D2 MDP 0.037 (inclusive) and D2COE MDP 0.113 (inclusive), the abbreviated design is adopted for LCD displayed symbols. After D2 MDP 0.038 (inclusive) and D2COE MDP 0.114 (inclusive), the numbered design is adopted for LCD displayed symbols.
- (2) ERR E18, ERR E25, and ERR E26 are only for the frame D model.

Table7.3.3 LCD displayed symbols for warning message

No.	LCD Symbol (Abbreviated)	LCD Symbol (Numbered)	Warning Message Displayed On Lightening
1	W01SWLL	WRN W01	Left SW limit
2	W02SWRL	WRN W02	Right SW limit
3	W03HWLL	WRN W03	Left HW limit
4	W04HWRL	WRN W04	Right HW limit
5	W05SVBIG	WRN W05	Servo voltage big
6	W06PE	WRN W06	Position error warning
7	W07VE	WRN W07	Velocity error warning
8	W08CUR.L	WRN W08	Current Limited
9	W09ACC.L	WRN W09	Acceleration Limited
10	W10VEL.L	WRN W10	Velocity Limited
11	W11BOTH	WRN W11	Both HW limits are active
13	W13HOM.E	WRN W13	Homing Fail
14	W14HOM.C	WRN W14	Pulse command and homing conflict
15	W15BAT.E	WRN W15	Absolute encoder battery warning
16	W16ABS.W	WRN W16	Wrong absolute position
17		WRN W17	MECHATROLINK communication warning
18		WRN W18	Absolute encoder position overflow
19		WRN W19	Serial encoder communication warning

Note:

Before D2 MDP 0.037 (inclusive) and D2COE MDP 0.113 (inclusive), the abbreviated design is adopted for LCD displayed symbols. After D2 MDP 0.038 (inclusive) and D2COE MDP 0.114 (inclusive), the numbered design is adopted for LCD displayed symbols.

7.4 Display parameters page

In the display parameters page, press the Up key or Down key to change the displayed parameter. The operation flow chart is shown in figure 7.4.1, and the definition of the displayed symbol for each parameter is given in table 7.4.1. In the LCD display, the first line is the parameter name, and the second line is its value or status.

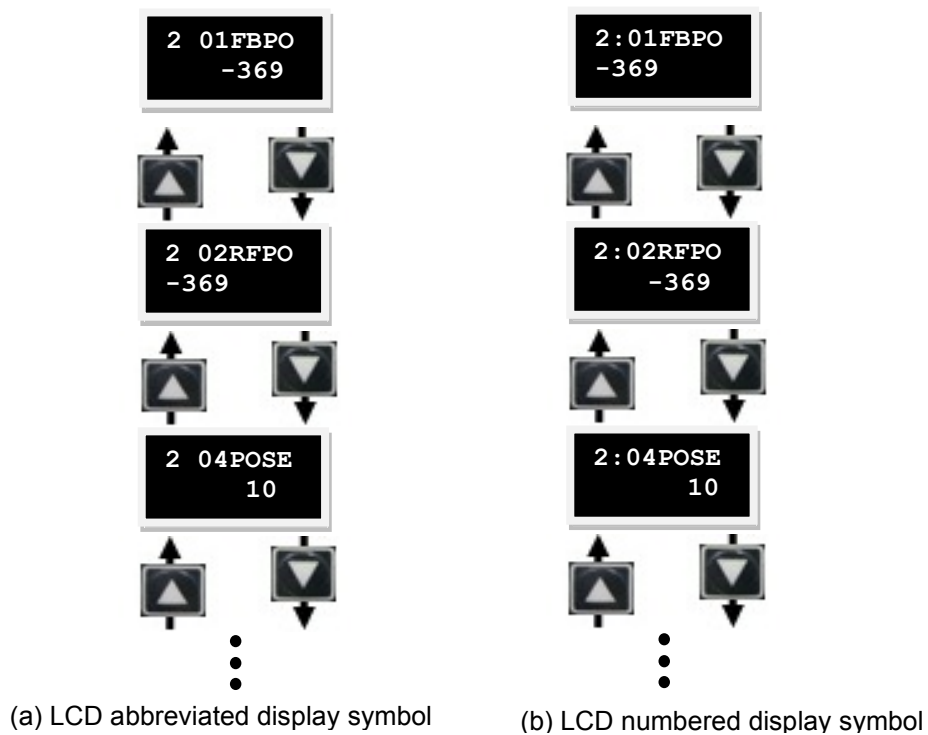


Figure7.4.1 Operation flow chart for display parameters page

Table 7.4.1 LCD displayed parameters in the display parameters page

Displayed Symbol	Physical Quantity	Description	Unit
01FBPO	Feedback Position	Motor feedback position	count
02RFPO	Reference Position	Drive reference position	count
04POSE	Position Error	Position error	count
05STPO	Single Turn Feedback Position	Feedback position of single-turn absolute encoder (Note 1)	count
06DLPO	Dual-loop Feedback Position	Feedback position of dual-loop encoder (Note 2)	count
10FBVE	Feedback Velocity	Motor feedback velocity	rpm
11RFVE	Reference Velocity	Drive reference velocity	rpm
12VELE	Velocity Error	Velocity error	rpm
30ACTC	Actual Current	Motor actual current	A _{amp}
31CMDC	Command Current	Drive current command	A _{amp}
32 CE	Current effective value	Effective value of current during the calculation period	A _{amp}
40ANAC	Analog Command	Analog voltage command (from the host controller)	Volt
41DCBU	Bus Voltage	Bus voltage	Volt
51SWTH	Soft-thermal Accumulator	Soft-thermal accumulator	-
53 ALR	Average load ratio	Average load ratio during the calculation period	%
54 PLR	Peak load ratio	Peak load ratio during the calculation period	%
61 I1	I1	Input 1	-
62 I2	I2	Input 2	-
63 I3	I3	Input 3	-
64 I4	I4	Input 4	-
65 I5	I5	Input 5	-
66 I6	I6	Input 6	-
71 I7	I7	Input 7	-
72 I8	I8	Input 8	-
67 I9	I9	Input 9	-
68 I10	I10	Input 10 (Note 3)	-
81 O1	O1	Output 1	-
82 O2	O2	Output 2	-
83 O3	O3	Output 3	-
83 O4	O4	Output 4	-
86 O5	O5	Output 5 (Note 3)	-
85 BRK	CN2 BRK	Brake signal output	-
90PHAS	Status: Phase Initialized	Phase initialization status	-
91MOVI	Status: Moving	Motion status	-
92HOME	Status: Homed	Homing status	-
93ERRM	Status: Error Map Active	Error map active status	-
94 VER	Status: MDP Version	MDP version status	-
95ELEC	Status: Elec. Angle corrected	Electrical angle correctness status (Note 4)	-

Note:

- (1) Only for the drive supporting the single-turn absolute encoder.
- (2) Only for the drive supporting the dual-loop encoder.
- (3) Only for D2T model.
- (4) Only for the drive supporting the 13-bit encoder.

The status display for parameters O1 - O5 is shown in figure 7.4.2 and the symbol of status display is described in table 7.4.2.

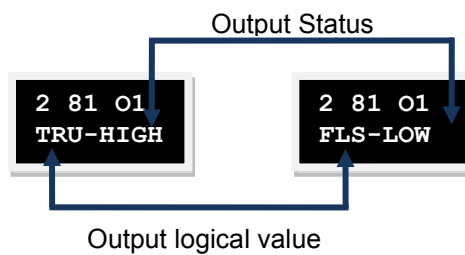


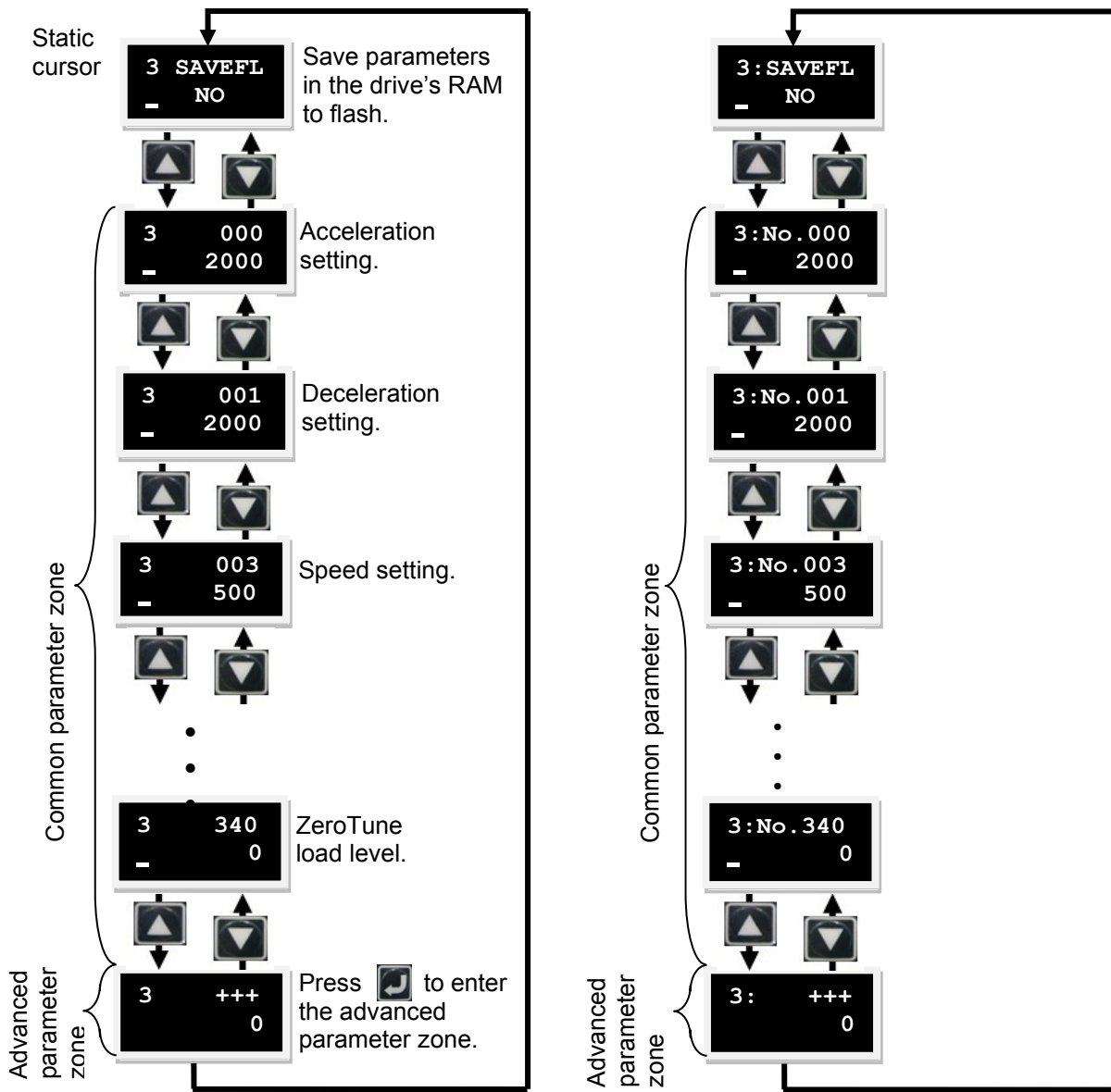
Figure7.4.2 Output status display

Table7.4.2 LCD displayed symbol for output status

LCD symbol	Description
TRU	True
FLS	False
HIGH	Open
LOW	Close

7.5 Change parameters page

The third page of LCD is the change parameters page, which is used to change the set parameter. The operation can be divided into two zones: common parameter zone and advanced parameter zone. The former is given in table 7.5.1 and the latter is given in table 7.5.3.1. In the change parameters page, press the Up key or Down key to change the edited parameter. The operation flow chart is described in figure 7.5.1. The detailed operation procedure is described in the next subsection (take the LCD abbreviated display symbol as an example).



Note:
Static cursor (flashing underscore). The parameter can be edited.

(a) LCD abbreviated display symbol

(b) LCD numbered display symbol

Figure 7.5.1 Operation flow chart for change parameters page

Table 7.5.1 Common parameter table (set parameter based on the actual application)

LCD No.	Function	Description
000	Acceleration	Maximum acceleration of motor during motion
001	Deceleration	Maximum deceleration of motor during motion
003	Velocity	Maximum velocity of motor during motion
024	f1	Cutoff frequency of closed-loop filter 1
028	f2	Cutoff frequency of closed-loop filter 2
065	Common Gains	The larger the value is, the higher the servo rigidity is.
081	Numerator of electronic gear ratio	Numerator of electronic gear ratio (output)
082	Denominator of electronic gear ratio	Denominator of electronic gear ratio (input)
083	Velocity command scale (velocity mode)	Velocity command scale; the speed corresponds to 1 V, or the maximum speed corresponds to "Full PWM".
085	Current command scale (torque mode)	Current command scale; the output current corresponds to 1 V, or the maximum current corresponds to "Full PWM".
115	Smooth factor	The larger the value is, the smoother the motion is. (range: 1 - 500)
129	Pulse Format	0: Quadrature (AqB) 1: Pulse/Direction 2: Pulse up/Pulse down (CW/CCW)
130	Inverse pulse command	0: Not inverse 1: Inverse
212	Primary operation mode	0: Stand-alone mode 1: Position mode 2: Velocity mode 3: Torque mode
216	High speed/ low speed pulse input switch	0: High-speed pulse input (CN6 pin 44, 45, 46, 47) 1: Low-speed pulse input (CN6 pin 1, 3, 4, 2, 5, 6)
219	Positive/negative logic of CW/CCW pulse Switch	0: No inverse 1: Inverse
243	Invert of input point 3	0: No inverse 1: Inverse
280	Invert of CN2 brake output	0: No inverse 1: Inverse
340	Zero Tune Level	The higher the level is, the heavier the load is. There are 5 levels to select: LV1 - LV5.

Note:

For the parameter name of LCD No. and its input range, refer to table 7.5.3.1.

7.5.1 Save to Flash

Use following steps to save parameters in the drive's RAM to Flash ("SAVEFL").

- Step 1: Press the Enter key to enter the "SAVEFL" option (the dynamic cursor appears on the left side of the second line).
- Step 2: Press the Up key or Down key to select whether to save parameters in the drive's RAM to Flash ("YES"/"NO"). Select "YES" to continue.
- Step 3: When the servo is disabled, the "PROCESS." message will be displayed on the screen after pressing the Enter key. This indicates that parameters are being saved to Flash. The "FINISH!" message will be displayed after the "Save" procedure is completed. The operation flow chart is given in figure 7.5.1.1. When the servo is enabled, pressing the Enter key will also do the same steps described in figure 7.5.1.1, but the motor will be disabled.

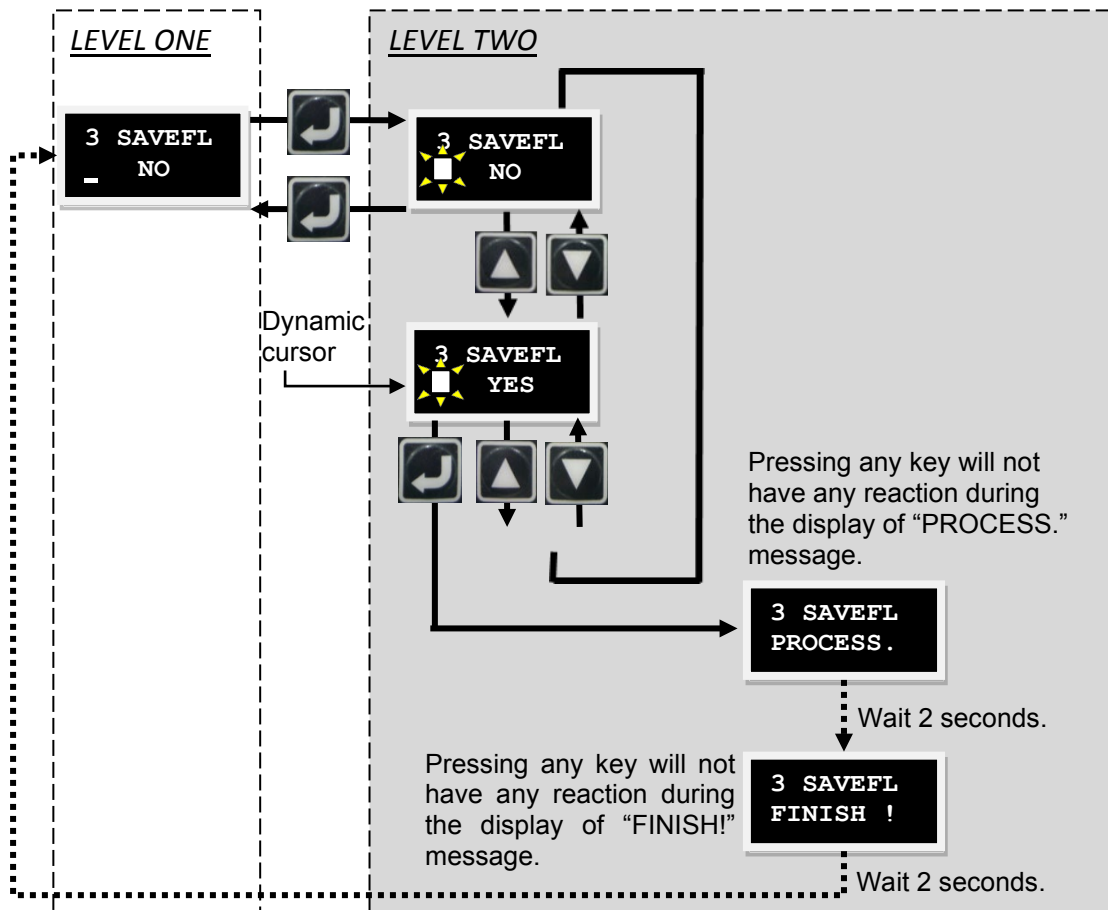


Figure 7.5.1.1 "Save to Flash" operation

7.5.2 Parameter edit function

LCD parameters are classified into two types: enumerated type and non-enumerated type. The parameter marked with “#” in table 7.5.3.1 is the enumerated-type parameter. For this type parameter, after pressing the Enter key, it changes to the edit mode. Press the UP key or Down key to select the desired parameter. The non-enumerated-type parameter requires users to enter the parameter value by themselves. In the edit mode of this type parameter, the UP key or Down key are used to move cursor or to change parameter value. To switch these functions, press the F key. Here, changing the value of common gain (CG, LCD No. 064) is taken as an operation example. For changing other parameter, refer to this operation. Assume that the CG value needs to be changed from 0.5 to 1.2. After entering the page of LCD No. 065, use following steps to change the parameter value. The operation flow chat is given in figure 7.5.2.1.

- Step 1: Press the Enter key to enter the edit mode of LCD No. 065 (the dynamic cursor appears on the left side of the second line).
- Step 2: Press the Down key once to move the flashing cursor to the “0” position.
- Step 3: Press the F key once (the function of Up key and Down key is switched to change parameter value).
- Step 4: Press the Up key twice and stop when the number turns to “1”. Refer to figure 7.5.2.2 for the number switching sequence.
- Step 5: Press the F key once (the function of Up key and Down key is switched to move cursor).
- Step 6: Press the Down key twice to move the flashing cursor to the “5” position.
- Step 7: Press the F key once (the function of Up key and Down key is switched to change parameter value.)
- Step 8: Press the Down key fourth times and stop when the number turns to “2”.
- Step 9: Press the Enter key to change CG to 1.2.

Note:

When using the LCD parameter edit mode, the notice of using F key is given as below:

- (1) Pressing the F key for less than one second switches the operation of Up key and Down key between moving cursor and changing parameter value.
- (2) Pressing and holding the F key for more than two seconds, the screen will return to LEVEL ONE and any change will be discarded.

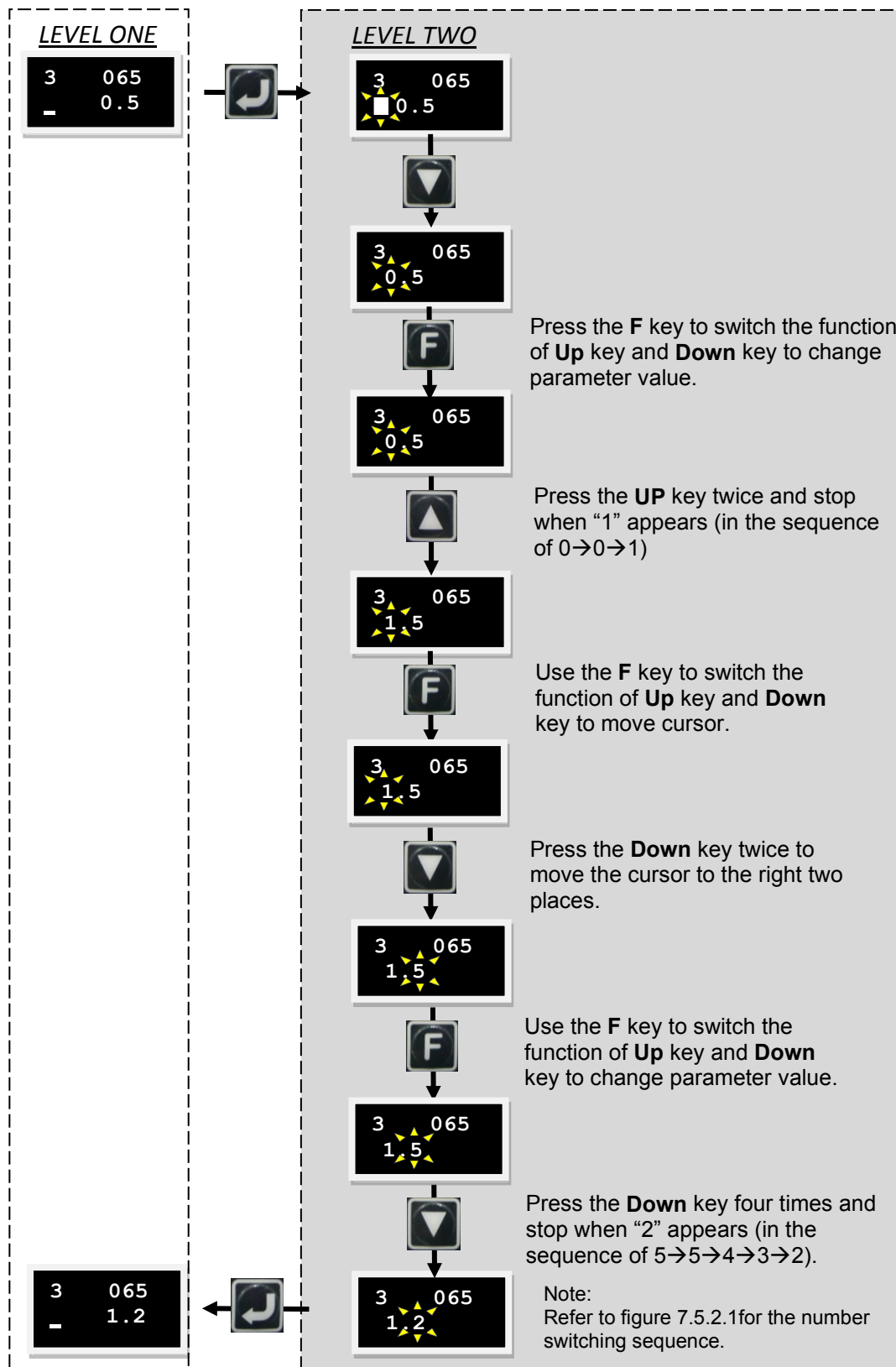


Figure7.5.2.1 Operation example of changing CG parameter (LCD No. 065)

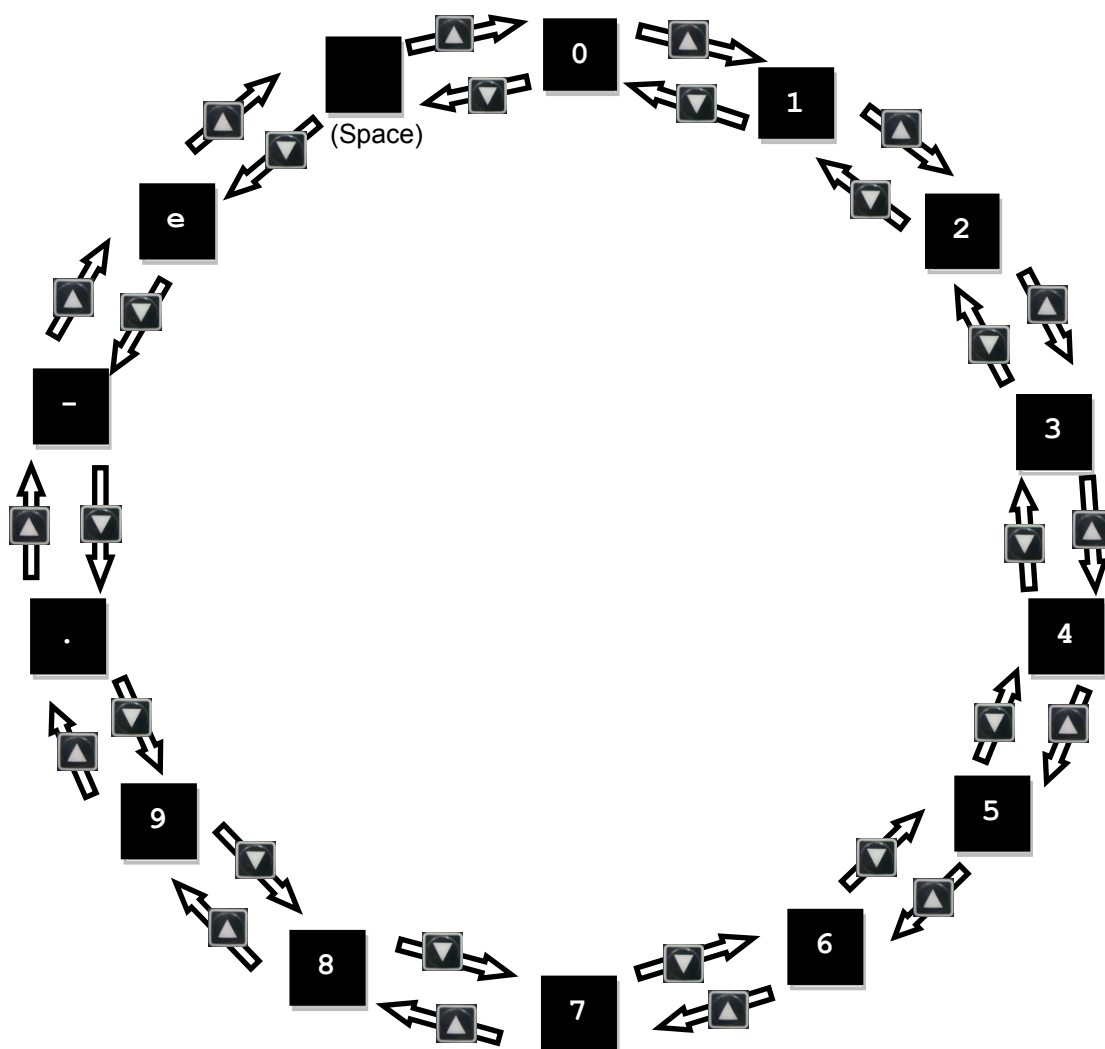


Figure7.5.2.2 Number switching sequence in the parameter edit mode

7.5.3 Advanced parameter zone

Use following steps to enter the advanced parameter zone.

- Step 1: Press the Down key to the “+++” page first, and then press the Enter key (the static cursor appears in the left side of the second line) to enter the advanced parameter zone. Advanced parameters are listed in table 7.5.3.1.
- Step 2: After entering the advanced parameter zone, the operation is the same as that described in Section 7.5.2.
- Step 3: After the parameter is edited, press the Enter key to complete the editing, return to the edited parameter, and display the edited parameter. To leave the advanced parameter zone, press and hold the F key for more than 2 seconds, as shown in figure 7.5.3.1.

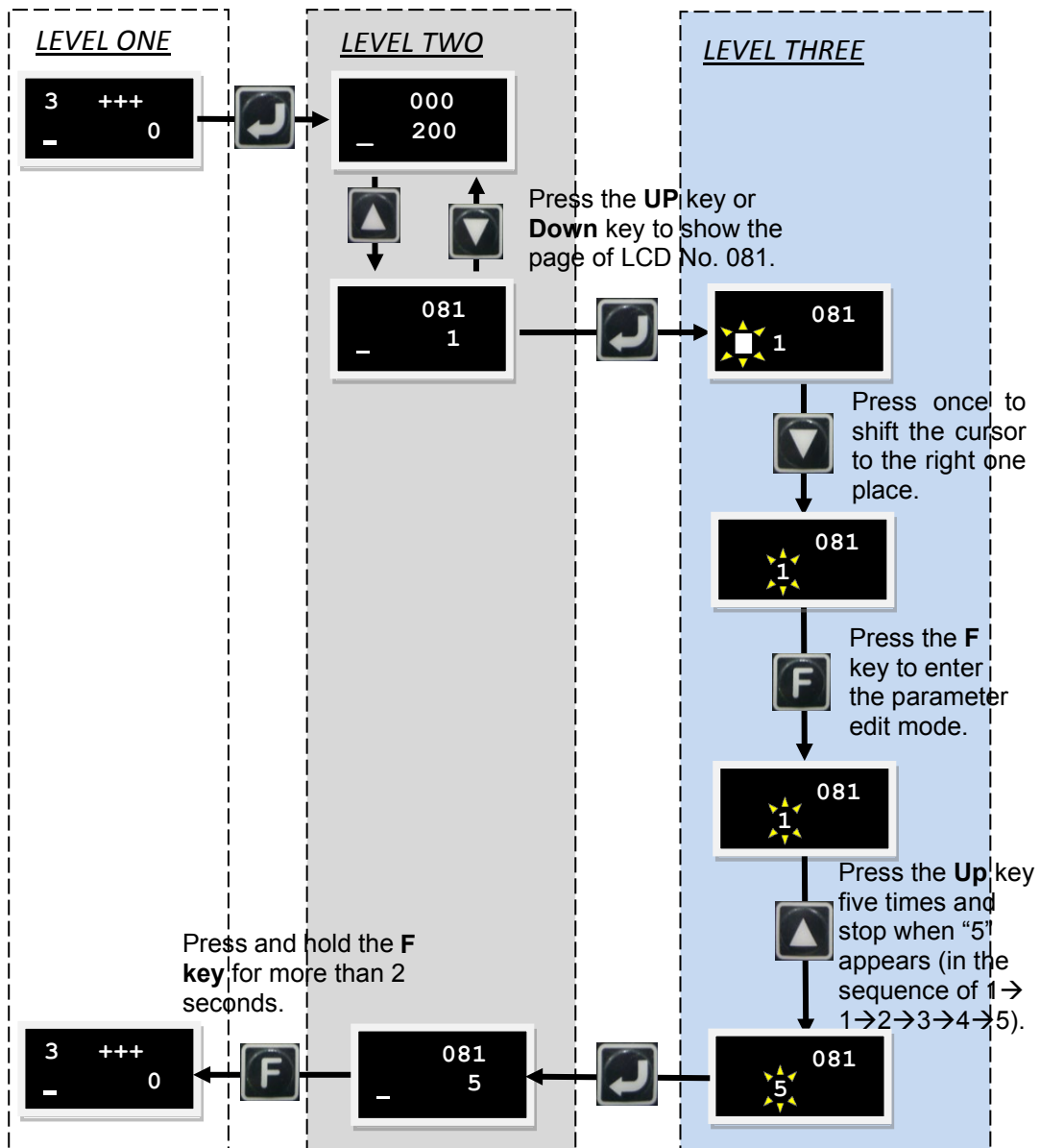


Figure 7.5.3.1 Operation example of advanced parameter zone

Table 7.5.3.1 Advanced parameter table (set parameter based on the actual application)

LCD No.	Parameter	Definition	Unit	Default	Max.	Min.
000	X_acc	Maximum acceleration of motor during motion (recommended value: ten times of motor's maximum velocity)	rev/s ²	Refer to Section 8.1	2 ³¹ - 1	1
001	X_dcc	Maximum deceleration of motor during motion (recommended value: ten times of motor's maximum velocity)	rev/s ²	Refer to Section 8.1	2 ³¹ - 1	1
002	X_dcc_kill	Deceleration of motor output during emergency stop (recommended: ten times of motor's maximum deceleration)	rev/s ²	Refer to Section 8.1	2 ³¹ - 1	1
003	X_vel_max	Maximum velocity of motor during motion (recommended value: do not exceed the rated motor speed)	rpm	Refer to motor catalog	2 ³¹ - 1	1
007	X_p2p_pos1	Position 1 for the point-to-point (P2P) motion	count	0	2 ³¹ - 1	-(2 ³¹ - 1)
008	X_p2p_pos2	Position 2 for the point-to-point (P2P) motion	count	0.05 rev	2 ³¹ - 1	-(2 ³¹ - 1)
024	X_f1_fr	Cutoff frequency of closed-loop filter 1	Hz	800	5,000	0
028	X_f2_fr	Cutoff frequency of closed-loop filter 2	Hz	0	5,000	0
032	X_Upi_kp	Proportional gain of current loop (D axis)	-	Refer to Section 6.6.5	100,000	1
033	X_Upi_ki	Integral gain of current loop (D axis)	-	Refer to Section 6.6.5	100,000	0
039	X_index_vel	Slower homing velocity ("Slower speed")	count/s	0.05 rev/s	2 ³¹ - 1	1
040	X_index_tout	Maximum search time of homing procedure	66.67 μs	25 sec	2 ³¹ - 1	1
050	X_max_err	Maximum position error	count	1 pole pair pitch	2 ³¹ - 1	1
059	X_vpg	Velocity proportional gain of close-loop control	-	0.001	1	10 ⁻⁶
064	X_affg	Acceleration feed-forward gain of close-loop control	-	0	1	0
065	X_CG	servo gain	-	0.3	10	0.01
066	X_sg_run	Schedule gain for the motion phase	-	1	10	0.01
067	X_sg_idle	Schedule gain for the in-position phase	-	1	10	0.01
074	X_tr_time	De-bounce time of in-position signal	66.67 μs	100 ms	2 ³¹ - 1	0
075	X_tr	Target radius of in-position signal	count	100	2 ³¹ - 1	0
079	X_gearRatyio	Gear ratio of AC servo motor	-	1	100	1
080	Vcmd_offs	Analog input bias correction	Volt	0	10	-10
081	X_cmd_ext_N	Numerator of electronic gear ratio (output)	-	1	2 ³¹ - 1	1
082	X_cmd_ext_M	Denominator of electronic gear ratio (input)	-	1	2 ³¹ - 1	1

LCD No.	Parameter	Definition	Unit	Default	Max.	Min.
083	X_cmd_ext_v_sc	Velocity command scale; the speed corresponds to 1 V, or the maximum speed corresponds to "Full PWM" (recommended value: rated speed/10)	rpm/V or rpm/Full PWM	60	3.4X10 ³⁸	-3.4X10 ³⁸
084	X_cmd_ext_v_dz	Dead band of velocity command. The speed command is 0 when the input voltage is less than the set value	Volt	0	10	0
085	X_cmd_ext_i_sc	Current command scale; the output current corresponds to 1 V, or the maximum current corresponds to "Full PWM"	A _{amp} /V or A _{amp} / Full PWM	Motor peak current/10	3.4X10 ³⁸	-3.4X10 ³⁸
086	X_cmd_ext_i_dz	Dead band of current command. The current command is 0 when the input voltage is less than the set value	Volt	0	10	0
088	X_pos_err_warn_win	Warning threshold for the position error	count	0.5 pole pair pitch	2 ³¹ - 1	1
089	X_vel_err_warn_win	Warning threshold for the velocity error	count/s	10 ⁸	3.4X10 ³⁸	1
092	X_vel_stop	Brake start speed	count/s	0.05 rev/s	3.4X10 ³⁸	1
093	X_delMaxEnToBrk	Delay time for starting brake	66.67 μs	500 ms	2 ³¹ - 1	1
094	X_delBrkToDis	Brake action time	66.67 μs	50 ms	2 ³¹ - 1	1
095	X_index_offs	Home offset	count	0	2 ³¹ - 1	0
115	X_new_sm_fac	Smooth factor	-	100	500	0
129#	X_pulse_mode	Pulse format 0: Quadrature (AqB) 1: Pulse/Direction 2: Pulse up/Pulse down (CW/CCW)	-	1: for 17 bit 0: for 13 bit	2	0
130#	X_pulse_dir	Invert pulse command 0: Not inverse 1: Inverse	-	0	1	0
131#	X_fall_rise	Trigger method of pulse command 0: Falling edge 1: Rising edge	-	0	1	0
132#	X_cmd_pwm_mode	Input command format for the velocity and torque modes 0: Analog 1: PWM 50% 2: PWM 100%	-	0	2	0
133	out_config[0]	CN2 BRK output signal setting	-	0	2 ¹⁵ - 1	0
134	out_config[1]		-	0	2 ¹⁵ - 1	0
135	out_config[2]		-	0	2 ¹⁵ - 1	0
136	out_config[3]		-	0	2 ¹⁵ - 1	0
137	out_config[4]	O1 output signal setting	-	0	2 ¹⁵ - 1	0
138	out_config[5]		-	2,048	2 ¹⁵ - 1	0
139	out_config[6]		-	0	2 ¹⁵ - 1	0
140	out_config[7]	O2 output signal setting	-	0	2 ¹⁵ - 1	0
141	out_config[8]		-	57,538	2 ¹⁵ - 1	0
142	out_config[9]		-	32,828	2 ¹⁵ - 1	0

LCD No.	Parameter	Definition	Unit	Default	Max.	Min.
143	out_config[10]	O3 output signal setting	-	34	$2^{15} - 1$	0
144	out_config[11]		-	1,683	$2^{15} - 1$	0
145	out_config[12]		-	8	$2^{15} - 1$	0
146	out_config[13]		-	0	$2^{15} - 1$	0
147	out_config[14]		-	0	$2^{15} - 1$	0
148	out_config[15]		-	0	$2^{15} - 1$	0
155#	X_sw_pos_prot_en	Enable/Disable the software limit 0: Disable the software limit 1: Enable the software limit	-	0	1	0
156#	X_hw_lim_prot_en	Enable/Disable the hardware limit 0: Disable the hardware limit 1: Enable the hardware limit	-	1	1	0
157	X_emu_N	Numerator of emulated encoder output	-	1	$2^{31} - 1$	1
158	X_emu_M	Denominator of emulated encoder output	-	1	$2^{31} - 1$	1
164	X_emu_i_radiu s	Index radius of emulated encoder	count	875: for 17 bit; 10: for 13 bit	$2^{31} - 1$	1
165	X_emu_i_jitter	Filter factor of emulated encoder	count	1	$2^{31} - 1$	0
172	X_vsf.fr	VSF frequency	Hz	0	200	0
173	X_vsf.xi	VSF damping factor	-	1	1.5	0.001
174#	X_vsf_en	Enable/disable VSF 0: Disable VSF 1: Enable VSF	-	0	1	0
175	X_cmd_ext_N2	Numerator of electronic gear ratio (second output)	-	1	$2^{31} - 1$	1
176	X_cmd_ext_N3	Numerator of electronic gear ratio (third output)	-	1	$2^{31} - 1$	1
177	X_cmd_ext_N4	Numerator of electronic gear ratio (fourth output)	-	1	$2^{31} - 1$	1
179	X_home_vel	Faster homing velocity ("Faster speed")	count/s	0.1 rev/s	$2^{31} - 1$	1
180#	X_home_option	Homing mode 0: Go left and right for homing 1: Use near home sensor/index for homing	-	1	1	0
181#	X_home_DIR	Start direction for homing 0: To left side 1: To right side	-	0	1	0
182#	X_home_opt0_i ndex	Searching index setting for the first homing mode 0: Home position at the middle of total travel 1: Home position at the index	-	0	1	0
183#	X_home_left_S W	Left side condition for homing 0: None 1: End stop 2: Limit switch	-	0	2	0
184#	X_home_right_ SW	Right side condition for homing 0: None 1: End stop 2: Limit switch	-	0	2	0

LCD No.	Parameter	Definition	Unit	Default	Max.	Min.
185	X_home_wall_CurrThrshld	Current threshold for searching end stop (Note: "curr_drv_peak" is the drive's peak current)	$(A_{amp} \times 1000) / (curr_drv_peak)$	0	$2^{31} - 1$	1
186	X_home_wall_CurrTime	Time limitation for searching end stop	msec	0	$2^{31} - 1$	1
187#	X_home_select_Speed	Initial speed setting for the second homing mode 0: Slower speed 1: Faster speed	-	0	1	0
188#	X_home_search_option	Searching home method for the second homing option 0: Index signal only 1: Near Home Sensor only 2: Near Home Sensor then change to lower speed, move left, search index 3: Near Home Sensor then change to lower speed, move right, search index	-	0	3	0
189	X_backlash	Backlash	count	0	$2^{31} - 1$	0
205	out_config[16]	O4 output signal setting	-	0	$2^{15} - 1$	0
206	out_config[17]		-	0	$2^{15} - 1$	0
207	out_config[18]		-	512	$2^{15} - 1$	0
208	out_config[19]		-	0	$2^{15} - 1$	0
209	X_Use_DynamicBrk	Dynamic brake (only for D frame model) 0: Not use dynamic brake 1: Use dynamic brake	-	0	1	0
212#	X_oper_mode1	Primary operation mode 0: Stand-Alone 1: Position mode 2: Velocity mode 3: Force/Torque mode	-	0	3	0
213#	X_oper_mode2	Secondary operation mode 0: Stand-Alone 1: Position mode 2: Velocity mode 3: Force/Torque mode	-	0	3	0
214	X_second_cg	Secondary CG	-	0.3	10	0.01
215	X_second_vpg	Secondary VPG	-	X_vpg	1	10^{-6}
216#	LCD.low_or_high	Switch between the high-speed and low-speed pulse inputs 0: High-speed pulse input 1: Low-speed pulse input	-	0	1	0
217#	LCD.buff_inv	Invert setting of buffered encoder output 0: Not inverse 1: Inverse	-	0	1	0
218#	LCD.emu_or_buff	Switch between the buffered and emulated encoder outputs 0: Buffered encoder output 1: Emulated encoder output	-	1: for 17 bit 0: for 13 bit	1	0

LCD No.	Parameter	Definition	Unit	Default	Max.	Min.
219#	LCD.cw_ccw_inv	Switch between the positive and negative logics for CW/CCW pulse command (CW_CCW_INV) 0: Not inverse 1: Inverse	-	0	1	0
241#	LCD.I1_inv	Invert of input 1	-	0	1	0
242#	LCD.I2_inv	Invert of input 2	-	0	1	0
243#	LCD.I3_inv	Invert of input 3	-	0	1	0
244#	LCD.I4_inv	Invert of input 4	-	0	1	0
245#	LCD.I5_inv	Invert of input 5	-	0	1	0
246#	LCD.I6_inv	Invert of input 6	-	0	1	0
247#	LCD.I7_inv	Invert of input 7	-	0	1	0
248#	LCD.I8_inv	Invert of input 8	-	0	1	0
249#	LCD.I9_inv	Invert of input 9	-	0	1	0
250#	LCD.I10_inv	Invert of input 10*	-	0	1	0
280#	LCD.brk_inv	Invert of CN2 BRK output	-	1	1	0
281#	LCD.O1_inv	Invert of output 1	-	0	1	0
282#	LCD.O2_inv	Invert of output 2	-	0	1	0
283#	LCD.O3_inv	Invert of output 3	-	0	1	0
284#	LCD.O4_inv	Invert of output 4	-	0	1	0
285#	LCD.O5_inv	Invert of output 5*	-	0	1	0
340#	X_ZT_loadLV	ZeroTune load level 0: Tuned (gains are modified by Auto tune or manually) 1 - 5: LV1 - LV5	-	3	5	0
341	out_config [20]	O5 output signal setting*	-	0	$2^{15} - 1$	0
342	out_config [21]		-	0	$2^{15} - 1$	0
343	out_config [22]		-	0	$2^{15} - 1$	0
344	out_config [23]		-	0	$2^{15} - 1$	0
345#	X_Use2ndEnc	Enable/Disable the dual-loop control 0: Disable the dual-loop control 1: Enable the dual-loop control	-	0	1	0
346	X_cntperunit2	Linear encoder resolution of dual-loop control	count	0	$2^{31} - 1$	0
347#	X_2ndEnc_sgn	Linear encoder direction of dual-loop control -1: Inverse 1: Not inverse	-	-1	1	-1
348	X_hybdev_threshold	Maximum tolerance of deviation input for the hybrid control	count	16,000	2^{27}	1
349#	X_VOF.FB_Switch	Switch between the enable and disable the velocity observer 0: Disable the velocity observer 1: Enable the velocity observer	-	1	1	0
353#	X_latch_err_tdrv	Latch the error message of "over temperature" 0: Disable 1: Enable	-	1	1	0

LCD No.	Parameter	Definition	Unit	Default	Max.	Min.
354#	X_latch_err_un derv	Latch the error message of "under voltage" 0: Disable 1: Enable	-	0	1	0
355#	X_mult_emu_in d	Emulated index output in every revolution 0: Disable 1: Enable	-	0	1	0
357#	AT.mode	Mode setting for the second generation of Auto tune 1: Standard 0: Advanced	-	1	2	1
358#	AT.stiff	Stiffness setting for the second generation of Auto tune 1: Soft 2: Normal 3: Rigid	-	2	3	1
359#	X_Mbus_Baud RateIndex	Baud rate for the Modbus communication 0: 9,600 (default) 1: 2,400 2: 4,800 3: 9,600 4: 14,400 5: 19,200 6: 38,400	bps	0	6	0
360	X_Mbus_Slave _Addr	Drive station number (for Modbus)	-	0	247	0
361#	X_Mbus_SetPa rity	Check setting for the Modbus parity 0: 8 data, Even parity, 1 stop bit 1: 8 data, Odd parity, 1 stop bit 2: 8 data, None parity, 2 stop bit 3: 8 data, Even parity, 1 stop bit 4: 7 data, Odd parity, 1 stop bit 5: 7 data, None parity, 2 stop bit 6: 7 data, Even parity, 1 stop bit	-	0	6	0
362	X_Mbus_T15	Maximum time interval for the Modbus RTU character	ms	3	$2^{31}-1$	1
363	X_Mbus_T35	Minimum time interval for the Modbus RTU frame	ms	4	$2^{31}-1$	1
364	X_TMO_Scale	Output scale of analog output 1	%	100	300	1
365	X_TMO_Offs	Output offset of analog output 1	mv	0	10,000	-10,000
366	X_VMO_Scale	Output scale of analog output 2	%	100	300	1
367	X_VMO_Offs	Output offset of analog output 2	mv	0	10,000	-10,000
368	UserPDL.X_fVa r[0]	PDL parameter which can be saved in Flash	-	0	3.4×10^{38}	-3.4×10^{38}
369	UserPDL.X_fVa r[1]	PDL parameter which can be saved in Flash	-	0	3.4×10^{38}	-3.4×10^{38}
370	UserPDL.X_fVa r[2]	PDL parameter which can be saved in Flash	-	0	3.4×10^{38}	-3.4×10^{38}
371	UserPDL.X_fVa r[3]	PDL parameter which can be saved in Flash	-	0	3.4×10^{38}	-3.4×10^{38}
372	UserPDL.X_fVa r[4]	PDL parameter which can be saved in Flash	-	0	3.4×10^{38}	-3.4×10^{38}
373	UserPDL.X_iVa r [0]	PDL parameter which can be saved in Flash	-	0	$2^{31}-1$	$-(2^{31} - 1)$

LCD No.	Parameter	Definition	Unit	Default	Max.	Min.
374	UserPDL.X_iVar [1]	PDL parameter which can be saved in Flash	-	0	$2^{31}-1$	$-(2^{31}-1)$
375	UserPDL.X_iVar [2]	PDL parameter which can be saved in Flash	-	0	$2^{31}-1$	$-(2^{31}-1)$
376	UserPDL.X_iVar [3]	PDL parameter which can be saved in Flash	-	0	$2^{31}-1$	$-(2^{31}-1)$
377	UserPDL.X_iVar [4]	PDL parameter which can be saved in Flash	-	0	$2^{31}-1$	$-(2^{31}-1)$
378	UserPDL.X_iVar [5]	PDL parameter which can be saved in Flash	-	0	$2^{31}-1$	$-(2^{31}-1)$
379	UserPDL.X_iVar [6]	PDL parameter which can be saved in Flash	-	0	$2^{31}-1$	$-(2^{31}-1)$
380	UserPDL.X_iVar [7]	PDL parameter which can be saved in Flash	-	0	$2^{31}-1$	$-(2^{31}-1)$
381	UserPDL.X_iVar [8]	PDL parameter which can be saved in Flash	-	0	$2^{31}-1$	$-(2^{31}-1)$
382	UserPDL.X_iVar [9]	PDL parameter which can be saved in Flash	-	0	$2^{31}-1$	$-(2^{31}-1)$
383	UserPDL.X_iVar [10]	PDL parameter which can be saved in Flash	-	0	$2^{31}-1$	$-(2^{31}-1)$
384	UserPDL.X_iVar [11]	PDL parameter which can be saved in Flash	-	0	$2^{31}-1$	$-(2^{31}-1)$
385	UserPDL.X_iVar [12]	PDL parameter which can be saved in Flash	-	0	$2^{31}-1$	$-(2^{31}-1)$
386	UserPDL.X_iVar [13]	PDL parameter which can be saved in Flash	-	0	$2^{31}-1$	$-(2^{31}-1)$
387	UserPDL.X_iVar [14]	PDL parameter which can be saved in Flash	-	0	$2^{31}-1$	$-(2^{31}-1)$

Note:

- (1) * Only D2T model supports functions of I10 and O5.
- (2) # It is the enumerated-type parameter. After pressing the Enter key to enter the edit mode, press the Up key or Down key to select the parameter value.

7.6 Actions page

This page allows users to perform functions of enabling or disabling motor, jogging, moving to absolute position, and setting the current position to zero. Besides, it can set the motion velocity and target position. Press the Up key or Down key to select the required function. The operation flow chart of actions page is given in figure 7.6.1 or figure 7.6.2. The detailed operation procedure is described in the next subsection (take the LCD abbreviated display symbol as an example).

Note:

The “MOTRSE” function will redo the procedure of initializing motor, referring to Section 7.2.

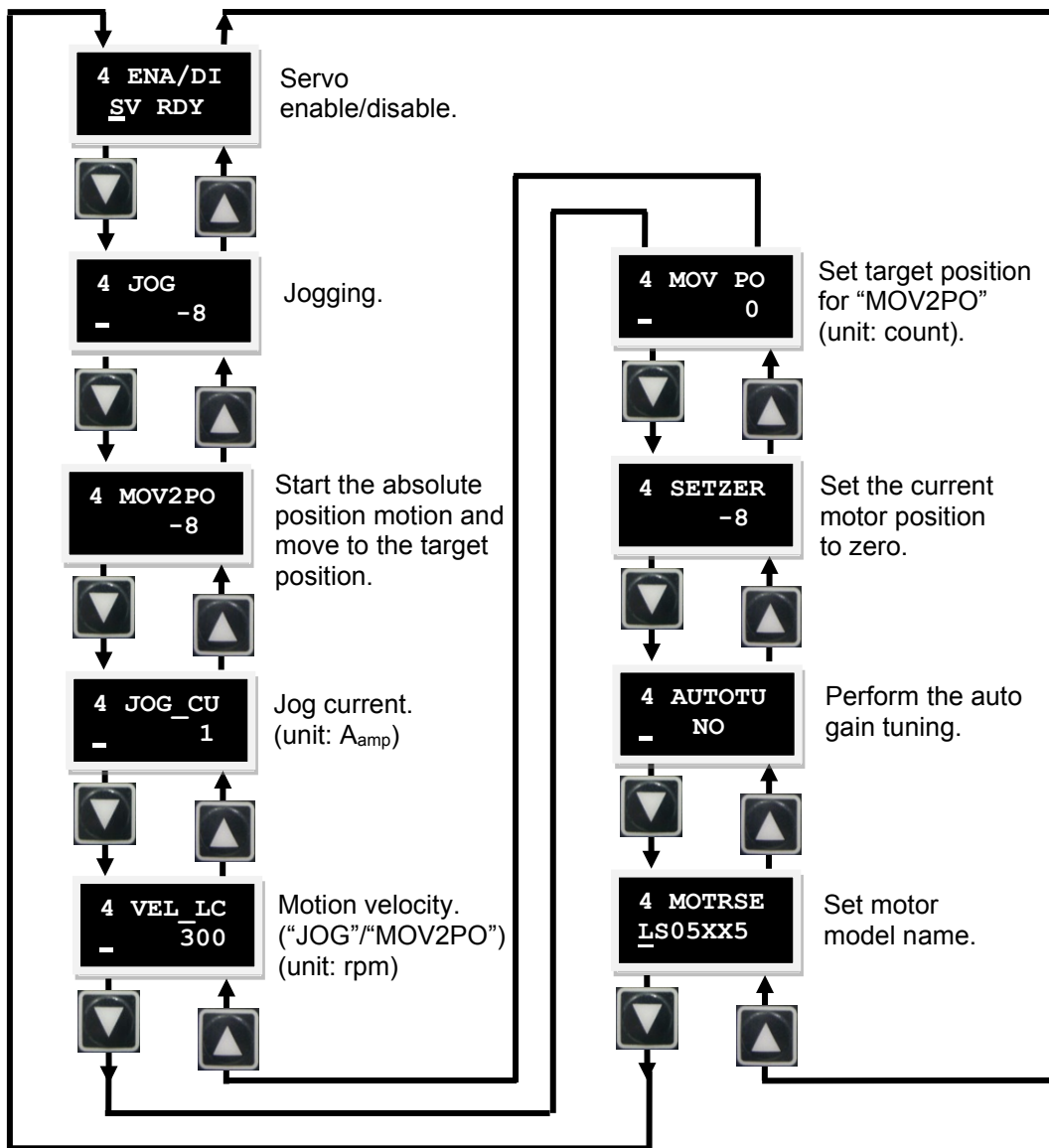


Figure 7.6.1 Operation flow chart of actions page (LCD abbreviated display symbol)

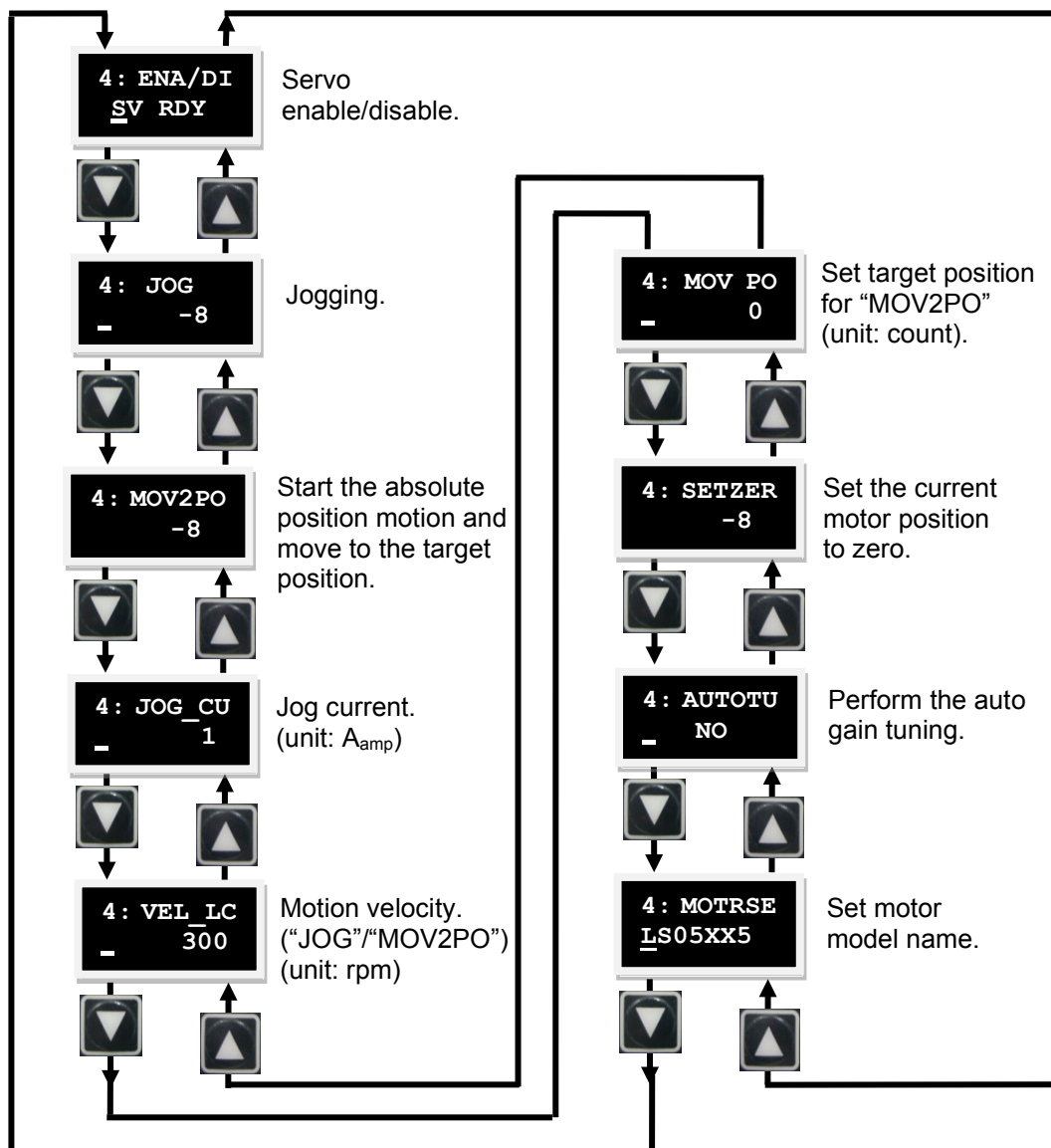


Figure 7.6.2 Operation flow chart of actions page (LCD numbered display symbol)

7.6.1 Enable/Disable

Before using this function to enable/disable the servo motor, ensure that the external enable signal is sent to the drive, or LCD No. 243 (inverse of I3) is set to 1. The default configuration for I3 is the input of “Axis Enable” signal. Use following steps to set the enable or disable. The operation flow chart is given in figure 7.6.1.1.

- Step 1: Press the Enter key to enter the “ENA/DI” option (the dynamic cursor appears on the left side of the second line).
- Step 2: Press the Up key or Down key to select “ENABLE” or “DISABLE”.
- Step 3: After selecting, press the Enter key to complete the setting.

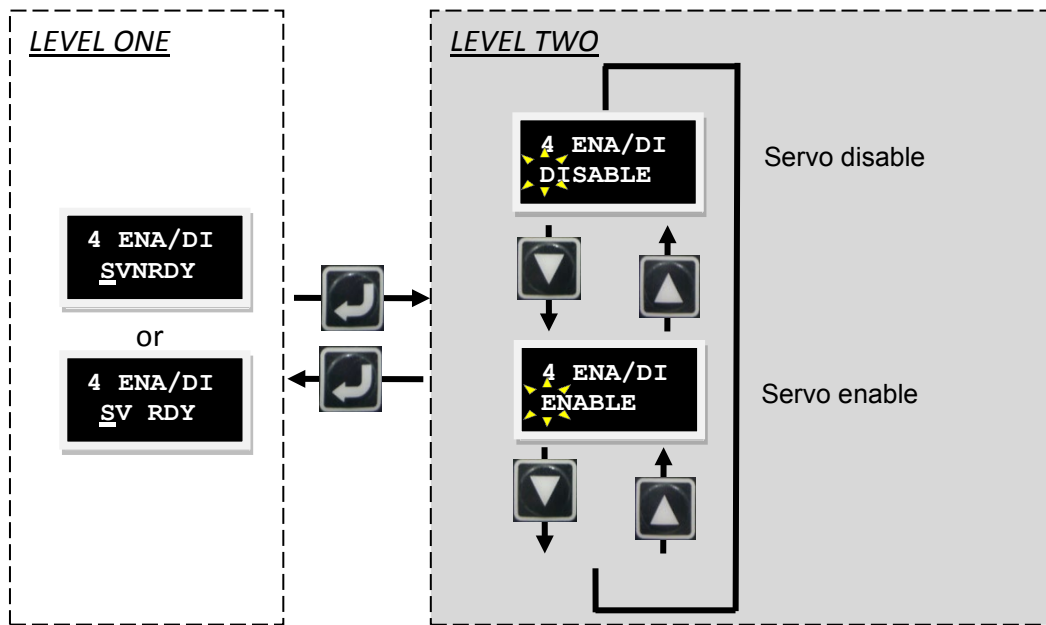


Figure7.6.1.1 Operation of servo enable/disable

7.6.2 JOG

Use following steps to perform the continuous motion (“JOG”). The operation flow chart is given in figure 7.6.2.1.

- Step 1: Press the Enter key to enter the “JOG” option (the dynamic cursor appears on the left side of the second line).
- Step 2: Press the Up key or Down key to let the motor rotate in the forward or reversal direction. The feedback position will be shown in the LCD display when the motor is in motion. The motor stops the movement immediately when the key is released.

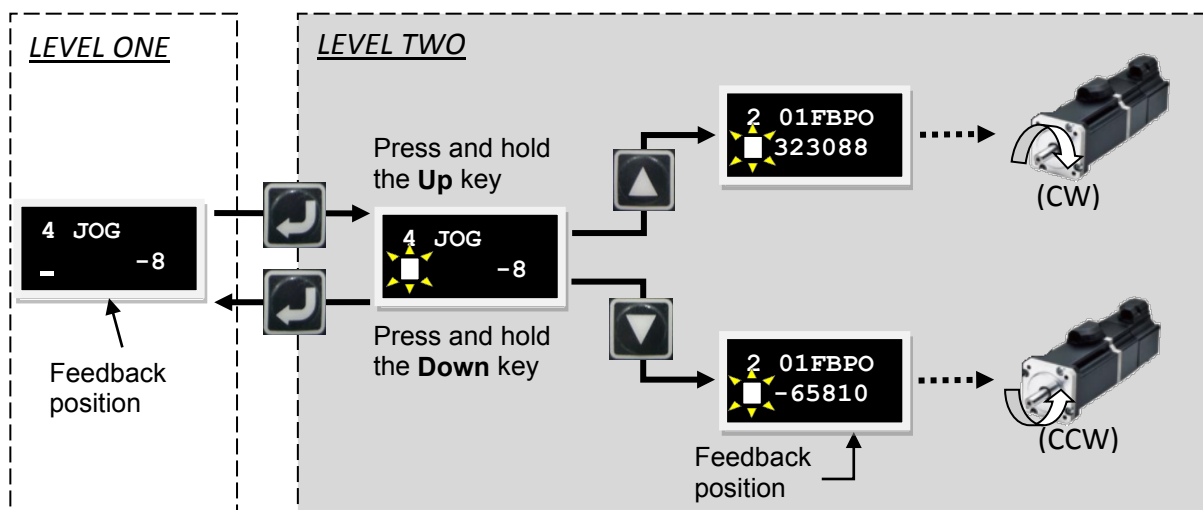


Figure7.6.2.1 Operation of continuous motion (“JOG”)

Note:

In the force/torque mode, the “JOG” speed for LCD operation is based on the “Speed” set in the motion protection, but not based on “VEL_LC” set in the LCD actions page.

7.6.3 Absolute coordinate motion

Use following steps to perform the action of moving to absolute target position. The operation flow chart is given in figure 7.6.3.1. Take the absolute coordinate of target position being 2,000 as an example.

- Step 1: Press the Up key or Down key to enter the “MOV PO” option for setting target position. Refer to Section 7.5.2 for the editing method. In this example, the target position will be set to 2,000.
- Step 2: Move to the “MOV2PO” option and press the Enter key (the dynamic cursor appears on the left side of the second line). The current position is displayed, but the motor does not yet start moving.
- Step 3: Press the Up key to start moving. The motor moves to the target position set in “MOV2PO” with the speed set in “VEL_LC”. The feedback position (“01FB PO”) is displayed on the second line of LCD screen during motion. To stop the movement during motion, just press the Enter key. To continue the motion, just press the Up key to continue moving to the original set target position.
- Step 4: Press the Enter key to return to LEVEL ONE.

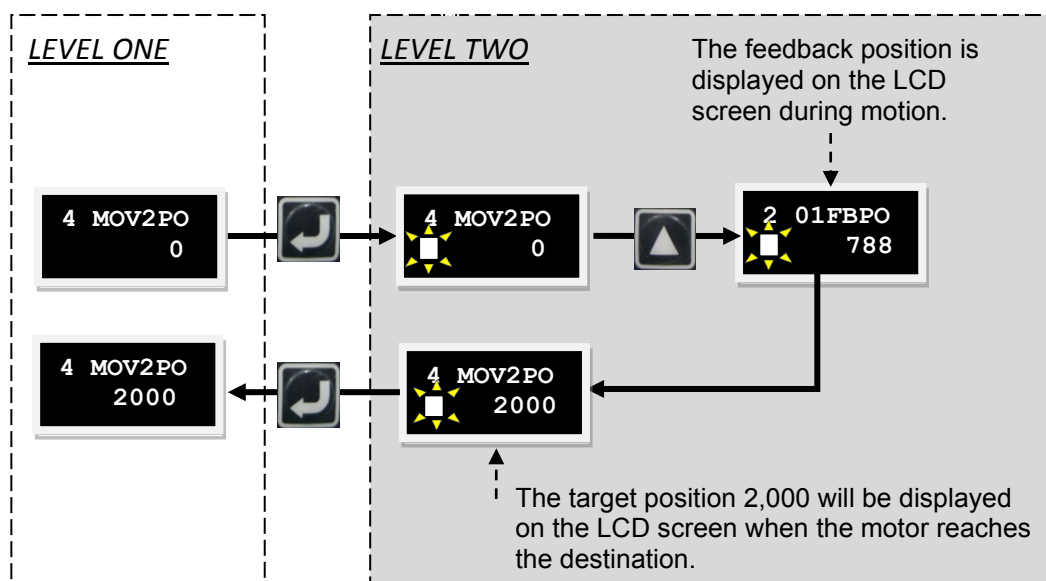


Figure7.6.3.1 Operation of absolute coordinate motion (“MOV2PO”)

7.6.4 Auto tune

For Lightening 0.183 and D2 MDP 0.036 (inclusive) or below, or D2COE MDP 0.112 (inclusive) or below, the auto gain tuning adopts the first-generation auto tune design. For Lightening 0.184 and D2 MDP 0.037 (inclusive) or above, or D2COE MDP 0.113 (inclusive) or above, the auto gain tuning adopts the second-generation auto tune design described in Section 5.4. Use following steps to perform the auto gain tuning (“AUTOTU”). The operation flow chart is given in figure 7.6.4.1.

- Step 1: Press the Enter key to enter the “AUTOTU” option (the dynamic cursor appears on the left side of the second line).
- Step 2: Press the Up key or Down key to select whether to execute the auto gain tuning.
- Step 3: The drive will execute the auto gain tuning when “AUTOTU YES” is selected and the Enter key is pressed. Otherwise, the drive does not execute the auto gain tuning when “AUTOTU NO” is selected.

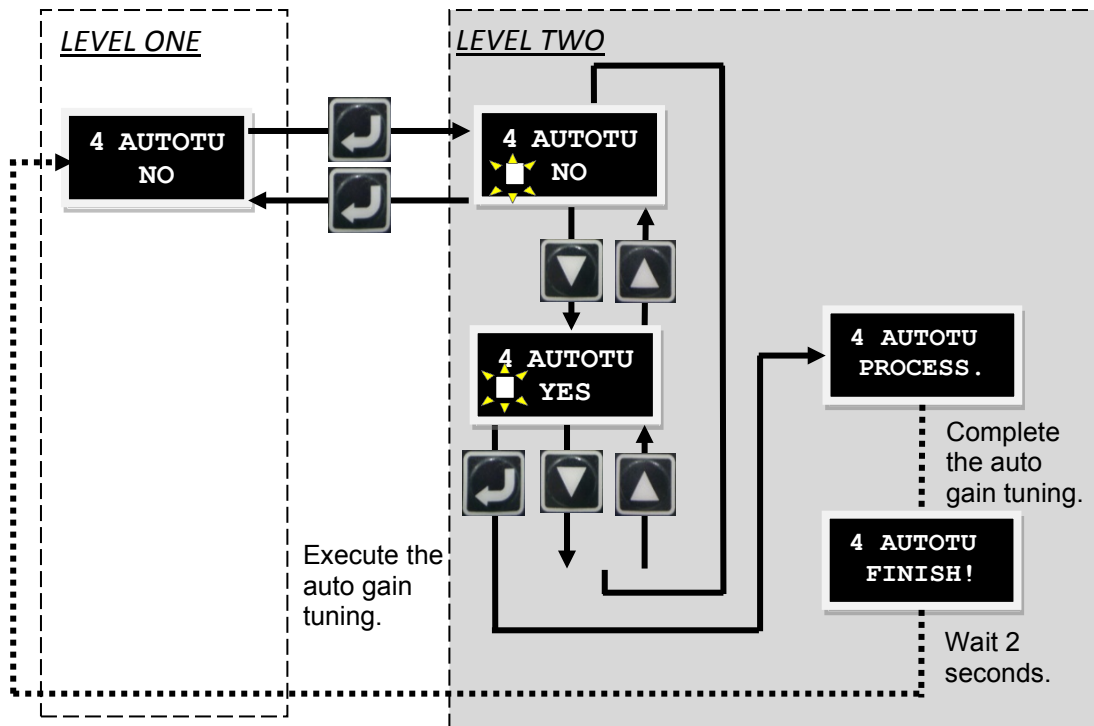


Figure7.6.4.1 Operation of executing the auto gain tuning

7.6.5 Set position to zero

Use following steps to set the current position to zero. The operation flow chart is given in figure 7.6.5.1.

Step 1: Press the Up key or Down key to go to the “SETZER” option.

Step 2: Press the Enter key to set the current position to zero.

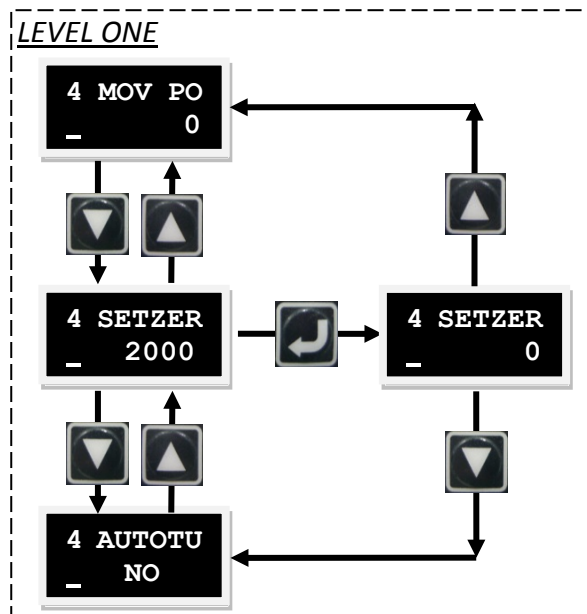


Figure7.6.5.1 Operation of setting current to zero (“SETZER”)

7.7 Parameter setting examples via LCD









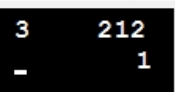

7.7.1 Position mode

In the position mode, the drive will move the corresponding distance when it receives the pulse command, referring to Section 3.1.1. The position mode configuration includes: the mode selection, pulse format selection, electronic gear ratio setting, and smooth factor setting. After all parameters are set, refer to Section 7.5.1 to save parameters to flash.

(1) Mode selection

Use following steps to select the position mode via LCD.

Table7.7.1.1

Step	LCD Display After Operation	Used Keys	Operation
1			Press the F key to change the LCD screen to the parameter change page.
2			Press and hold the Down key to go to LCD No. 212 page (refer to note 1), i.e. the setting page of operation mode.
3			Press the Enter key to enter the edit mode.
4			Press the Up key once to set this parameter to 1, i.e. the position mode.
5			Press the Enter key to complete the setting.

Note:

The operation mode can be set via the following parameter.

Table7.7.1.2

LCD No.	Parameter	Definition	Initial value
212	X_oper_mode1	Primary operation mode 0: Stand-Alone 1: Position mode 2: Velocity mode 3: Force/Torque mode	0

(2) Pulse format selection

D2 drive supports three types of command format, referring to Section 3.1.1.

Use following steps to select the pulse format via LCD.

Table7.7.1.3

Step	LCD Display After Operation	Used keys	Operation
1			Continue the last setting screen of operation mode.
2			Press the Down key twice to go to LCD No. 129 page (refer to note 2), i.e. the setting page of pulse format.
3			Press the Enter key to enter the edit mode.
4			Press the Up key or Down key to select the required input pulse format. (Note. This example is to select the pulse format of "Pulse up/Pulse down (CW/CCW)".)
5			Press the Enter key to complete the pulse format setting.

To set "invert pulse command" (LCD No. 130) or "switch positive/negative logic" (LCD No. 219), the setting procedure is the same as that for "pulse format" (LCD No. 129).

Note:

The pulse format can be set via following parameters.

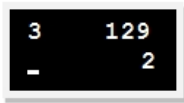



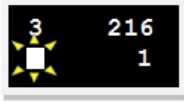

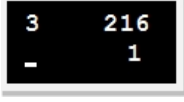

Table7.7.1.4

LCD No.	Parameter	Definition	Initial value
129	X_pulse_mode	Pulse format 0 : Quadrature (AqB) 1 : Pulse/Direction 2 : Pulse up/Pulse down (CW/CCW)	0
130	X_pulse_dir	Invert pulse command 0: Not inverse 1: Inverse	0
219	LCD.cw_ccw_inv	Switch between the positive and negative logic for CW/CCW pulse command 0: Not inverse 1: Inverse	0

(3) High/Low speed pulse channel setting

D2 drive provides the high-speed and low-speed pulse inputs for flexible use. Use following steps to set the high-speed or low-speed pulse input via LCD.

Table7.7.1.5

Step	LCD Display After Operation	Used Keys	Operation
1			Continue the last setting screen of pulse format.
2			Press and hold the Up key to go to LCD No. 216 page (refer to note 3), i.e. the setting page of switching between the high-speed and low-speed pulse channels.
3			Press the Enter key first, and press the Up key once to set this parameter to 1. (Note. This example is the high-speed pulse channel.)
4			Press the Enter key to complete the setting.

Note:

The high/low speed pulse channel can be set via the following parameter.

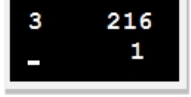

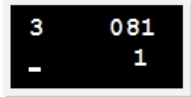



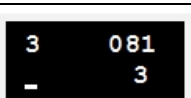

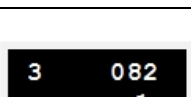

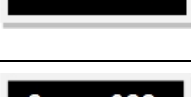



Table7.7.1.6

LCD No.	Parameter	Definition	Initial Value
216	LCD.low_or_high	Switch between the high-speed and low-speed pulse inputs 0: High-speed pulse input 1: Low-speed pulse input	0

(4) Electronic gear ratio setting

D2 drive provides four sets of electronic gear ratio, referring to Section 5.5.1. Use following steps to set the electronic gear ratio via LCD.

Table 7.7.1.7

Step	LCD Display After Operation	Used Keys	Operation
1			Continue the last setting screen of "HI/LO speed pulse channel".
2			Press and hold the Down key to go to LCD No. 081 page (refer to note 4), i.e. the setting page of the numerator of electronic gear ratio (output).
3			Press the Enter key first and change the parameter from 1 to 3. (Note. This example sets the electronic gear ratio to 2:3.)
4			Press the Enter key to complete the setting of the numerator of electronic gear ratio.
5			Press the Up key once to go to LCD No. 082 page (refer to note 4), i.e. the setting page of the denominator of electronic gear ratio (input).
6			Press the Enter key first and set the parameter from 1 to 2.
7			Press the Enter key to complete the setting of the denominator of electronic gear ratio.

Note:

The electronic gear ratio can be set via following parameters.

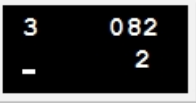

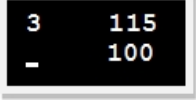

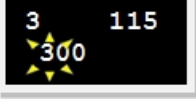

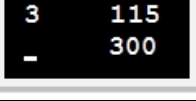

Table 7.7.1.8

LCD No.	Parameter	Definition	Initial Value
081	Xcmd_ext_N	Numerator of electronic gear ratio (output)	1
175	X_cmd_ext_N2	Numerator of electronic gear ratio (second output)	1
176	X_cmd_ext_N3	Numerator of electronic gear ratio (third output)	1
177	X_cmd_ext_N4	Numerator of electronic gear ratio (fourth output)	1
082	Xcmd_ext_M	Denominator of electronic gear ratio (input)	1

(5) Smooth factor setting

D2 drive provides the function of “Smooth factor”, referring to Section 3.4. Use following steps to set the smooth factor via LCD.

Table 7.7.1.9

Step	LCD Display After Operation	Used Keys	Operation
1			Continue the last setting screen of electronic gear ratio.
2			Press and hold the Down key to go to LCD No. 115 page (refer to note 5), i.e. the setting page of smooth factor.
3			Press the Enter key first and set this parameter to the required value.
4			Press the Enter key to complete the smooth factor setting.

Note:

The smooth factor can be set via the following parameter.

Table 7.7.1.10

LCD No.	Parameter	Definition	Initial value
115	X_new_sm_fac	Smooth factor	100









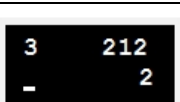

7.7.2 Velocity mode

D2 drive can transfer the voltage command and PWM command to the velocity command, referring to Section 3.1.2. The velocity mode configuration includes: the mode selection and input command format setting. After all parameters are set, refer to Section 7.5.1 to save parameters to flash.

(1) Mode selection

Use following steps to select the velocity mode via LCD.

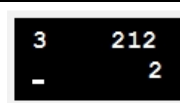

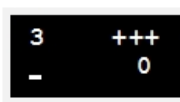

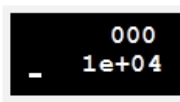

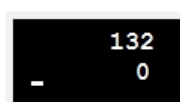



Table7.7.2.1

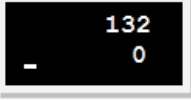

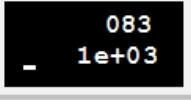



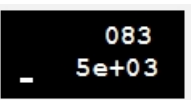

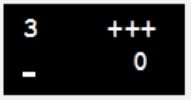

Step	LCD Display After Operation	Used Keys	Operation
1			Press the F key to change the LCD screen to the parameter change page.
2			Press and hold the Down key to go to LCD No. 212 page, i.e. the setting page for operation mode.
3			Press the Enter key to enter the edit mode.
4			Press the Up key twice to set this parameter to 2, i.e. the velocity mode.
5			Press the Enter key to complete the setting.

(2) Input command format setting

Use following steps to set the input command format via LCD.

Table7.7.2.2

Step	LCD Display After Operation	Used Keys	Operation
1			Continue the last setting screen of operation mode.
2			Press and hold the Down key to go to the “+++” page.
3			Press the Enter key to enter the advanced parameter zone.
4			Press and hold the Up key to go to LCD No. 132 page (refer to note 1), i.e. the setting page of input command format for the velocity and torque modes.
5			Press the Up key or Down key to set this parameter to the required value. (Note. This example is the analog command input.)

Step	LCD Display After Operation	Used Keys	Operation
6			Press the Enter key to complete the “input command format” setting.
7			Press and hold the Down key to go to LCD No. 083 page (refer to note 1), i.e. the setting page of velocity command scale.
8			Press the Enter key first and set this parameter to the required value. (To invert the voltage or PWM command, simply add a minus sign to “velocity command scale”.)
9			Press the Enter key to complete the “velocity command scale” setting.
10			Press and hold the F key to go back to the “+++” page, i.e. the common parameter zone.

To set the dead band for velocity command (LCD No. 084), the setting procedure is the same as that for setting velocity command scale (LCD No. 083).

Note:

The input command format can be set via following parameters.

Table7.7.2.3

LCD No.	Parameter	Definition	Initial value
132	X_cmd_pwm_mode	Input command format for the velocity and torque modes 0: Analog 1: PWM 50% 2: PWM 100%	0
083	X_cmd_ext_v_sc	Velocity command scale; the speed corresponds to 1V, or the maximum speed corresponds to Full PWM. (unit: rpm = 1 V or rpm = Full PWM)	60
084	X_cmd_ext_v_dz	Dead band of velocity command. The speed command is 0 when the input voltage is less than the set value. (unit: volt)	0

7.7.3 Force/torque mode

D2 drive can transfer the voltage command and PWM command to the current command, referring to Section 3.1.2. The force/torque mode configuration includes: the mode selection and input command format setting. After all parameters are set, refer to Section 7.5.1 to save parameters to flash.

(1) Mode selection

Use following steps to select the force/torque mode via LCD.

Table7.7.3.1

Step	LCD Display After Operation	Used Keys	Operation
1			Press the F key to change the LCD screen to the parameter change page.
2			Press and hold the Down key to go to LCD No. 212 page, i.e. the setting page of operation mode.
3			Press the Enter key to enter the edit mode.
4			Press the Up key three times to set this parameter to 3, i.e. the force/torque mode.
5			Press the Enter key to complete the setting.

(2) Input command format setting

Use following steps to set the input command format via LCD.

Table7.7.3.2

Step	LCD Display After Operation	Used Keys	Operation
1			Continue the last setting screen of operation mode.
2			Press and hold the Down key to go to the “+++” page.

3			Press the Enter key to enter the advanced parameter zone.
4			Press and hold the Up key to go to LCD No. 132 page (refer to note 1), i.e. the setting page of input command format for the velocity and torque modes.
5			Press the Up key or Down key to set this parameter to the required value. (Note. This example is the analog command input.)
6			Press the Enter key to complete the "input command format" setting.
7			Press and hold the Down key to go to LCD No. 085 page (refer to note 1), i.e. the setting page of current command scale.
8			Press the Enter key first and set this parameter to the required value. (To invert the voltage or PWM command, simply add a minus sign to "current command scale".)
9			Press the Enter key to complete the "current command scale" setting.
10			Press and hold the F key to go back to the "+++" page, i.e. the common parameter zone.

To set the dead band for current command (LCD No. 086), the setting procedure is the same as that for setting current command scale (LCD No. 085).

Note:

The input command format can be set via following parameters.

Table7.7.3.3

LCD No.	Parameter	Definition	Initial value
132	X_cmd_pwm_mode	Input command format for the velocity and torque modes 0: Analog 1: PWM 50% 2: PWM 100%	0
085	X_cmd_ext_i_sc	Current command scale; the output current corresponds to 1 V, or the maximum current corresponds to Full PWM. (unit: $A_{amp} = 1 V$ or $A_{amp} = Full PWM$)	Motor peak current/10
086	X_cmd_ext_i_dz	Dead band of current command. The current command is 0 when the input voltage is less than the set value. (unit: volt)	0

7.7.4 Stand-alone mode

In the stand-alone mode, the drive will execute the internal path planning to drive the motor, referring to Section 3.1.4. The stand-alone mode configuration includes the mode selection. After all parameters are set, refer to Section 7.5.1 to save parameters to flash.

(1) Mode selection

Use following steps to select the stand-alone mode via LCD.

Table7.7.4.1

Step	LCD Display After Operation	Used Keys	Operation
1			Press the F key to change the LCD screen to the parameter change page.
2			Press and hold the Down key to go to LCD No. 212 page, i.e. the setting page of operation mode. (Note. This example is to change it from the position mode to the stand-alone mode.)
3			Press the Enter key to enter the edit mode.
4			Press the Down key once to set this parameter to 1, i.e. the stand-alone mode.
5			Press the Enter key to complete the setting.

(This page is intentionally left blank.)

8. Protection function

8. Protection function	8-1
8.1 Motion protection	8-2
8.2 Position and velocity errors protection	8-5
8.2.1 Position error limit	8-5
8.2.2 Position error and velocity error warnings	8-6
8.3 Brake output	8-6
8.4 Limit protection	8-10
8.4.1 Hardware limit protection	8-10
8.4.2 Software limit protection	8-11
8.5 Over temperature protection	8-12
8.5.1 Soft-thermal protection	8-12
8.5.2 Drive over temperature protection	8-12
8.6 Over voltage protection	8-12

8.1 Motion protection

The main function of motion protection is to limit or specify the maximum speed, maximum acceleration, maximum deceleration, emergency stop deceleration of motor output during motor movement. When the speed and acceleration corresponding to the pulse command or voltage command sent from the host controller are too high, the protection function is activated and the motion characteristic is limited to the set value. The drive has various protection functions for different operation modes. The following is applicable parameters for each operation mode.



Table8.1.1

Limit parameter Operation mode	Velocity	Acceleration	Deceleration	Emergency Stop Deceleration
Position mode	O	O	O	O
Velocity mode	O	O	O	O
Force/Torque mode	O	X	X	X
Stand-Alone mode	O	O	O	O

Note:

“O” means it is active, and “X” means it is inactive.

■ Speed, acceleration, and deceleration limitations

Click  to enter the performance center to display the configuration page for the motion protection, as shown in the following figure. In addition, clicking  can enter the protection center to observe the same setting of motion protection in the “Motion Protection” area on the “Protection” tab. However, this area can only be displayed, but not be modified.

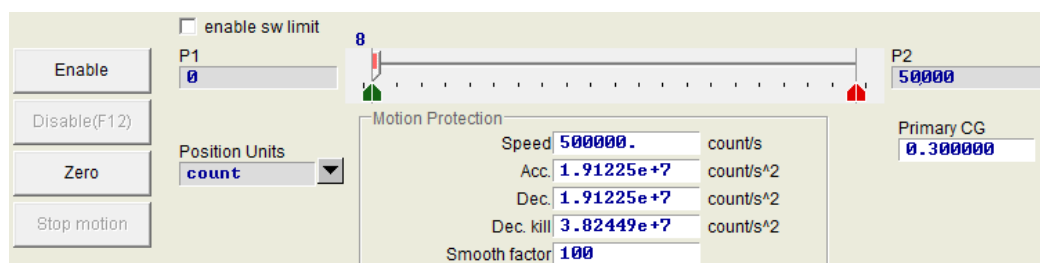


Figure8.1.1

Table8.1.2

Parameter Name	Description	Default Value
Speed	Set the maximum velocity of motor during motion	AC servo motor: 3,000 rpm
Acc.	Set the maximum acceleration of motor during motion	AC servo motor: $1/2 * (Kt * Ip / (10 * Jm))$
Dec.	Set the maximum deceleration of motor during motion	AC servo motor: $1/2 * (Kt * Ip / (10 * Jm))$
Dec. kill	Set the deceleration of motor for emergency stop	AC servo motor: $2 * Acc.$
Smooth factor	Smooth factor	AC servo motor: 100

Note:

Jm is the moment of inertia obtained by the inertia estimation.

As shown in figure 8.1.1, the “Motion Protection” area displays the maximum speed, maximum acceleration, and maximum deceleration of movement. The unit can be set according to the user’s custom unit by clicking “Position Units”. These settings are not only used for the motion protection, but also used as test run parameters. Therefore, when the motion function (“P2P”, “Relative move”, or “Jog”) in the performance center is used, it is important to check whether the data in the “Motion Protection” area is the user’s motion protection setting, as shown in figure 8.1.2. In the position mode or velocity mode, be sure to set “Acc.” and “Dec.” to the required value multiplied by 10 times, to avoid being limited by the motion protection function. If this action is ignored, the desired speed or acceleration/deceleration may not be achieved when the motion command is sent from the host controller.

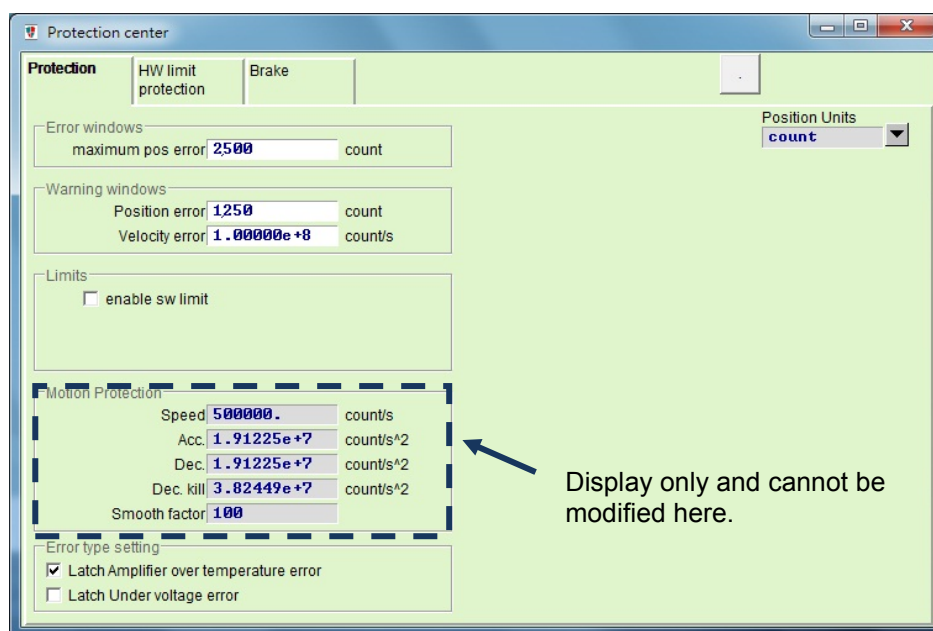


Figure8.1.3

■ Cancel velocity, acceleration, and deceleration limits

In the position mode, when “Smooth factor” is set to 1, it indicates that drive’s limit functions of speed, acceleration, and deceleration are canceled, and the motor movement completely follows the path planning based on the pulse command sent from the host controller. Users can decide whether to cancel the drive’s limit function based on the requirement.

■ Applicable scope of emergency stop deceleration

The emergency stop deceleration (“Dec. kill”) will be activated in following cases.

- (1) In the position and velocity modes, it is the deceleration when the motor in motion is disabled to the emergency stop condition.
- (2) When executing “P2P” or “Relative move” in the performance center, it is the deceleration after pressing the “Stop motion” button.
- (3) When performing the homing procedure, it is the deceleration after finding the home position.
- (4) In the “Jog” operation, it is the deceleration after the “Jog” motion is stopped.

“Dec. kill” is used for the case of requiring a high deceleration. Thus, it is recommended to set “Dec. kill” based on the maximum capacity of motor. The formula for the rotary motor is described as follows:

Peak current = min (motor peak current, drive peak current).

Dec. kill = (peak current x torque constant)/load inertia.

■ Smooth motion

The function of smooth motion is used to reduce the impact of motor force to the load in the acceleration/deceleration phase of motion process. This purpose is achieved by setting “Smooth factor”. This parameter is designed according to the number of samples in the moving average filter, as shown in figure 8.1.4. The relationship of filter time constant and “Smooth factor” is described as follows.

- (1) Non CoE model: filter time constant = “Smooth factor” × 0.5333 ms;
- (2) CoE model: filter time constant = “Smooth factor” × 0.5 ms.

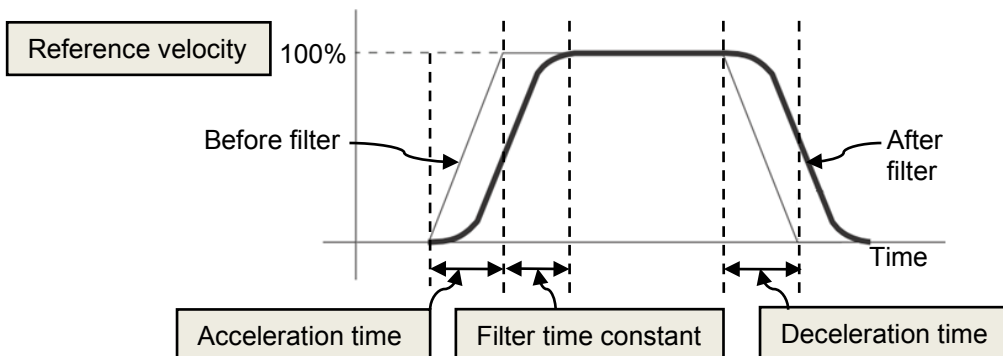


Figure8.1.4

The value of “Smooth factor” is between 1 and 500. The higher the value is, the smaller the impact is. The value of 1 means no smooth function. In some cases, increasing the smooth factor will be helpful for the final settling performance of positioning process due to the impact reduction of motor force. However, the smoother motion inevitably increases the move time (see Section 3.7). How to obtain the balance between the two must be practically tested and tuned in the machine.

8.2 Position and velocity errors protection

8.2.1 Position error limit

There is a position error in the servo control. The position error is usually larger when the motor moves. Moreover, some external factors may also cause that the position error becomes abnormally large, such as that bearings or linear guideways on the mechanism have a high friction due to the lack of lubricators, the winding or cable tray is too tight, foreign objects invades on the motor travel, the motor hits the abnormal object or hard stop, the position encoder is abnormal or interfered, and other conditions. In order to avoid all kinds of anomalies leading the position error too big, D2 drive has a “Error windows”. When the position error is over this “Error windows”, the drive will generate an error message of “Position error too big”, start the emergency stop procedure, send the brake signal, and disable the motor.

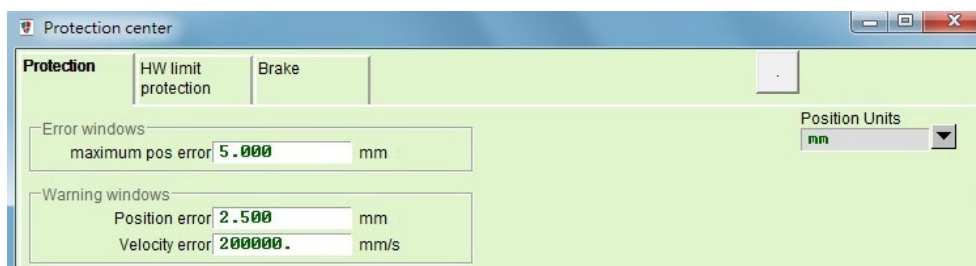


Figure8.2.1.1

Table8.2.1.1

Parameter	Description
Maximum Pos Error	Maximum position error limit
Position Error	Position error warning value
Velocity Error	Velocity error warning value

If the drive is the dual-loop model and uses the dual-loop function, the “Protection” tab in the protection center has a “Hybrid deviation error” field to be set to prevent the mixed control deviation from being too large, as shown in figure 8.2.1.2. This may cause the velocity loop or position loop becomes unstable. When the actual error exceeds this set, the drive generates an error message of “Hybrid deviation too big”. If the dual-loop function is not used, the “Hybrid deviation error” field is anti-gray and cannot be set.

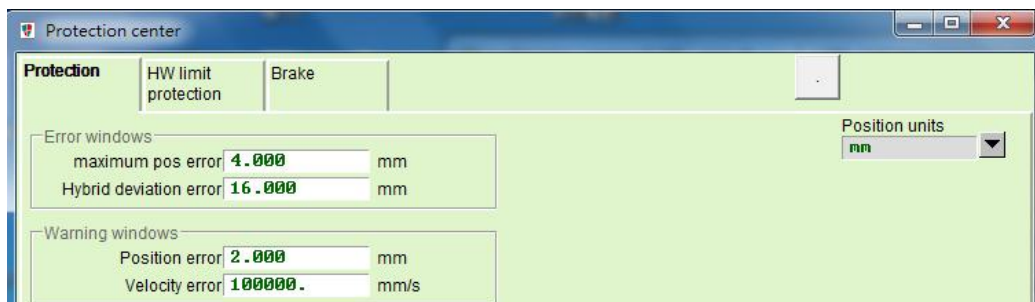



Figure8.2.1.2

8.2.2 Position error and velocity error warnings

In addition to the setting of position error limit described above, D2 drive also provides an early warning function. When the position error or velocity error exceeds the set value in “Warning windows”, the warning message will be displayed on the “Status” area of main window to warn the user that an abnormality has occurred in advance.

8.3 Brake output

In order to protect the motor and the system structure, D2-series drives provide a brake signal output to actuate an external electromagnetic brake, which is often used in the Z-direction motor actuation. There are some timing motion issues in this application. For example, when the motor moves in the Z direction and the drive receives a disable command, if the brake directly starts at the high speed, the great shock will be generated to damage the mechanism. In addition, if the motor is disabled early, there is a risk that the mechanism and the motor may slip. D2-series drives have proprietary brake parameters to reduce this risk.

Click  to enter the protection center and select the “Brake” tab to open the configuration page for braking timing. The output pin of brake can be set by clicking the “Set...” button on this page. The default pin is CN2_BRK for frame A - C models and O5 for the frame D model. Click this button to show the configuration page of I/O center. Refer to Section 5.5.2 for the setting information.

■ Brake configuration page for frame A - C models

The brake configuration page for frame A - C models is shown in figure 8.3.1. After the drive receives the hardware input signal or software disable operation, it starts the following action sequence.

Step 1: When the drive receives the disable command, the brake will be started after the delay time of starting brake (“delMaxEnToBrk”). However, if the motor speed is reduced to the brake start speed (“vel_stop”), the brake is started first.

Step 2: Counting from the drive starting the brake, the post-stage power will be turned off after the set brake action time (“delBrkToDis”). Its main purpose is to completely and truly execute the brake action.

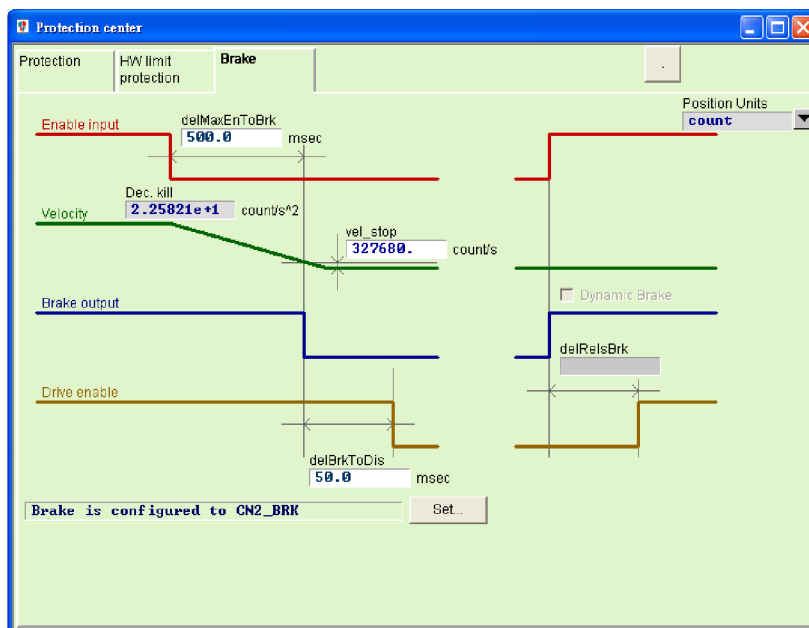


Figure8.3.1

Table8.3.1

Parameter Name	Description
Delay time of starting brake (“delMaxEnToBrk”)	The maximum time from receiving the disable command to starting the brake.
Emergency stop deceleration (“Dec. kill”)	The deceleration of motor brake during emergency stop. Refer to Section 8.1.
Brake start speed (“vel_stop”)	The speed for starting the brake after receiving the disable command.
Brake action time (“deBrkToDis”)	The delay time from starting the brake to shutting down the post-stage current.
Delay time for the dynamic brake relay (“delRelsBrk”)	The delay time from closing the brake to completing the switchover of dynamic brake relay. (Frame A - C models do not support this function. Hence, this field is anti-gray and cannot be set.)

■ Brake configuration page for frame D model

The frame D model has the built-in dynamic brake resistor. Its characteristics are described as follows.

- (1) It is only applicable to the transient braking effect, and cannot achieve the bite ability of general mechanical brake.
- (2) The braking performance is poor in comparison to the emergency deceleration. Its main function is to compensate some error cases that the braking function does not apply the emergency deceleration.

The brake configuration page for the frame D model is shown in figure 8.3.2, and brake parameters are the same as those given in table 8.3.1. To enable the dynamic brake function, simply check the option of “Enable Dynamic Brake”. If the option of “Enable Dynamic Brake” is unchecked, this function is disabled. Although the frame D model has the built-in dynamic brake resistor, in most cases, it will first use the mechanical brake process to decelerate. Only when the error of E01, E02, E03, E04, E07, E10, or E12 occurs (see Section 9.3 for error codes), the dynamic brake is activated first, and then the mechanical brake process is activated. Refer to figure 8.3.3 to figure 8.3.5 for the dynamic brake timing.

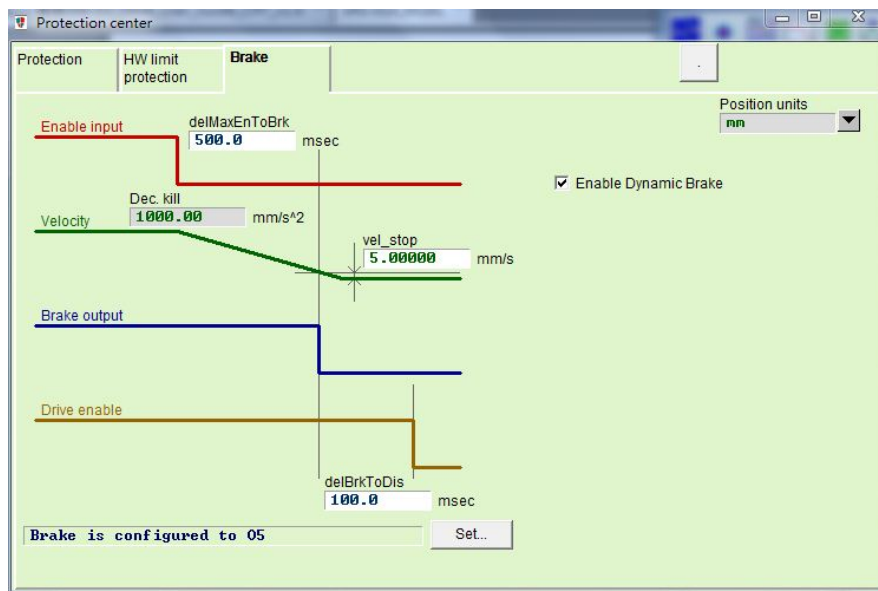
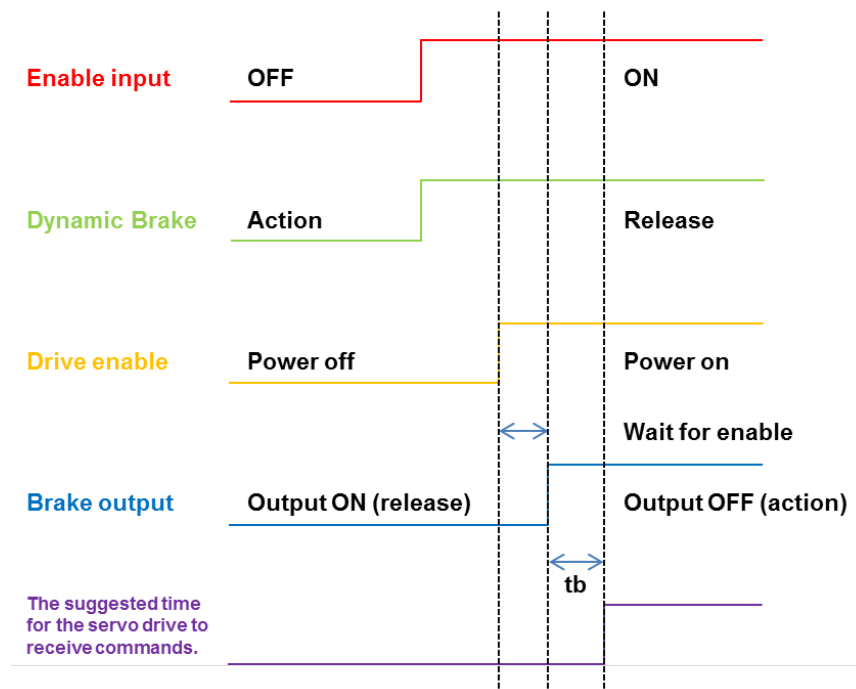


Figure8.3.2

◆ Enable timing



Note: tb is the delay time for mechanical brake to switch relay.

Figure8.3.3 Dynamic brake timing - enable

◆ Disable timing at the motor movement

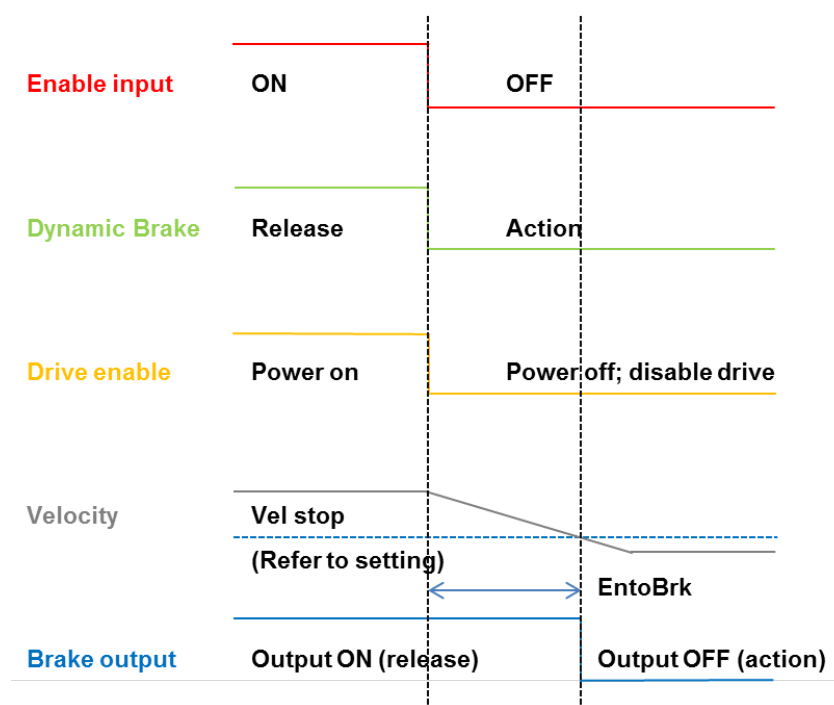
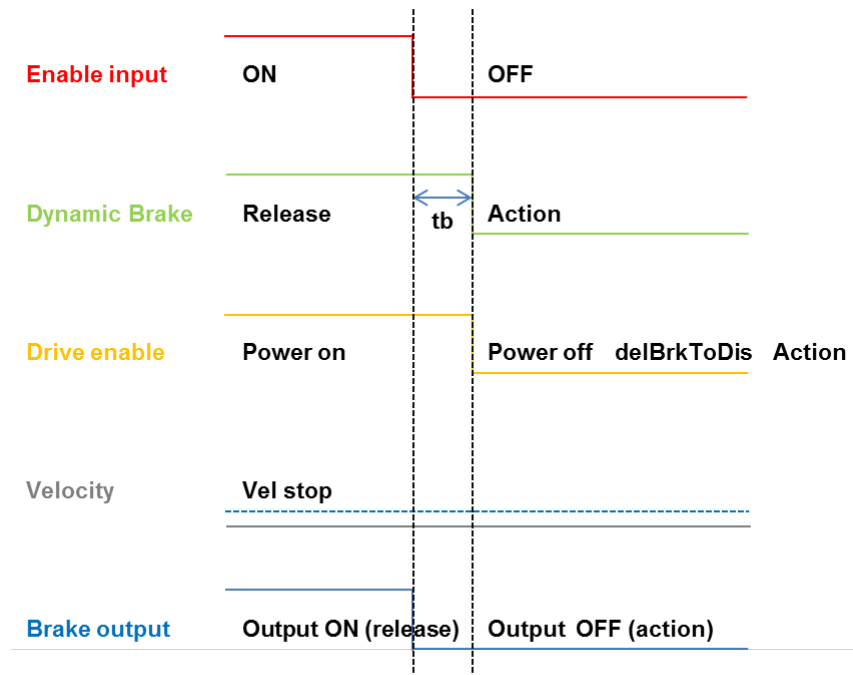


Figure8.3.4 Dynamic brake timing – disable at the motor movement

◆ Disable timing at the motor stop




Note: t_b is the delay time for mechanical brake to switch relay.

Figure8.3.5 Dynamic brake timing - disable at the motor stop

8.4 Limit protection

8.4.1 Hardware limit protection

D2 drive has a hardware limit protection. The hardware limit is usually the photoelectric switch or micro switch installed in the positioning platform. It is used to identify the stroke of mechanical movement. When the motor hits the hardware limit, the emergency brake protection will be activated. Usually, the hardware limit switch is a normally close sensor. When the hardware limit switch is touched, the drive stops the motor by using the emergency stop deceleration (“Dec. kill”). At this moment, the drive can only accept the motion command in the opposite direction.

After clicking  to enter the protection center, select the “HW limit protection” tab to open the configuration page of hardware limits. To enable the hardware limit protection, the option of “enable HW limit” (enable HW limit) must be checked. The digital input pin of hardware limit can be set by clicking the “Set...” button on this page. Clicking this button will appear the configuration page of I/O center. Refer to Section 5.5.1 for the setting information.

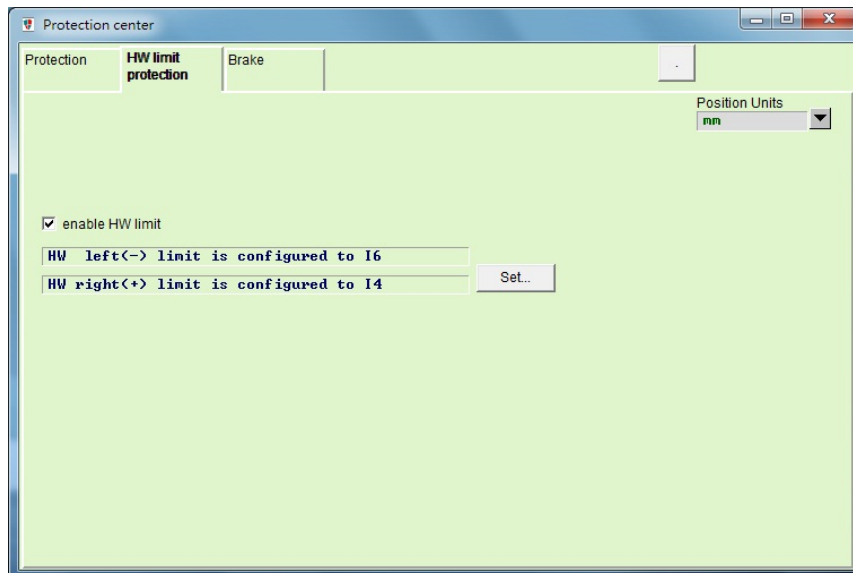



Figure8.4.1.1

8.4.2 Software limit protection

In addition to the hardware limit protection, D2 drive also has the software limit protection. It also plays the role of protecting over stroke. When the motor reaches the position of software limit, the drive can only accept the command to move in the opposite direction.

Click  to enter the protection center, and select the "Protection" tab. The "Limits" area is the configuration page of software limits. After checking the option of "enable sw limit", the upper and lower software limits can be set. Moreover, the software limit protection can be activated by checking the option of "enable sw limit" in the performance center.

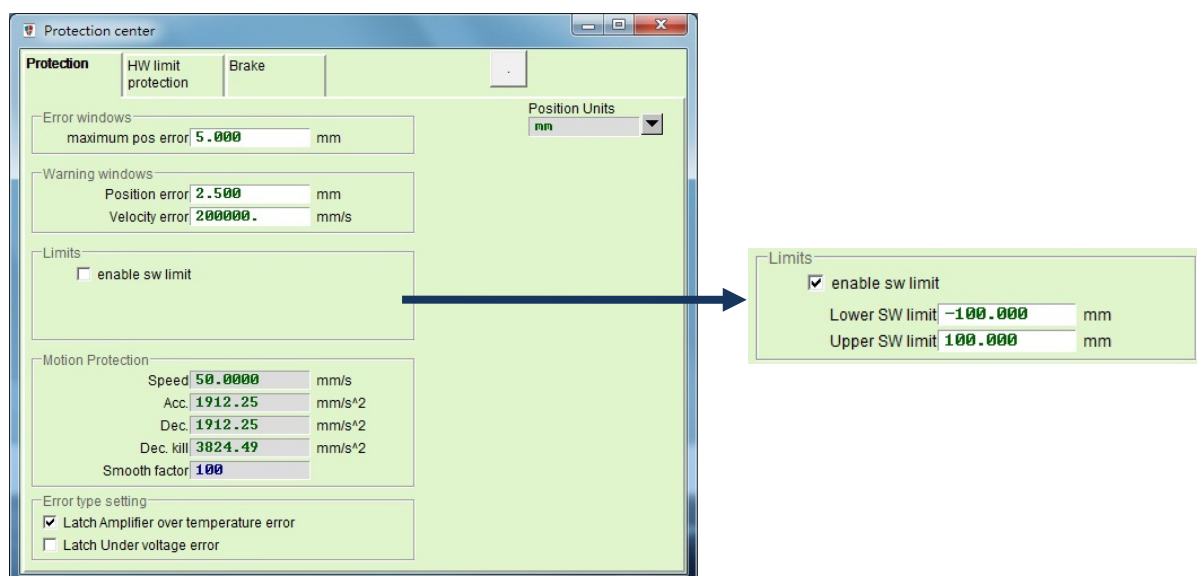


Figure8.4.2.1

Table8.4.2.1

Parameter Name	Description
enable sw limit	To activate the software limit protection. Check it to activate.
Lower SW limit	Lower software limit position.
Upper SW limit	Upper software limit position.

8.5 Over temperature protection

8.5.1 Soft-thermal protection

D2 drive has the function of estimating the motor temperature by using the software. Utilizing the current output to estimate the motor power and then estimate the motor temperature. When it reaches the default value of drive, the drive issues an error message of “Soft-thermal threshold reached”, enters the emergency stop process, and finally disables the motor. Select the “Soft-thermal Accumulator” item in “Quick view” to observe the current estimation of motor temperature.

8.5.2 Drive over temperature protection

D2 drive has the protection of drive over temperature. When the drive’s temperature reaches 80 °C, the error message of “Amplifier over temperature” is displayed, and the motor is stopped.

8.6 Over voltage protection

When the motor is decelerating, the kinetic energy is converted into the thermal energy for the consumption. The remaining energy charges the drive’s capacitor. When the energy exceeds the capacity of drive’s capacitor, the energy must be consumed on the regenerative resistor in the regenerative circuit to protect the drive. The regenerative resistor of D2 drive has the turn-on voltage of 370 Vdc and the turn-off voltage of 360 Vdc. Users can refer to the following characteristic of each motor specification (under the deceleration of 10 m/s² and the screw pitch of 10 mm) to determine whether the regenerative resistor is needed or not. Take the motor of 750 W as an example. If the motor is operated at the highest speed of 3,000 rpm and the load inertia is more than 0.00082 Kg-m², a regenerative resistor is needed. Refer to table 7.1.1 to select an appropriate regenerative resistor model.

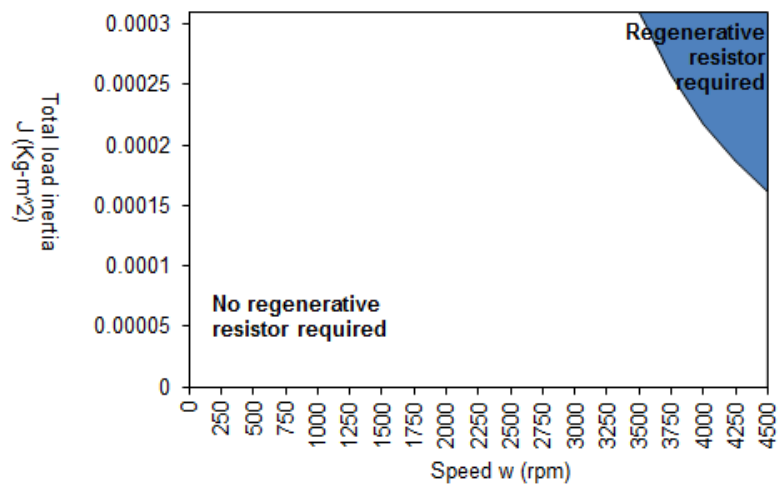


Figure 8.6.1 Motor regenerative curve of FRLS402XX

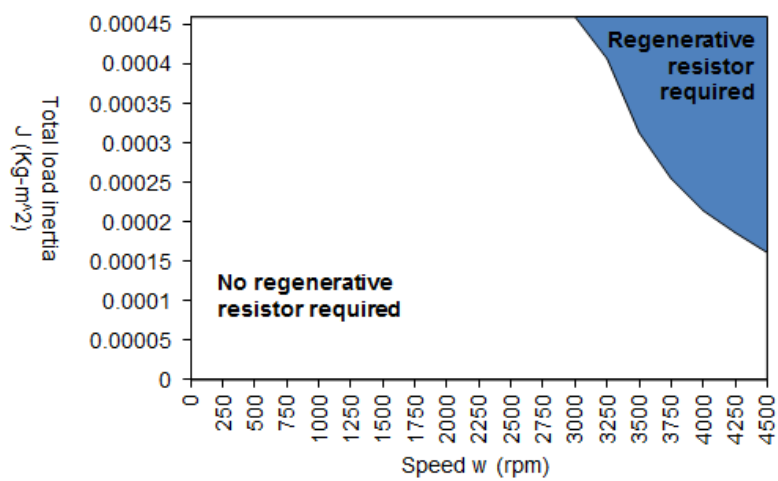


Figure 8.6.2 Motor regenerative curve of FRMS4B2BX

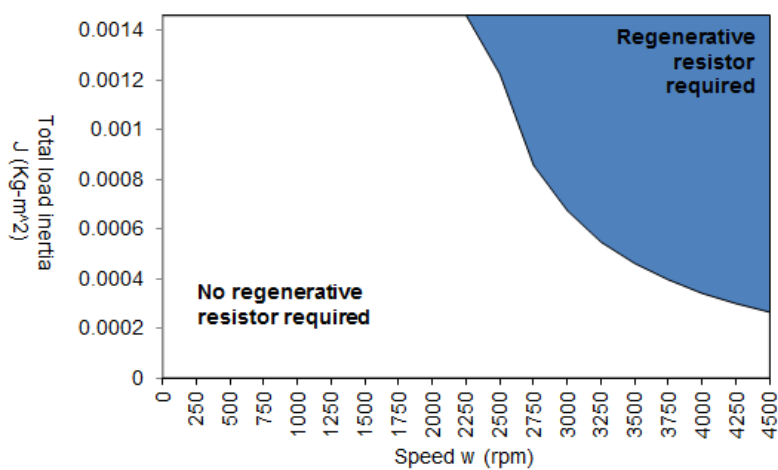


Figure 8.6.3 Motor regenerative curve of FRMS752XX

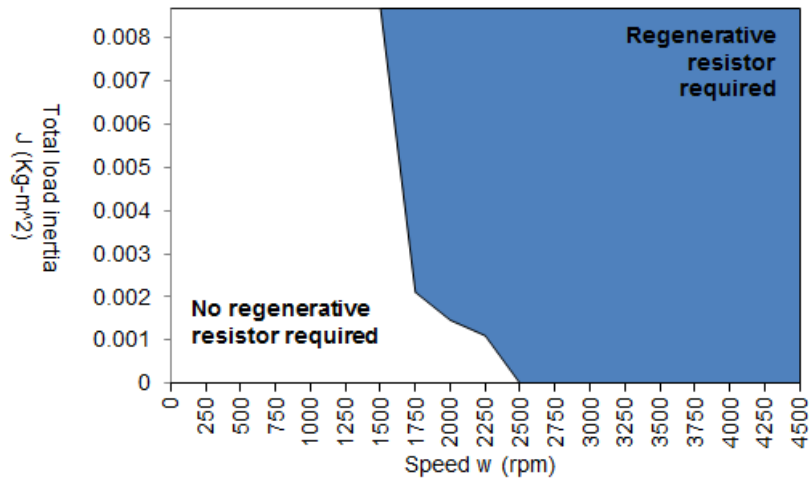


Figure 8.6.4 Motor regenerative curve of FRMM1K2XX

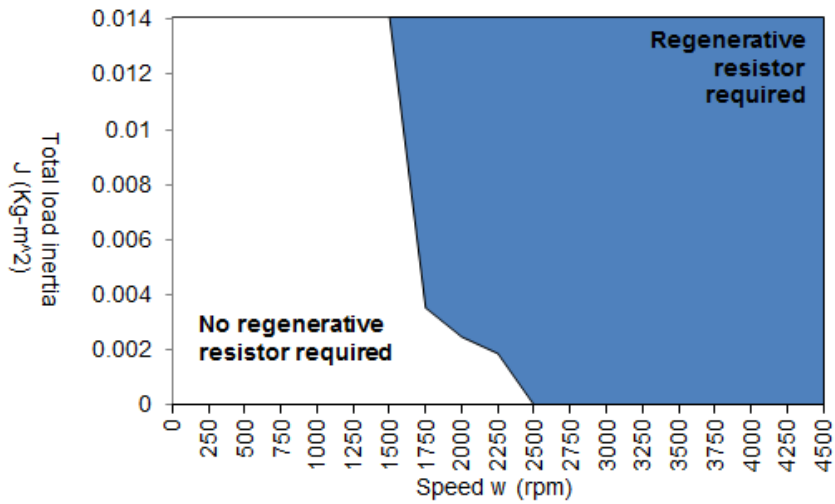


Figure 8.6.5 Motor regenerative curve of FRMM2K2XX

The regenerative resistor model of HIWIN standard product is given in table 8.6.1. Users can use them in series or in parallel according to the requirement. The appearance and size are given in table 8.6.2 and figure 8.6.6.

Table 8.6.1

Regenerative Resistor Model	HIWIN Part No.	Resistance Value	Rated Power/ Peak Power
RG1	050100700001	68 Ω	100 W / 500 W
RG2	050100700009	120 Ω	300 W / 1500 W
RG3	050100700008	50 Ω	150 W / 750 W
RG4	050100700019	50 Ω	600 W / 3000 W

Table8.6.2

Regenerative Resistor Model	L1	L2	W	W1	H
RG1	165 ± 2 mm	150 ± 2 mm	40 ± 0.5 mm	5.3 ± 0.5 mm	20 ± 0.5 mm
RG2	215 ± 2 mm	200 ± 2 mm	60 ± 1 mm	5.3 ± 1 mm	30 ± 1 mm
RG3	190 ± 2 mm	175 ± 2 mm	40 ± 1 mm	5.2 ± 1 mm	20 ± 1 mm
RG4	390 ± 2 mm	360 ± 2 mm	60 ± 1 mm	9 ± 1 mm	28 ± 1mm

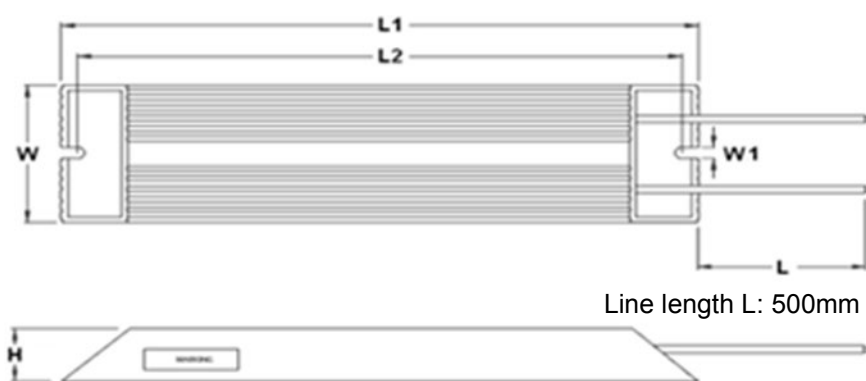


Figure8.6.6

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9. Troubleshooting

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9.1 Drive's status indicator

The drive's status indicator is LED on the front panel of drive, which shows the current status of drive. Its status is described in the following table.



Status indicator

Status indicator	Drive's status
No light	The drive has no control power.
Green and red lights flash simultaneously	The drive is booting.
Green light flashes	The motor has no power.
Green light constantly lights	The motor has power.
Green light flashes and red light constantly lights	The motor has no power, and an error occurs.

Note:

The status indicator will look like orange when the red and green lights are enabled at the same time.

Figure9.1.1

9.2 Drive's errors and warnings

9.2.1 Status display area on Lightning HMI

When D2 drive detects an error, in addition to starting the protection mechanism, it also displays the last error message in the error message display area ("Last error"), as shown in figure 9.2.1.1. Users can judge the error condition of drive based on this message. On the other hand, when the event occurs and needs to be warned during the operation, the warning message will be shown in the warning message display area ("Last warning").

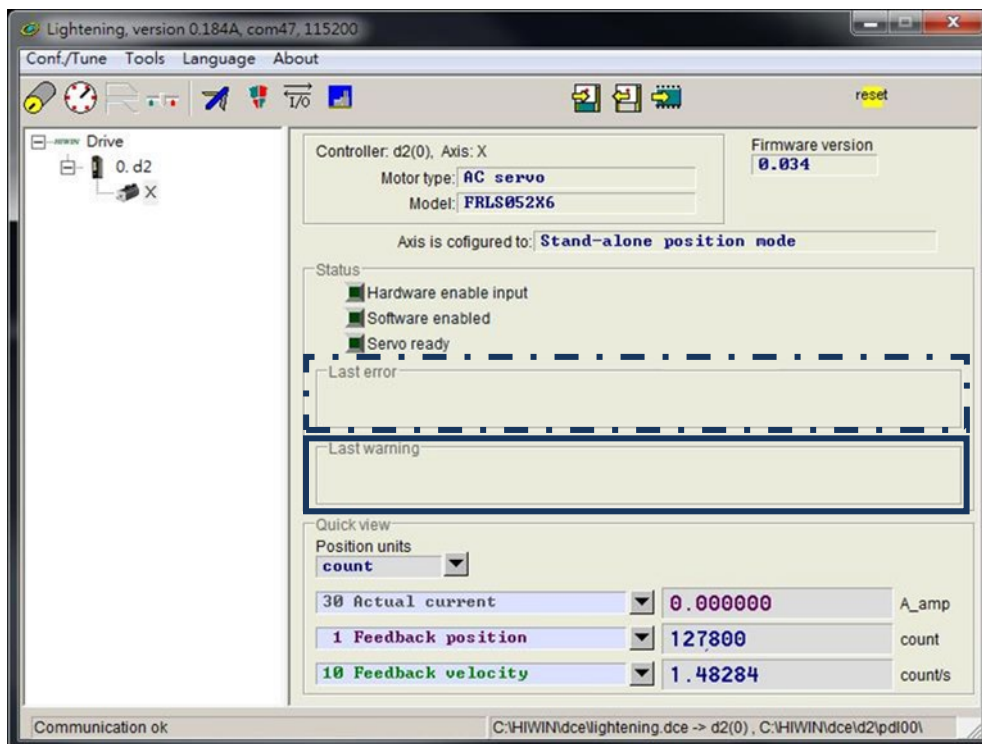


Figure9.2.1.1 Status display area

9.2.2 LCD status

The servo status will be displayed in the home page of LCD screen, as shown in figure 9.2.2.1.

- (1) SVNRDY: Servo disabled. It is at the “Servo OFF” status. The motor has no power.
- (2) SV RDY: Servo enabled. It is at the “Servo ON” status. The motor has power.

When an error or warning occurs, the second line of home page displays an error or warning message code. For LCD error codes, refer to Sections 9.3 and 9.4 error/warning codes and troubleshooting.

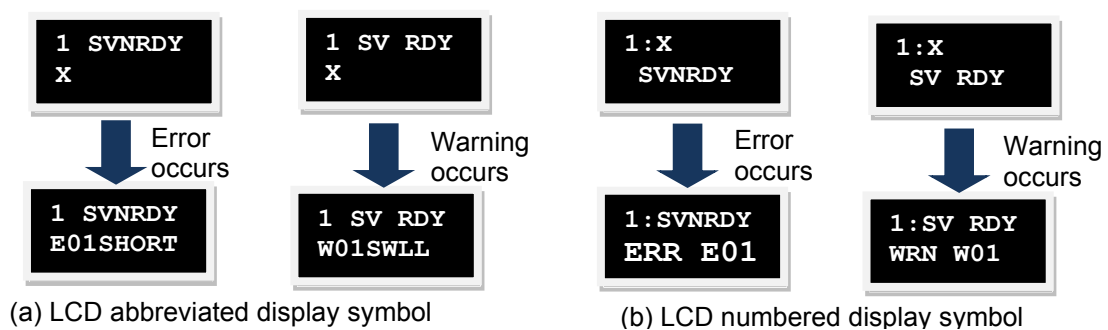


Figure9.2.2.1

9.2.3 Errors and warnings log

When D2 drive detects an error or warning event, in addition to showing it in the error message display area and warning message display area on the main window, as given in figure 9.2.1.1, it is also recorded in “Errors and warnings Log”. The opening method is shown in figure 9.2.3.1.

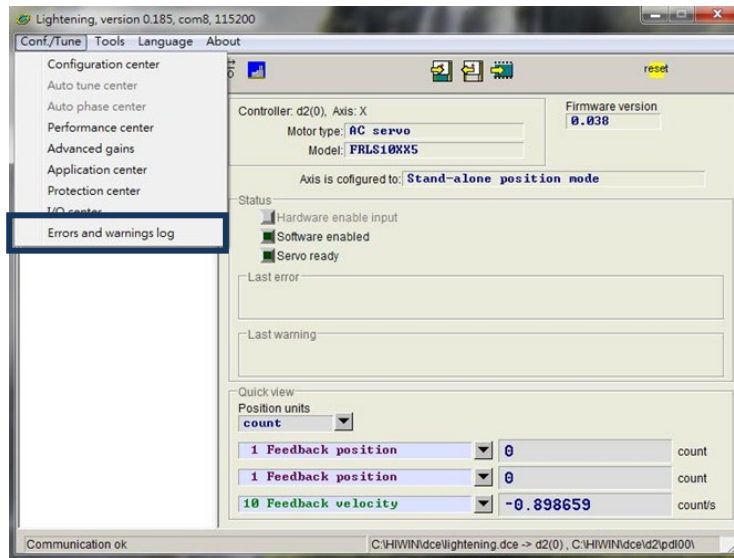


Figure9.2.3.1 Open “Errors and warnings Log”

Lightening provides this function to prevent that errors and warnings reported by the drive are flashing. This may cause that users lose the error and warning messages. The error and warning messages and the number, occurred after the drive is powered on, are recorded in “Errors and warnings log”. Refer to figure 9.2.3.2 for the “Time log” tab in “Errors and warnings log”. All occurred error and warning messages are recorded in “Type of error/warning” in the chronological order. The occurrence time is recorded in the “Time (seconds)” column.

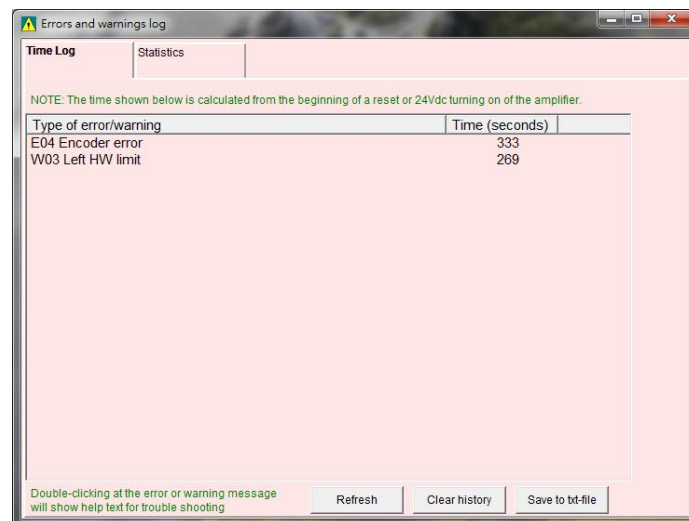


Figure9.2.4 Errors and warnings log

Refer to figure 9.2.5 for the “Statistics” tab in “Errors and warnings log”. The number of errors or warnings (“Frequency”) occurred in the drive is recorded in this window. This can help users to understand which events occur most frequently and to debug.

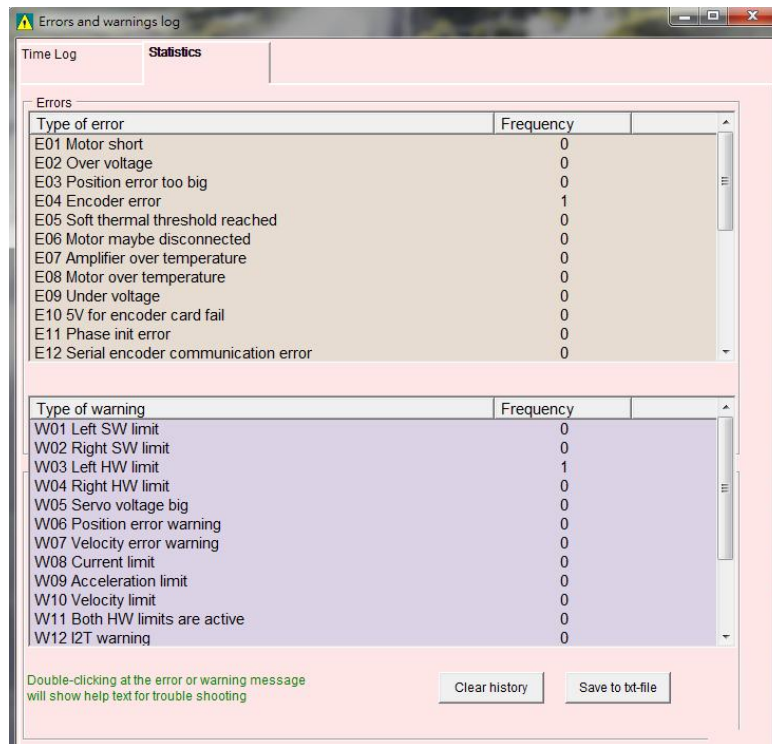


Figure9.2.5 Statistics in “Errors and warnings log”

Moreover, when users want to know more about the content of errors and warnings, double-click the name of error or warning event to appear the “Help tips” window. For example, as shown in figure 9.2.6, if the error event of “E04 Encoder error” is clicked, the possible cause and solution can be obtained from this window.

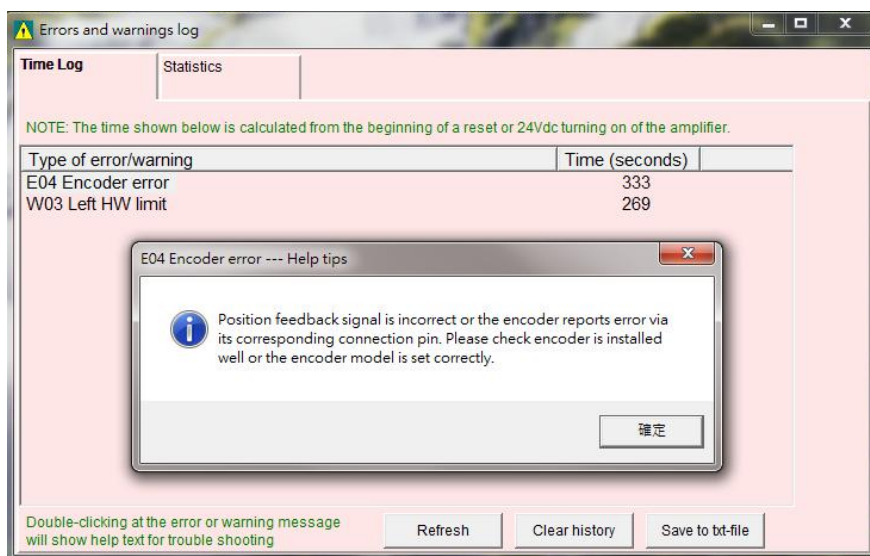


Figure9.2.6 “Help tips” window in “Errors and warnings log”

9.2.4 Error at loading PRM file

To ensure the compatibility between the loaded PRM parameter file and the drive firmware, Lightening will check if the PRM file is suitable for the current firmware version. When the following error message appears, it means that the PRM file is unsuitable, and need to re-set parameters or replace an appropriate firmware version. The number in the parentheses denotes the PRM error scenario, referring to table 9.2.4.1.

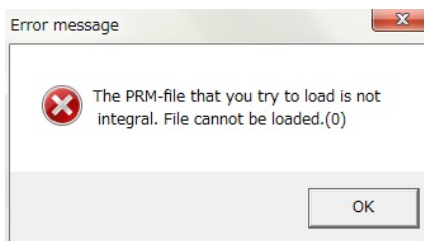


Figure9.2.4.1

Table9.2.4.1

Number	PRM Error Scenario
0	The MDP version of loaded PRM file is greater than the drive's MDP version.
1	The AC motor model name in the loaded PRM file is not the standard product.
2	The 9-th bit of AC motor model name in the loaded PRM file is 1, but the enable method cannot correspond.
3	The 9-th bit of AC motor model name in the loaded PRM file is 3 or 4, but the enable method cannot correspond.
4	The 9-th bit of AC motor model name in the loaded PRM file is 5, but the enable method cannot correspond.
5	The 9-th bit of AC motor model name in the loaded PRM file is 6, but the enable method cannot correspond.
6	The "X_id_secondary" parameter in the loaded PRM file does not match that in the drive.

9.3 Error codes and troubleshooting

Table9.3.1

No.	Error	LCD Error Code	Description Troubleshooting
1	Motor short (over current) detected	E01 SHORT or ERR E01	<p>The short of three motor phases is detected.</p> <ol style="list-style-type: none"> (1) After power-off, unplug the UVW-phase connector at the drive-side and measure the resistance between each phase of UVW and ground to check if there is a short circuit. The short circuit may burn the motor. (2) Measure the line-to-line resistance between motor UVW phases to check that they are close to the specification. If the line-to-line resistance is lower than the specification too much, the motor may be burned. (3) Separate the motor from the motor power cable, and use a multimeter to check if the motor power cable is short.
2	Over voltage detected	E02 OVERV or ERR E02	<p>The DC bus voltage in the drive exceeds the limit.</p> <p>When the motor has a heavy load and is operated at high speed, the back EMF exceeding the voltage limit will cause this error. Check if the regenerative resistor needs to be installed, which is selected according to the load and the motion specification.</p>
3	Position error too big	E03 PEBIG or ERR E03	<p>The position error is greater than “maximum pos error” set in the “Motion Protection” area.</p> <ol style="list-style-type: none"> (1) Check if the gain tuning is improper. (2) Confirm that the maximum position error is set properly (“Application center” -> “Protection” -> “maximum pos error”). (3) Check if the motor movement is obstructed. (4) Check if the load is too heavy. (5) Check if the guideway is without maintenance for a long time. (6) Check if the cable tray is installed too tight. (7) “W05 SVBIG” continues occurring before “E03”. Use 220 V power.
4	Encoder error	E04 ENCOD or ERR E04	<p>The encoder signal is incorrect or the alarm pin reports an error.</p> <ol style="list-style-type: none"> (1) Confirm that all encoder connectors are connected firmly. (2) Confirm that the encoder wiring is correct. (3) If the encoder is a digital type, it may be caused by the external interference. Confirm that the encoder cable has an anti-interference twisted wire and shield, or is equipped with an iron core.
5	Soft-thermal threshold reached	E05 SWHOT or ERR E05	<p>Motor overload. (The software detects the motor over-temperature.)</p> <ol style="list-style-type: none"> (1) Confirm that the continuous current and peak current during motor movement comply with the motor specification. (2) Check if the motor movement is obstructed. (3) It can be eliminated by resetting and re-enabling the drive. However, if the current exceeds the motor specification due to the load and motor parameters, it may occur again. (4) Reduce the speed, acceleration, and deceleration. (5) Check if the motor model name or motor current parameter is set incorrectly.
6	Motor maybe disconnected	E06 UVWCN or ERR E06	<p>The motor power cable is not physically connected to the drive.</p> <ol style="list-style-type: none"> (1) Check if the connector of UVW cable is loose. (2) Check if the motor model name is set incorrectly.
7	Amplifier over	E07 D.HOT	The drive is over temperature.

No.	Error	LCD Error Code	Description Troubleshooting
	temperature	or ERR E07	(1) Check that the drive is placed in a well-ventilated location. (2) Check if the ambient temperature is too high. (3) Wait for the internal temperature of drive to decrease. (4) To drive a large load or operate at a high duty cycle, install the heat sink if needed.
9	Under voltage detected	E09 UND.V or ERR E09	The DC bus in the drive is too small. Confirm that L1 and L2 of drive are connected to 220 Vac power source. Use a multimeter to check whether the input is 220 Vac.
10	5V for encoder card fail	E10 V5ERR or ERR E10	The 5V power supply of encoder interface is abnormal. (1) Unplug CN6, CN7, and motor power cable of D2 drive. Check whether there is still the error of "E10 V5ERR". If yes, contact the manufacturer for repair; otherwise, check if there is a short circuit and then modify the wiring. (2) Do not hot-plug CN6 and CN7 of D2 drive.
11	Phase initialization error	E11 PHINI or ERR E11	Motor phase initialization is failed. (1) Check that the encoder signal is normal and motor parameters are set correctly. (2) Check if the payload is too high, the friction is too high, and whether obstacles are on the way.
12	Serial Encoder Communication Error	E12 SER.E or ERR E12	The serial encoder communication has an error. (1) Check that the encoder cable is connected to the drive. (2) Check that the encoder cable complies with the motor specification.
13	Hall sensor error	E13 HAL.E or ERR E13	The less-wire encoder detects a hall signal error. Check that the encoder cable is properly connected to the drive.
13	Current control error	E15CURER or ERR E15	The current control has an error. (1) Check that the motor model name is set correctly. (2) Check that the current-loop gain ("Kp") and servo gain are set appropriately. (3) Check that the encoder cable is connected correctly.
17	Hybrid deviation too big	E17HYBDV or ERR E17	In the architecture of dual-loop control, the hybrid control deviation exceeds the allowable maximum of hybrid control deviation. (1) Check that the parameter of linear encoder is set correctly. (2) Check that the direction of linear encoder is consistent with the rotary encoder, or if the linear encoder has the signal interference. (3) Check if the coupling is loose, the gear is not tightly engaged, or the pitch tolerance or backlash of screw is too large.
18	STO active	E18STO or ERR E18	The STO safety function is triggered. Reconnect STO to 24 V after the risk has been removed, and then contact "DSF+" with "DSF-" for 1 second to release the error condition.
19	HFLT inconsistent error	E19HFLT or ERR E19	Drive hardware signals are conflicted abnormally. Check that each cable is grounded.
21	Incompatible motor model and drive	E21WRGMT or ERR E21	The motor model name is not compatible with the drive. Check that the motor model name is correct.

No.	Error	LCD Error Code	Description Troubleshooting
22	DC bus voltage abnormal	E22BUS.E or ERR E22	The DC bus voltage is abnormal. Check that the input voltage is well.
23	EtherCAT interface is not detected	E23NOET or ERR E23	The drive does not detect the EtherCAT interface or the drive has no EtherCAT interface. (1) Re-power the drive to re-detect it. (2) The drive does not support EtherCAT. Check that the drive has this function.
24	CiA-402 homing error	E24HOM.E or ERR E24	An error occurs while performing the CiA-402 homing. This causes the homing fail. (1) Check that the left and right limits, near home sensor, and index signals are normal. (2) Check that the used homing method is appropriate.
25	Fan fault error	E25FAN.E or ERR E25	The fan system is abnormal. Check if the fan is stuck in a foreign object.
26	Drive overload error	ERR E26	The motor was operated over the rated current for longer than the sustainable duration. Check that the motion profile is appropriate, or if the load is too heavy.

■ Supplement for E03 error correction

- (1) Modify the maximum position error by steps described in figure 9.3.1.
- (2) It is not recommended to set the position error higher than the default value. If “E03 PEBIG” or “ERR E03” appears at the default value, adjust the servo rigidity.

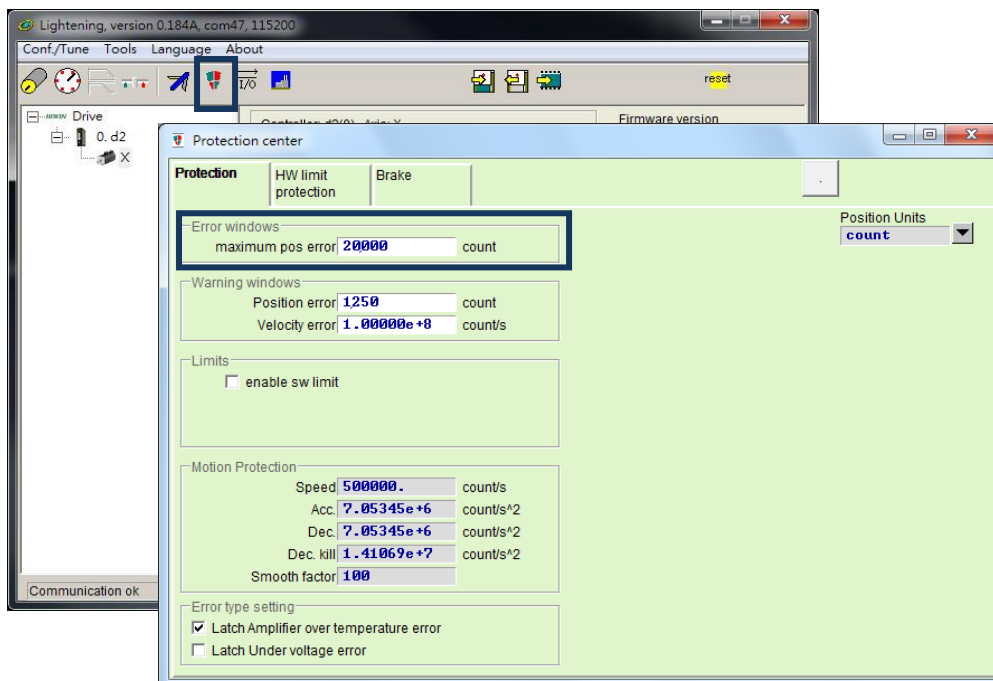


Figure9.3.2

■ Latch amplifier over temperature error

D2 servo drive is able to report error and warning. Normally when an error occurs, user needs to perform troubleshooting and then clear the error in Lightning. For convenience and efficiency, Lightning provides an automatic error handling function. User can choose whether to enable this function on error message “Amplifier over temperature”.

Click on **Protection** tab in Protection center. Enable or disable this function in the setting area of **Error type setting**, as figure 9.3.1. Check the checkbox of **Latch amplifier over temperature error** to disable automatic error handling function. If the checkbox is not checked, automatic error handling function will be enabled.

➤ Example 1

When error “Amplifier over temperature” occurs, it means the servo drive is overheating. If user would like the motor to be enabled automatically after the cause of the error is cleared, uncheck the checkbox of **Latch amplifier over temperature error**. If the servo drive cools down naturally, the motor will be enabled automatically.

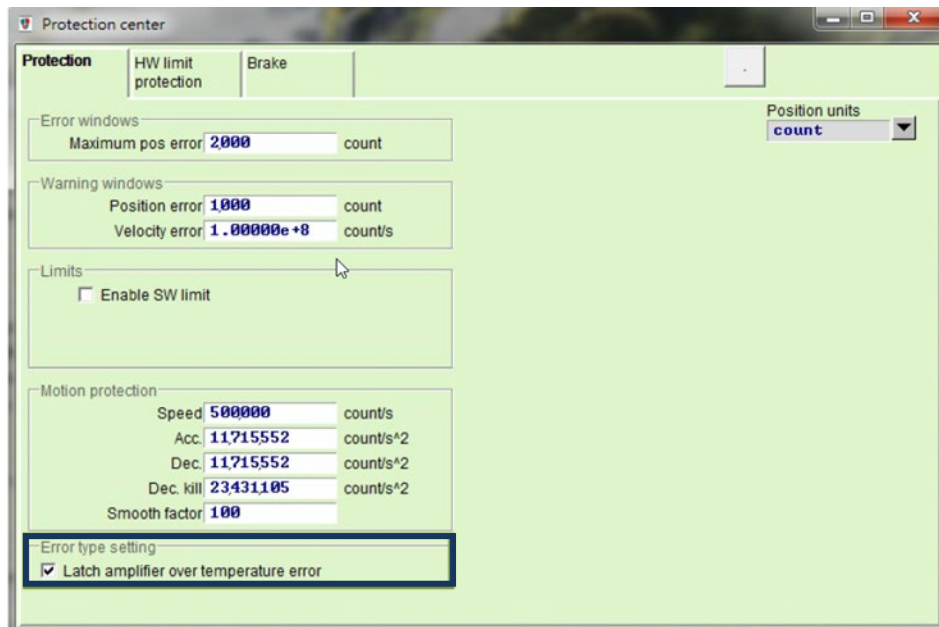


Figure9.3.1

9.4 Warning codes and troubleshooting

Table9.4.1

No.	Error	LCD error code	Description Troubleshooting
1	Left SW limit	W01 SWLL or WRN W01	The set left software limit is reached, and the motor can no longer move to the left.
2	Right SW limit	W02 SWRL or WRN W02	The set right software limit is reached, and the motor can no longer move to the right.
3	Left HW limit	W03 HWLL or WRN W03	The hardware limit switch on the left side has been detected and the motor can no longer move to the left. (1) If the hardware limit is not connected to the drive and the false trigger occurs, cancel the enable of hardware limit. (2) If it is confirmed that the limit switch is not actually triggered, check that the wiring or actuation logic is correct.
4	Right HW limit	W04 HWRL or WRN W04	The hardware limit switch on the right side has been detected and the motor can no longer move to the right. (1) If the hardware limit is not connected to the drive and the false trigger occurs, cancel the enable of hardware limit. (2) If it is confirmed that the limit switch is not actually triggered, check that the wiring or actuation logic is correct.
5	Servo voltage big	W05 SVBIG or WRN W05	The drive's PWM output switch is greater than the limit value and the current output cannot be increased. If this warning continues occurring in the position control, the error of "E03 PEBIG" will happen. (1) Change the power source to 220 V. (2) Reduce the speed, acceleration, or deceleration.
6	Position error warning	W06 PE or WRN W06	The position error exceeds the set warning window for position error. (1) Check that the servo gain is properly tuned. (2) Check if the warning threshold is set too small. (3) Sometimes, this phenomenon may occur since the maintenance period is over or the lubrication is not implemented.
7	Velocity error warning	W07 VE or WRN W07	The velocity error exceeds the set warning window for velocity error. (1) Check that the servo gain is properly tuned. (2) Check if the warning threshold is set too small. (3) Sometimes, this phenomenon may occur since the maintenance period is over or the lubrication is not implemented.
8	Current Limited	W08 CUR.L or WRN W08	The current has saturated in the specification of motor peak current. If this warning continues occurring, the error of "E05 SWHOT" will happen and the motor will be disabled. (1) Reduce the speed, acceleration, or deceleration. (2) Decrease the load.
9	Acceleration Limited	W09 ACC.L or	In the position mode or velocity mode, the acceleration protection setting is reached when the motor is moving.

No.	Error	LCD error code	Description Troubleshooting
		WRN W09	To increase the acceleration, increase the acceleration setting in the motion protection.
10	Velocity Limited	W10 VEL.L or WRN W10	In the velocity mode or torque mode, the velocity protection setting is reached when the motor is moving. To increase the velocity, increase the velocity setting in the motion protection.
11	Both HW limits active	W11 BOTH or WRN W11	Both the left and right hardware limits have been triggered. (1) If the hardware limit is not connected to the drive and the false trigger occurs, cancel the enable of hardware limit. (2) If it is confirmed that the limit switch is not actually triggered, check that the wiring or actuation logic is correct.
13	Homing fail	W13 HOM.E or WRN W13	Failed to perform the homing procedure. (1) Check that the left and right limits, near home sensor, and index signal are normal. (2) Check that "Time out" and "Search end stop current" are set properly.
14	Pulse command and homing conflict	W14HOM.C or WRN W14	In the position mode, the conflict situation of receiving the pulse command and homing command simultaneously occurs. Do not send the pulse command and perform the built-in homing function at the same time.
15	Absolute encoder battery warning	W15BAT.E or WRN W15	The encoder battery has no power. Replace the battery.
16	Wrong absolute position	W16ABS.W or WRN W16	The absolute encoder feedbacks the error absolute position. Reset the home position.
17	MECHATROLINK communication warning	WRN W17	MECHATROLINK communication warning Check if communication cable is correctly connected.
18	Absolute encoder position overflow	WRN W18	Absolute encoder feedback position overflow Command the motor to move towards the opposite direction.
19	Serial encoder communication warning	WRN W19	Serial encoder communication warning Check if the encoder cable is correctly connected.

■ Supplement for W03 and W04 warning correction

If the hardware limit is not connected to the drive and the false trigger occurs, the hardware limit function can be turned off.

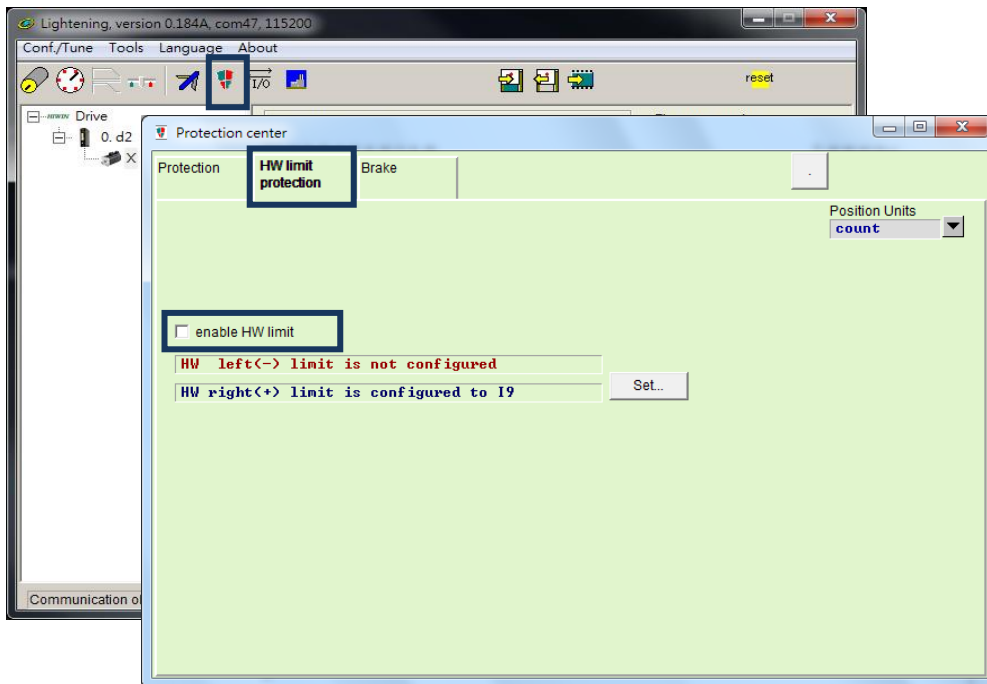


Figure9.4.1

■ Supplement for W09 and W10 warning correction

When the acceleration and deceleration (“Acc.” and “Dec.”) in the performance test is set to be less than the command, the warning message of “W09 ACC.L” or “WRN W09” will appear and the acceleration will be limited. To solve this problem, increase the acceleration and deceleration. It is recommended to set “Acc.” and “Dec.” to 10 times the current “Speed”.

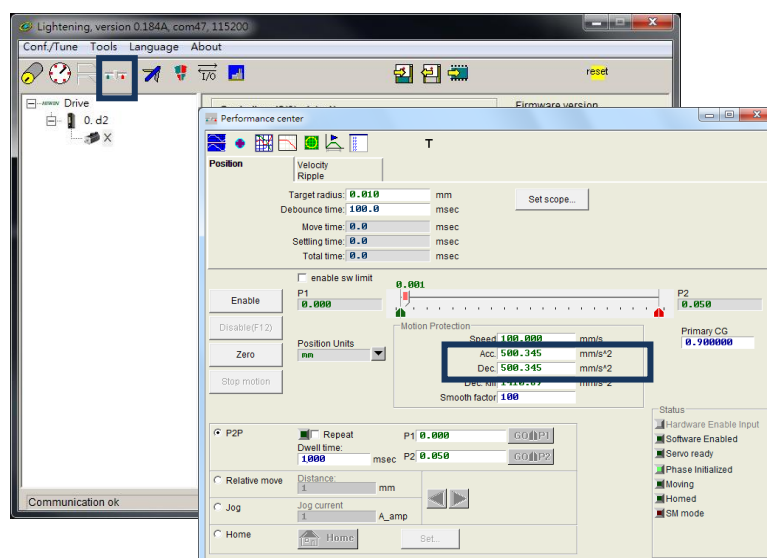


Figure9.4.2

When the speed (“Speed”) in the performance test is set to be less than the command, the warning message of “W10 VEL.L” or “WRN W10” will appear and the speed will be limited. To solve this problem, increase the speed. For example, if the required speed is 500 mm/s and “Speed” is set to 100 mm/s, “W10 VEL.L” or “WRN W10” will appear. “Speed” can be changed to a value larger than the target value, e.g. 600 mm/s.

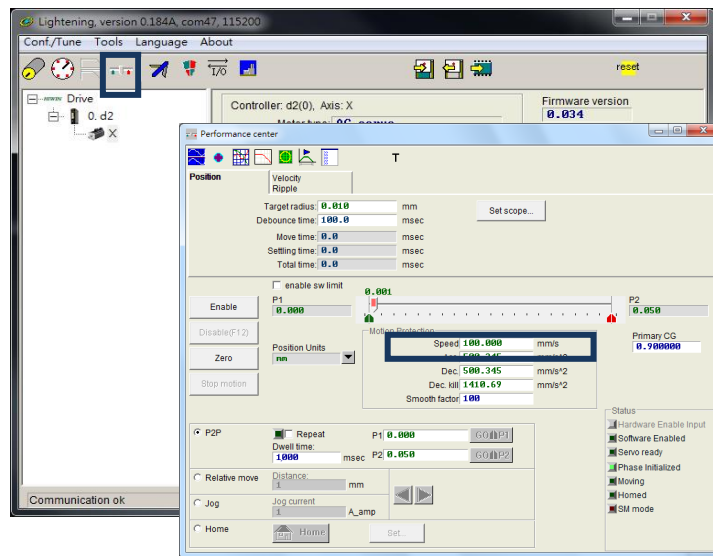


Figure9.4.2

9.5 Troubleshooting for common issues

No.	Issue	LCD code	Troubleshooting
1	The speed or acceleration is limited when the motion command is sent by using the pulse or voltage command. Or, the host controller has sent out all pulse commands for the movement, but the motor is still slowly moving to the target position.	W10 VEL.L (WRN W10) W09 ACC.L (WRN W09)	Check if the speed, acceleration, and deceleration in the “Motion Protection” area of performance center are set too small.
2	The motor direction is opposite to the customer-defined direction.	None	(1) In the “Details” menu of auto phase center, select “Toggle direction” to reset the motor direction. (2) Check the “Invert” option in the mode configuration page to invert the command.
3	“Error map” is not activated.	None	Open the “Error Map” tab in the application center to confirm the following items: (1) Confirm that the “Error map enable” option is checked. Refer to Section 6.9.2. (2) Confirm that the homing process has been done or the related homing signal has been set in the “Input” tab.

No.	Issue	LCD code	Troubleshooting
4	After enabling, the motor moves without any command.	None	<ol style="list-style-type: none"> (1) Use “Quick View” or “Scope” to check if “Target Position” has received the input pulse signal. (2) Check if the pulse signal cable is disconnected or poor contact. (3) Check that the signal of 0 V is connected to the shield or ground. (4) Check that the drive and machine are grounded. (5) Add a core to the pulse cable for filtering, if needed.
5	After enabling, the motor does not move when the command is sent out.	None	<ol style="list-style-type: none"> (1) Confirm that the command unit is correct. (2) Check if the speed or acceleration is set to 0. (3) Check if the “Enable SW Limit” option has been enabled. If yes, check that “Upper limit” or “Lower limit” is set correctly. (4) After disabling, turn the motor spindle to confirm that the rotation is smooth.
6	The pulse command has sent out, but the motor does not move.	None	<ol style="list-style-type: none"> (1) Use “Quick View” or “Scope” to confirm that “Target Position” has received the input pulse signal. (2) Check if the pulse signal cable is disconnected or poor contact. (3) Check if the electronic gear ratio is set to small.
7	The analog voltage command (V Command) has sent out, but the motor does not move.	None	<ol style="list-style-type: none"> (1) Use “Quick View” or “Scope” to confirm that “Analog Command” has received the input voltage. (2) Set the voltage offset in the “Analog input” tab of “Advanced gains” window.
8	The motor is moving with a loud noise.	None	<ol style="list-style-type: none"> (1) Reduce the servo gain (common gain). (2) Set the filter in the “Filter” tab of “Advanced gains” window.
9	The drive temperature is too high.	E07D.HOT (ERR E07)	<ol style="list-style-type: none"> (1) Check that the drive is placed in a well-ventilated location. (2) Check that the ambient temperature is not too high.
10	The position feedback sensor (reader) sends an incorrect signal.	E04 ENCOD (ERR E04)	Check that the drive and machine are grounded, and the shield is grounded.
11	The DC bus voltage is too small.	E09 UND.V (ERR E09)	<ol style="list-style-type: none"> (1) Check whether the drive’s main power is connected to 220 Vac, or disconnected. (2) Use a multimeter to check that there is a 220 Vac power supply.
12	The DC bus voltage is too large.	E02 OVERV (ERR E02)	<ol style="list-style-type: none"> (1) Confirm that the speed, acceleration, and load meet specifications. (2) Check whether a regenerative resistor needs to be installed when the motor is operated at the high speed. (3) Check if the load is too heavy. (4) Check if the speed is too high.

No.	Issue	LCD code	Troubleshooting
13	The position error exceeds the setting of maximum position error.	E03 PEBIG (ERR E03)	<ol style="list-style-type: none"> (1) Check if the servo gain (common gain) is too small and the maximum position error ("maximum pos error") is too small. (2) Check if the motor movement is obstructed. (3) Check if the load is too heavy.
14	The motor UVW has a short circuit.	E01 SHORT (ERR E01)	<ol style="list-style-type: none"> (1) Solve the short circuit between the motor UVW phases and wiring problems. (2) Solve the short circuit between the motor power phase (UVW) and ground. (3) Measure the line-to-line resistance of motor phase (UVW), and confirm that resistances between lines are the same. (4) Check if the motor cable is too old.
15	The equivalent current of drive output exceeds the limit of motor continuous current.	E05 SWHOT (ERR E05)	<ol style="list-style-type: none"> (1) Confirm that the motor continuous current and peak current comply with the motor specification. (2) The acceleration command in the path planning is higher than the motor rated acceleration.
16	The computer cannot communicate with the drive.	None	Confirm that the transmission rate ("BPS") and communication port ("Port") are set correctly.
17	The host controller receives an incorrect position when using the emulated encoder function.	None	When "Use emulated encoder" is set, the motor moves due to various factors during the operation of "Save to flash" (📁) on the main window. The emulated output function has no effect when "Save to flash" is performing.

10. Axis enable setting

10. Axis enable setting	10-1
10.1 Start enable method	10-2
10.2 Confirm enable status via HMI	10-3

10.1 Start enable method

■ Enable via host controller

Usually, the host controller sends a command to the drive to control the motor enable. This is done through the drive's input pin. Normally, the "Axis Enable" function is set to the digital input I3 (see Section 5.5.1), as shown in figure 10.1.1.

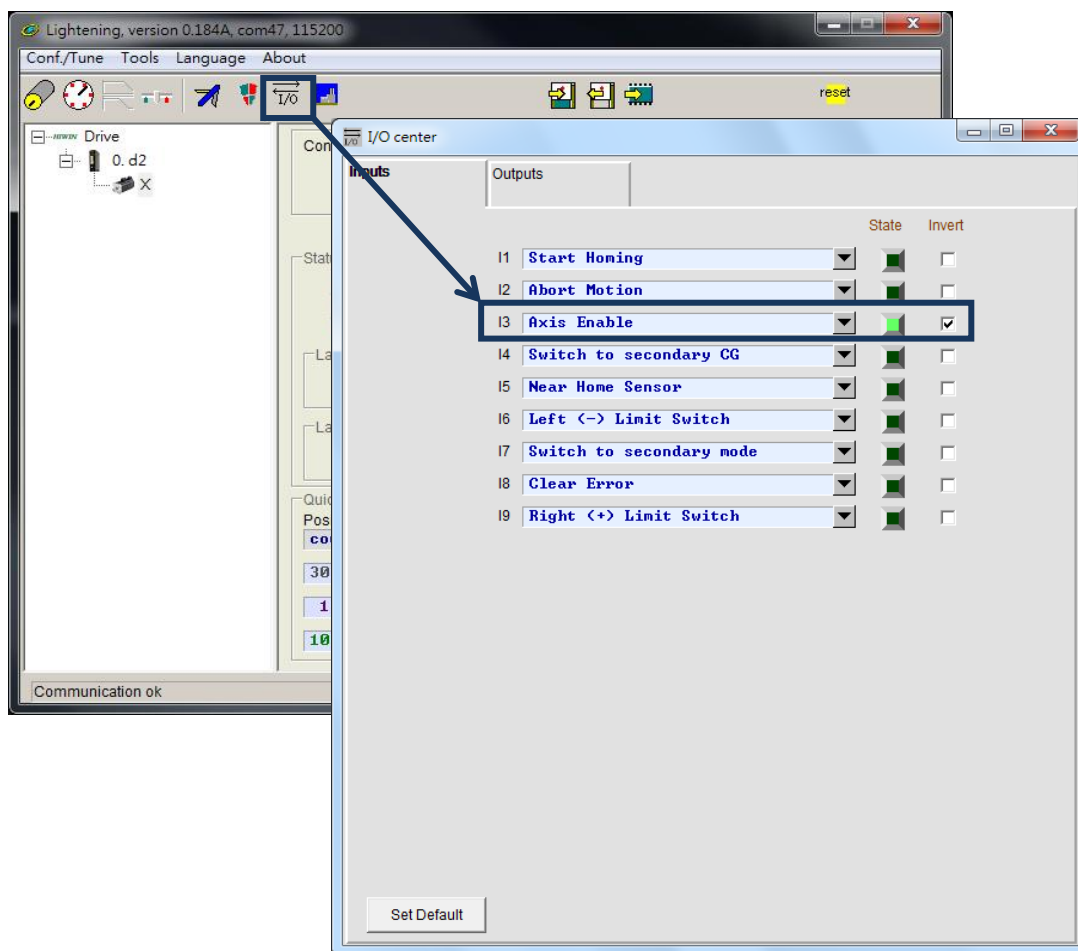



Figure10.1.1

■ Temporary hardware enable

When the user does not have the host controller to send the hardware enable signal to the drive, the following method can be used to provide the hardware enable temporarily. First, click the  button in the main toolbar to open the I/O center, as shown in figure 10.1.1. Confirm that the status light of "Axis Enable" is green. Generally, I3 is set to the input of hardware enable signal. Since each input pin has an "Invert" function, the signal logic can be reversed via this "Invert" option to temporarily provide a simulated hardware enable signal according to the test requirement. When the status light in the "State" column is green, it indicates that the drive has received a hardware enable signal.

10.2 Confirm enable status via HMI

When the light of “Hardware enable input” in the HMI main window is green, it indicates that the drive has received a hardware enable signal from the host controller, as shown in figure 10.2.1.

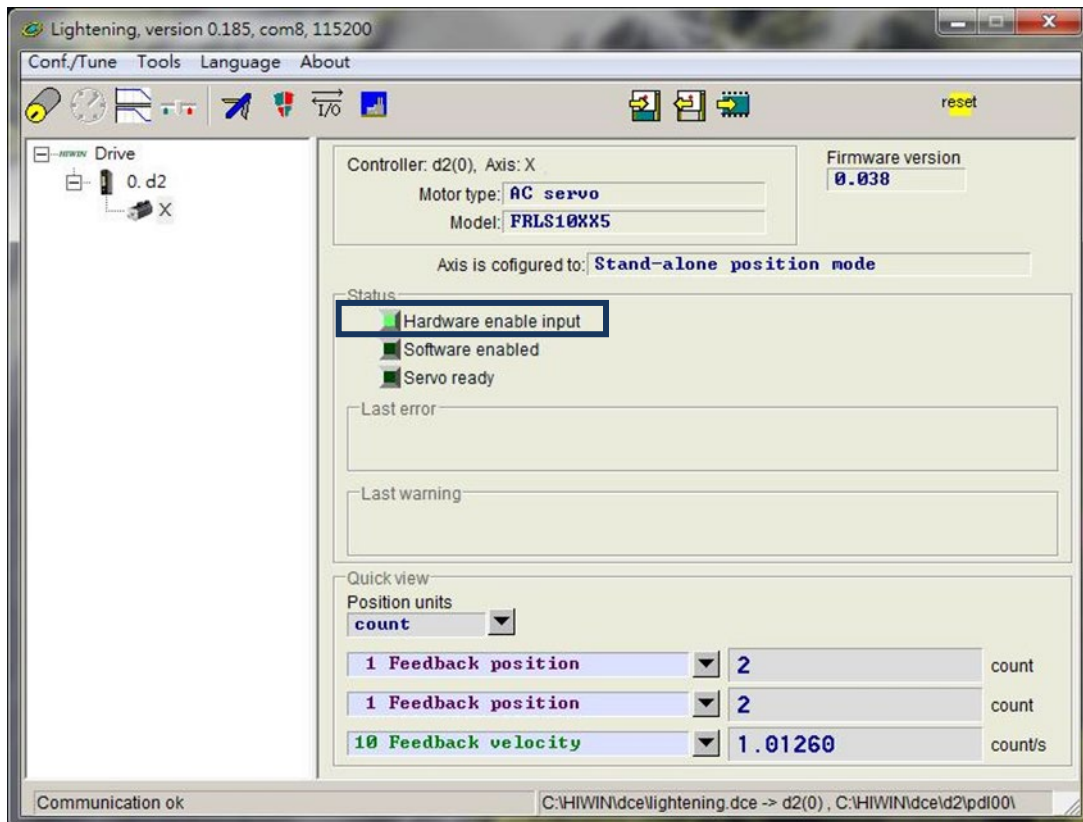


Figure10.2.1

Usually, the motor enable is controlled by the “Axis Enable” signal sent from the host controller to the drive’s input pin. When HMI is turned on, following items must be noticed.

- (1) When Lightening is a valid window on the computer, the F12 key can be pressed to disable the motor at any time. Usually, it is useful in the emergency situation.
- (2) When the performance center in Lightening is turned on, the “Disable” button (same as F12) can be pressed to disable the motor. Click the “Enable” button on the window to enable the motor again (but only if the “Hardware enable input” light is still green).

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11. Parameter comparison

11. Parameter comparison	11-1
11.1 Comparing parameters in RAM and Flash	11-2

11.1 Comparing parameters in RAM and Flash

When motor parameters are modified during the operation of Lightning and do not save in the drive's Flash, the prompt window of "Compare parameter RAM to Flash" appears at the situation of closing Lightning or saving error map parameters in Flash (see Section 6.9.1), as shown in figure 11.1.1. This window mainly reminds the user that parameters have been modified but not yet saved in Flash.

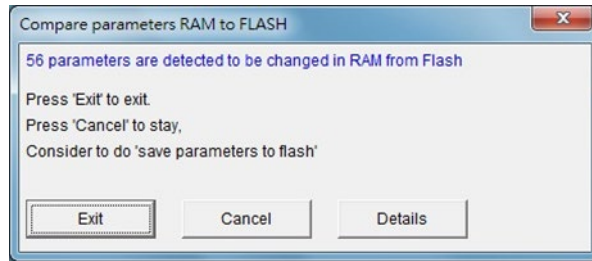


Figure11.1.1

Click the "Details" option on the window to open the advanced comparison window. It can be used to further observe which parameters in RAM and Flash have different settings, as shown in figure 11.1.2. If the RAM data and Flash data are not the same, the parameter name and its value are listed in blue. In addition, the "Flash values" filed displays one of following two states.

- (1) =: The parameter in Flash is the same as that in RAM.
- (2) **: The parameter has performed the "Undo" action and the value in RAM has been changed to that in Flash, as shown in figure 11.1.3.

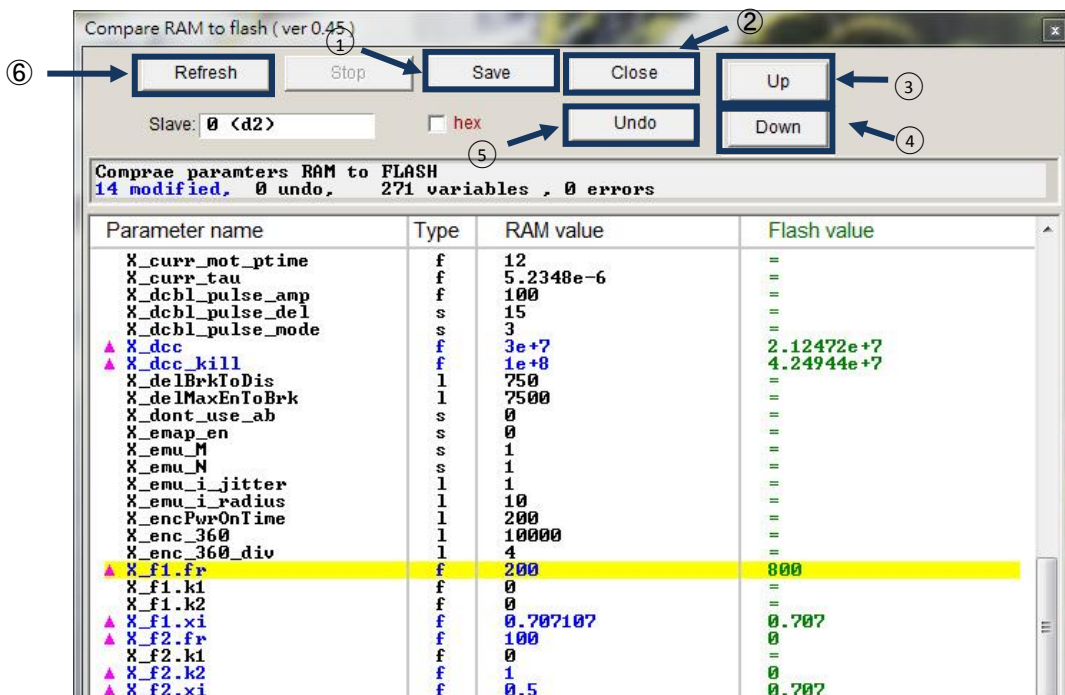


Figure11.1.2

The following is the function description of main button:

- ① Save: Save parameters to Flash.
- ② Close: Close the window.
- ③ Up: Go to the previous parameter which is different in RAM and Flash.
- ④ Down: Go to the next parameter which is different in RAM and Flash.
- ⑤ Undo: Restore the selected parameter saved in RAM to that saved in Flash
- ⑥ Refresh: Re-compare parameters saved in RAM and Flash.

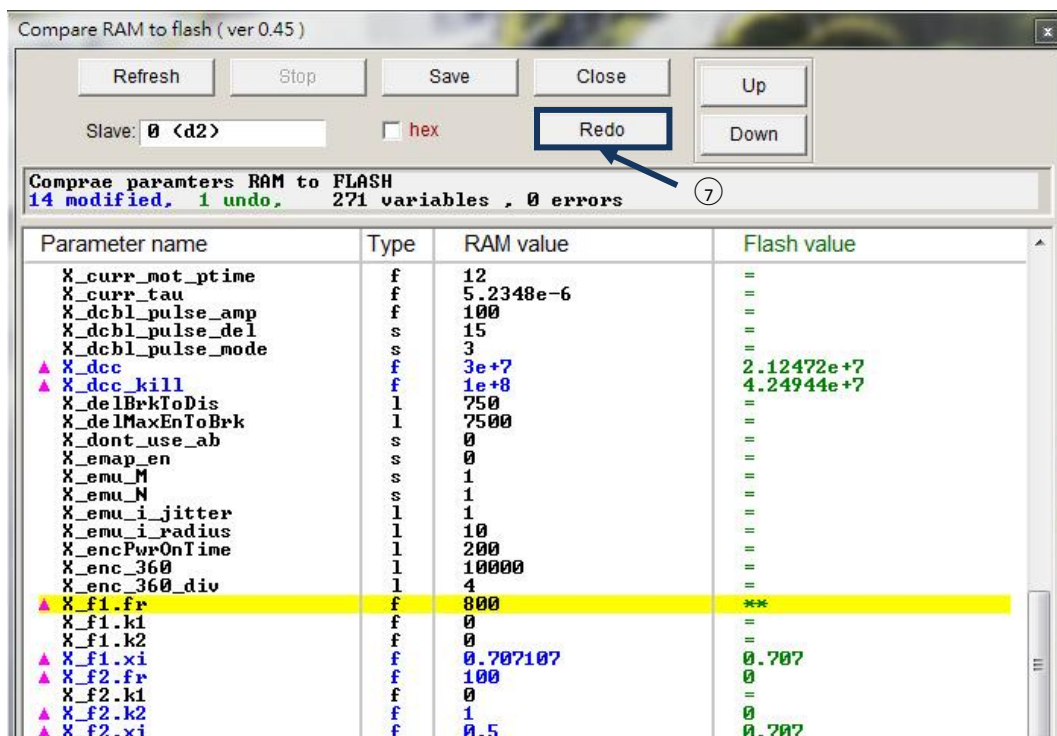


Figure11.1.3

- ⑦ Redo: Cancel the previous “Undo” action for the selected parameter.

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12. Update firmware and load PDL

12. Update firmware and load PDL	12-1
12.1 Update drive's firmware	12-2
12.2 Load PDL program into drive	12-5
12.3 Load parameter patch	12-7

12.1 Update drive's firmware

If the drive's firmware needs to be updated, click the "Tools" option on the main window and select "Upgrade/Downgrade firmware...", as shown in figure 12.1.1. Clicking "Upgrade/Downgrade firmware..." will appear the window of figure 12.1.2.

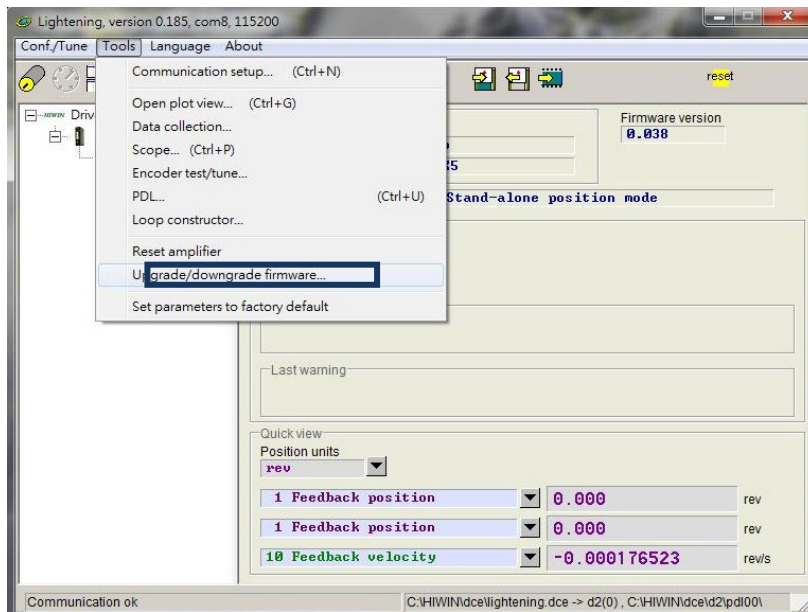


Figure 12.1.1

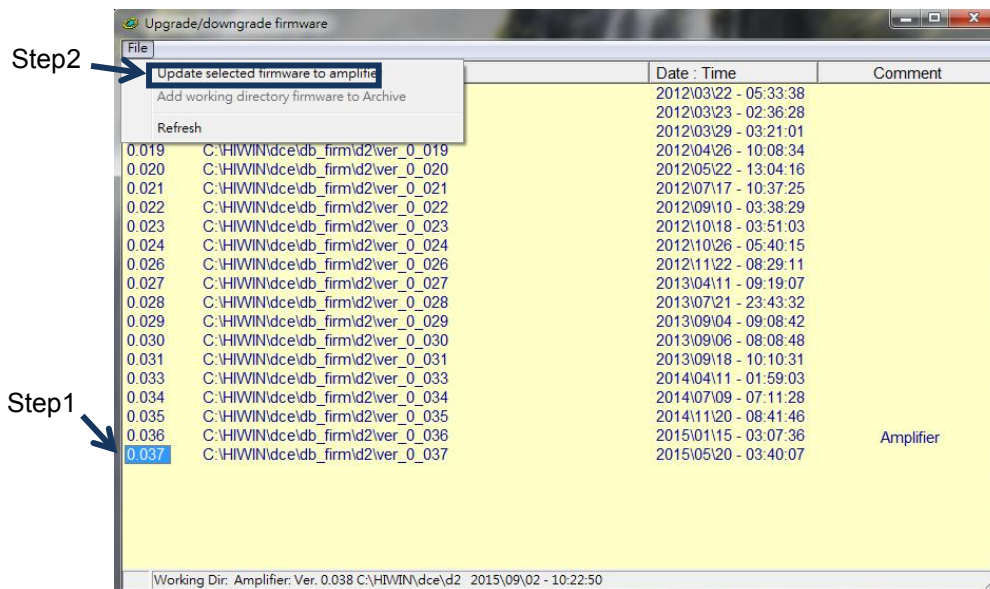


Figure 12.1.2 "Upgrade/Downgrade firmware" window

In the “Upgrade/Downgrade firmware” window, use following steps to complete the firmware update.

- Step 1: Click the left mouse button on the firmware version required to update, such that it is with white letters on the blue background.
- Step 2: Click the “File” option in the upper left corner of window and select “Update selected firmware to amplifier” to appear the dialog window of figure12.1.3.

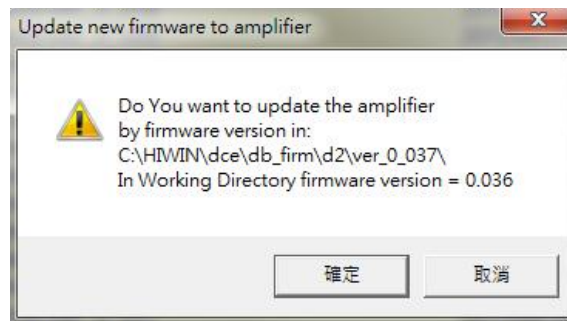


Figure12.1.3

- Step 3: Click the “Confirm” button to appear the “Auto load programs” window. The firmware will be loaded to the drive automatically, as shown in figure 12.1.4.

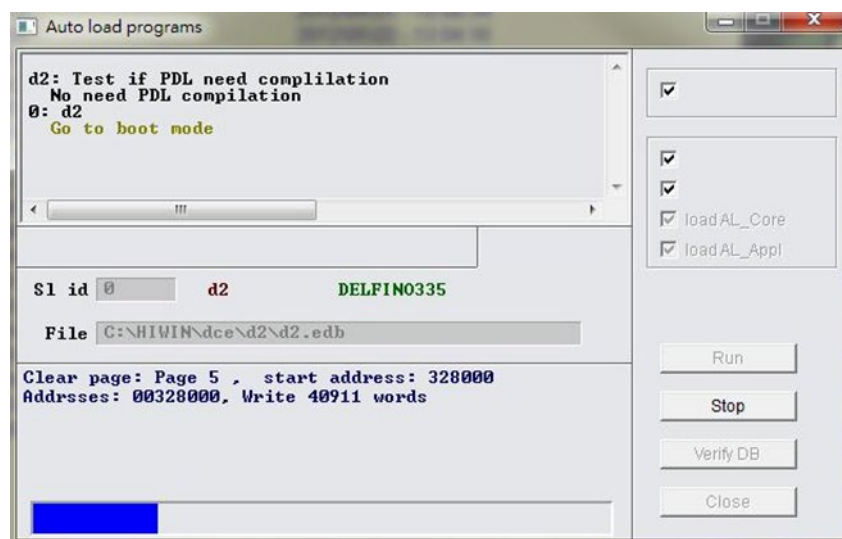


Figure12.1.4

- Step 4: After the firmware update is completed, the message window of figure 12.1.5 appears. Click the “Conform” button.

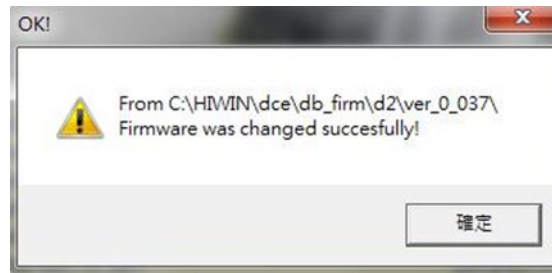


Figure12.1.5

Note:

If a power failure or communication error occurs during the firmware update, Lightning may stay at “Boot mode” and cannot be changed after the power is restored or the communication cable is connected again, as shown in figure 12.1.6. Please contact the franchised dealer to help eliminating it.

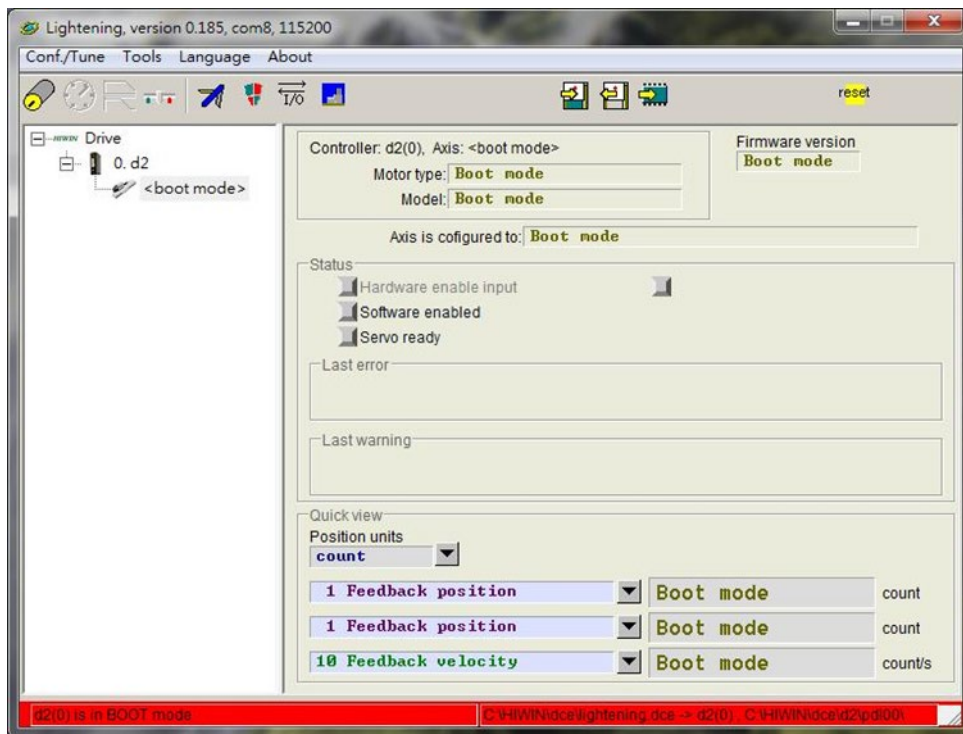


Figure12.1.6

12.2 Load PDL program into drive

To load the PDL program into the drive, use following steps to do it. To clear the PDL program in the drive, delete the code in “user.pdl” and use same steps to load the codeless “user.pdl” into the drive.

Step 1: Click the icon () shown in figure 12.2.1 to open the “PDL” window.

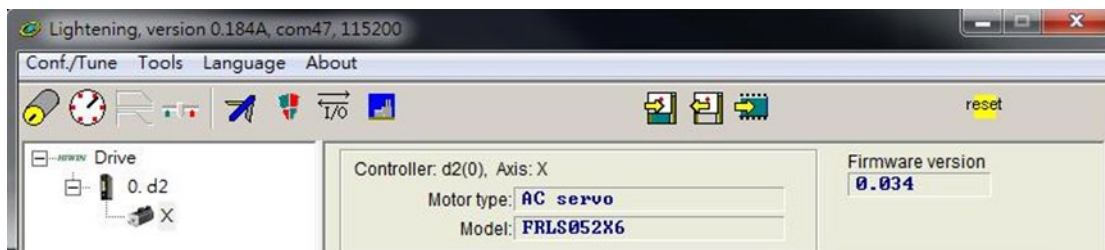


Figure12.2.1

Step 2: Click the “Edit” button to appear the PDL edit interface.

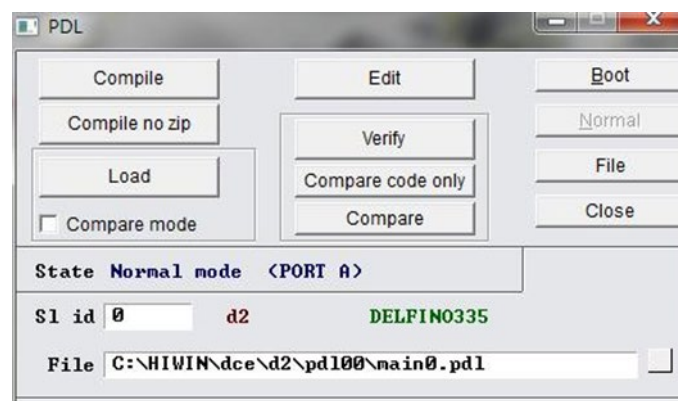


Figure12.2.2

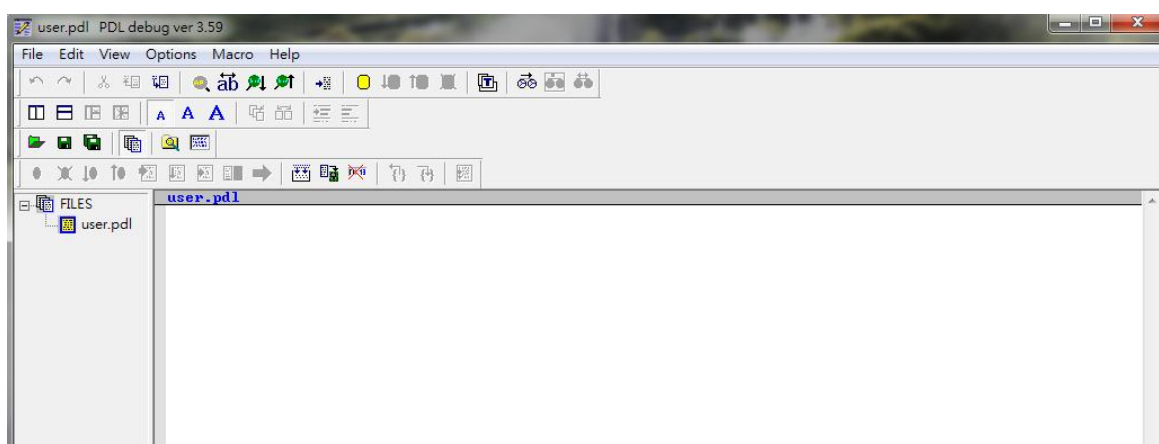


Figure12.2.3

Step 3: After pasting the PDL program or writing the PDL program, click the “Compile” icon () to appear the “Compile” window, as shown in figure 12.2.4.

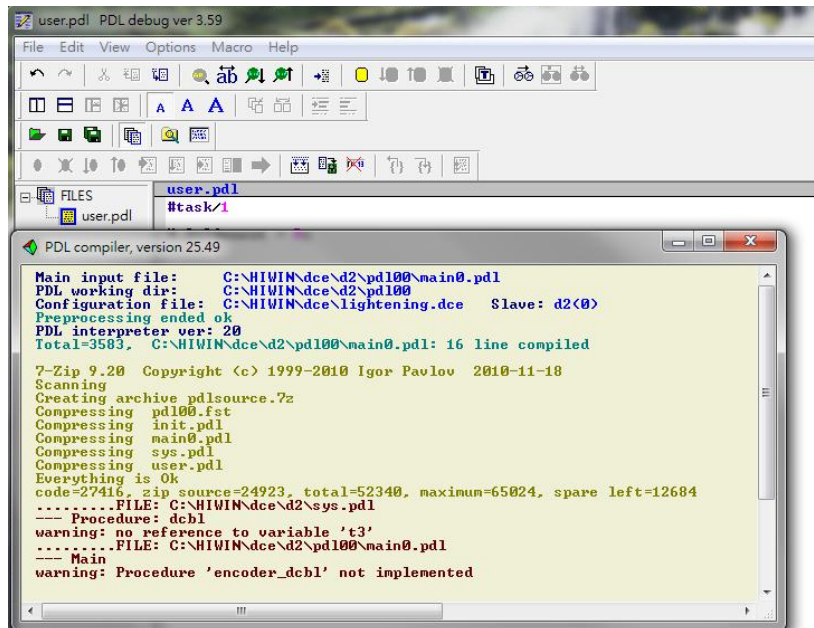


Figure12.2.4

Step 4: After “Compile” is completed, click the “Send to slave” icon () and click the “Confirm” button in the dialog window of figure 12.2.5 to appear the execution window of figure 12.2.6 After loading the PDL program is completed, this window will be closed automatically.

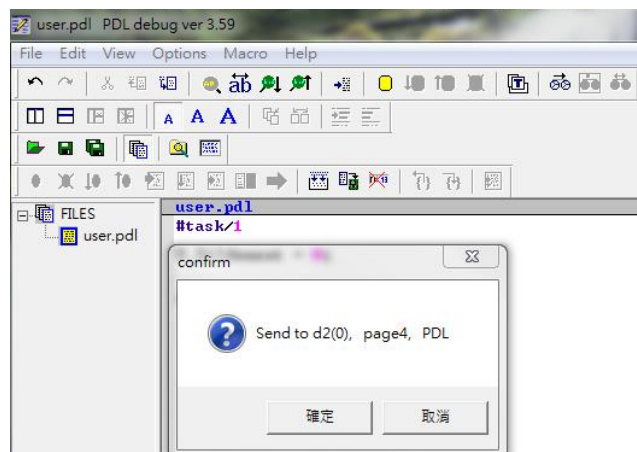


Figure12.2.5

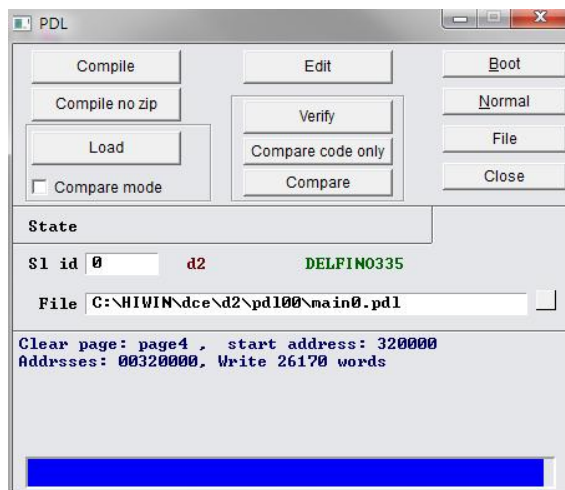


Figure12.2.6

12.3 Load parameter patch

The download path of parameter patch is the same as that of Lightning. The latest parameter patch is parameter_patch_4.6.

■ Extract parameter patch

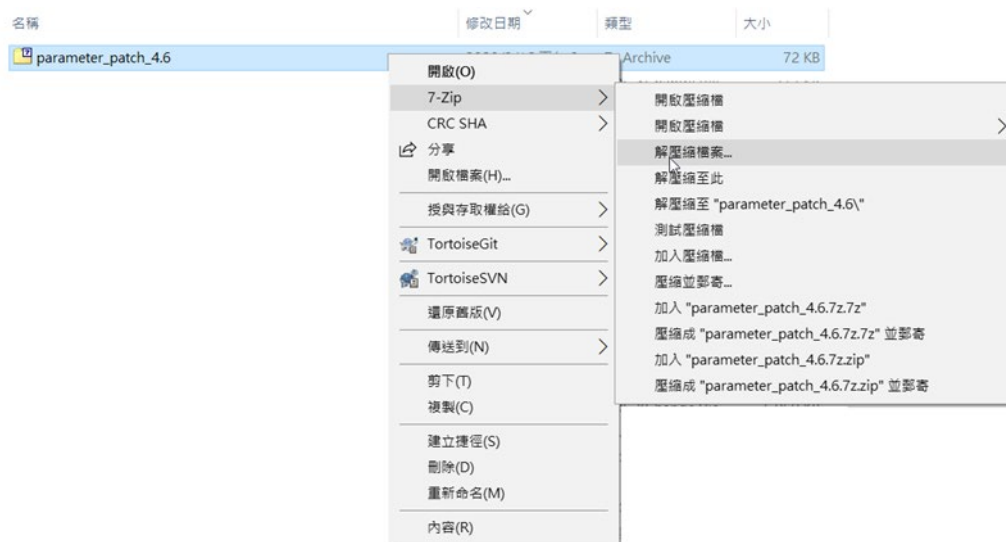


Figure12.3.1

■ Install parameter patch

After parameter patch is extracted, parameter_patch_4.6.exe appears. Click on this file. Then **HIWIN .mot generator dialog** window appears. Click on **(Y)** button to install the patch. Ignore the windows which appear during the installing process. After all the windows close, the installation completes.

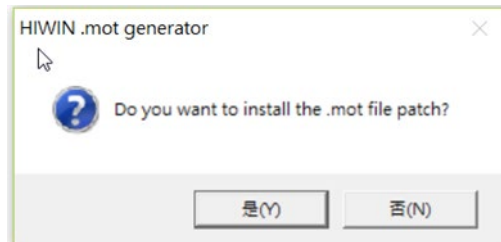


Figure12.3.2

■ Other

If Lightening is not installed, a warning window appears informing user that Lightening is not installed.



Figure12.3.3

13. Modbus communication

13. Modbus communication	13-1
13.1 Modbus communication specification	13-2
13.2 Function code	13-2
13.3 Modbus objects	13-6
13.3.1 Input register	13-7
13.3.2 Holding register	13-12

13.1 Modbus communication specification

The Modbus communication specification for D2-series drives is shown in the following table.

Table13.1.1

Interface	RS-485 2W-cabling	
Communication Cycle	Asynchronous (half duplex)	
Communication Parameters	Baud rate	2,400, 4,800, 9,600 (default), 14,400, 19,200, 38,400 bps
	Protocol	RTU (default), ASCII
	Data length ^(note 1)	8 bits (default), 7 bits
	Parity	Even (default), odd, none
	Start bit	1 bit
	Start bit ^(note 2)	1 bit (default), 2 bits
	Slave address	1 - 247

Note:

- (1) The data length in the RTU communication protocol is 8 bits; while that in the ASCII communication protocol is 7 bits.
- (2) The stop bit for the odd parity and even parity is 1 bits; while that for the none parity is 2 bits.

13.2 Function code

D2-series drives provide three types of function code, as given in the following table.

Table13.2.1

Function Code	Definition	Message Length (Bytes)			
		Command		Response*	
		Max	Min	Max	Min
03h	Read holding registers	8	8	255	7
04h	Read input registers	8	8	255	7
10h	Write multiple registers	255	11	8	8

Note:

*The message length of exception response is 5 bytes.

- (1) Read holding registers (03h)

This function is used to read the contents of the consecutive blocks of holding registers in the drive. The related data format is given in the following table. The content of each register is divided into the 8-bits higher data (“Hi”) and the 8-bits lower data (“Lo”). The maximum of consecutive blocks read at the same time is 125.

Table13.2.2

	Data Length	Value
Request		
Function code	1 Byte	03h
Starting address	2 Bytes	0x0000 - 0xFFFF
Quantity of registers	2 Bytes	1 - 125
Response		
Function code	1 Byte	03h
Byte count	1 Byte	2 x N
Register value	2 x N Bytes	
Error		
Error code	1 Byte	83h
Exception code	1 Byte	01h, 02h, 03h, 04h

Note:

N is the quantity of registers.

Table13.2.3

Exception Code	Exception Name	Cause
01h	Illegal function	The function code is not supported.
02h	Illegal data address	Try to read an illegal register.
03h	Illegal data value	The quantity of registers is too large (>125).
04h	Server device failure	The accessed data includes the incomplete data. For example, the host controller only requests 16 bits of 32-bits parameter.

The following table is an example of requesting to read registers 0x006B - 0x006D. For the case of normal response, the content of register 0x006B is shown as the 2-bytes value of "02 2Bh", the content of register 0x006C is the 2-bytes value of "00 00h", and the content of register 0x006D is the 2-bytes value of "00 64h".

Table13.2.3

Command			Response			Error		
Slave address	01h		Slave address	01h		Slave address	01h	
Function code	03h		Function code	03h		Error code	83h	
Starting address	Hi	00h	Byte count	06h		Exception code	02h	
	Lo	6Bh		Register 0x006B	Hi		02h	CRC
Quantity of registers	Hi	00h	Register 0x006C		Lo	2Bh	Hi	
	Lo	03h		Register 0x006D	Hi	00h		
CRC	Lo	74h	Lo		00h			
	Hi	17h	Hi	00h				
			CRC	Lo	64h			
				Lo	05h			

Command	Response		Error
	Hi	7Ah	

(2) Read input registers (04h)

This function is used to read the contents of the consecutive blocks of input registers in the drive. The related data format is given in the following table. The content of each register is divided into the 8-bits higher data (“Hi”) and the 8-bits lower data (“Lo”). The maximum of consecutive blocks read at the same time is 125.

Table13.2.4

	Data Length	Value
Request		
Function code	1 Byte	04h
Starting address	2 Bytes	0x0000 - 0xFFFF
Quantity of registers	2 Bytes	1 - 125
Response		
Function code	1 Byte	04h
Byte count	1 Byte	2 x N
Register value	2 x N Bytes	
Error		
Error code	1 Byte	84h
Exception code	1 Byte	01h, 02h, 03h, 04h

Note:

N is the quantity of registers.

Table13.2.5

Exception Code	Exception Name	Cause
01h	Illegal function	The function code is not supported.
02h	Illegal data address	Try to read an illegal register.
03h	Illegal data value	The quantity of registers is too large (>125).
04h	Server device failure	The accessed data includes the incomplete data. For example, the host controller only requests 16 bits of 32-bits parameter.

The following table is an example of requesting to read the register 0x0008. For the case of normal response, the content of register 0x0008 is shown as the 2-bytes value of “00 0Ah”.

Table13.2.6

Command			Response			Error		
Slave address	01h		Slave address	01h		Slave address	01h	
Function code	04h		Function code	04h		Error code	84h	
Starting address	Hi	00h	Byte count		02h	Exception code		02h
	Lo	08h	Register 0x0008	Hi	00h	CRC	Lo	C2h
Quantity of registers	Hi	00h		Lo	0Ah		Hi	C1h
	CRC	Lo	01h	CRC	Lo	35h		
Lo		B0h	Hi		37h			
Hi		08h						

(3) Write multiple registers (10h)

This function is used to write the data into consecutive blocks of registers in the drive. The maximum of consecutive blocks read at the same time is 123.

Table13.2.7

	Data Length	Value
Request		
Function code	1 Byte	10h
Starting address	2 Bytes	0x0000 - 0xFFFF
Quantity of registers	2 Bytes	1 - 123
Byte count	1 Byte	2 x N
Register value	2 x N Bytes	
Response		
Function code	1 Byte	10h
Starting address	2 Bytes	0x0000 - 0xFFFF
Quantity of registers	2 Bytes	1 - 123
Error		
Error code	1 Byte	90h
Exception code	1 Byte	01h, 02h, 03h, 04h

Note:

N is the quantity of registers.

Table13.2.8

Exception Code	Exception Name	Cause
01h	Illegal function	The function code is not supported.
02h	Illegal data address	Try to write an illegal register.
03h	Illegal data value	The quantity of registers is too large (>123).
04h	Server device failure	The accessed data includes the incomplete data. For example, the host controller only writes 16 bits of 32-bits parameter.

The following table is an example of requesting to write the data of “00 0Ah” and “01 02h” into 2 registers, where the starting address is 0x0001.

Table13.2.9

Command			Response			Error					
Slave address	01h		Slave address	01h		Slave address	01h				
Function code	10h		Function code	10h		Function code	90h				
Starting address	Hi	00h	Starting address	Hi	00h	Exception code					
	Lo	01h		Lo	01h	CRC	Lo	CDh			
Quantity of registers	Hi	00h	Quantity of registers	Hi	00h		Hi	C1h			
	Lo	02h		Lo	02h	/					
Byte count		04h	CRC	Lo	10h						
Register 0x0001	Hi	00h		Hi	08h						
	Lo	0Ah									
Register 0x0002	Hi	01h									
	Lo	02h									
CRC	Lo	92h									
	Hi	30h									

13.3 Modbus objects

The data type of Modbus object is listed in the following table.

Table13.3.1

Code	Data Type	Range
INT16	Signed 16 bit	-32,768 to +32,767
INT32	Signed 32 bit	-2,147,483,648 to +2,147,483,647
UINT16	Unsigned 16 bit	0 to 65,535
UINT32	Unsigned 32 bit	0 to 4,294,967,295
REAL32	Float 32 bit	-

13.3.1 Input register

The data length of each readable input register is 32 bits.

Table13.3.1

Object	Register Address	Description	Type	Unit	
1	0x0000	Feedback position	Lower data	INT32	counts
	0x0001		Higher data		
2	0x0002	Reference position	Lower data	INT32	counts
	0x0003		Higher data		
4	0x0006	Position error	Lower data	INT32	counts
	0x0007		Higher data		
10	0x0012	Feedback velocity	Lower data	REAL32	count/s
	0x0013		Higher data		
11	0x0014	Reference velocity	Lower data	REAL32	count/s
	0x0015		Higher data		
12	0x0016	Velocity error	Lower data	REAL32	count/s
	0x0017		Higher data		
30	0x003A	Actual current	Lower data	REAL32	A _{amp}
	0x003B		Higher data		
31	0x003C	Command current	Lower data	REAL32	A _{amp}
	0x003D		Higher data		
40	0x004E	Analog command	Lower data	REAL32	mV
	0x004F		Higher data		
41	0x0050	Bus voltage	Lower data	REAL32	V
	0x0051		Higher data		
51	0x0064	Soft-thermal accumulator	Lower data	REAL32	%
	0x0065		Higher data		
53	0x0068	Average load ratio	Lower data	REAL32	%
	0x0069		Higher data		
54	0x0070	Peak load ratio	Lower data	REAL32	%
	0x0071		Higher data		
55	0x0072	Current effective value	Lower data	REAL32	A _{amp}
	0x0073		Higher data		
61	0x0078	Status 5	Lower data	UINT32	-
	0x0079		Higher data		
81	0x00A0	Status 4	Lower data	UINT32	-
	0x00A1		Higher data		
90	0x00B2	Status 6	Lower data	UINT32	-

Object	Register Address	Description	Type	Unit	
	0x00B3		Higher data		
91	0x00B4	Status 0	Lower data	UINT32	-
	0x00B5		Higher data		
2001	0x0FA0	Mode of operation display	Lower data	INT32	-
	0x0FA1		Higher data		
2002	0x0FA2	Drive error events 1	Lower data	UINT32	-
	0x0FA3		Higher data		
2003	0x0FA4	Drive error events 2	Lower data	UINT32	-
	0x0FA5		Higher data		
2004	0x0FA6	Status 1	Lower data	UINT32	-
	0x0FA7		Higher data		
2005	0x0FA8	Status 2	Lower data	UINT32	-
	0x0FA9		Higher data		
2006	0x0FAA	Status 3	Lower data	UINT32	-
	0x0FAB		Higher data		
2008	0x0FAE	Feedback position of secondary encoder	Lower data	INT32	count
	0x0FAF		Higher data		
2009	0x0FB0	Hybrid deviation error	Lower data	REAL32	count
	0x0FB1		Higher data		

(1) Object 61 – Status 5

Table13.3.2

Bit	Definition
0	I1
1	I2
2	I3
3	I4
4	I5
5	I6
6	I7
7	I8
8	I9
9	I10
10 - 15	-

(2) Object 81 – Status 4

Table13.3.3

Bit	Definition
0 - 3	-
4	O1
5	O2
6	O3
7	O4
8	O5
9 - 11	-
12	CW/CCW input
13	Buffer encoder invert
14	Buffer/emulated encoder output
15	-

(3) Object 90 – Status 6

Table13.3.4

Bit	Definition
0	-
1	Index
2 - 15	-

(4) Object 91 – Status 0

Table13.3.5

Bit	Definition
0	Moving
1	Encoder error
2	-
3	In position
4	Right hardware limit
5	Left hardware limit
6	Position error too big
7	Soft thermal threshold reached
8	Axis disable
9	-
10	Homed
11	-
12	Both hardware limits are active
13	Serial encoder communication error
14	Motor over temperature
15	Amplifier over temperature

(5) Object 2002 – Drive error events 1

Table13.3.6

Bit	Definition
0	-
1	Encoder error
2 - 5	-
6	Position error too big
7	Soft-thermal threshold reached
8 - 12	-
13	Serial encoder communication error
14	Motor over temperature sensor activated
15	Amplifier over temperature
16 - 17	-
18	Motor short (over current) detected
19	Over voltage detected
20	Under voltage detected
21	Motor maybe disconnected
22 - 30	-
31	5V for encoder card fail

(6) Object 2003 – Drive error events 2

Table13.3.7

Bit	Definition
0	-
1	Phase initialization error
2 - 4	-
5	Hall sensor error
6	Hall phase check error
7 - 15	-
16	Current control error
17	HFLT inconsistent error
18	Auto phase center not complete error
19	-
20	Hybrid deviation too big
21 - 22	-
23	DC bus voltage abnormal
24 - 29	-
30	EtherCAT interface disconnected
31	CiA-402 home failed

(7) Object 2004 – Status 1

Table13.3.8

Bit	Definition
0 - 1	-
2	Motor short
3	Over voltage
4	Under voltage
5	Motor may be disconnect
6	Left software limit
7	Right software limit
8	Current limited
9	Acceleration limited
10	Velocity limited
11	Servo ready
12	Servo voltage big
13	Position error warning
14	Velocity error warning
15	5V for encoder card fail

(8) Object 2005 – Status 2

Table13.3.9

Bit	Definition
0	Emulated index
1	Phase initialization error
2 - 4	-
5	Hall sensor error
6	Hall phase check error
7 - 8	-
9	Zero speed detected
10 - 13	-
14	I2T warning
15	Pulse command and home conflict

(9) Object 2006 – Status 3

Table13.3.10

Bit	Definition
0	Current control error
1	HFLT inconsistent error
2 - 4	-
5	Homing fail
6	Absolute encoder battery warning
7	DC bus voltage abnormal
8	Wrong absolute position
9 - 15	-

13.3.2 Holding register

The data length of each readable/writable holding register is 32 bits.

Table13.3.2.1

Object	Register Address	Description	Type	Unit	
0	0x0000	Maximum acceleration	Lower data	REAL32	count/s ²
	0x0001		Higher data		
1	0x0002	Maximum deceleration	Lower data	REAL32	count/s ²
	0x0003		Higher data		
2	0x0004	Kill deceleration	Lower data	REAL32	count/s ²
	0x0005		Higher data		
3	0x0006	Maximum velocity	Lower data	REAL32	count/s
	0x0007		Higher data		
39	0x004E	Home velocity (Index search speed)	Lower data	INT32	count/s
	0x004F		Higher data		
40	0x0050	Homing time out	Lower data	INT32	1s/15,000
	0x0051		Higher data		
50	0x0064	Maximum following error	Lower data	REAL32	A _{amp}
	0x0065		Higher data		
79	0x009E	AC servo gear ratio	Lower data	REAL32	-
	0x009F		Higher data		
81	0x00A2	Numerator of electronic gear ratio	Lower data	INT32	-
	0x00A3		Higher data		
82	0x00A4	Denominator of electronic gear ratio	Lower data	INT32	-
	0x00A5		Higher data		

Object	Register Address	Description		Type	Unit
83	0x00A6	Velocity scale for external command	Lower data	REAL32	count/s = 1 V
	0x00A7		Higher data		
85	0x00AA	Current scale for external command	Lower data	REAL32	$(A_{amp} \times 1,000) / (\text{curr_drv_peak}) = 1 \text{ V}$
	0x00AB		Higher data		
115	0x00E6	Smooth factor	Lower data	UINT32	-
	0x00E7		Higher data		
129	0x0102	Pulse mode	Lower data	INT32	-
	0x0103		Higher data		
130	0x0104	Pulse command inversion	Lower data	UINT32	-
	0x0105		Higher data		
212	0x01A8	Operation mode	Lower data	UINT32	-
	0x01A9		Higher data		
216	0x01B0	Encoder output setting	Lower data	INT32	-
	0x01B1		Higher data		
219	0x01B6	CW/CCW logic	Lower data	UINT32	-
	0x01B7		Higher data		
241	0x01E2	Input signal logic	Lower data	INT32	-
	0x01E3		Higher data		
280	0x0230	Output signal logic	Lower data	UINT32	-
	0x0231		Higher data		
340	0x02A8	Load level	Lower data	UINT32	-
	0x02A9		Higher data		
347	0x02A2	Direction of second encoder	Lower data	INT32	-
	0x02A3		Higher data		
348	0x02A4	Hybrid deviation limit	Lower data	INT32	-
	0x02A5		Higher data		
350	0x02BC	Brake activation delay time	Lower data	INT32	-
	0x02BD		Higher data		
355	0x02C6	Output emulated index per revolution	Lower data	INT32	-
	0x02C7		Higher data		
368 ~ 372	2 x index ~ 2 x index + 1	General purpose REAL32 parameter	Lower data Higher data	REAL32	-
373 ~ 387	2 x index ~ 2 x index + 1	General purpose INT32 parameter	Lower data Higher data	INT32	-
2000	0x0FA0	Target position	Lower data	INT32	count
	0x0FA1		Higher data		
2001	0x0FA2	Target velocity	Lower data	INT32	count/s
	0x0FA3		Higher data		

Object	Register Address	Description		Type	Unit
2002	0x0FA4	Target current	Lower data	INT32	0.1%A
	0x0FA5		Higher data		
2003	0x0FA6	Stop motion	Lower data	UINT32	-
	0x0FA7		Higher data		
2007	0x0FAE	Jog velocity	Lower data	REAL32	count/s
	0x0FAF		Higher data		

14. EMC solution

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14.1 Common-mode motor filter

A common-mode motor filter can be considered when following situations occur.

- (1) For the drive with the 17-bit encoder, the encoder feedback is disturbed and the error of “serial encoder communication error” occurs when the drive is enabled.
- (2) Reduce the common-mode noise at the drive’s output.

The part number of HIWIN self-made common-mode motor filter is MC-CM-S. It is suitable for D2-series drives with the power less than 2 KW (inclusive). The specification is given in the following table. When the external common-mode motor filter is used, the effect of common-mode inductor should be considered to improve the performance of motor control.

Table14.1.1

Item		Specification
Input	Maximum voltage	373 Vdc
	Maximum current	11 A _{rms}
Output	Maximum voltage	373 Vdc
	Maximum current	11 A _{rms}
Peak current* /Maximum duration of peak current		33 A _{rms} / 1 second
Ambient operating temperature [†]		0 to 50°C
Common-mode inductor (line)		1,100 μH (nominal)

Note:

- (1) *The maximum input/output peak current can be maintained for 1 second from the start.
- (2) [†]If the drive is operated below the maximum temperature, no cooling fan is required. However, if the ambient temperature exceeds 50°C, an external fan should be used for cooling. The fan should have a flow rate of at least 110 cubic feet (CFM).

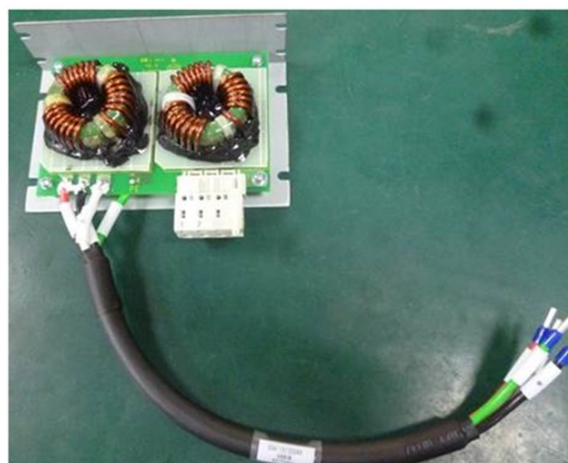


Figure14.1.1

The MF-CM-S dimensions are shown as follows.

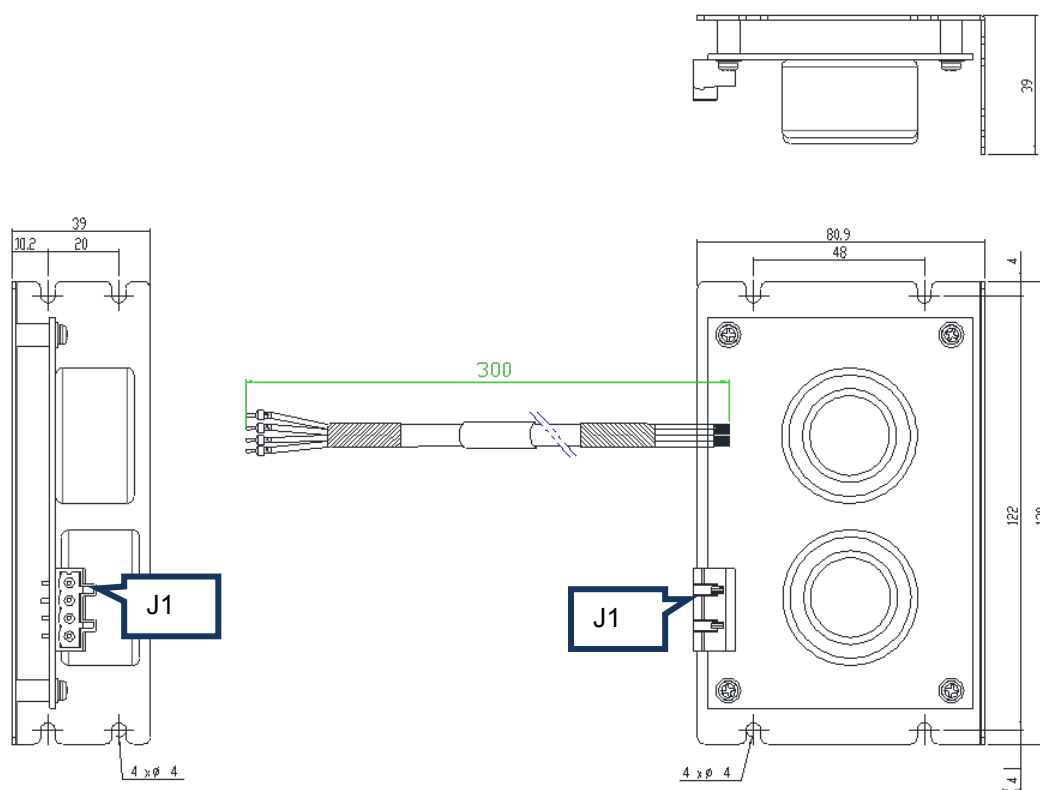


Figure14.1.2

The wiring diagram of common-mode motor filter with the drive and motor is given as follows.

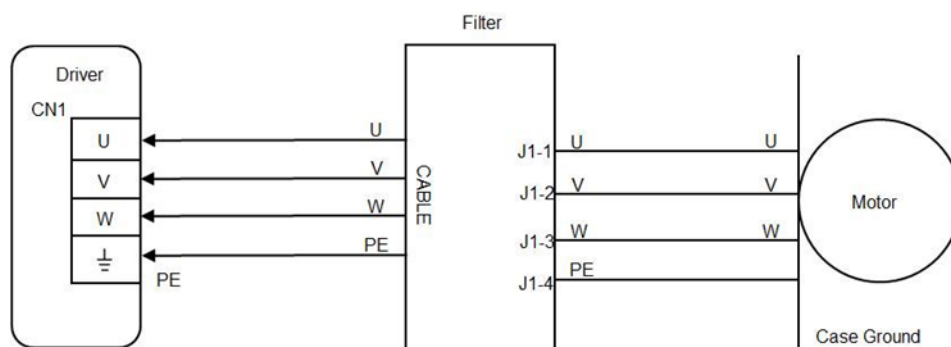


Figure14.1.3

■ Instruction

- (1) Insert the terminal of common-mode motor filter into the drive CN1 in sequence based on the line marked.
- (2) Insert the motor cable into the connector of common-mode motor filter based on the label on the connector.

A. Filter to drive

Table14.1.1 Specification for the filter-to-drive cable

Description	E191346 AWM 2586 2mm 2x4C 105°C 600V VW-1 AWM I/II B 2mm2x4C 105°C 600V FT1 SIN YU RoHS SUPER FLEXIBLE AND OIL RESISTANCE CE
Cable Size	14 AWG

Table14.1.2 Pin assignment for the filter-to-drive cable

Pin (Color)	Name	Function
Red	U	Connect to the drive's U-phase (input)
White	V	Connect to the drive's V-phase (input)
Black	W	Connect to the drive's W-phase (input)
Green	PE	Housing ground and cable shielding

B. Filter (J1) to motor

Table14.1.3 Specification for the filter J1

Description	4 position, 7.5mm pluggable female terminal block.
Manufacturer PN	Wago 721-864/001-000
Cable Size	28 – 12 AWG
Recommended Wire	14 AWG, 600 V
Wire Insertion/ Extraction Tool	475604 (SUPU) 4PIN, Female, pitch 7.5mm

Table14.1.4 Connector definition

Pin	Name	Function
1	U	Connect to the motor's U-phase (output)
2	V	Connect to the motor's V-phase (output)
3	W	Connect to the motor's W-phase (output)
4	PE	Housing ground and cable shielding

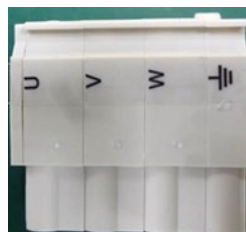


Figure14.1.4 Connector

⚠ DANGER

- It has the risk of electric shock.
- The cable and J1 connector are the high-voltage circuit and are connected to the main power.
- Not paying attention to these warnings could result in the equipment damage, injury, or death.
- Be careful when installing.
- Not paying attention to these warnings could result in the equipment damage, injury, or death.

14.2 Motor power cable with magnetic rings

When the motor (100 W - 750 W) is at the enable state, if the control signal is subject to the noise interference, a magnetic ring can be considered to install in the motor power cable.

(1) Motor power cable including internal magnetic rings

Table14.2.1

Part No.	Specification	Quantity	Description	Note
HE00831M2800	AC P.C. + Core	1	Motor filter (100 W to 750 W only)	1. The power cable does not contain the brake signal. 2. The length of power cable is about 2.4 meters.

Table14.2.2

Item	Specification
Maximum Voltage	240 Vac
Maximum Current	7.5 A _{rms}
Peak Current/Maximum Duration Of Peak Current	15 A _{rms} /1 second
Ambient Operating Temperature	0 to 40 °C

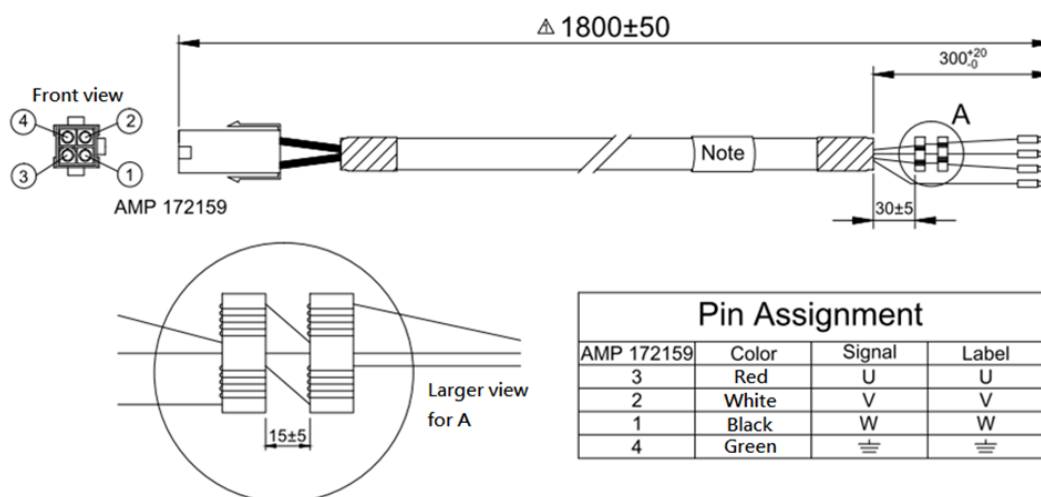


Figure14.2.1

(2) Cable with plug-in magnetic rings

The electrical specification for this product is the same as that given in table 14.2.3.

Table14.2.3

Part No.	Specification	Quantity	Description	Note
HE00831RB200	Plug-in CM choke filter	1	Motor filter (100 W to 750 W only)	-

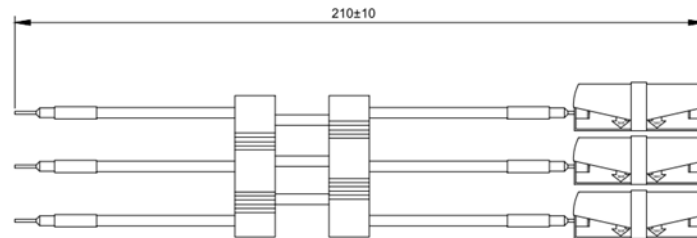


Figure14.2.2