



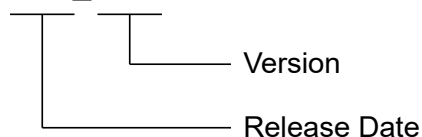
D1 Servo Drive

User Manual

Revision History

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

MD20UE01-2206_V3.1



Release Date	Version	Applicable Product	Revision Contents
Jun. 22 nd , 2022	3.1	D1 servo drive	(1) Add section 2.5 Derated value .
Sep. 24 th , 2021	3.0	D1 servo drive	(1) Update section 2.1.2 Model explanation . (2) Update section 2.2 Basic specifications . (3) Update section 4.1.1 System connection . (4) Update section 4.2 Wiring for main circuit . (5) Update section 10.2 Heat sink . (6) Delete the related information of Hybrid brake regenerate .
Jan. 20 th , 2021	2.9	D1 servo drive	(1) Update section 2.2 Basic specifications . (2) Update section 4.2 Wiring for main circuit . (3) Update section 8.3 Brake protection .
Mar. 11 th , 2020	2.8	<ul style="list-style-type: none"> D1 firmware version 0.250 or later version D1 CoE firmware version 0.33 or later version Lightening version 0.197 or later version 	This user manual is translated from the Chinese user manual D1驅動器使用者操作手冊 (version 2.8), so the version number starts from 2.8.

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1. About this user manual

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1.1 General precautions

Before using the product, please carefully read through this user 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 user 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 user.
- ◆ 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 specifications noted on the product label or technical document. Install the product according to its specifications and installation instructions stated in this user manual.
- ◆ Ensure the product is used with the power supply specified on the product label or in the product requirement. HIWIN is not responsible for any damage, accident or injury caused by incorrect power supply.
- ◆ Ensure the product is used with its 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 servo drive, please refer to section 9.4 and follow the instructions for troubleshooting. After the error is cleared, power on the servo 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. Warranty starts on the shipping date of the product. The warranty does not cover damage caused by improper usage (Refer to the notices and instructions stated in this user manual.) or natural disaster.







CAUTION

- The maximum ambient temperature must be below 55 °C.
- The product can only be installed in an environment with pollution degree not exceeding 2.
- The control power input must be: 24 Vdc, 1 A and level 2.
- The rated voltage input is 240 V. Short-circuit current must be below 5000 A.
- Before inspection, please turn off the power and wait for at least 5 minutes. To avoid electric shock, ensure the residual voltage between P and N terminals has dropped to 50 Vdc or lower by using multimeter.

1.2 Safety precautions

- Carefully read through this user 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 operation.
- Safety precautions in this user 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 servo drive is correctly grounded. Use PE bar in the control cabinet as reference potential. Perform low-ohmic grounding for safety reason.
- Do not touch motor power connectors even when motor is not moving. Do not remove motor power cable from the servo drive when it is still power-on, or there is a risk of electric shock or damage to the contacts.
- Do not touch live part (contact or bolt) or connector within 5 minutes after disconnecting the servo drive from power supply. For safety reason, we suggest measuring the voltage in the intermediate circuit and wait until it falls to 40 Vdc.

◆ 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 the internal part of the product within 10 minutes after power off, or the residual voltage may cause electric shock. ◆ Do not modify the wiring when power on, or it may cause electric shock. ◆ Do not damage, apply excessive force to, place any heavy object on the cables or put the cables between two objects, or it may cause electric shock or fire. ◆ If motor with brake is used, follow the enabling procedure stated in section 8.3. Do not command the motor to move right after enabling.
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 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.
<p>◆ Storage</p>	
 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.
<p>◆ Transportation</p>	
 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.
<p>◆ Installation site</p>	
 Required	<ul style="list-style-type: none"> ◆ Do not install the product in location with high ambient temperature or high humidity. Do not install the product in location which is subject to dust, iron powder or cutting powder. ◆ Install the product in location with ambient temperature stated in the user manual. Use cooling fan when 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 while 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.
<p>◆ Installation</p>	
 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. ◆ While installing the product, please consider its weight. Improper installation may cause damage. ◆ Install the product on noncombustible object, such as metal to avoid fire.
<p>◆ Wiring</p>	
 Attention	<ul style="list-style-type: none"> ◆ Ensure wiring is correctly performed. Otherwise, it may lead to malfunction or motor burn-out, causing a risk of injury or fire.

◆ Operation and transportation

 Attention	<ul style="list-style-type: none"> ◆ 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.
 Required	<ul style="list-style-type: none"> ◆ Set external wiring for emergency stop to stop the motor at any time.

◆ Maintenance

 Prohibited	<ul style="list-style-type: none"> ◆ Do not disassemble or modify the product. ◆ Do not repair the product by yourself, please contact HIWIN for repair.
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2.1 Safety certificates and model explanations

2.1.1 Safety certificates

D1 servo drive complies with the following safety standards.

■ CE compliance

Table2.1.1.1

EMC	EN61800-3: 2004 (Category C3)
	EN61000-3-2: 2006/A1: 2009/A2: 2009
	EN61000-3-3: 2008
	EN61000-6-2: 2005
	IEC CISPR 11: 2009/A1: 2010
	IEC61000-4-2: 2008
	IEC61000-4-3: 2006/A1: 2007/A2: 2010
	IEC61000-4-4: 2004
	IEC61000-4-5: 2005
	IEC61000-4-6: 2008
	IEC61000-2-1: 1990
	IEC61000-2-4: 2003
	IEC60146-1-1: 1993
LVD	EN 61800-5-1: 2007

2.1.2 Model explanation

The model explanation of D1 servo drive is provided as below.

Column	1	2	2A	3	4	5	6	7	8	9	10	11	12	13	14	15
Example	D	1		-	3	6	-	S	2	-	2	-	0	-	0	0

Product Name

D1.....= D1

Rated Output

36 A.....= 36

Communication Interface

Standard format RS232 (No communication interface)....= S

EtherCAT (CoE)= E

EtherCAT (mega-ulink).....= F

Encoder Type

Analog.....= 2

Digital.....= 3

Resolver= 4

Input Voltage

1Φ/3Φ 220 V= 2

Heat Sink

Without heat sink.....= 0

High profile (H1).....= 1

Reserved Code

Standard.....= 00

2.2 Basic specifications

Table2.2.1

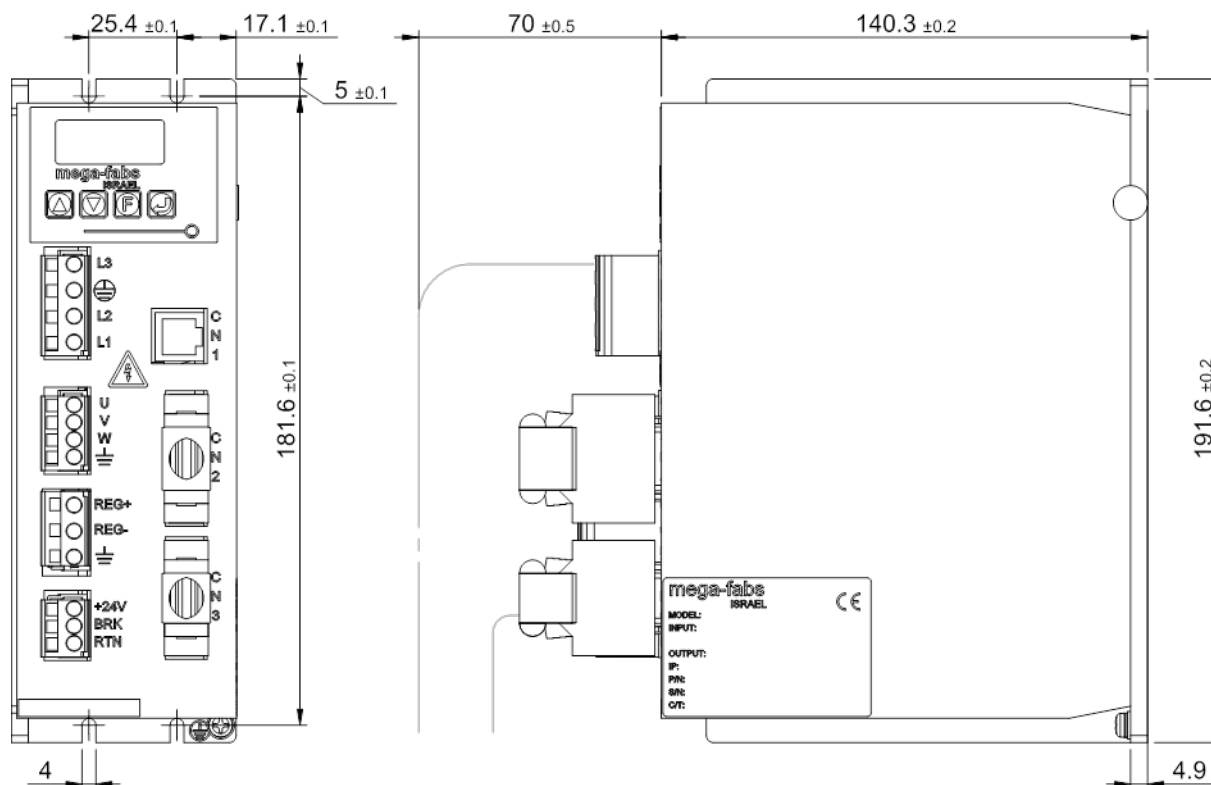
D1				D1-36	
Input Power	Voltage			100 - 240 Vac ±10%	
	Frequency			47 to 63 Hz	
	Phase			1 Ø or 3 Ø	
	Control Voltage			+24 Vdc ±10%	
	Control Current			1 A minimum	
Output Power	Continuous Current			12 A_amp [8.5 A_rms] (Note: with external heat sink)	
	Instantaneous Current			36 A_amp [25.4 A_rms]	
	Allowable Continuous Time for Instantaneous Current			1 second maximum	
Servo Drive Startup Time				1~2 seconds	
Servo Drive Reset Time				3~4 seconds	
Main Circuit Control				IGBT PWM space vector control	
Control Motor Type				• 13 bit AC servo motor • Linear motor • Torque motor	
Status LED Indicator		Servo Drive Status		Red: Error Green: Servo ready	
Control Mode	Position Mode	Input Pin		[I9, I9M], [I10, I10M] differential inputs or I9, I10 single-ended inputs	
		Pulse Command Type		• Pulse/Direction • CW/CCW • AqB	
		The Maximum Input Pulse Frequency	Differential Signal	Pulse input (2 M pulses/s max.); Quad A/B (8 M counts/s max.)	
			Single-ended Signal	Pulse input (500 K pulses/s max.); Quad A/B (2 M counts/s max.)	
		Command Source		Pulse from controller	
		Electronic Gear		Electronic gear ratio: pulses /counts Pulses: 1~2147483647; Counts: 1~2147483647	
	Velocity Mode	Analog Input Command	Input Impedance	10 KΩ	
			Voltage Range	±10 Vdc	
			Time Constant	2.2 us	
			Resolution	12 bits	
		Digital Input Command	PWM 100%	I9: PWM = 0% - 100% I10: Direction = 1/0	
			PWM 50%	I9: PWM = 50% ± 50% I10: No function	
			Frequency Range	36.5 KHz minimum, 100 KHz maximum	
			Pulse Width Limit	220 ns minimum	
	Command Source		Voltage or PWM from controller		

	Force/ torque Mode	Analog Input Command		The specification is the same as the one in velocity mode.
		Digital Input Command		The specification is the same as the one in velocity mode.
		Command Source		Voltage or PWM from controller
Encoder Type	Operating Voltage		+5 Vdc ± 5% @400 mA	
	Digital	Input Signal	A, /A, B, /B, Z, /Z, RS422 differential signal	
		Bandwidth	5 MHz line frequency, x 4 frequency: 20 M counts/s	
	Analog	Input Amplitude	1 Vpp (sin/cos), differential signal	
		Bandwidth	1 MHz maximum line (cycle) frequency	
		Resolution	Maximum 65528 counts/cycle	
Resolver		Sin/Cos, differential signal Reference 3 KHz, 6 Vpp, 100 mA		
Encoder Counting Range				-2147483648~2147483647 (32 bits) The motor commutation is normal and is not affected by encoder counting range.
Buffered Encoder Output	Digital Encoder		<ul style="list-style-type: none">Without being processed by the servo drive, A/B phase signals are directly sent to the controller. (Maximum 18 M counts/s, digital AqB output, differential signal output)Without being processed by the servo drive, Z phase signals are directly sent to the controller. (Differential signal)The delay time between the time the servo drive receives encoder signal from the encoder and the time the servo drive outputs signal from output pin is less than 100 nanosecond (ns).	
	Analog Encoder		<ul style="list-style-type: none">Maximum 18 M counts/s, digital AqB output, differential signal outputThe resolution is the grating period of analog encoder/4. (If grating period = 40 um, the resolution of buffered encoder output = 10 um/count)The delay time between the time the servo drive receives encoder signal from the encoder and the time the servo drive outputs signal from output pin is less than 100 nanosecond (ns).	
Emulated Encoder Output				<ul style="list-style-type: none">Maximum 18 M counts/s, digital AqB output, differential signal outputThe ratio of encoder input to emulated encoder output can be adjusted. The width of emulated index signal output can be adjusted.Linear motor: (1) Outputs one index (Z phase) signal per travel distance Rotary motor: (1) Outputs one index (Z phase) signal per travel distance (2) Outputs one index (Z phase) signal per motor revolutionThe maximum delay time between the time the servo drive receives encoder signal from the encoder and the time the servo drive outputs signal from output pin is 66.67 us.
Digital Hall Signal				Digital single-ended signal with 120 degrees phase difference HA, HB, HC
Communication	Interface		Connect to PC via RS232	
	Protocol		<ul style="list-style-type: none">Full-duplexBaud rate: 9,600 ~ 115,200 bpsBinary	
Programmable I/O Interface	Digital Input		74HC14 Schmitt trigger input Inputs [I1~I6] [I11, I12] [I9, I10] 10 digital inputs are provided.	

		Note: When I9 and I10 are set for digital inputs, they cannot be programmed as general inputs.
	Digital Output	0.3 Adc max, +40 Vdc max (Open drain) [O1~O3]
	Brake Output	Brake [O4], 1 Adc max.
PDL Editor	The Maximum Storage for Codes	32K Bytes
	Storage for Variables	800 Bytes
	Supported Variable Type	Float: 32 bits Integer: 16 bits and 32 bits (Array and pointer are supported.)
	Execution Cycle	66.67 us
	Multitasking	Four tasks can be run at the same time.
	Control Commands for Program Flow	Supports commands such as "if", "else", "while loop", "for loop", "goto", "till", etc.
	Operator	Includes arithmetic operators, logic operators and comparison operators.
	Task Synchronization	Supports Lock and Unlock commands to perform task synchronization.
	Length Limit for User-defined Name	<ul style="list-style-type: none"> Variable: 17 characters Label: 24 characters Proc: 24 characters
Regenerative Resistor	Resistor	External connection
	Voltage Threshold for Activation	+HV > 390 Vdc
	Voltage Threshold for Deactivation	+HV < 380 Vdc
	Hysteresis	10 V ± 0.5 Vdc
	DC Link Capacity	1880 uF
Protection Function		Short circuit, Overvoltage (> 400 Vdc ± 5%), Position error too big, Encoder error, Motor cable lost connection, Drive over temperature (IGBT > 80 °C ± 3 °C), Motor over temperature, Undervoltage (< 60 Vdc), I2T current limit protection
Error Compensation	Applicable Motor	Linear motor
	Compensation Method	Creates error map table to compensate encoder error by means of linear interpolation.
	Storage Point	Maximum 5,000 points
	Storage Location	Flash ROM, disk file
	Unit	um, count
	Enabling Method	<ul style="list-style-type: none"> Enabled after internal homing completes. Enabled by external input signal.
Frequency Suppression Range for Vibration Suppression Filter (VSF)		0.1 Hz~200 Hz
Environment	Operating Temperature	0~50 °C (If temperature is above 55 °C, forced ventilation will be required.)
	Storage Temperature	-20 °C ~65 °C
	Humidity	0 to 90%RH (No condensation)
	Altitude	Altitude 1000 M or lower
	Vibration	1G (10 to 500 Hz)
	IP Rating	IP20
Cooling		Natural cooling or external heat sinks
Weight		1,250 g (min.)
Dimensions		191.6 mm X 139.8 mm X 64.8 mm
Case		Complies with CE U.L. Spec 94 V-0 Flammability Rating

2.3 Dimensions

The dimensions and mounting holes of D1 and D1 EtherCAT (CoE and mega-ulink) servo drives are shown in figures 2.3.1 and 2.3.2. The unit is mm. The diameter of the mounting hole is 4 mm.



D1-DNN03A

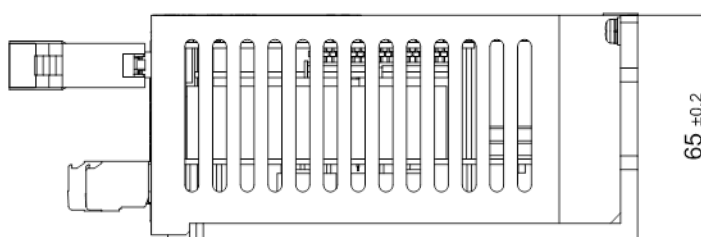
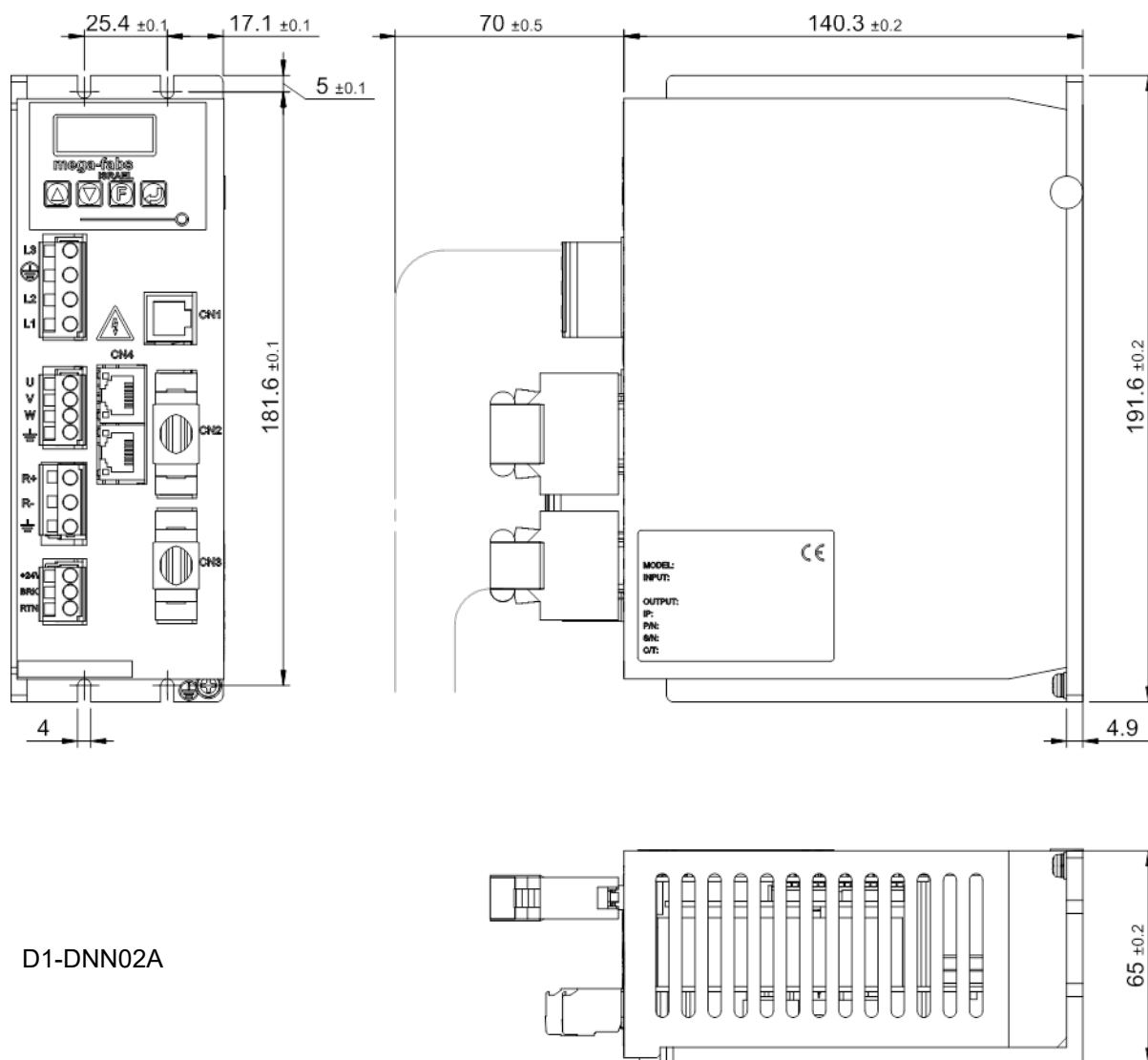


Figure 2.3.1 D1 servo drive



D1-DNN02A

Figure2.3.2 D1 EtherCAT servo drive

2.4 Installation

If the servo drive is installed in a control box, ensure it is mounted with conductive screws. The insulating materials, such as paint, on the contact surface of the control box must be removed for grounding the servo drive through the control box. When the input power of the servo drive is 220 V, the grounding resistance must be lower than 50 Ω ; when the input power of the servo drive is 110 V, the grounding resistance must be lower than 100 Ω .

The suction hole and vent hole of the servo drive must not be obstructed. Install the servo drive according to the specified orientation; otherwise, it may malfunction. For well cooling and circulation effect, there must be enough clearance between the servo drive and the adjacent objects or baffle plates. While installing multiple servo drives, the clearance between two servo drives must be at least 20 mm. Install a fan in the control box to facilitate heat dissipation.

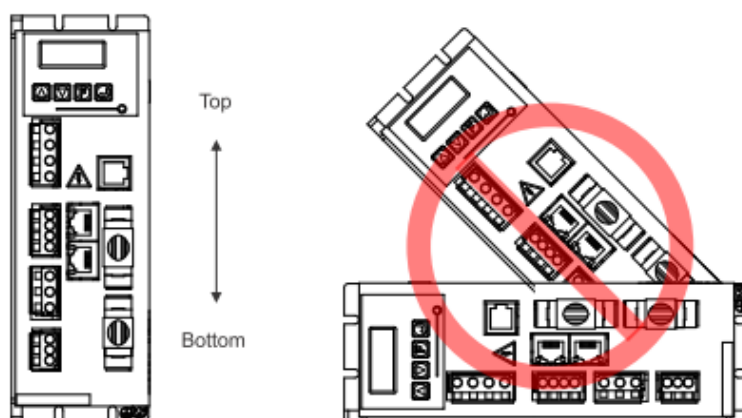


Figure2.4.1

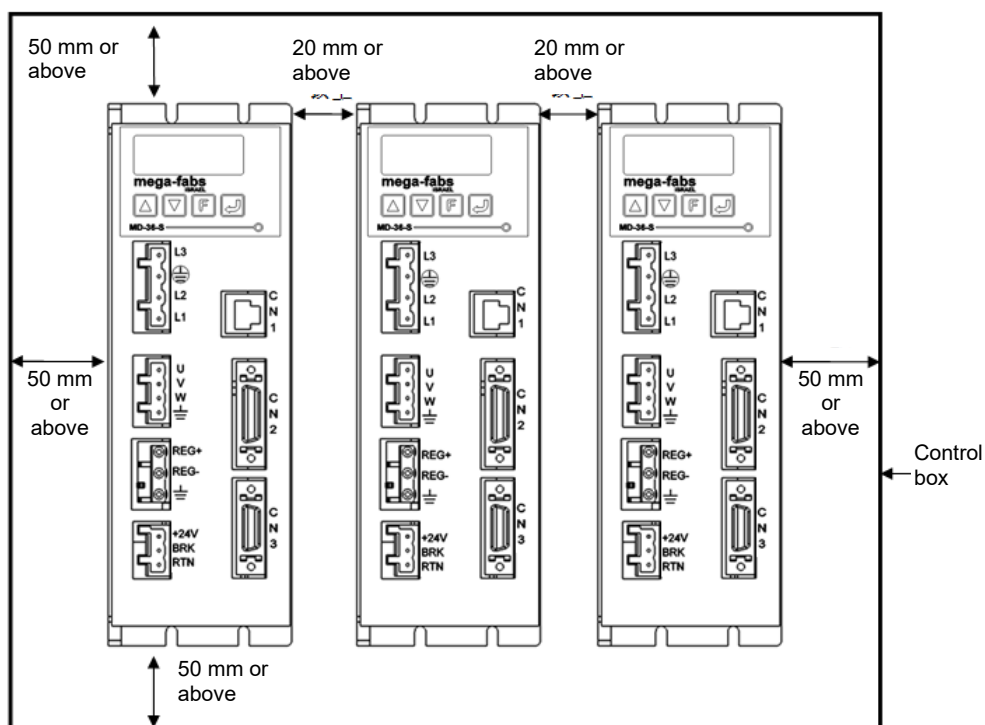


Figure2.4.2

2.5 Derated value

When the drive is operated under condition of temperature 45~50°C or altitude 1000~3000M, please use the drive according to the decrease rate of deration, which is displayed in below figures.

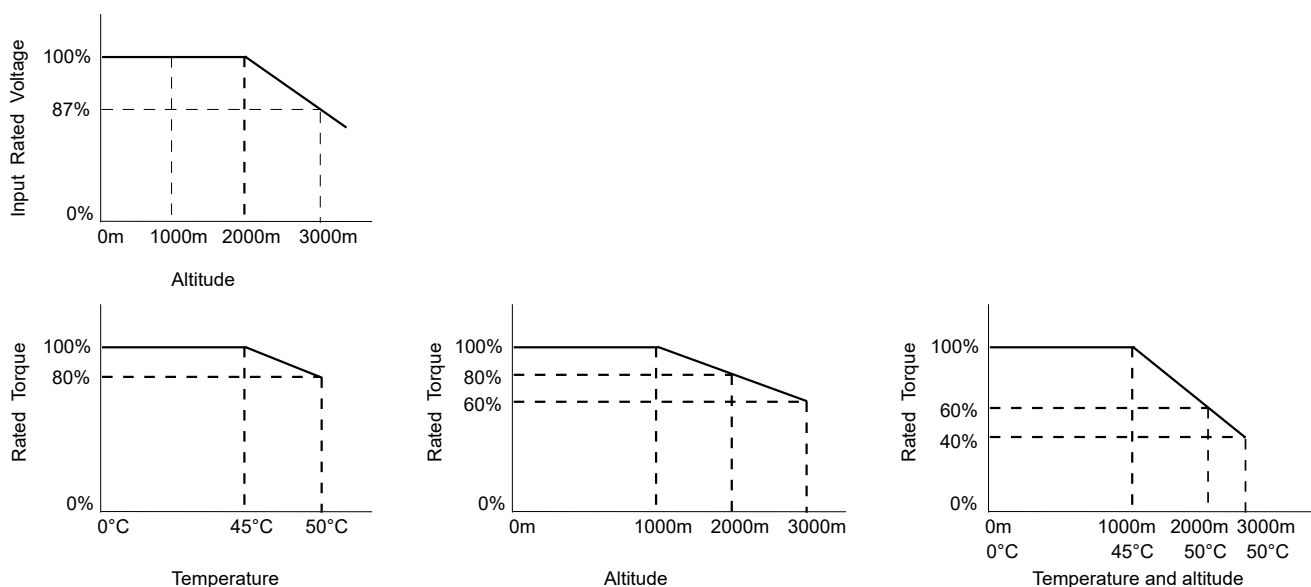


Figure2.5.1

Note: When the altitude is 2000~3000M, the curve of deration must be limited to OVC II based on the overvoltage type of IEC/EN 61800-5-1.

2.6 System requirement

Table2.6.1

CPU	1.0 GHz or higher
RAM	512 MB or more
Hard Disk Space	50 MB or more
Communication Port	RS232 communication port If there is no RS232 communication port, use USB to RS232 adapter.
Operating System	Win 2000, Win XP, Win 7
Display	1024*768 pixel or higher

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3. Operation principles

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3.1 Operation mode

D1 servo drive supports the following operation modes.

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

Each operation mode will be described in the following sections.

3.1.1 Position mode

In position mode, controller sends pulses to the servo drive. These pulses are position commands. When a pulse is received, the servo drive commands motor to run a corresponding distance. Path planning is done by controller. At what speed motor runs is decided by the sending frequency of pulses. Motor runs at faster speed as pulses are sent at faster speed; motor runs at constant speed as pulses are sent at fixed speed. As figure 3.1.1.1, three pulse types are supported: Pulse/Direction (Pulse/Dir), Pulse up/Pulse down (CW/CCW) and Quadrature (A/B phase). By different wirings, pulse signal can be TTL differential signal or single-ended signal. User can set electronic gear ratio in position mode. Normally one pulse is equivalent to one encoder count. For instance, when electronic gear ratio is set to 2:3, it means two pulses is equivalent to three encoder counts.

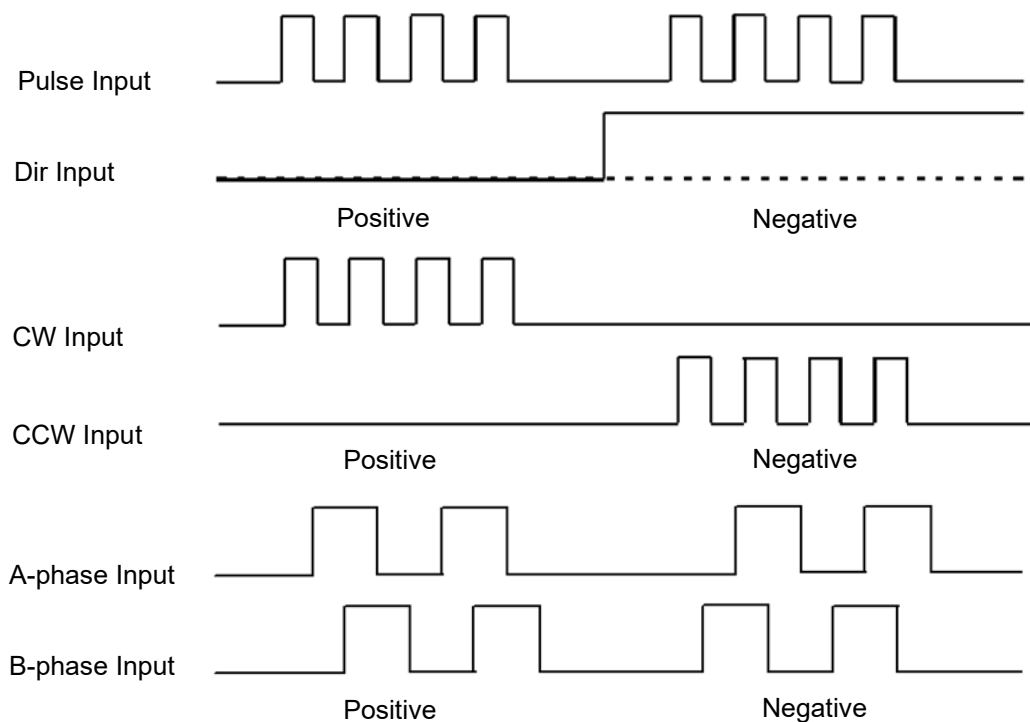


Figure3.1.1.1

3.1.2 Velocity mode

In velocity mode, the servo drive receives analog command (V command) from controller. The input voltage range is from -10 V to +10 V. The input voltage is transformed into corresponding velocity command to drive motor. In addition to V command, the servo drive can also receive PWM command. The servo drive outputs different velocity command based on different duty cycle. Two settings are supported, PWM 50% and PWM 100%. PWM 50% uses duty cycle 50% as base. When duty cycle is lower than 50%, the servo drive commands motor to move in negative direction. When duty cycle is larger than 50%, the servo drive commands motor to move in positive direction. For PWM 100%, an additional pin is required for controlling the moving direction of motor.

(1) Using V command

Analog voltage is transformed into velocity command to drive motor. The velocity increases as the analog voltage increases, but the maximum velocity does not exceed the maximum velocity limited by the servo drive. The velocity decreases as the analog voltage decreases. If the voltage value is negative, motor moves in negative direction. The corresponding velocity command of input voltage can be set in the servo drive.

(2) Using PWM command

PWM command is transformed into velocity command to drive motor. The corresponding velocity of full PWM can be set in the servo drive.

3.1.3 Force/torque mode

In force/torque mode, the servo drive receives analog command (V command) or PWM command from controller. The received command is transformed into corresponding current command to drive motor.

(1) Using V command

Analog voltage is transformed into current command to control the force and torque of motor. The current increases as the analog voltage increases, but the maximum current does not exceed the maximum current of the motor. The current decreases as the analog voltage decreases. If the voltage value is negative, motor moves in negative direction. The corresponding current of input voltage can be set in the servo drive.

(2) Using PWM command

PWM command is transformed into current command to control the force and torque of motor. The corresponding current of full PWM can be set in the servo drive.

3.1.4 Stand-alone mode

The servo drive has one high-speed digital signal processor (DSP), so the servo drive is able to do path planning. Select stand-alone mode when user would like the servo drive to be tested alone or operate without controller. In stand-alone mode, servo loops are handled by the servo drive.

3.2 Encoder types

Encoder plays an essential role in controlling servo motor. With position and angle information provided by encoder, the servo drive is able to control servo loops. The commonly-used encoders are optical scale and magnetic scale which obtain current position by means of optics and variation of magnetic field. The position signal obtained by optical scale or magnetic scale is transformed into digital signal or analog signal. Normally optical scale or magnetic scale may support either digital signal output or analog signal output.

3.2.1 Digital type

Digital encoder (or incremental encoder) normally outputs TTL RS422 differential signal. TTL RS422 differential signal includes two digital pulses with 90 degrees phase difference. Its resolution definition is shown in figure 3.2.1.1. The resolution of linear optical scale is usually 1 μm .

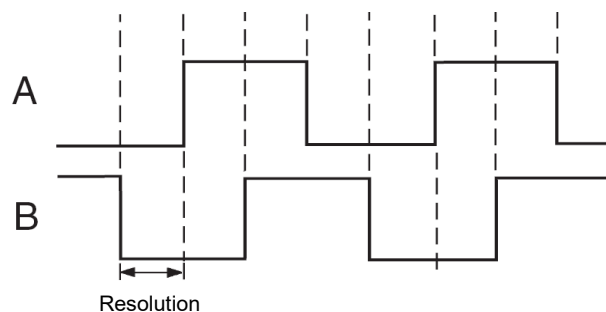


Figure3.2.1.1

3.2.2 Analog type

Analog encoder outputs signal with two phases, sin and cos. The output signal is usually 1 Vpp differential signal. 1 Vpp differential signal consists of two sinusoidal signals with 90 degrees phase difference. The specification of analog encoder is usually shown by grating period. For instance, the grating period of commonly-used linear analog optical scale is 40 μm . The grating period can be finer by adjusting multiplier factor in D1 servo drive to have better resolution than nanometer.

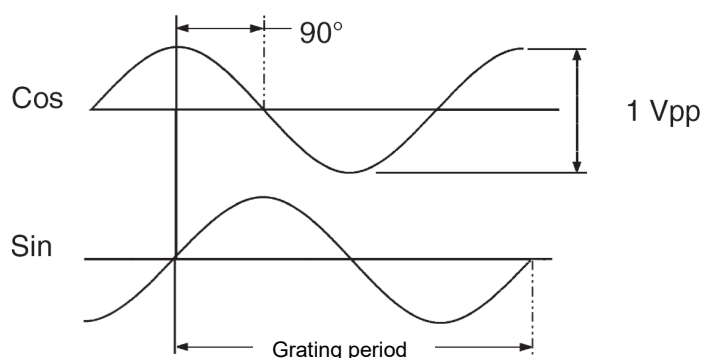


Figure3.2.2.1

3.3 Buffered encoder output and emulated encoder output

The input signal from encoder is used by the servo drive to perform servo control. When the servo drive is used with controller, the servo drive transmits the position or angle signal received from encoder to the controller. D1 servo drive provides two types of encoder signal outputs.

(1) Buffered encoder output

When buffered encoder output is selected, signals received from encoder are directly sent to controller. Invert function is provided in D1 servo drive. When invert function is selected, the signals received from encoder will be inverted before being sent to controller.

(2) Emulated encoder output

When emulated encoder output is selected, the position information received from encoder will be multiplied by a scale factor before being sent to controller. In some occasions, if controller cannot receive encoder signals sent at high frequency, a scale factor can be set to lower the frequency. In addition, if the multiplier factor of an analog encoder is set to be too high, a scale factor 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.

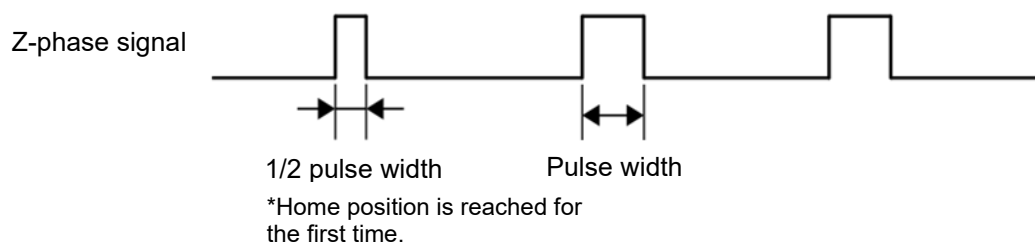


Figure3.3.1

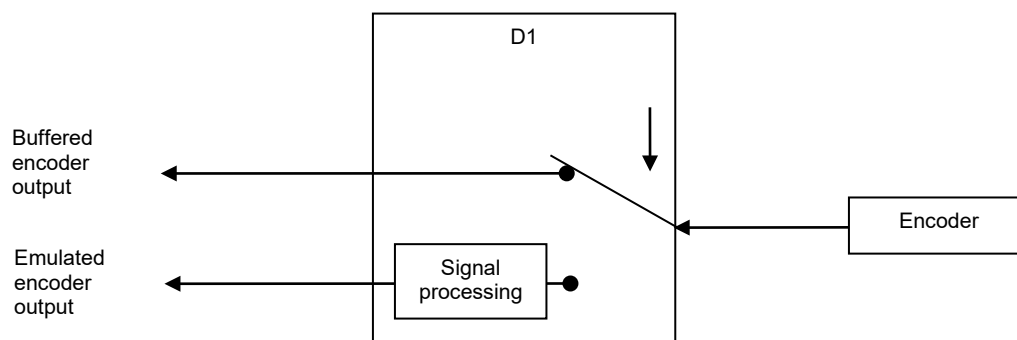


Figure3.3.2

3.4 Path planning

Path planning is usually done by controller. The controller calculates suitable motion command based on the required distance, velocity, acceleration and smooth factor. These commands (Pulse commands or V commands) will be sent from the controller to the servo drive or calculated by the servo drive (Stand-alone mode).

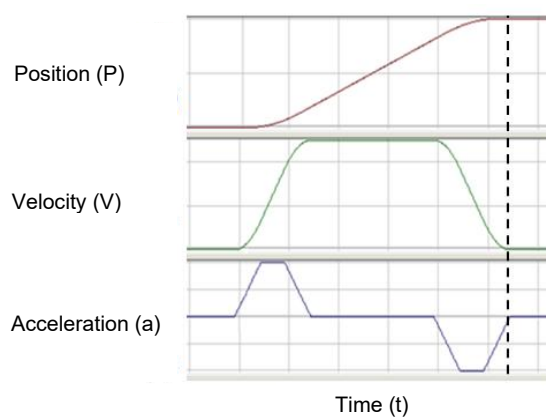


Figure3.4.1

(1) Position

Optical scale or encoder provides the servo drive with the current position of motor. Units used for different motion types are as below. In D1 servo drive, reference position means position command. Reference position is calculated by the path generator according to the related parameters. Target position is the desired position set by user or controller. After target position is set, it is calculated by the path generator before the servo drive commands motor to move.

Table3.4.1

Motion	Unit
Linear Motion	um, mm and m
Rotary Motion	Encoder count

(2) Velocity

Velocity is the displacement per unit time. Units used for different motion types are as below.

Table3.4.2

Motion	Unit
Linear Motion	um/sec, mm/sec and m/sec
Rotary Motion	count/sec, rps and rpm

(3) Acceleration

Acceleration is the change in velocity per unit time. Units used for different motion types are as below.

Table3.4.3

Motion	Unit
Linear Motion	um/sec ² , mm/sec ² and m/sec ²
Rotary Motion	rps ²

(4) Smooth factor

When acceleration or deceleration is dramatically increased or decreased in a short time, the force applied to the motor and load will be increased or decreased accordingly. Smooth factor is used to create S-curve or T-curve velocity profile to moderate the impact from such change. The setting range of smooth factor is from 0 to 500. Increase the value of smooth factor to have S-curve velocity profile and smaller impact. Decrease the value of smooth factor to have T-curve velocity profile. Set smooth factor to 1 to disable smoothing function. In some occasions, settling performance can be enhanced by increasing smooth factor since the impact from the motor force is reduced. However, smoother motion may have longer move time. Find the suitable value of smooth factor by executing test run and tuning on your machine. When smooth factor is set to 0, the motion protection of the servo drive is disabled.

(5) Emergency stop

D1 servo drive has emergency stop function. When I1 signal (Axis enable) is OFF, the emergency stop function is activated. The servo drive commands the motor to decelerate at the speed set for Dec. kill to a stop.

3.5 Servo loops and servo gains

(1) Servo loops

D1 servo drive has three servo loops, including current loop, velocity loop and position loop, to control servo motor. The servo loops are shown in figure 3.5.1. In position mode, all loops are handled by the servo drive. In velocity mode, velocity loop and current loop are handled by the servo drive. In torque/force mode, only current loop is handled by the servo drive. Current loop receives voltage command from controller and controls motor commutation. For easy operation, the servo loops of D1 servo drive can be set and adjusted by one common gain (CG).

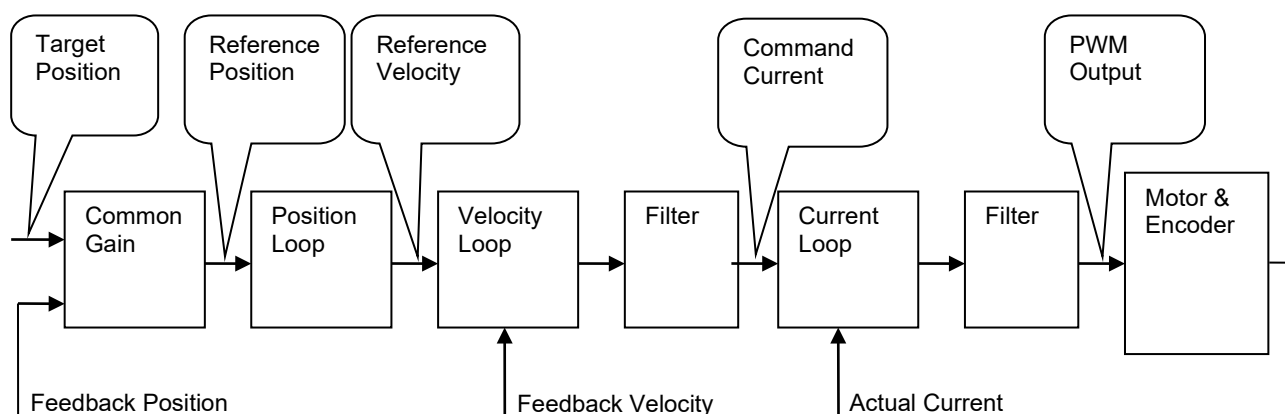


Figure3.5.1

(2) Servo gains

D1 servo drive uses one high-speed digital signal processor (DSP) to control motor. Normally if servo loops are controlled via digital method, user needs to adjust several servo gains. But for easy operation, D1 servo drive provides one common gain (CG) for user to adjust all servo gains at the same time.

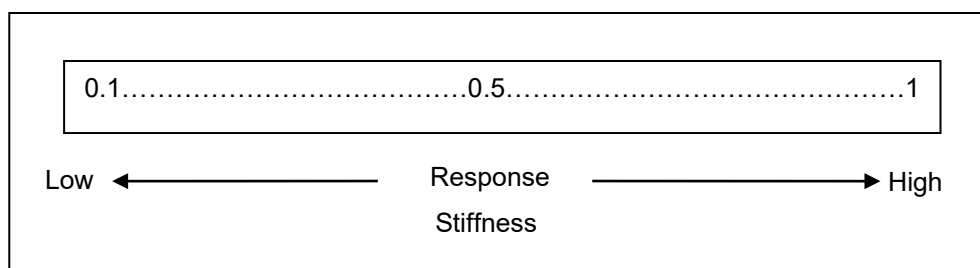


Figure3.5.2

3.6 Gain margin and phase margin

3.6.1 Nyquist plot

Gain margin (GM) (Unit: db) is the allowable loop gain which can be increased before closed-loop system becomes unstable. Phase margin (PM) is the allowable phase delay which can be increased before closed-loop system becomes unstable.

(1) Gain margin

$G(j\omega_p)$ is the relative distance from where the Nyquist plot intersects with the negative real axis to $(-1, j0)$. ω_p is the phase crossover frequency. In figure 3.6.1.1, $\angle G(j\omega_p) = 180^\circ$. For the transfer function $G(s)$ in a loop system, its gain margin =

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

From figure 3.6.1.1 and the Nyquist plot, the following conclusion is known.

- A. If $G(j\omega)$ does not intersect with the negative real axis, $|G(j\omega_p)| = 0$ and $GM = \infty \text{ dB}$.
When the Nyquist plot does not intersect with the negative real axis at any non-zero finite frequency, $GM = \infty \text{ dB}$. Theoretically, loop gain can be infinite before instability occurs.

- B. If $G(j\omega)$ intersects with the negative real axis between 0 and -1, $0 < |G(j\omega_p)| < 1$ and $GM > 0 \text{ dB}$. When the Nyquist plot intersects with the negative real axis between 0 and -1 at any frequency, the system is stable as loop gain increases.
- C. If $G(j\omega)$ is on $(-1, j0)$, $|G(j\omega_p)| = 1$ and $GM = 0 \text{ dB}$. When $G(j\omega)$ is on $(-1, j0)$. It means $GM = \infty \text{ dB}$ and the system has reached the boundary of instability. Loop gain must not be increased anymore.
- D. If $G(j\omega)$ passes $(-1, j0)$, $|G(j\omega_p)| > 1$ and $GM < 0 \text{ dB}$. When $G(j\omega)$ passes $(-1, j0)$, $GM < 0 \text{ dB}$. Loop gain must be decreased to have stable system.

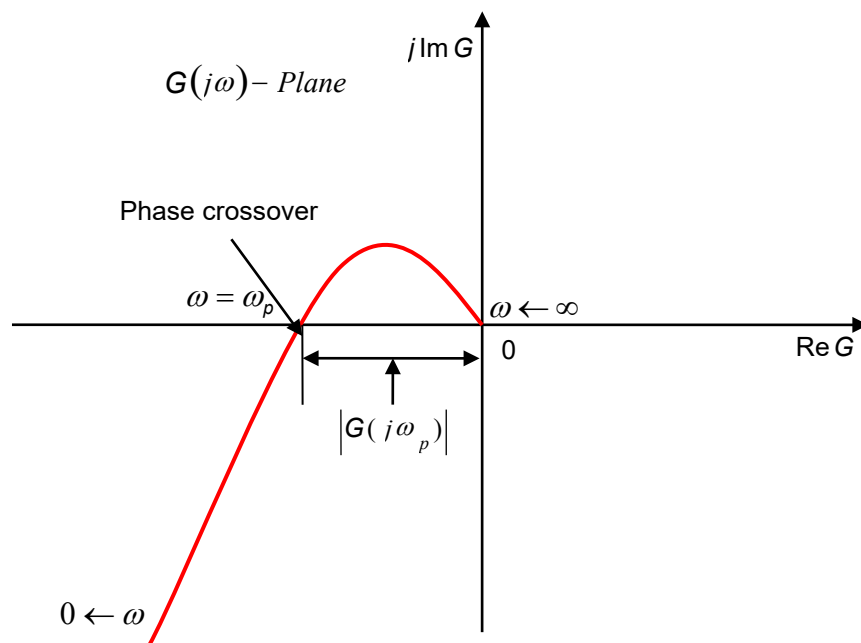


Figure3.6.1.1 Gain margin

(2) Phase margin

As figure 3.6.1.2, phase margin is the angle between the straight line passing through gain crossover and the negative real axis of $G(j\omega)$ -Plane.

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

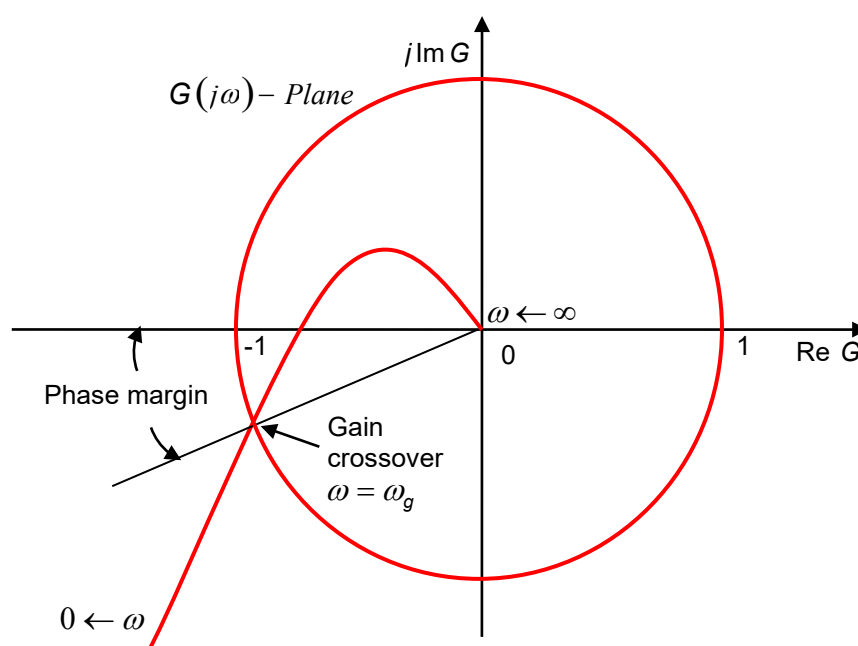


Figure3.6.1.2 Phase margin

3.6.2 Bode plot

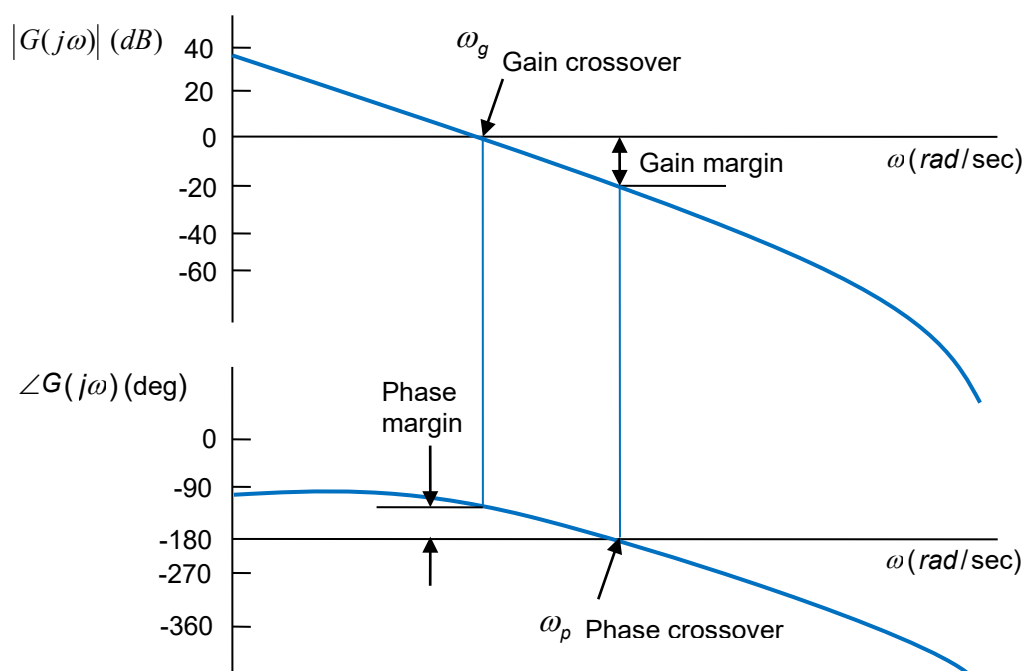


Figure3.6.2.1 The gain margin and phase margin in Bode plot

As figure 3.6.2.2, the bandwidth of Bode plot is at -3 dB.

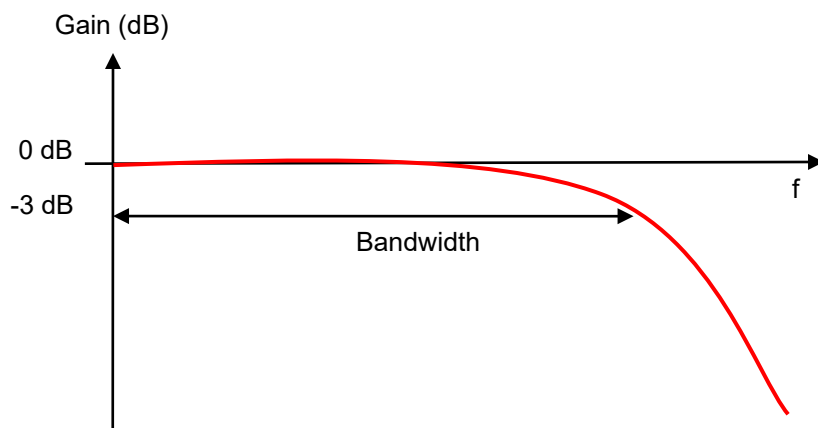


Figure3.6.2.2 The bandwidth of Bode plot

3.7 Move and settling

Motor moves according to the path planned by controller. When motor arrives at target position, it is able to accurately position and stop. This is called move and settling.

(1) Position error

In a servo system, there is certain difference between target position and encoder feedback position. This difference is called position error.

(2) Target radius

After motor arrives at target position, the difference between encoder feedback position and target position must be controlled in a specific range. This range is called target radius.

(3) Total time of move and settling

As figure 3.7.1, after the motor arrives at target position and position error is within target radius for a period of time (Debounce time), in-position signal is ON. Then the motor is regarded as in-position. If position error is not within target radius, the motor will not be regarded as in-position. Total time (Total time is the time when the motor starts to move to the time settling completes.) is the sum of move time and settling time.

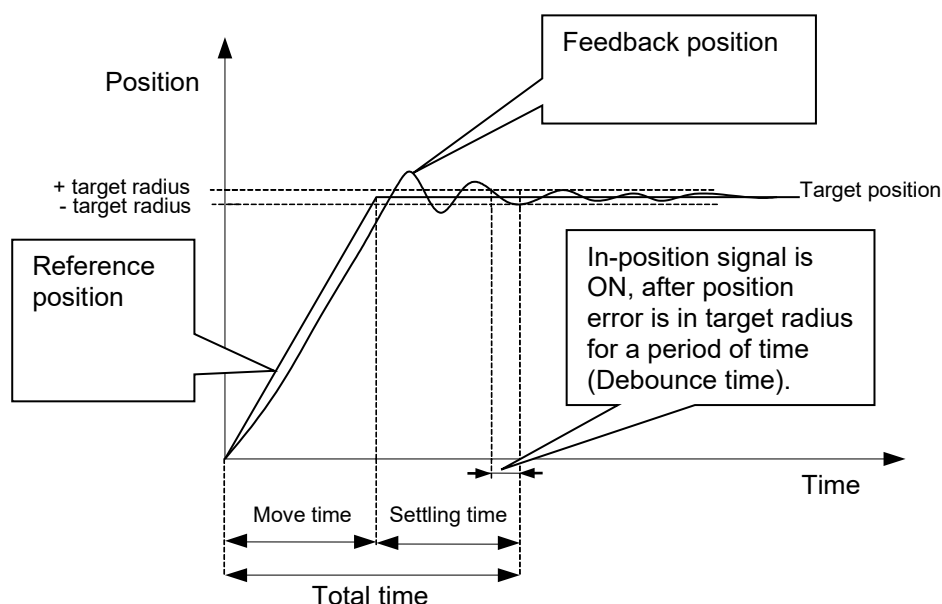


Figure3.7.1

3.8 Error compensation

Normally the positioning accuracy of a servo drive is decided by encoder. When an encoder cannot meet user's requirement for accuracy, user may use equipment with higher accuracy level (such as laser interferometer) to measure system error. As figure 3.8.1, D1 servo drive is able to store system error and calculate error compensation value by means of linear interpolation between fixed distances to enhance positioning accuracy.

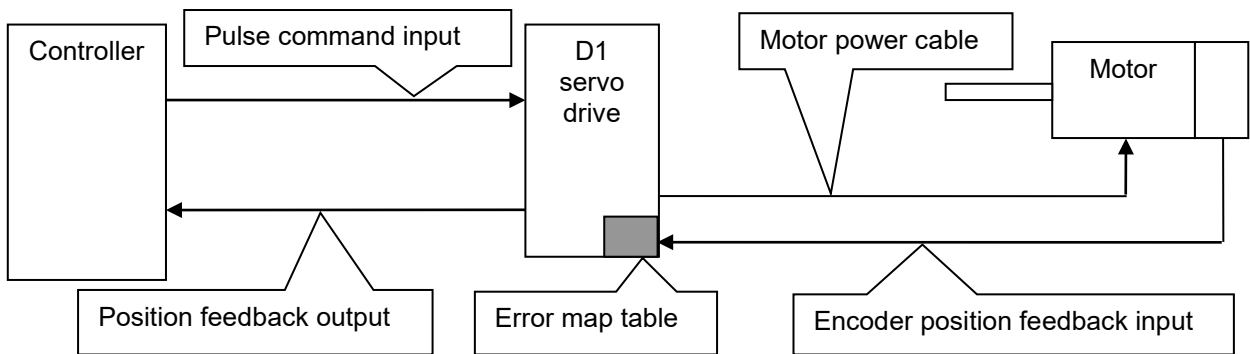


Figure3.8.1

The effective range of error compensation is determined by index signal. Error compensation is effective only in the positive direction starting from index signal. If home offset is applied, the effective range of error compensation is still the same as home offset is set to zero.

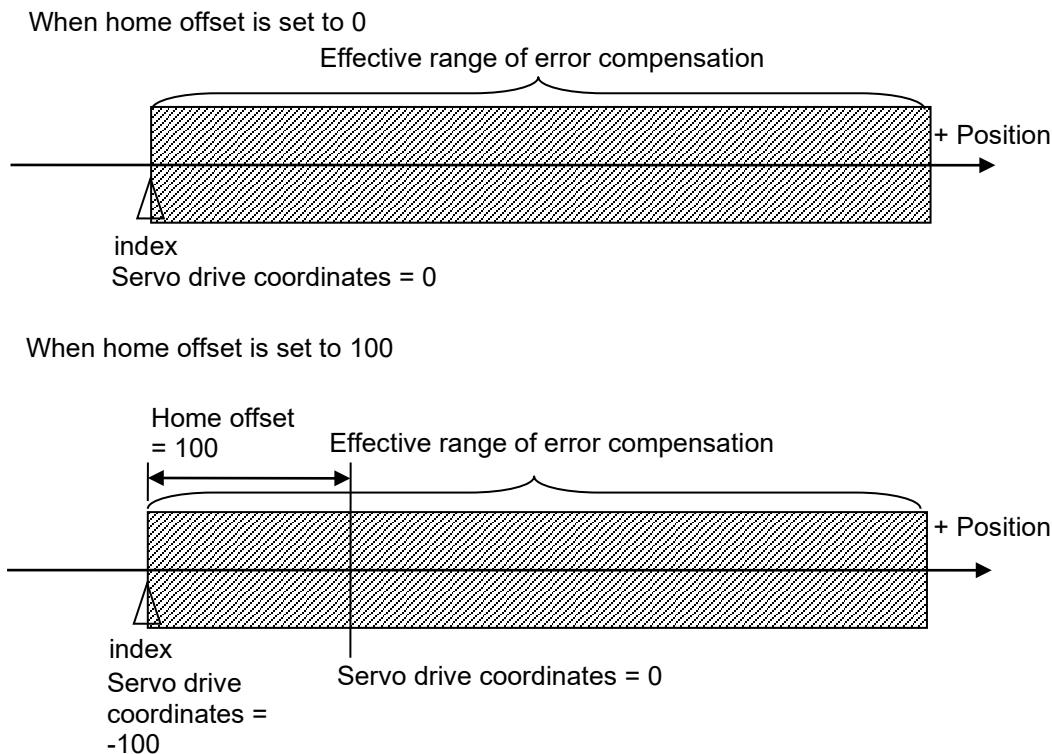


Figure3.8.2

3.9 Velocity ripple

In motion control, it is preferable to have smoother motion in constant speed phase. Velocity ripple is used to check if the motion is stable or not. In constant speed phase, velocity may vary due to cogging force from motor, cable chain, air pipeline or guideway friction. Velocity ripple is normally used when equipment requires high stability while operating at constant speed, such as scanning machine or inspection machine. The formula of velocity ripple is:

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

V_{target} is target velocity. V_{\max} is the maximum velocity in constant speed phase. V_{\min} is the minimum velocity in constant speed phase. As figure 3.9.1, velocity ripple in figure (a) is larger, which means the motion is less stable; velocity ripple in (b) is smaller, which means the motion is more stable.

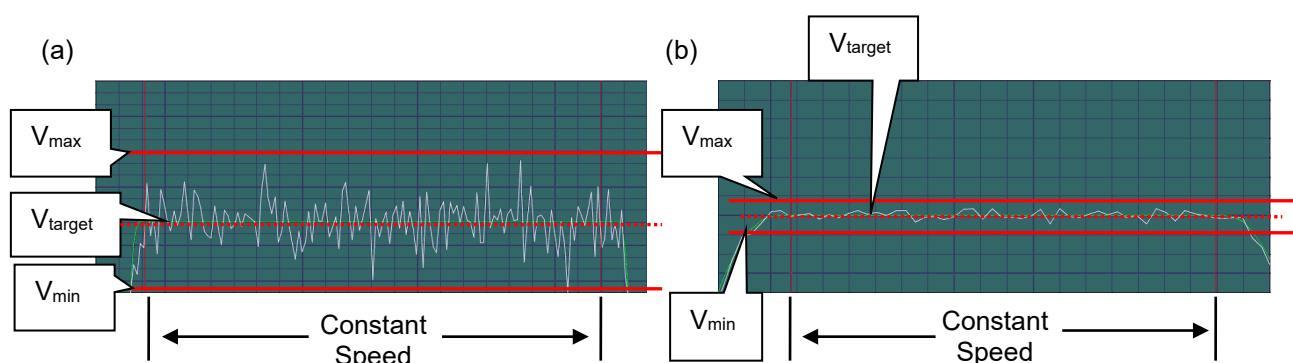


Figure3.9.1

3.10 Enabling

Enabling must be completed before motor receives any motion command. After enabling, the servo drive is able to receive pulse command or voltage command from controller to perform motion control.

(1) Step motion mode (SM mode)

Step motion mode (SM mode) is an open loop control architecture. In this mode, the movement of motor is similar to step motor. Feedback position signal is not adopted when enabling. This mode can be used to check if force direction is consistent with encoder feedback direction. If force direction and encoder feedback direction are different, phase initialization could fail.

(2) Phase initialization

If the servo drive is used with incremental encoder, when its power is turned on for the first time, the procedure of finding electrical angle or phase initialization must be done. For HIWIN linear servo motor, electrical angle can be successfully found without moving the motor for a long distance. Another commonly-used method for phase initialization is by using Hall sensor. Normally phase initialization and enabling can be completed via an output signal from controller (such as I1 input of D1 servo drive).

3.11 Basic physical quantities

Table3.11.1

Number	Name	Description
1	Feedback position	Feedback position
2	Reference position	Position command
3	Target position	Target position
4	Position error	Position error
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
40	Analog command	Voltage command (From controller)
41	Bus voltage	Line voltage
42	Servo voltage percentage	Servo voltage
43	SIN-analog encoder	Sine signal of analog encoder
44	COS-analog encoder	Cosine signal of analog encoder
45	PWM command	Torque/force/velocity command (From controller)
46	Digital hall bits	Digital Hall signal
50	Amplifier temperature	Servo drive temperature
51	Soft-thermal accumulator	Temperature estimation by software
52	I2T accumulator	I2T estimation
61	I1	Input 1
62	I2	Input 2
63	I3	Input 3
64	I4	Input 4
65	I5	Input 5 (Motor over temperature signal)

Number	Name	Description
66	I6	Input 6
67	I9	Input 9 (Pulse command)
68	I10	Input 10 (Pulse command)
69	I11	Input 11
70	I12	Input 12
81	O1	Output 1
82	O2	Output 2
83	O3	Output 3
84	O4/BRK	Output 4 (For brake signal)

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4. Wiring

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4.1 System configuration and wiring

The system configuration and wiring of the servo drive are described in this section.

4.1.1 System connection

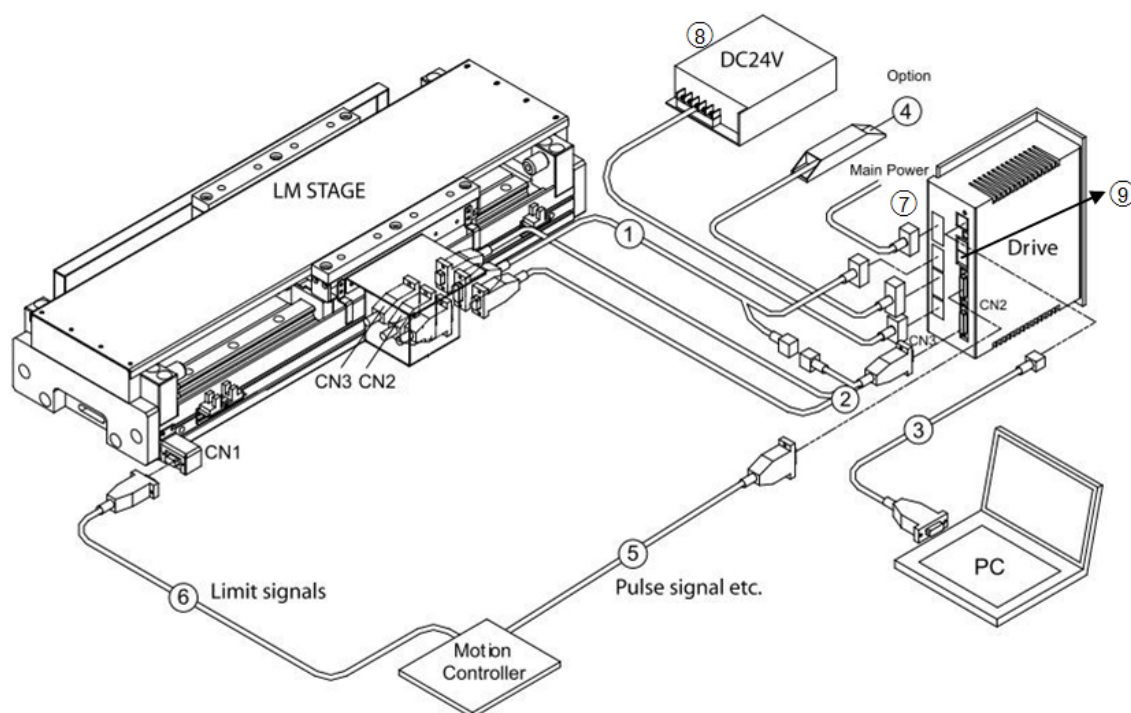


Figure4.1.1.1

Table4.1.1.1

Item	Name	Description
①	Motor power cable	Connect to motor. Three-phase power for motor
②	Feedback signal (CN3)	Connect to the encoder of motor.
③	RS232 communication (CN1)	Connect to PC for parameter setting. After parameters are set, please abort the connection.
④	Regenerative resistor	Connect to regenerative resistor. (Optional) (Install according to actual application.)
⑤	Control signal (CN2)	Connect to controller.
⑥	Limit cable	Connect to the limit switches of LM stage. (Optional) (Install according to actual application.)
⑦	AC main power cable	Connect to single or three-phase AC power.
⑧	Control power cable	24 V power for servo drive control
⑨	EtherCAT communication (CN4)	Connect to controller via EtherCAT communication. (This communication port only exists in the model which supports EtherCAT communication.)

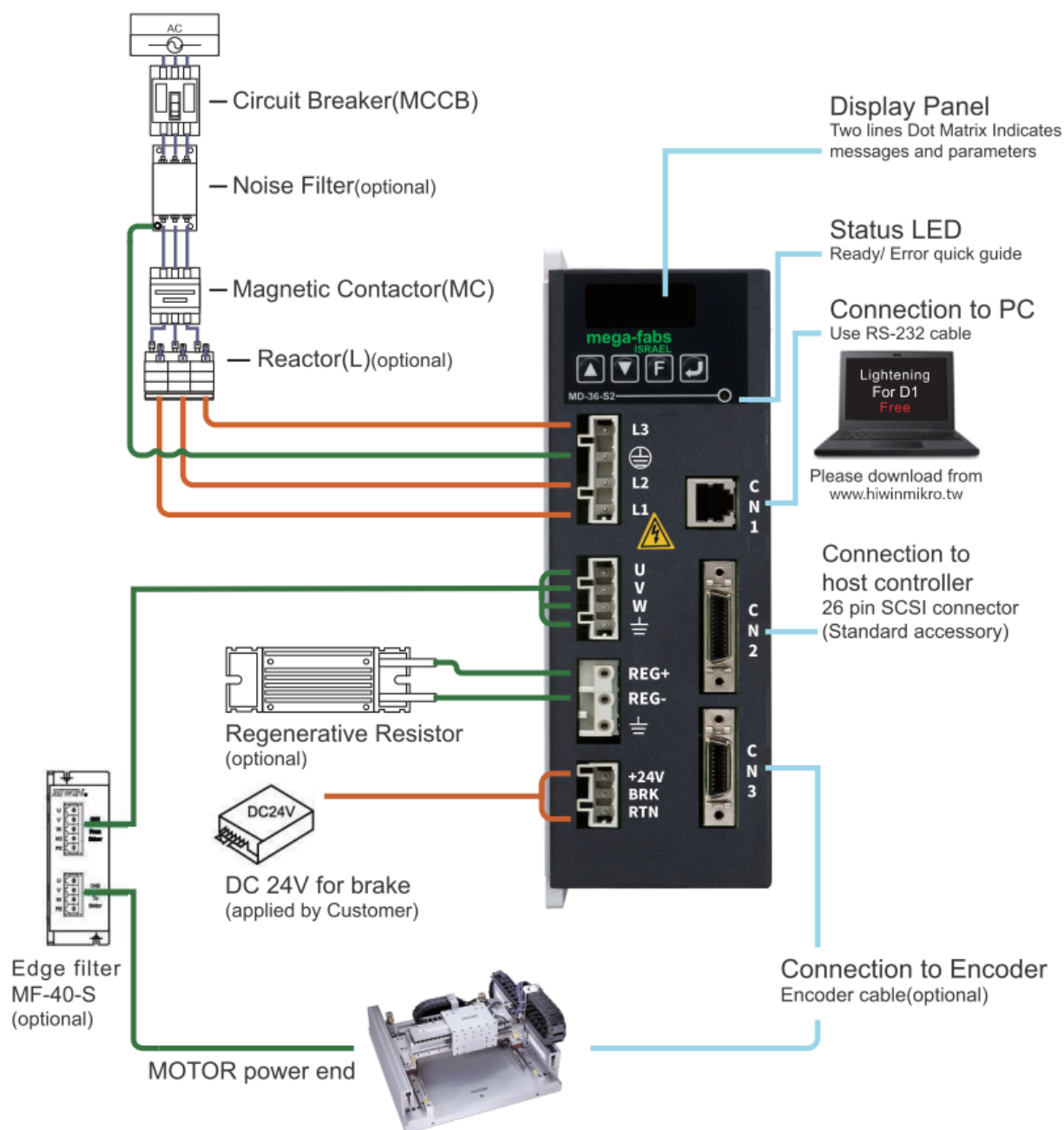


Figure4.1.1.2

4.1.2 Connector specifications

Table 4.1.2.1

Connector	Specification	Manufacturer	Wire Gauge Range	Note
Connector for AC main power cable	European standard 4-pin 7.5 mm pluggable connector (Female)	Wago Part number: 721-204/026-000	22 - 12 AWG Suggested: 12 AWG, 600 V	Wiring tool: Wago 231-131
Connector for motor power cable	European standard 4-pin 5.0 mm pluggable connector (Female)	Wago Part number: 721-104/026-000	22 - 12 AWG Suggested: 12 AWG, 600 V	Wiring tool: Wago 231-131
Connector for regenerative resistor	European standard 3-pin 5.0 mm pluggable connector (Male)	Wago Part number: 723-603	22 - 14 AWG Suggested: 14 AWG, 600 V	Wiring tool: Wago 231-131
Connector for control power	European standard 3-pin 5.0 mm pluggable connector (Female)	Wago Part number: 721-103/026-000	22 - 14 AWG Suggested: 18 AWG	Wiring tool: Wago 231-131
Connector for RS232 communication	6-pin module connector (RJ-11 type)			
Connector for control signals	26-pin, .050" Mini D Ribbon (MDR), standard solder connector	3M Part number: 10126-3000	24 - 30 AWG	
		Molex Part number: 0543062619		
	26-pin, .050" Mini D connector, molded insulation displacement (IDC) type	Molex Part number: 0523162619	28 AWG	
	Back cover	3M Part number: 10326-52F0-008		
		Molex Part number: 0543310261		
Connector for feedback signals	20-pin, .050" Mini D Ribbon (MDR), standard solder connector	3M Part number: 10120-3000	24 - 30 AWG	
		Molex Part number: 0543062019		
	20-pin, .050" mini D connector, molded insulation displacement (IDC) type	Molex Part number: 0523162019	28 AWG	
	Back cover	3M Part number: 10320-52F0-008		
		Molex Part number: 0543310201		

Note:

Use wiring tool to avoid electric shock when wiring.

4.2 Wiring for main circuit

Ensure the servo drive is properly grounded before connecting to its main circuit.

(1) Wiring for AC power supply (Single-phase)

While selecting single-phase filter, FN2090-10-06 filter from Schaffner is suggested.

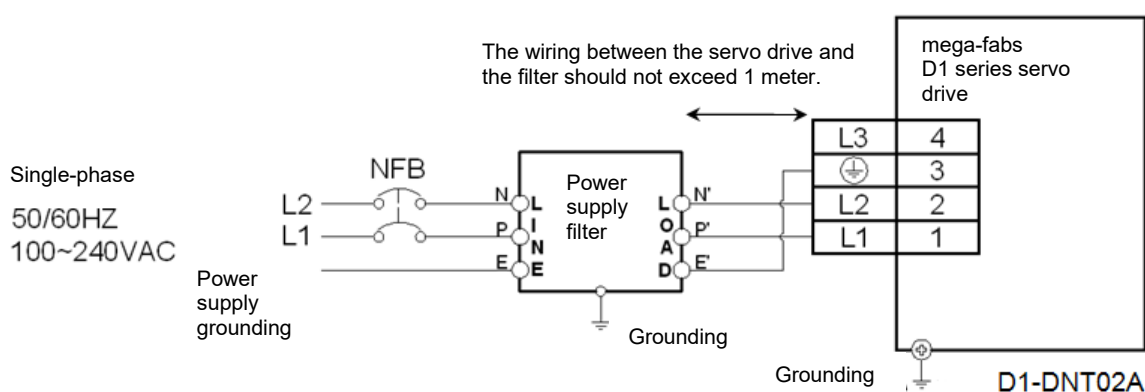


Figure4.2.1

(2) Wiring for AC power supply (Three-phase)

While selecting three-phase filter, FN3258-7-45 filter from Schaffner is suggested.

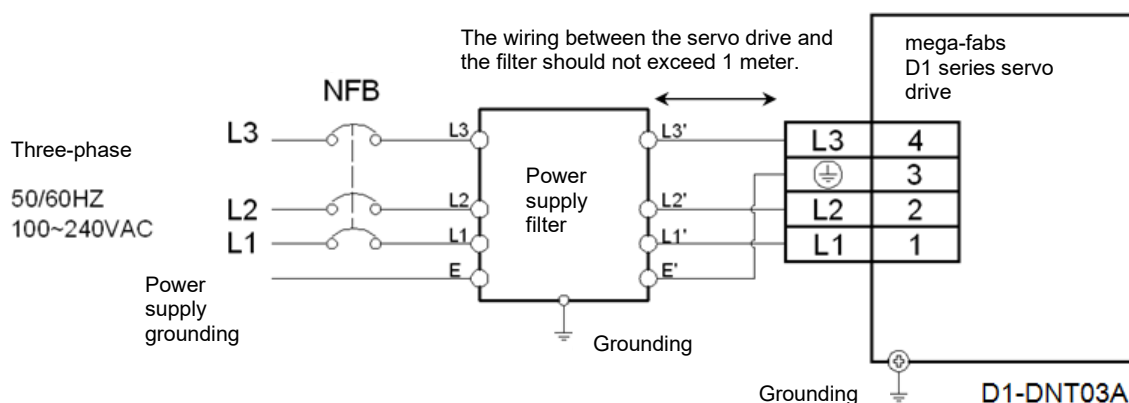


Figure4.2.2

■ How to select no-fuse breaker (NFB)

While using no-fuse breaker for current shunt, its rated capacity should be 1.5 to 2.5 times of the rated current of the servo drive.

While using one servo drive: $I_B = C \times I_n$

While using two or more servo drives, but do not power on at the same time:

$$I_B = (\sum I_n - I_{nMAX}) \times K + C_{MAX} I_{nMAX}$$

While using two or more servo drives, and power on at the same time:

$$I_B = C1 \times I_{n1} + C2 \times I_{n2} + \dots + CN \times I_{nN}$$

Note:

I_B : The rated current of no-fuse breaker

I_n : The rated current of servo drive

I_{nMAX} : The largest rated current of servo drive while using servo drives of different specifications

C : The multiple of rated current (Note: The multiple is usually 1.5 to 2.5. If user is not sure about the multiple, please use 1.5.)

C_{MAX} : The multiple of the largest rated current of servo drive

K : Demand rate (Note: If user is not sure about the demand rate, please use 1.)

■ Example

If three D1-36 servo drives are used:

We assume C and C_{MAX} are 2.

Do not power on at the same time: $I_B = (3 \times 12 - 12) \times 1 + 12 \times 2 = 48 \text{ A}_{rms}$

Power on at the same time: $I_B = 2 \times 12 + 2 \times 12 + 2 \times 12 = 72 \text{ A}_{rms}$

Table4.2.1 The rated current of D1 servo drive

Model	Rated Current
D1-36	12 A _{rms}

■ The inrush current of main power of D1 series servo drive

When selecting breaker, the inrush current as power is supplied to the servo drive in the first 100 ms must be considered. If several servo drives share the same breaker, please add up the inrush currents of all the used servo drives to select a suitable breaker which can withstand the total inrush current.

Table4.2.2 The inrush current of D1 servo drive

Model	Inrush Current
D1-36	15.5 A _{rms}

4.3 Wiring for motor

■ Wiring for motor

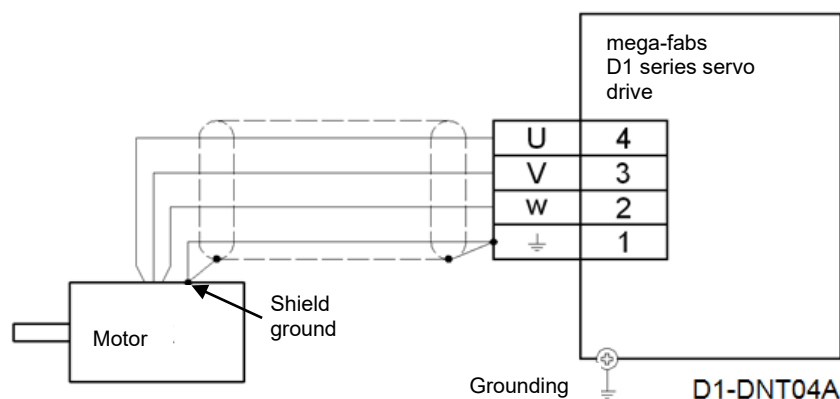


Figure4.3.1

4.4 Wiring for regenerative resistor

Regenerative resistor is optional.

■ Wiring for regenerative resistor

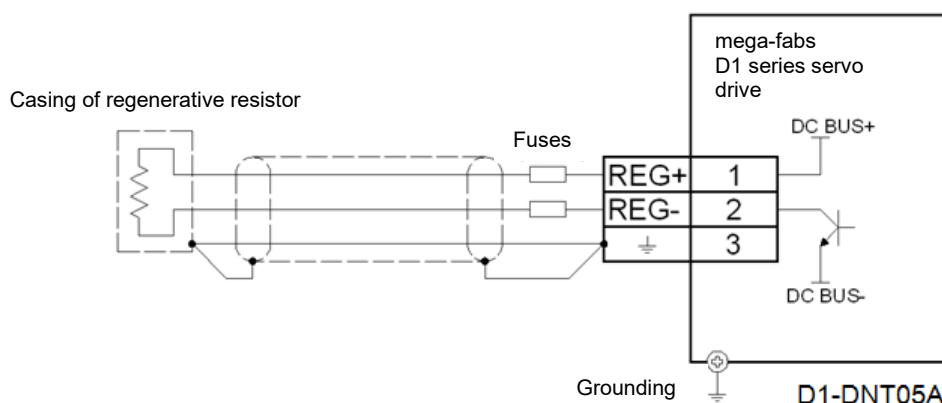


Figure4.4.1

4.5 Wiring for control power and brake

For wiring 24 V DC control power and brake, please refer to figure 4.5.1. If there is no brake, connect +24 V to the +24 V pin (Pin3) of Wago standard connector 721-103, and connect 0 V to RTN pin (Pin 1). If there is brake, connect brake output pin (BRK) with relay. When brake signal is output, the dynamic brake or electromagnetic brake on motor can be activated via relay. The output for brake output (BRK) signal is open-drain output which can withstand maximum voltage 40 V and maximum current 1 A. The default output for brake output (BRK) signal is O4, but O4 can still be set for other output function. For setting output function, pleas refer to section 5.4.2.

■ Wiring for control power and brake

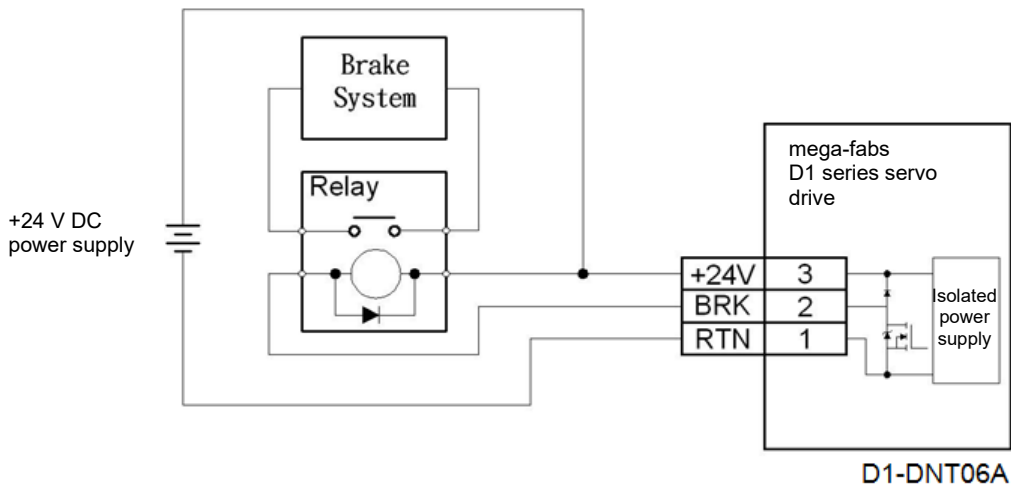


Figure4.5.1

4.6 RS232 communication (CN1)

(1) Pin assignment

Table4.6.1

Pin	Signal	Function
1	N/C	Do not connect.
2	RXD	Receive data from PC.
3	SG	Signal ground
4	SG	Signal ground
5	TXD	Send data to PC.
6	N/C	Do not connect.

(2) Connection for RS232 communication

Use HIWIN LMACR21D RS232 communication cable.

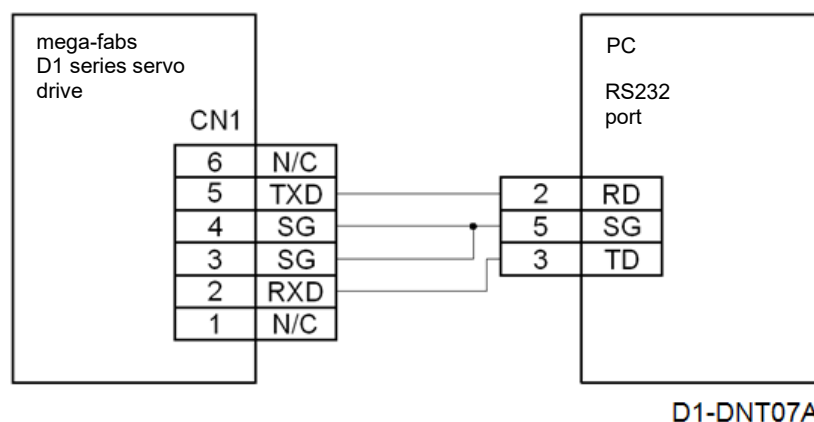


Figure4.6.1

(3) CN1 RJ11 pin assignment

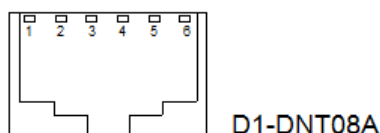


Figure4.6.2

4.7 Wiring for control signals (CN2)

(1) Pin assignment

Table4.7.1

Pin	Signal	Function	
1	FG	Frame ground (For connecting cable shield)	
2	SG	Signal ground	
-	-	Set inputs as pull up or pull down in Lightning.	
3	I1	For enabling or disabling motor The pin can also be set for other function.	Group A
4	I2	General-purpose input signal (Programmable)	Group A
5	I3		Group A
6	I4		Group B
7	I6		Group C
8	I9M	In position mode, these 4 pins are used for receiving pulse command. In other mode, I9 and I10 are general-purpose inputs. I9M and I10M have no function. In velocity mode and force/torque mode, I9 and I10 are for PWM signal input.	-
9	I10M		-
10	I9		Group D
11	I10		Group D

Pin	Signal	Function	
12	I11	I11, general-purpose input signal (Programmable)	Group D
13	O1	General-purpose output signal (Programmable)	
14	O2		
15	O3		
16	A	Feedback pulse output (Buffered encoder or emulated encoder)	
17	/A		
18	B		
19	/B		
20	Z		
21	/Z		
22	+5 V	Encoder +5 Vdc power output The total load current cannot exceed 400 mA.	
23	SG	Signal ground	
24	Ref +	Positive pin for analog command input	
25	Ref -	Negative pin for analog command input	
26	I12	D1 model: I12, general-purpose input signal (Programmable)	Group D

Note:

The high-level input voltage of pulse command and PWM command must be greater than 2 V. The low-level input voltage must be lower than 0.8 V.

(2) Dedicated inputs in operation mode

The dedicated inputs in each operation mode are listed in the table below.

Table4.7.2

Mode	Input	Function		
Position mode	-	Pulse/Direction command input	CW/CCW command input	AqB command input
	I9, I9M	Pulse	CW	A
	I10, I10M	Direction	CCW	B
Force/torque mode and velocity mode	I9, I10	General-purpose input		
	I9M, I10M	No function		

(3) CN2 pin assignment

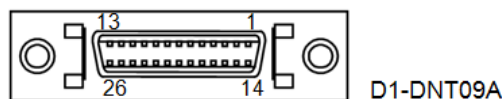


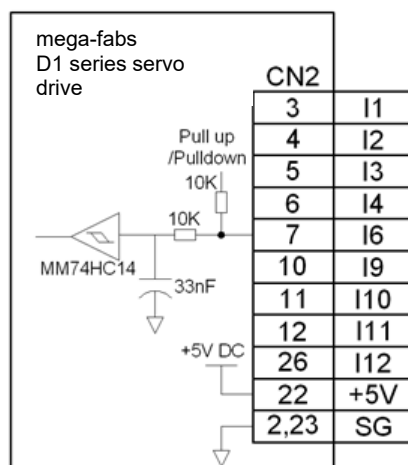
Figure4.7.1

4.7.1 Wiring diagram for digital inputs

The CN2 connector on D1 servo drive provides 9 digital inputs. The input interface circuit is shown in the figure below. The maximum voltages for I9 and I10 are 12 V, and the maximum voltages for other inputs can be 24 V. The inputs of the servo drive can be set as pull up or pull down for different controller. When the output of controller is sink type (For example, NPN transistor output), the input of the servo drive should be set as pull up. When the output of controller is source type (For example, PNP transistor output), the input of the servo drive should be set as pull down. To set the input as pull up or pull down in Lightening, please refer to section 5.4.1.

Note:

The high-level input voltage must be greater than 2 V and the low-level input voltage must be lower than 0.8 V.



The pull-up resistance (R) of I9 and I10 is 1.3 K. The pull-up resistance (R) of other inputs is 10 K.

D1-DNT10A

Figure4.7.1.1

The actual wiring may vary with the output type of controller. The wiring examples for controllers using PNP transistor output, NPN transistor output and relay are provided below.

(1) The wiring example for general-purpose digital inputs (The output type of controller is sink.)

The input group should be set as pull up in Lightning.

a If the photoelectric switch in controller is using NPN transistor

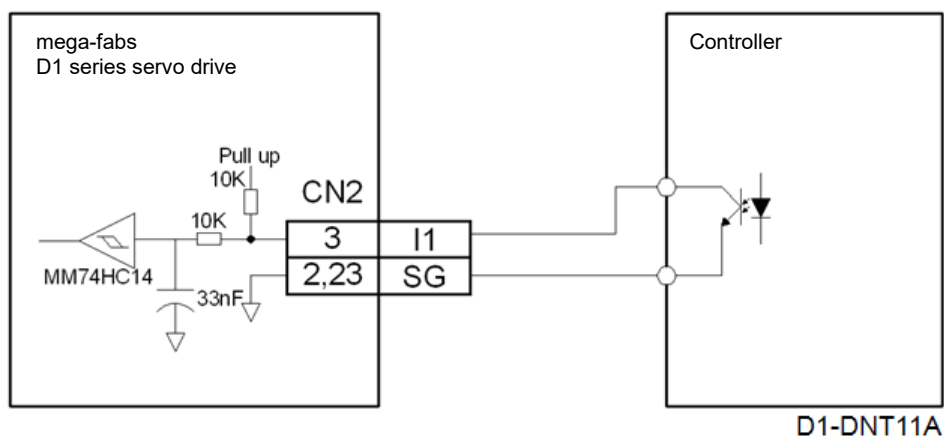


Figure4.7.1.2

b If the controller is using output switch

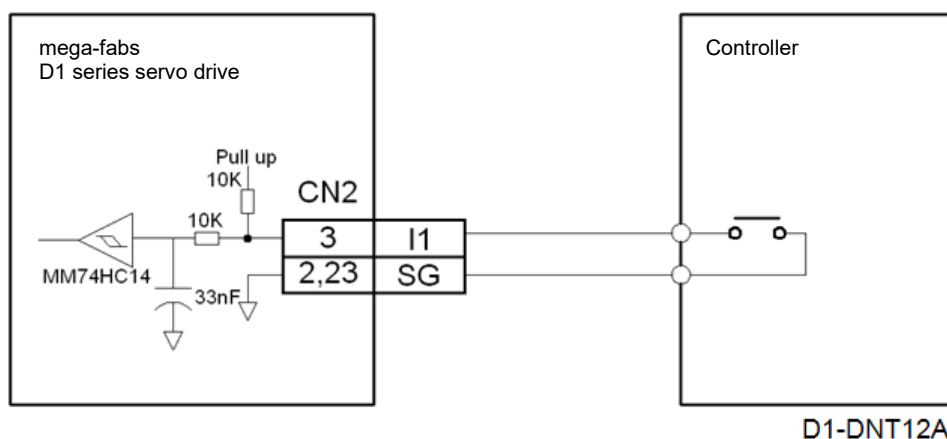


Figure4.7.1.3

- (2) The wiring example for general-purpose digital inputs (The output type of controller is source.)
The input group should be as pull down in Lightening.

- a If the photoelectric switch in controller is using PNP transistor

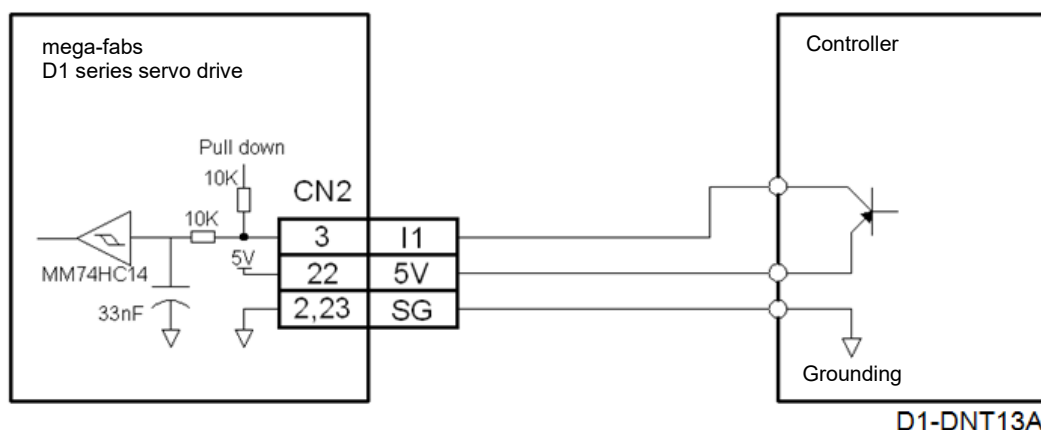


Figure4.7.1.4

Note:

If the required power for the photoelectric switch in controller is 5 V, the 5 V power can be provided via pin 22 on CN2. The total load current must not exceed 400 mA.

4.7.2 Wiring diagram for digital outputs

The CN2 connector on D1 servo drive provides 3 digital outputs (O1~O3). The output interface circuit is shown in the figure below. The outputs are open-drain outputs with allowable maximum voltage 40 V and maximum current 0.3 A. Output O4 is on control power connector. O4 is usually used for brake output, but it can also be set as general-purpose output. For setting output signal in Lightening, please refer to section 5.4.2.

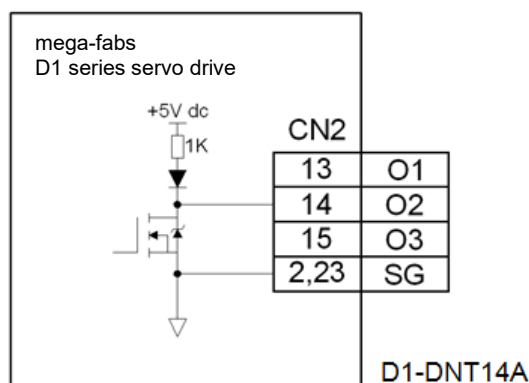


Figure4.7.2.1

(1) The wiring example for connecting to controller

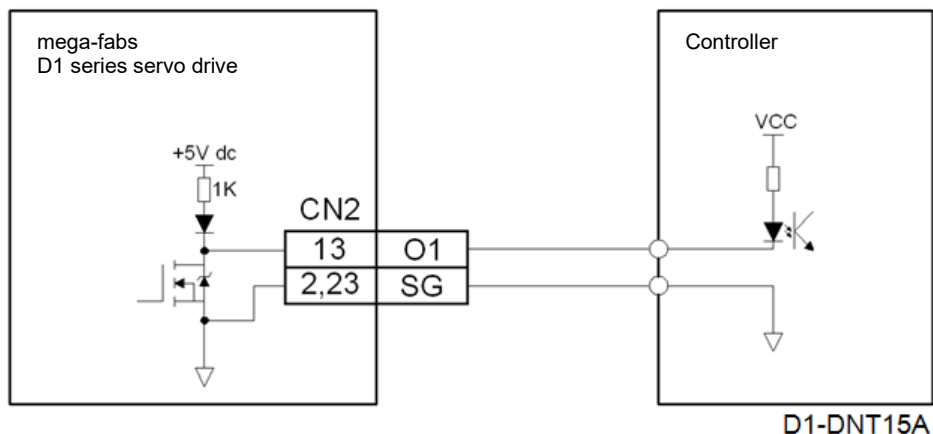


Figure4.7.2.2

(2) The wiring example for connecting to relay

When a relay is used, please also connect a diode with the relay, please refer to the figure below.

Ensure the direction of the diode is correct to avoid damage to the servo drive.

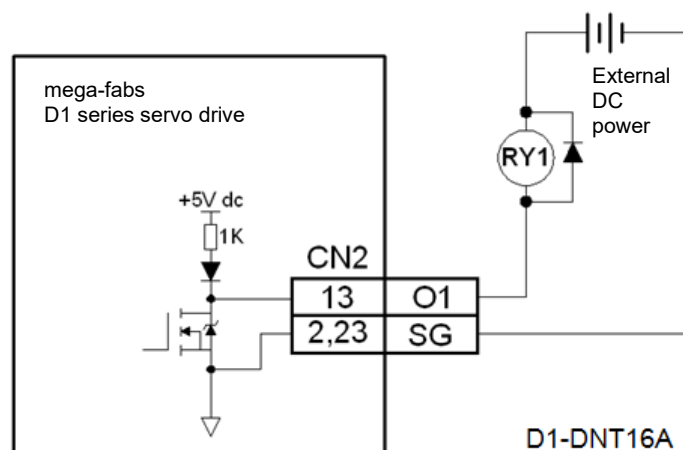


Figure4.7.2.3

(3) Wiring example for directly connecting to external load

The output can be directly connected to load (For example, indicator). For the wiring method, please refer to the figure below. The voltage and current of external DC power cannot exceed 40 V and 0.3 A.

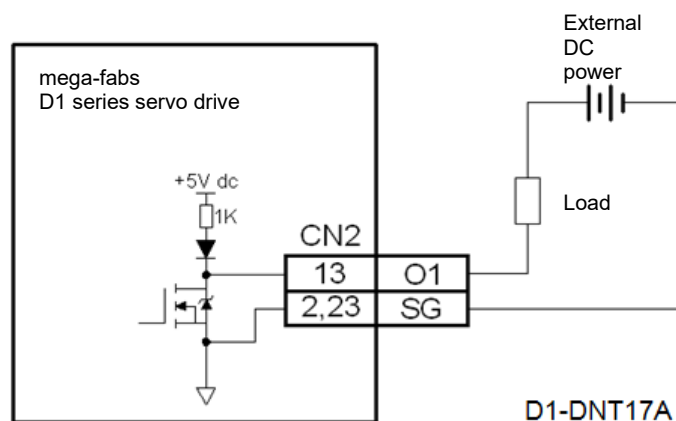


Figure4.7.2.4

4.7.3 Wiring diagram for pulse command input

In position mode, I9, I9M, I10 and I10M are used to receive pulse command. There are two wiring methods, please refer to below.

(1) Wiring example for controller sending differential signal

The setting of differential signal must be completed in Lightning, please refer to section 5.2.4. The maximum input pulse frequency while using differential signal: pulse input (2M pulses/s max.) and Quad A/B (8M counts/s max.).

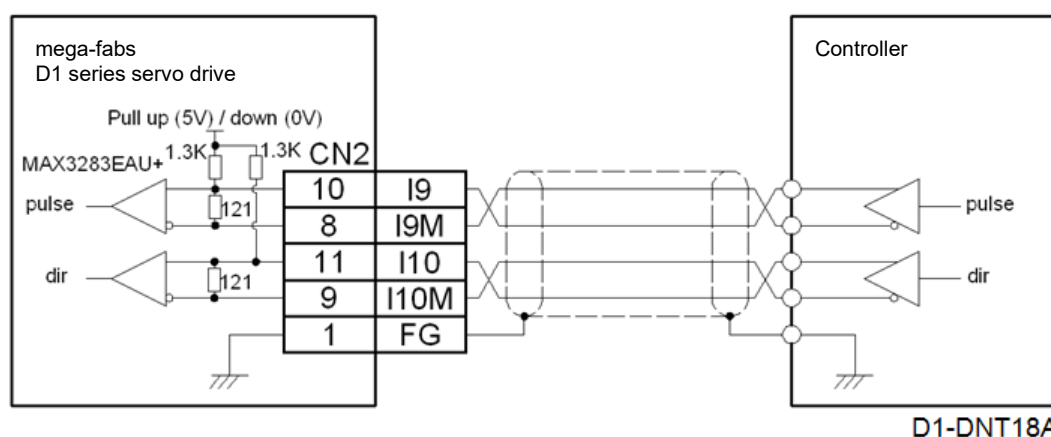


Figure4.7.3.1

(2) Wiring example for controller sending single-ended signal

When D1 servo drive is used with controller sending single-ended signal, pulse adapter cable (815AB3) must be connected to CN2. Refer to the figure below. The pin assignment of the pulse adapter cable (815AB3) is the same as CN2, except for pin 23 and pin 22. Pin 23 is OPC1 and pin 22 has no function. The setting of single-ended signal must be completed in Lightning, please refer to section 5.2.4. Set the trigger method of group D to pull-up in **I/O center** window, please refer to section 5.4.1. The maximum input pulse frequency while using single-ended signal: pulse input (500K pulses/s max.) and Quad A/B (2M counts/s max.).

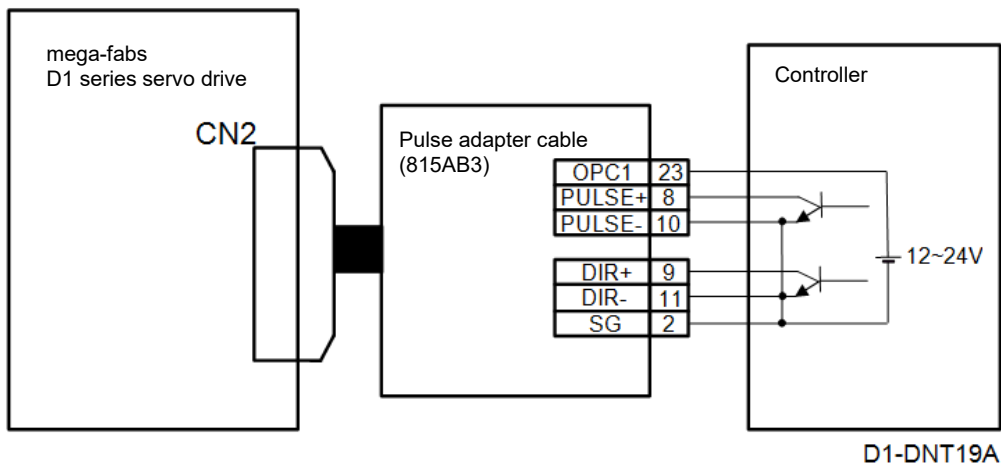


Figure4.7.3.2

■ Installation procedure

Step 1: Connect pulse adapter cable (815AB3) to CN2 of D1 servo drive.

Step 2: Connect HIWIN pulse control cable (LMACK30R) or self-made control cable with the pulse adapter cable.

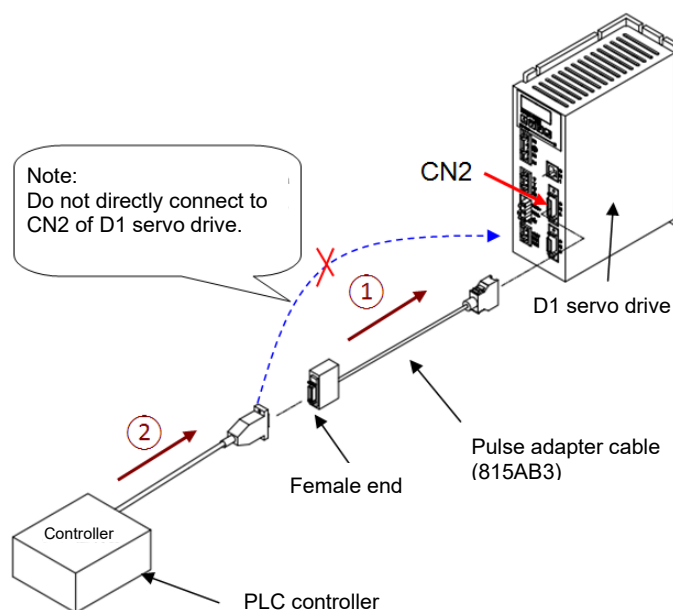


Figure4.7.3.3

■ The using range of pulse adapter cable (815AB3)

- (1) The cable can be used with PLC single-ended pulse control interface.
- (2) The cable can be used with 12 V~24 V pulse control power.
- (3) The maximum operating bandwidth is 500 Kpps.

■ Note

- (1) The pins 8, 9, 10, 11, 22 and 23 of pulse adapter cable (815AB3) are different from the pin definition of D1 servo drive.
- (2) Pulse adapter cable (815AB3) is used for interface conversion of pulse signal to improve compatibility.
- (3) In Lightening, go to **Mode** tab in Configuration center and select **Single ended signals**.

Refer to table 4.7.3.2 while connecting HIWIN pulse control cable (LMACK30R) with pulse adapter cable (815AB3). When other cable is used, please refer to the signals on the female end of the pulse adapter cable (815AB3).

- (3) Wiring example for controller sending single-ended signal and pulse adapter cable (815AB3) is not used

External resistor is required to ensure the NPN transistor output of controller can meet the lowest limit of breakover current, so operating velocity can be reached and pulse reception can be normal.

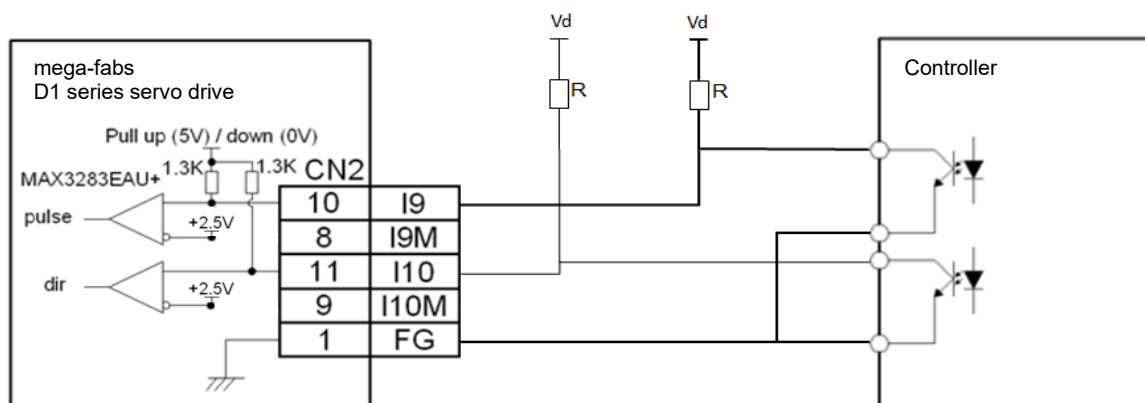


Figure4.7.3.4

Example:

If the pulse frequency output from controller needs to be 200 KHz, the internal NPN transistor needs to be within the range of 12 mA IL (min) and 500 mA IL (max) (Refer to the datasheet of PLC.). The external resistor must be: $R = V_d / \{I_L(\min) \times (1 + 10\%) - 3.8\text{mA}\}$

Table4.7.3.1

External Voltage (Vd)	Applicable Resistance (R)	Watt	D1 Setting
5	392~523	0.25W	Pull up
12	787~1.3K	0.25W	Pull up
24	1.37K~2K	0.5W	Pull up

Table4.7.3.2

The wire color table of HIWIN pulse control cable (LMACK30R) when connected with pulse adapter cable (815AB3)					
Pin	Wire Color	Signal on Female End (815AB3)	Pin	Wire Color	Signal on Female End (815AB3)
1	Brown	Frame Ground	14	Blue	O2
2	Brown/Black	Signal Ground	15	Blue/Black	O3
3	Red	I1	16	Light Blue	Encoder A
4	Red/Black	I2	17	Light Blue/Black	Encoder /A
5	Orange	I3	18	Purple	Encoder B
6	Orange/Black	I4	19	Purple/Black	Encoder /B
7	Green	I6	20	Gray	Encoder Z
8	Pink	PULSE+	21	Gray/Black	Encoder /Z
9	Yellow	DIR+	22	White/Red	-
10	Pink/Black	PULSE-	23	Black	OPC1
11	Yellow/Black	DIR-	24	White	Analog Ref In (+)
12	Green/Black	I11	25	White/Black	Analog Ref In (-)
13	Light Green	O1	26	Light Green/Black	I12
case	-	Shield	-	-	-

Note:

This table is not applicable to CN2 on D1 servo drive. Pin 23 on the female end of pulse adapter cable (815AB3) is for 12~24 V input, but CN2-Pin 23 on D1 servo drive is for 0 V reference.

■ Wiring diagram for position control

(1) Do not use external resistor

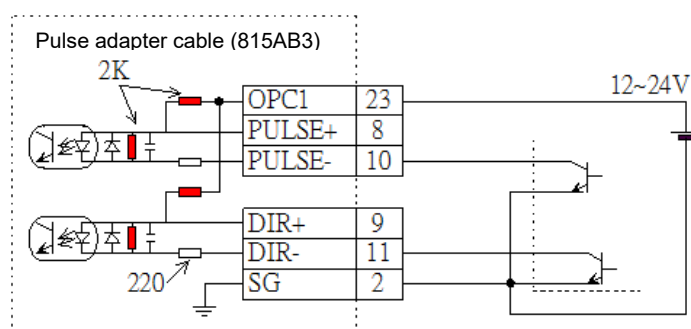


Figure4.7.3.5

(2) Use external resistor

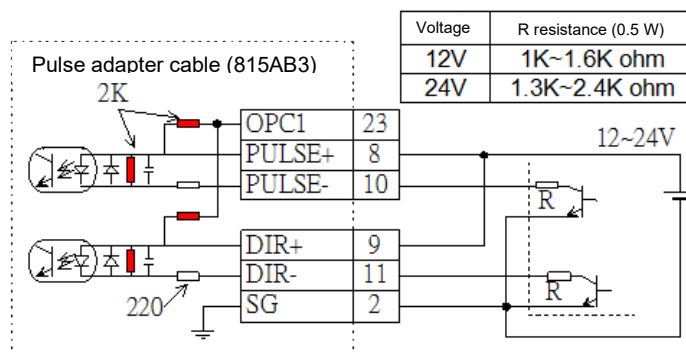


Figure4.7.3.6

■ Wiring example for PLC pulse input

- (1) In the figure below, Mitsubishi PLC FX3U-48MT/□S is used as the example for the wiring of Pulse/Dir and A/B single-ended (NPN) commands.

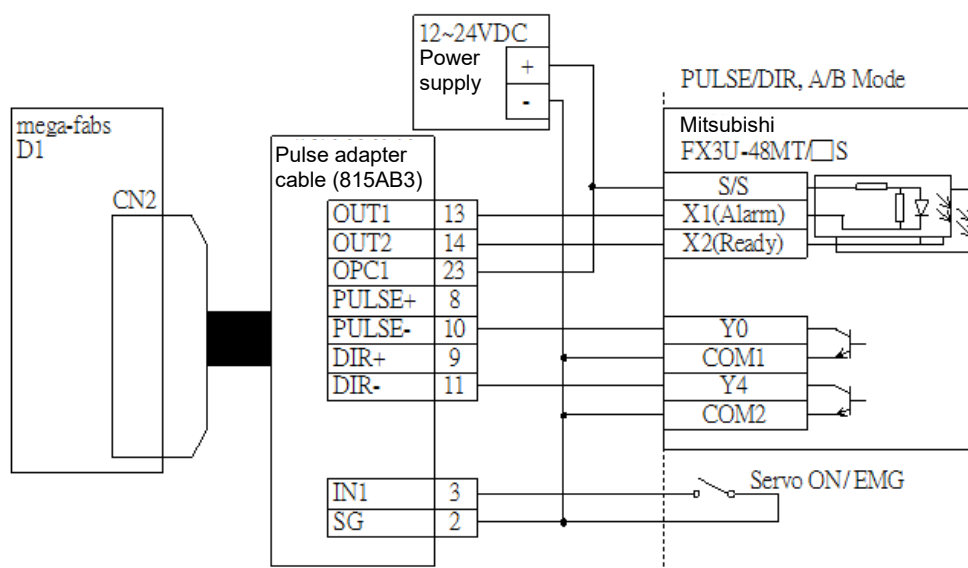


Figure4.7.3.7

- (2) In the figure below, Mitsubishi PLC FX3U-48MT/□S is used as the example for the wiring of CW/CCW single-ended (NPN) command.

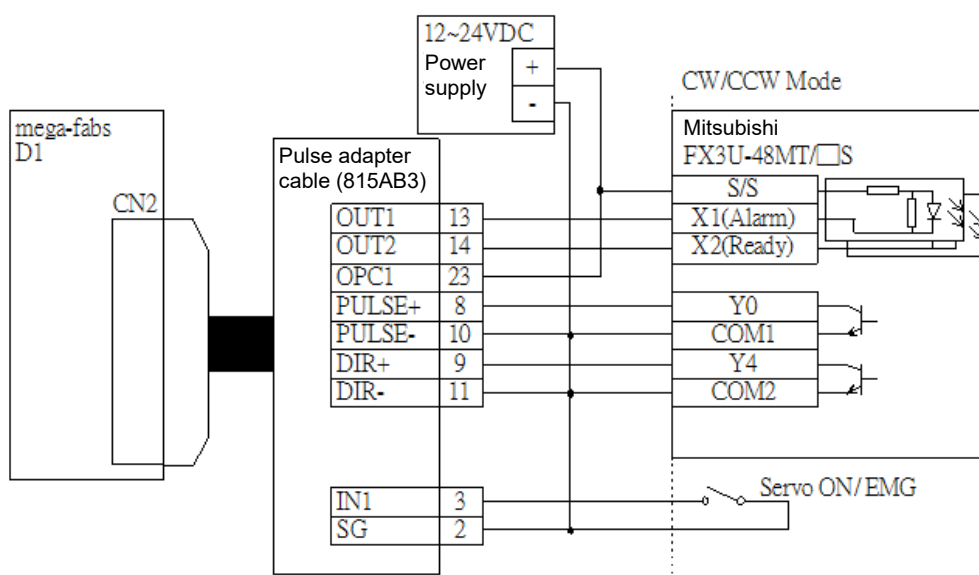


Figure4.7.3.8

4.7.4 Wiring diagram for encoder feedback pulse output

- (1) Wiring example (Differential input from controller)

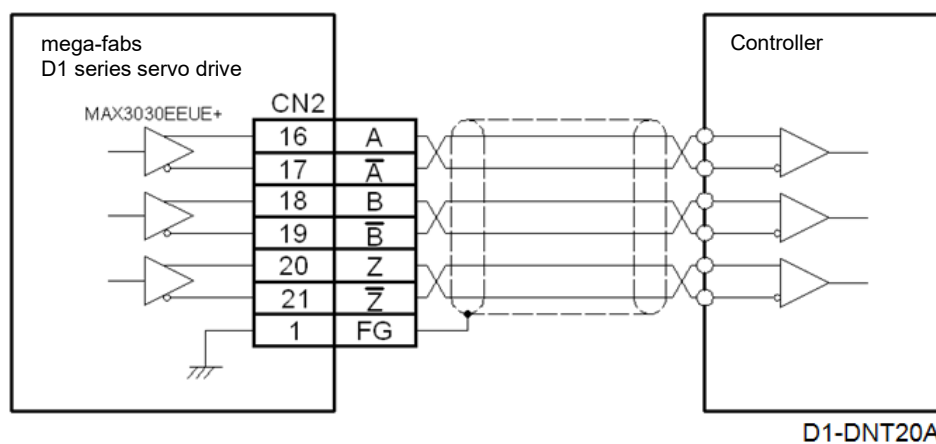


Figure4.7.4.1

(2) Wiring example (Controller is using optical coupling.)

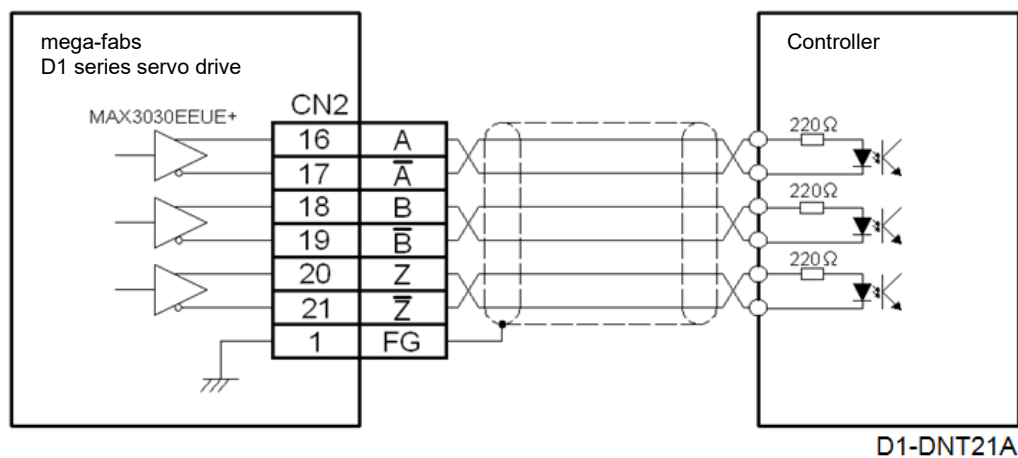


Figure4.7.4.2

4.7.5 Wiring diagram for analog command

The input impedance is 10 KΩ and the range of voltage command is ± 10 V.

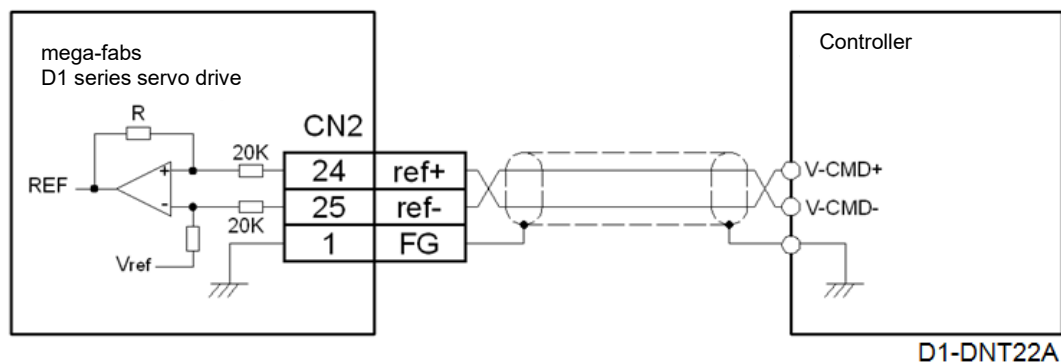


Figure4.7.5.1

4.7.6 Wiring diagram for PWM command input

In velocity mode and force/torque mode, in addition to analog command, D1 servo drive can also receive PWM command. Two PWM command types are supported, PWM 50% and PWM 100%. For more information, please refer to section 5.2.4.

(1) Wiring example for PWM 50%

While using PWM 50%, I9 is used to receive PWM command and I10 has no function. Refer to the wiring below.

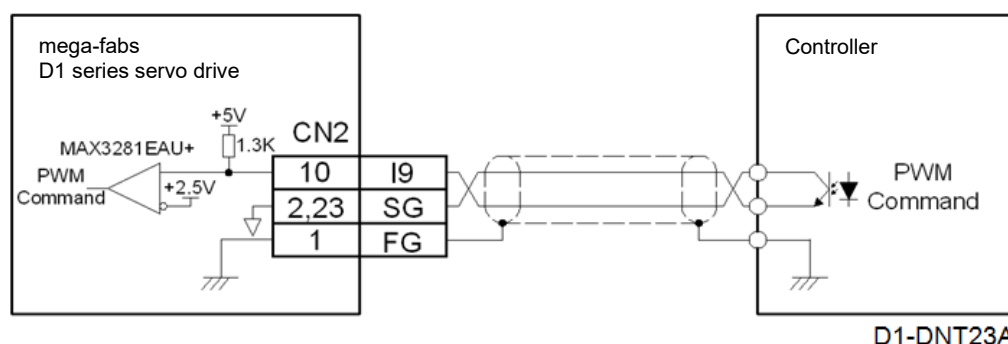


Figure4.7.6.1

(2) Wiring example for PWM 100%

While using PWM 100%, I9 is used to receive PWM command and I10 is used to receive direction command. Refer to the wiring below.

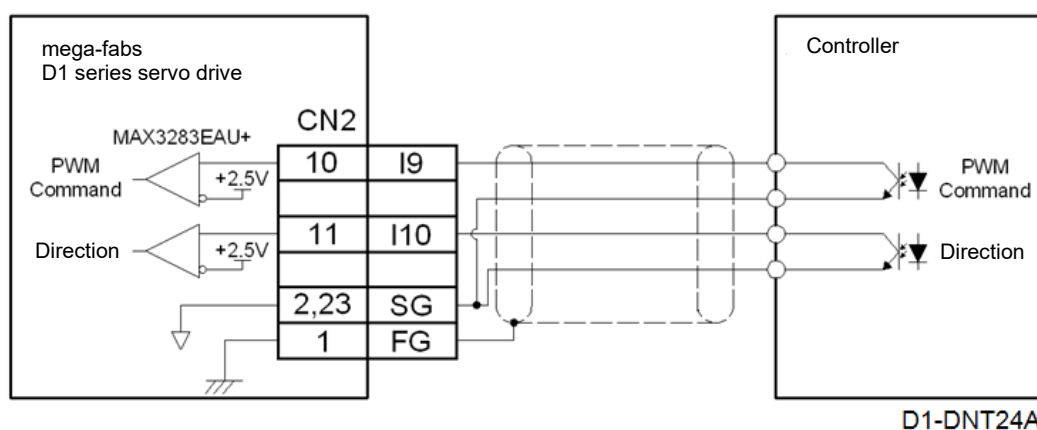


Figure4.7.6.2

4.8 Wiring for feedback signals (CN3)

(1) D1△-△△-△2 CN3 pin assignment

Table4.8.1

Pin	Signal	Function		
1	FG	Frame ground For connecting cable shield		
2	SG	Signal ground and +5 Vdc ground If double-shielded cable is used, it is for connecting the inner shield.		
3	+5V	Encoder and Hall sensor +5 Vdc power output The total load current cannot exceed 400 mA.		
4	A	Digital incremental encoder input		
5	/A			
6	B			
7	/B			
8	Z			
9	/Z			
10	SG	Signal ground and +5 Vdc ground		
11	HA	Motor Hall sensor input		
12	HB			
13	HC			
14	I5	The default setting is for motor over temperature switch, but it can still be set for other function.	Velocity standard	Set I5 as pull up or pull down in group B.
15	SG	Signal ground and +5 Vdc ground		
16	sin+	Analog incremental encoder input		
17	sin-			
18	cos+			
19	cos-			
20	SG	Signal ground and +5 Vdc ground If double-shielded cable is used, it is for connecting the inner shield.		

(2) D1△-△△-△3 CN3 pin assignment

Table4.8.2

Pin	Signal	Function		
1	FG	Frame ground For connecting cable shield		
2	SG	Signal ground and +5 Vdc ground If double-shielded cable is used, it is for connecting the inner shield.		
3	+5V	Encoder and Hall sensor +5 Vdc power output The total load current cannot exceed 400 mA.		
4	A	Digital incremental encoder input		
5	/A			
6	B			
7	/B			
8	Z			
9	/Z			
10	SG	Signal ground and +5 Vdc ground		
11	HA	Motor Hall sensor input		
12	HB			
13	HC			
14	I5	The default setting is for motor over temperature switch, but it can still be set for other function.	Velocity standard	Pull up/pull down is group B.
15	SG	Signal ground and +5 Vdc ground		
16	PS+	Serial data signal cable		
17	PS-			
18	nENC_FLT	Encoder error signal cable		
19	N.A	No function		
20	SG	Signal ground and +5 Vdc ground If double-shielded cable is used, it is for connecting the inner shield.		

(3) Pin assignment of CN3

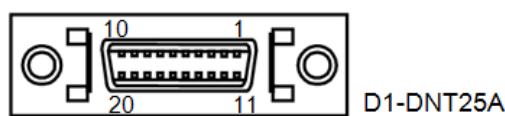


Figure4.8.1

4.8.1 Wiring diagram for digital incremental encoder

When Renishaw digital optical scale (Encoder alarm signal is supported.) is used, the wiring diagram is as below. When digital incremental encoder (Encoder alarm signal is not supported.), remove the wire connected to pin 18 on CN3.

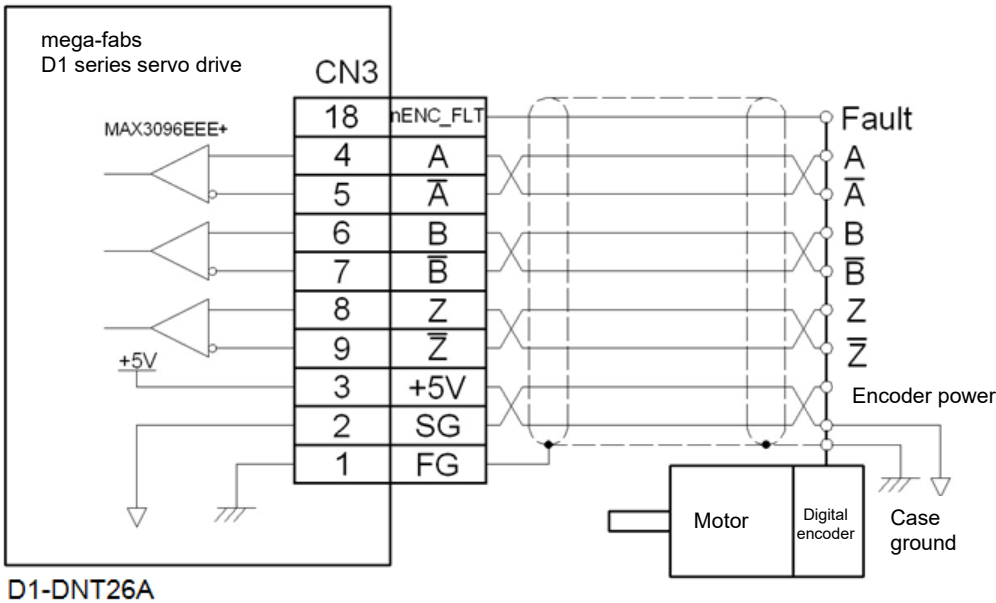


Figure4.8.1.1

4.8.2 Wiring diagram for analog incremental encoder

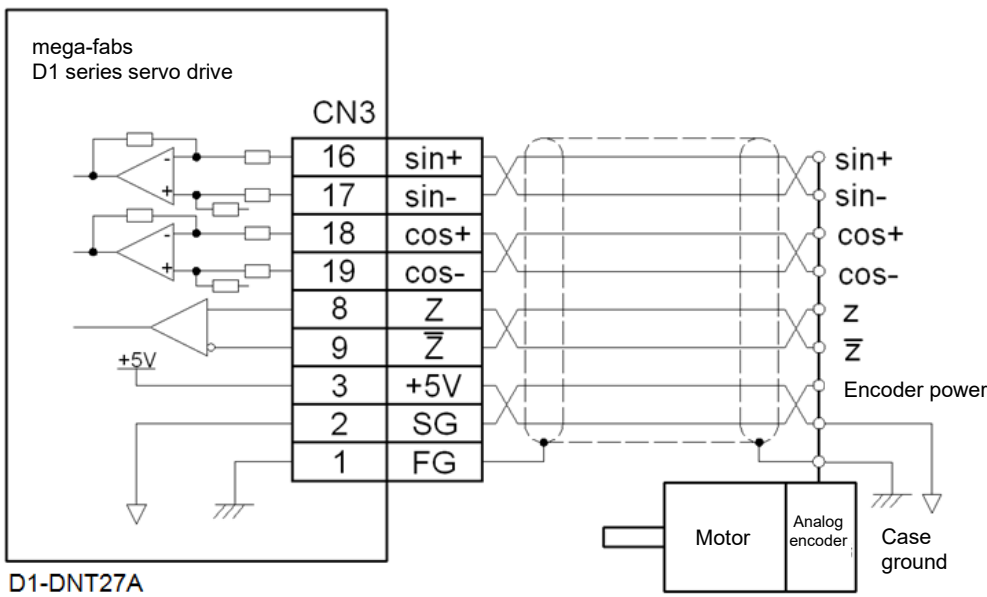


Figure4.8.2.1

4.8.3 Wiring diagram for motor over temperature protection

When HIWIN motor is used, I5 input group B must be pull-up, so the motor over temperature protection can be normal.

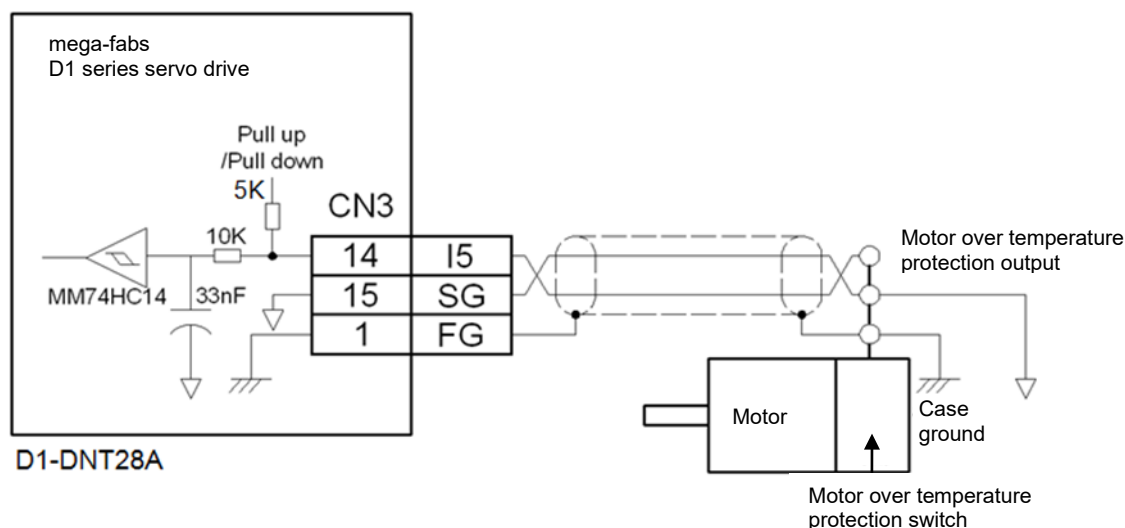


Figure4.8.3.1

4.8.4 Wiring diagram for Hall sensor

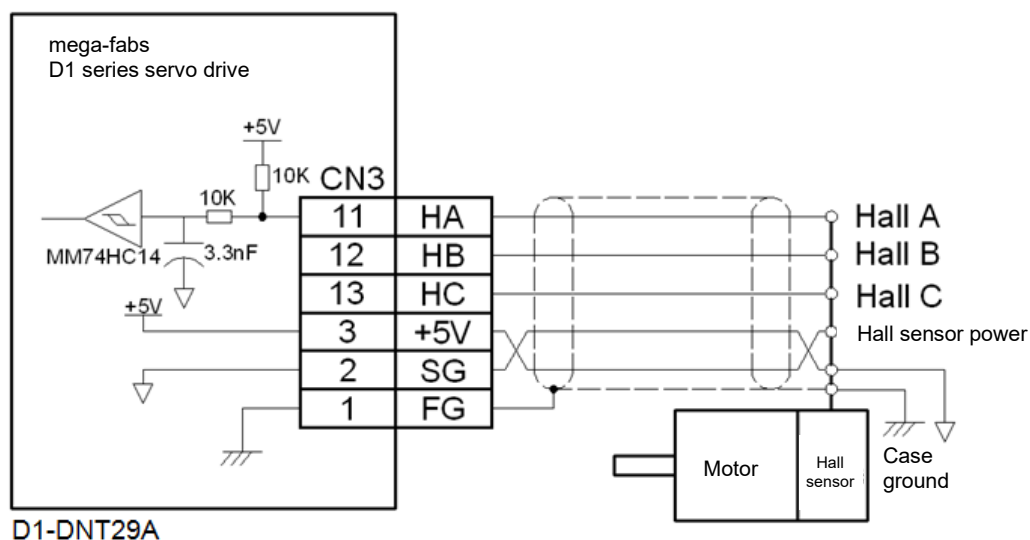


Figure4.8.4.1

4.9 EtherCAT communication (CN4)

(1) Pin assignment

Table4.9.1

Pin	Signal	Function
1	TX+	Data transmission (Positive)
2	TX-	Data transmission (Negative)
3	RX+	Data reception (Positive)
4	EtherCAT Gnd	EtherCAT signal ground
5	EtherCAT Gnd	EtherCAT signal ground
6	RX-	Data reception (Negative)
7	EtherCAT Gnd	EtherCAT signal ground
8	EtherCAT Gnd	EtherCAT signal ground

(2) CN4 RJ45 pin assignment

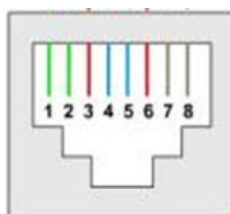


Figure4.9.1

4.10 Accessories of D1 servo drive

(1) Motor power cable

Table4.10.1

Product Name	Model	Description
Motor Power Cable	LMACS□□D	Applicable linear motor: LMS, LMSA, LMC-EFE and LMC-EFF series Supports motor over temperature signal. (Withstand voltage 500 V)
	LMACS□□K	Applicable linear motor: LMCA, LMCB, LMCC, LMCD, LMCE, LMC-EFC and LMT series Supports motor over temperature signal.
	LMACS□□L	Applicable linear motor: LMCF series Supports motor over temperature signal.
	LMACS□□F	Torque motor power cable Applicable torque motor: TMS, TMN and TMY series Do not support motor over temperature signal.
	LMACS□□T	Applicable linear motor: LMSA series Supports motor over temperature signal (Withstand voltage 600 V).
	LMACS□□J	Applicable linear motor: LMF and LMFA series Supports two over temperature signals, KTY and PTC. (Applicable continuous current is below 24 Arms.)
	LMACS□□Q	Applicable linear motor: LMF◇◇L and LMFA◇◇L series Supports two over temperature signals, KTY and PTC. (◇◇ is motor model.)(Applicable continuous current is between 24 to 35 Arms.)
	LMACS□□P	Applicable linear motor: LMF and LMFA series Supports one over temperature signal, PTC.

□□ stands for cable length (Unit: m), refer to the tables below.

a LMACS□□D

Table4.10.2

□□	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Cable Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

b LMACS□□K

Table4.10.3

□□	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Cable Length	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

c LMACS□□L

Table4.10.4

□□	03	04	05	06	07	08	09	10	15
Cable Length	3	4	5	6	7	8	9	10	15

d LMACS□□F

Table4.10.5

□□	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	25
Cable Length	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	25

e LMACS□□T

Table4.10.6

□□	03	04	05	06	07	08	09	10	11	12	13	14	15
Cable Length	3	4	5	6	7	8	9	10	11	12	13	14	15

f LMACS□□J

Table4.10.7

□□	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Cable Length	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

g LMACS□□Q

Table4.10.8

□□	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Cable Length	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

h LMACS□□P

Table4.10.9

□□	03	04	05	06	07	08	09	10	11	12	13	14	15
Cable Length	3	4	5	6	7	8	9	10	11	12	13	14	15

(2) Feedback signal cable

A. D1△-△△-△2: linear motor

Table4.10.10

Product Name	Model	Description
Feedback Signal Cable	LMACE□□C	For Renishaw analog optical scale and HIWIN magnetic scale, D type 15 pin connector Supports motor over temperature signal.
	LMACE□□J	For Renishaw analog optical scale and HIWIN magnetic scale, D type 15 pin connector Supports motor over temperature signal and digital Hall signal.

□□ stands for cable length (Unit: m), refer to the tables below.

a LMACE□□C

Table4.10.11

□□	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Cable Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

b LMACE□□J

Table4.10.12

□□	03	04	05	06	07	08	09	10
Cable Length	3	4	5	6	7	8	9	10

B. D1△-△△-△2: TMS, TMN◇◇E, TMN◇◇EH and TMN◇◇R torque motors

Table4.10.13

Product Name	Model	Description
Feedback Signal Cable	LMACE□□AA	For JENA analog encoder Applicable torque motor: TMS, TMN◇◇E, TMN◇◇EH and TMN◇◇R series Supports motor over temperature signal. Do not support Hall signal. ◇◇ is motor model.
	LMACE□□AM	For JENA analog encoder Applicable torque motor: TMS, TMN◇◇E, TMN◇◇EH and TMN◇◇R series Supports motor over temperature signal and Hall signal. ◇◇ is motor model.

□□ stands for cable length (Unit: m), refer to the tables below.

a LMACE□□AA

Table4.10.14

□□	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	25
Cable Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	25

b LMACE□□AM

Table4.10.15

□□	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Cable Length	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

C. D1△-△△-△3: linear motor

Table4.10.16

Product Name	Model	Description
Feedback Signal Cable	LMACE□□AW	For Renishaw digital optical scale and HIWIN magnetic scale, D type 15 pin Supports digital encoder alarm signal. Do not support Hall signal.
	LMACE□□AV	For Renishaw digital optical scale and HIWIN magnetic scale, D type 15 pin Supports digital encoder alarm signal and Hall signal.

□□ stands for cable length (Unit: m), refer to the tables below.

a LMACE□□AW

Table4.10.17

□□	02	03	04	05	06	07	08	09	10	11	12	13	14	15
Cable Length	2	3	4	5	6	7	8	9	10	11	12	13	14	15

b LMACE□□AV

Table4.10.18

□□	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Cable Length	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

D. D1△-△△-△4: TMY and TMN◇◇A torque motors

Table4.10.19

Product Name	Model	Description
Feedback Signal Cable	LMACE□□AU	Dual resolver Applicable torque motor: TMY and TMN◇◇A series Supports over temperature signal. ◇◇ is motor model.

□□ stands for cable length (Unit: m), refer to the table below:

a LMACE□□AU

Table4.10.20

□□	02	03	04	05	06	07	08	09	10
Cable Length	2	3	4	5	6	7	8	9	10

(3) Control signal cable

Table4.10.21

Product Name	Model	Description
Control Signal Cable	LMACK□□R	3 meters Signal cable for connecting to controller With bare wires at one end (controller end) for soldering by user
Pulse Adapter Cable	LMACK□□A	Signal cable for connecting to ACS SPiiPlus SA controller
-	815AB3	For controller sending single-ended pulse signal (optional)

□□ stands for cable length (Unit: m), refer to the tables below.

a LMACK□□R

Table4.10.22

□□	30	50
Cable Length	3	5

b LMACK□□A

Table4.10.23

□□	01	02	03	04	05	06	07	08	09	0A	0B	0C
Cable Length	1	2	3	4	5	6	7	8	9	10	11	12

c 815AB3

Table4.10.24

Cable Length	0.3
--------------	-----

(4) RS232 communication cable

Table4.10.25

Product Name	Model	Description
RS232 Communication Cable	LMACR21D	2 meters RJ11 connector for connecting to servo drive

(5) Connector kit and EMC kit

A. Connector kit

Table4.10.26

Product Name	Model	Description	Qty.
D1 Servo Drive Accessory Pack (Without CN3 connector)	D1-CK1	Connector for AC main power cable 4 pin, pitch 7.5 mm	1
		Connector for motor power cable 4 pin, pitch 5 mm	1
		Connector for regenerative resistor 3 pin, pitch 7.5 mm	1
		Connector for control power 3 pin, pitch 5 mm	1
		Connector for CN2 (control signal) MDR 26P solder connector	1
		Connector tool Wago 231-131	1
D1 Servo Drive Accessory Pack (With CN3 connector)	D1-CK2	Connector for AC main power cable 4 pin, pitch 7.5 mm	1
		Connector for motor power cable 4 pin, pitch 5 mm	1
		Connector for regenerative resistor 3 pin, pitch 7.5 mm	1
		Connector for control power 3 pin, pitch 5 mm	1
		Connector for CN2 (control signal) MDR 26P solder connector	1
		Connector for CN3 (feedback signal) MDR 20P solder connector	1
		Connector tool Wago 231-131	1

B. EMC kit

Table4.10.27

Product Name	Model	Description	Qty.
D1 EMC accessory kit (single-phase)	D1-EMC1	Single-phase filter FN2090-10-06 (Rated current: 10 A, Leakage current: 0.67 mA)	1
		EMI Core KCF-130-B	2
D1 EMC accessory kit (Three-phase)	D1-EMC2	Three-phase filter FN3258-7-45 (Rated current: 7 A, Leakage current: 33 mA)	1
		EMI Core KCF-130-B	2
D1 EMC accessory kit (Three-phase)	D1-EMC3	Three-phase filter FN3025HL-20-71 (Rated current: 20 A, Leakage current: 0.4 mA)	1
		EMI Core KCF-130-B	2
D1 EMC accessory kit (Three-phase)	D1-EMC4	Three-phase filter FN3025HL-10-71 (Rated current: 10 A, Leakage current: 0.4 mA)	1
		EMI Core KCF-130-B	2

Note:

Depending on user's need, EMI core can be used on main power cable, motor power cable, encoder cable or pulse control cable to reduce interference.

◆ Filter dimensions

(1) D1-EMC1

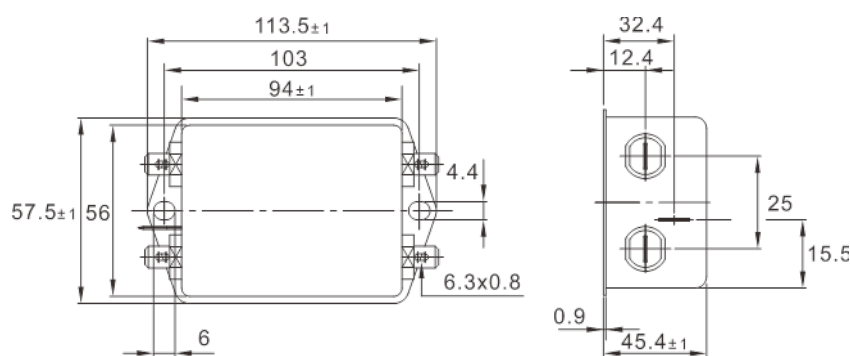


Figure4.10.1

(2) D1-EMC2

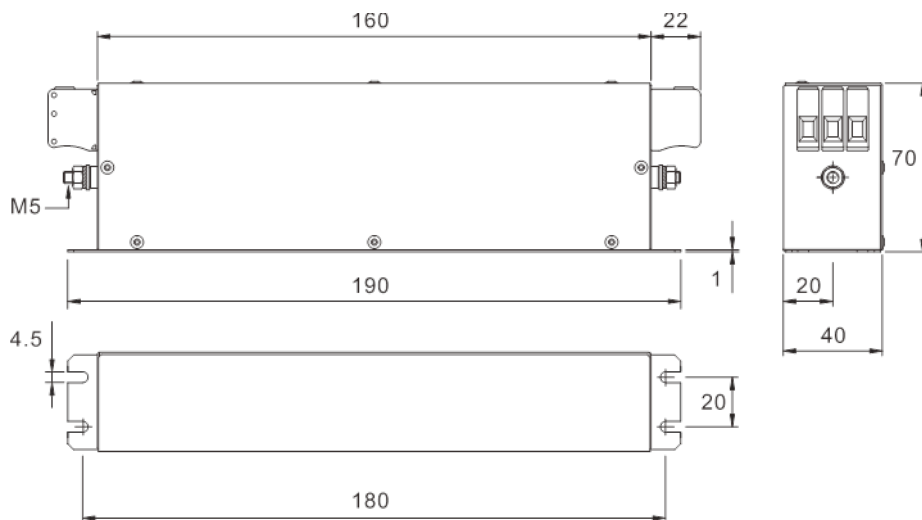


Figure4.10.2

(3) D1-EMC3

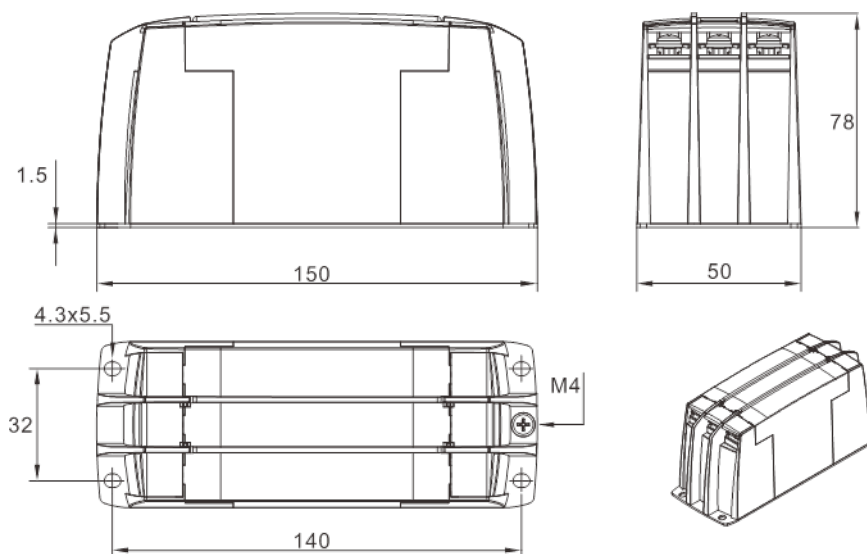


Figure4.10.3

(4) D1-EMC4

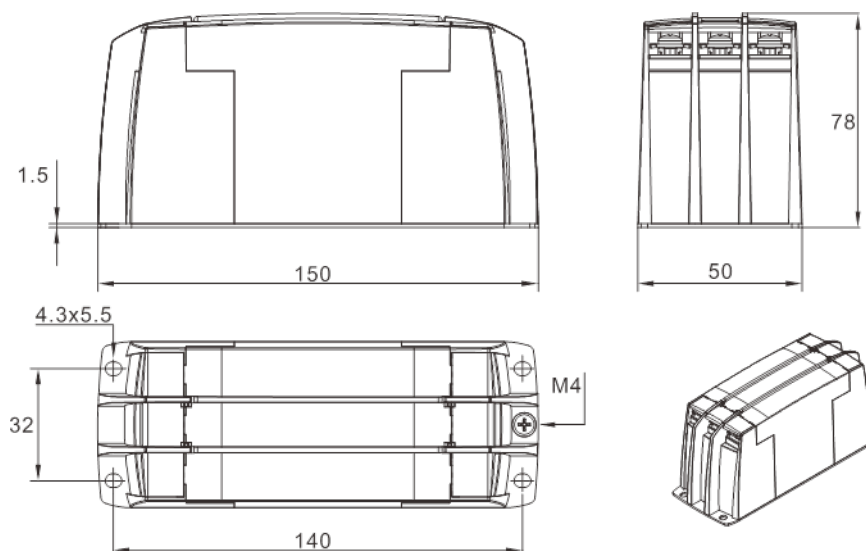


Figure4.10.4

C. Harmonic suppression reactor

Table4.10.28

Product Name	Model	Description
Single-phase AC Reactor	TS10C-16	<ol style="list-style-type: none"> 1. The servo drive complies with EN61000-3-2 Class A. 2. Reactance: 2 mH (at 60 Hz 16 A/220 V) 3. Connect to L1 and L2 on the servo drive.

(6) Regenerative resistor

Table4.10.29

Product Name	Model	Description
Regenerative Resistor	050100700001	68 Ω Rated power: 100 W Instantaneous power: 500 W
	050100700009	120 Ω Rated power: 300 W Instantaneous power: 1500 W
	050100700008	50 Ω Rated power: 150 W Instantaneous power: 750 W
	050100700019	50 Ω Rated power: 600 W Instantaneous power: 3000 W

(7) Heat sink

Table4.10.30

Product Name	Model	Description
External Heat Sink	D1-H1	Standard

5. Servo drive configuration

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5.1 Installation and communication

Lightening is the human machine interface of D1 servo drive. Connect PC and D1 servo drive via RS232 connection for servo drive initialization, setting, operation, test run and parameter saving in Lightening. This chapter describes how to install Lightening and connect to the servo drive.

5.1.1 Installing Lightening

The files in the setup folder of Lightening are shown in figure 5.1.1.1, including setup file (setup.exe) and firmware folder (dce).

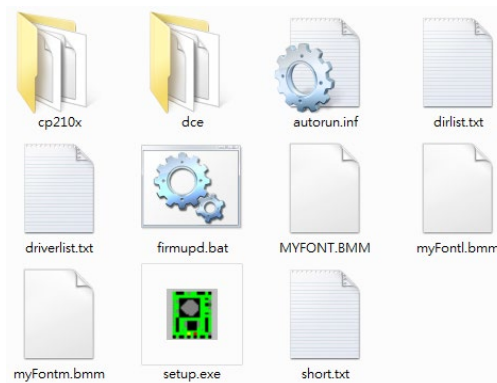


Figure5.1.1.1

If user is using installation CD to install Lightening, the setup program will run automatically. The setup folder can also be downloaded from our website, please go to <https://www.hiwinmikro.tw/en/download>. After the setup folder is downloaded, click on setup file (setup.exe) to install Lightening. The default installation path is "C:\HIWIN\", please do not change the path. The installation window is as figure 5.1.1.2. Click on **Start** button to start installation. When the installation finishes, a message dialog will appear as figure 5.1.1.3. Click on **OK** button to complete the installation.

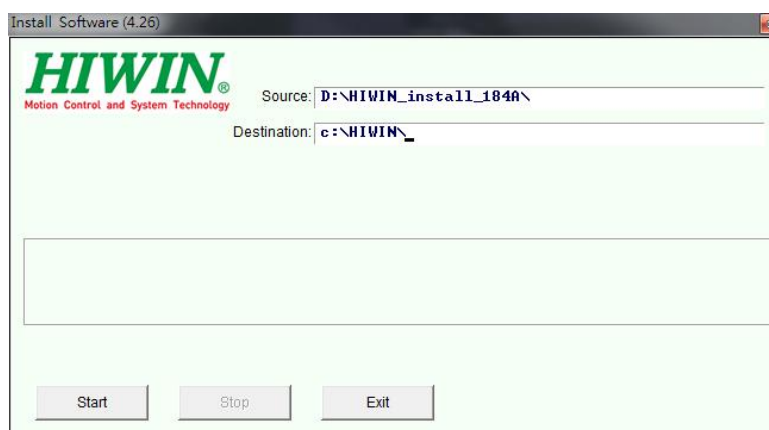


Figure5.1.1.2

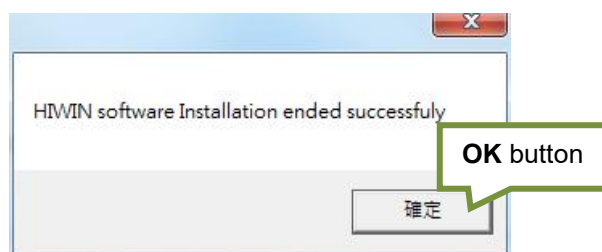


Figure 5.1.1.3

A shortcut of Lightening which is shown as figure 5.1.1.4 will be created on the desktop. The path of the shortcut is “C:\HIWIN\dce\toolswin\winkmi\lightening.exe”.



Figure 5.1.1.4

5.1.2 Communication setup

There are three ways to communicate with the servo drive:

- RS232 communication
- mega-ulink communication
- CoE communication

Section 5.1.2 will introduce how to set up RS232 communication and mega-ulink communication. For CoE communication, please refer to *HIWIN CoE Drive User Guide*. While using mega-ulink communication or CoE communication, it is suggested to use network card with the network chip certified by Beckhoff.

(1) RS232 communication

Before opening Lightening, connect to the servo drive via RS232 communication and turn on 24 Vdc power supply. Normally the servo drive will be automatically connected after Lightening is opened. To modify communication setting, please click on **Tools** and select **Communication setup....**

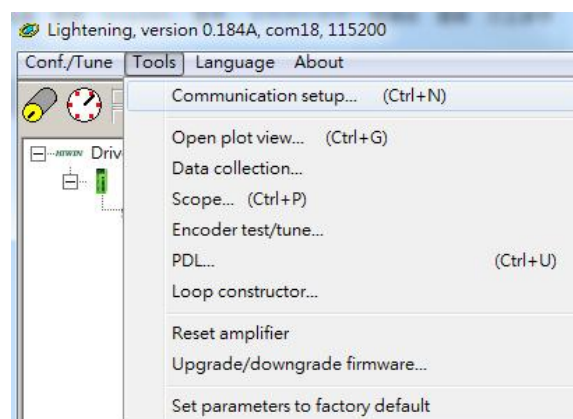


Figure 5.1.2.1

The communication setting window is shown as figure 5.1.2.2. In **lightening Communication Setup** window, **BPS** field shows transmission rate. The default setting of transmission rate is 115,200 and should not be changed. **Port** field shows communication port. All the communication ports of PC will be listed. Select the communication port in use. Normally Lightning can successfully communicate with the servo drive without changing the values in other fields.

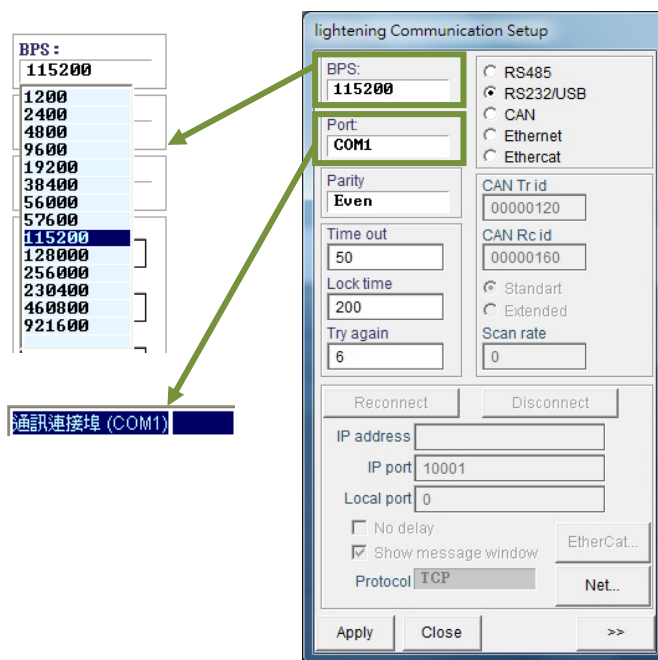


Figure5.1.2.2

(2) mega-ulink communication

While using mega-ulink communication for the first time, please download and install WinPcap. After the installation of WinPcap completes, click on **Tools** and select **Communication setup...** to open **lightening Communication Setup** window. Then select **Ethercat** and click on **EtherCat...** button.

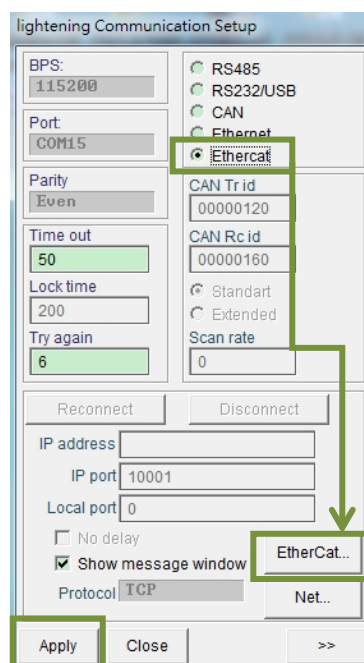


Figure5.1.2.3

EtherCat set up window appears as figure 5.1.2.4. All the network cards of PC will be shown in the window. Select the network card in use and close **EtherCat set up** window. Then click on **Apply** button in **lightening Communication Setup** window.

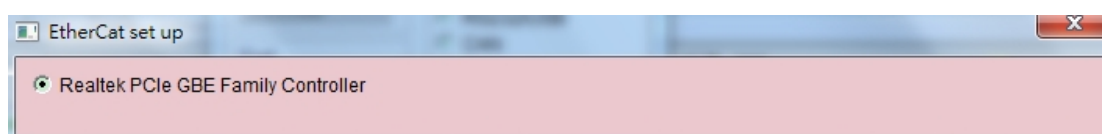


Figure5.1.2.4

After setting completes, a window appears as figure 5.1.2.5. The connected slaves will be shown in the window. Return to the main window of Lightening. The connection is established and **Ethercat** will appear in the title of the window, as figure 5.1.2.6.

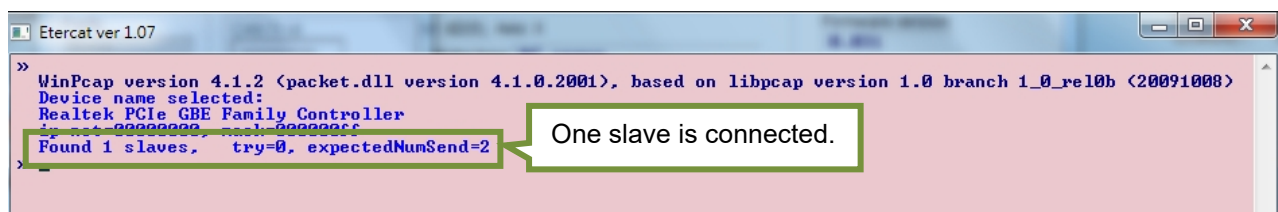


Figure5.1.2.5

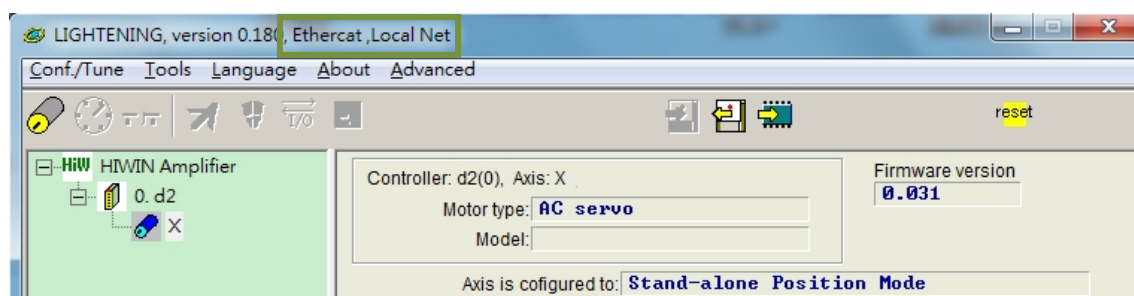


Figure5.1.2.6

5.1.3 Main window

After connection is established, the main window of Lightning is shown as figure 5.1.3.1. Right click on the axis and select **Rename** to change axis name, or directly click on the axis to change axis name.

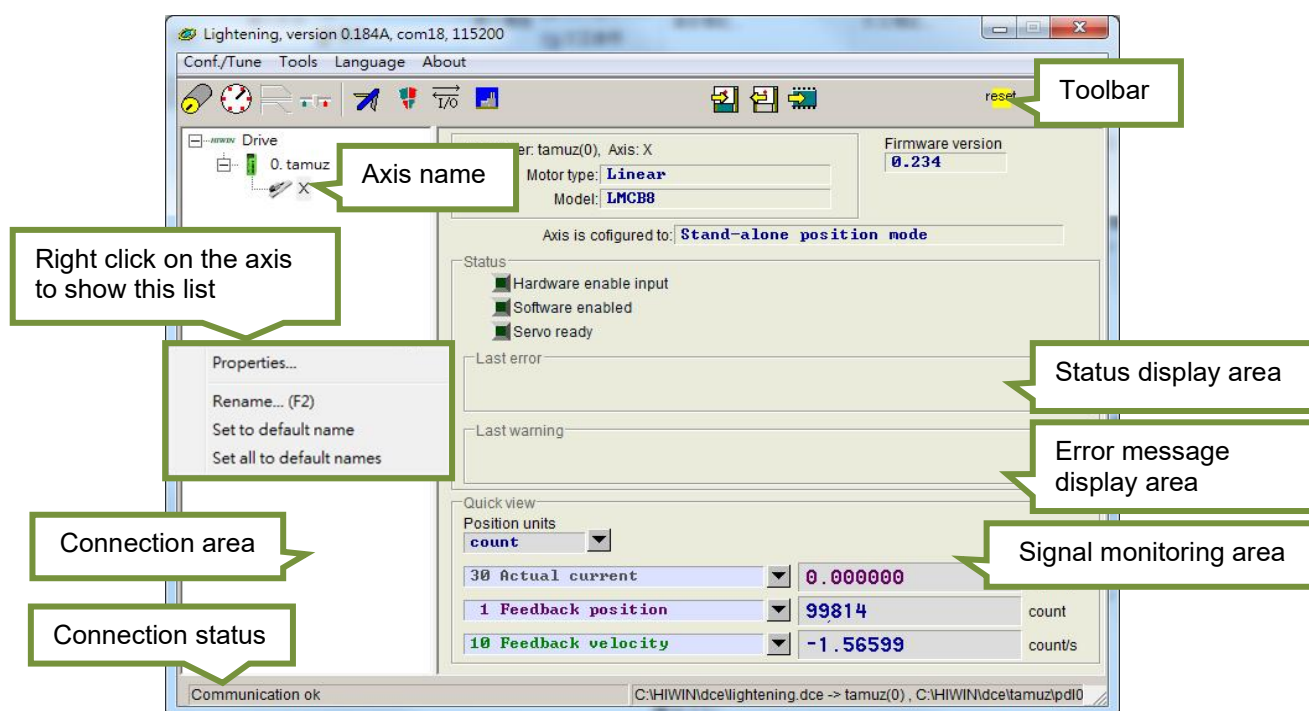


Figure5.1.3.1

(1) Toolbar



: Open the operation window for PDL program.



: Save the parameters in the servo drive RAM as file.



: Load parameters from file to the servo drive RAM.



: Save the parameters from the servo drive RAM to Flash.



: Reset the servo drive.

(2) Status indicator



Servo ready : The indicator is off when the servo drive is in disabling state. When the servo drive is in enabling state, the indicator will be green.



Hardware Enable Input : The indicator is green for hardware enabling. If hardware enabling is not activated first, the motor cannot be successfully enabled. For the setting method of hardware enabling by external input, please refer to section 5.4.1 and chapter 12.



Software Enabled : The indicator is green for software enabling. Only when hardware enabling and software enabling are both activated, the motor can be successfully enabled. In Performance center, click on **Enable** button to activate software enabling. Click on **Disable** button to deactivate software enabling. When PC and the servo drive are not connected, the status of software enabling varies with the status of hardware enabling. If PC and the servo drive are connected, while closing the window, a message dialog will appear asking whether the software enabling should still be activated or not.

(3) Drive property

Right click on axis name and select **Properties**, the properties of the servo drive will be displayed as figure 5.1.3.2.

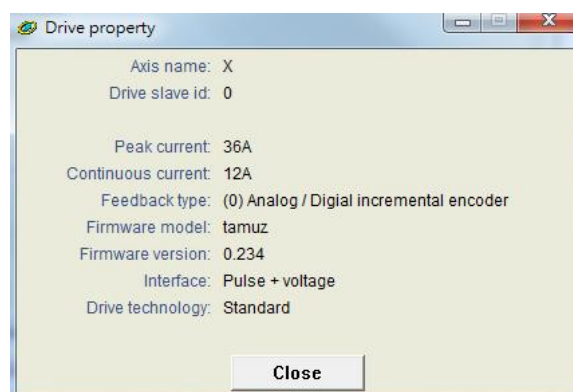



Figure5.1.3.2

5.2 Configuration center

While using a new servo drive or new hardware component such as motor or optical scale, related parameters must be set in Configuration center based on actual application. Click on  on the toolbar or select **Configuration center** from the submenu of **Conf./Tune** to open Configuration center.

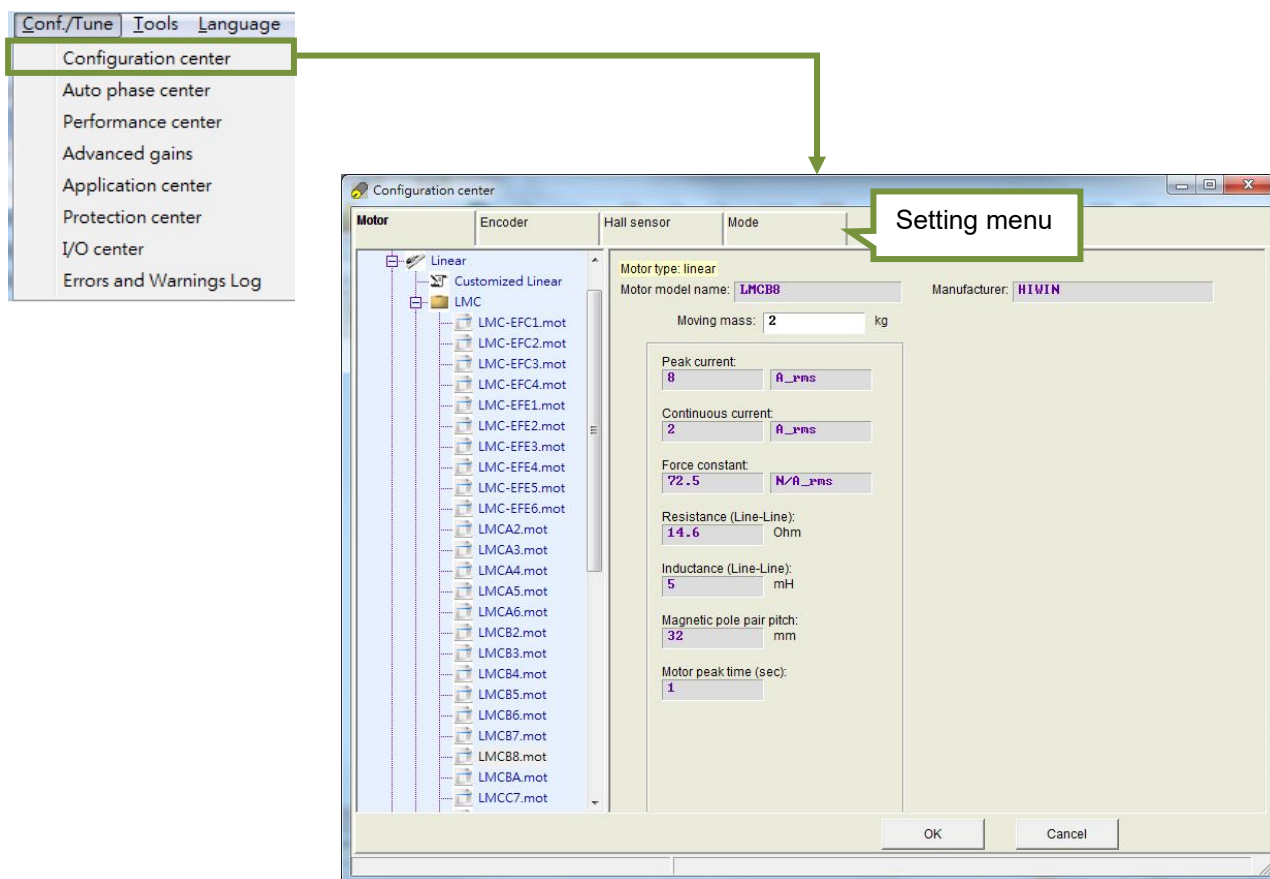


Figure5.2.1

The following settings must be completed to drive motor by D1 servo drive.

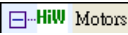
- (1) Motor: Set motor type and related parameters.
- (2) Encoder: Set encoder type and encoder resolution.
- (3) Hall sensor: Set Hall sensor type.
- (4) Mode: Set operation mode.

Refer to sections 5.2.1~5.2.5 for the detailed instructions of the above settings.

Note:

- (1) If HIWIN torque motor is used, encoder parameters of the torque motor will be automatically set after the model is selected. If HIWIN linear motor is used, linear digital 1 um encoder will be automatically selected.
- (2) If a servo drive has not been initialized before, the **OK** button in Configuration center will be grayed out first. After motor parameters, encoder parameters and operation mode are set, the **OK** button becomes clickable.

5.2.1 Setting parameters of motor

D1 servo drive supports linear motor and torque motor. The first page in Configuration center is for setting motor parameters. The supported motors are listed by groups and can be found under . In each groups, user is able to select HIWIN motors, such as LMC, LMS, TMS, etc.

(1) Linear motor

A. Motor parameters

Select the model of HIWIN linear motor to display and set motor parameters.

B. Operation parameter

Moving mass: Set the load mass of motor, including forcer and its housing. (Unit: kg)

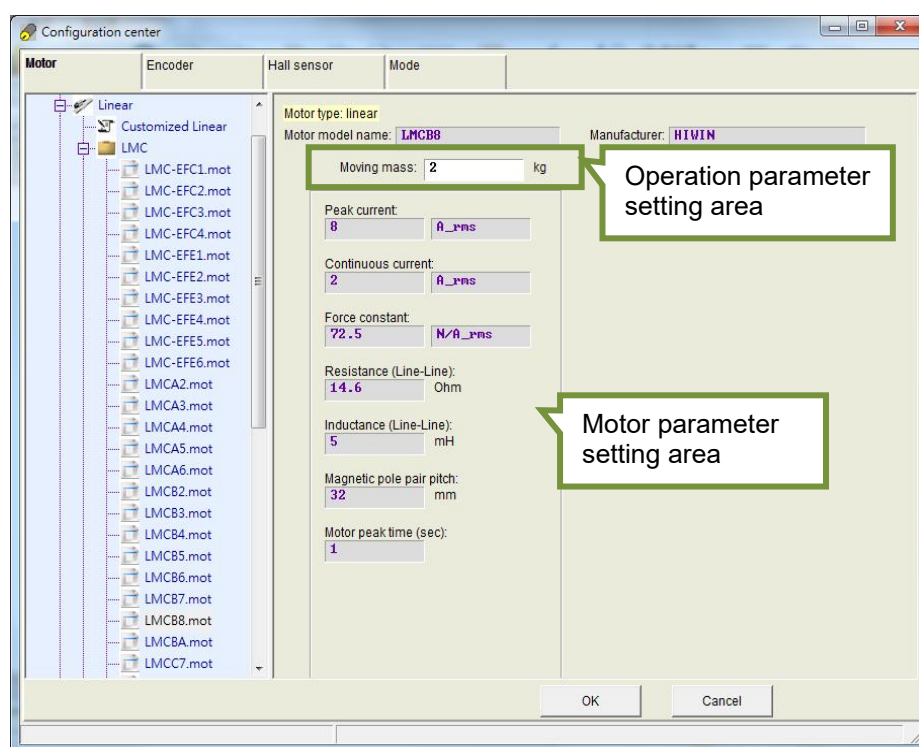


Figure5.2.1.1

Note:

If the peak current of the selected motor exceeds the peak current of the servo drive, a warning dialog will appear to inform user that the motor may have a weaker performance.

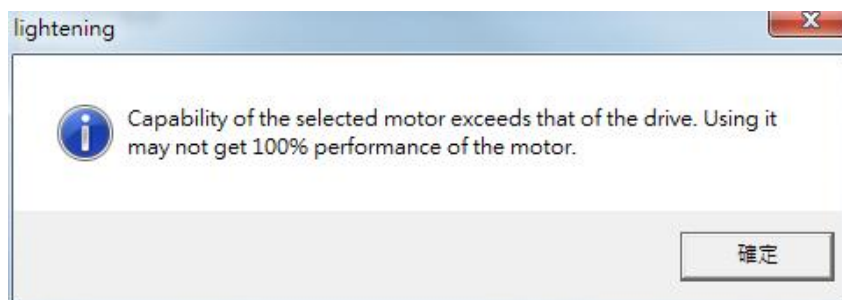


Figure5.2.1.2

(2) Torque motor

A. Motor parameters

Select the model of HIWIN torque motor to display and set motor parameters.

B. Operation parameters

Total moment of inertia: Moment of inertia of torque motor (rotor included) (Unit: $\text{kg} \cdot (\text{m}^2)$)

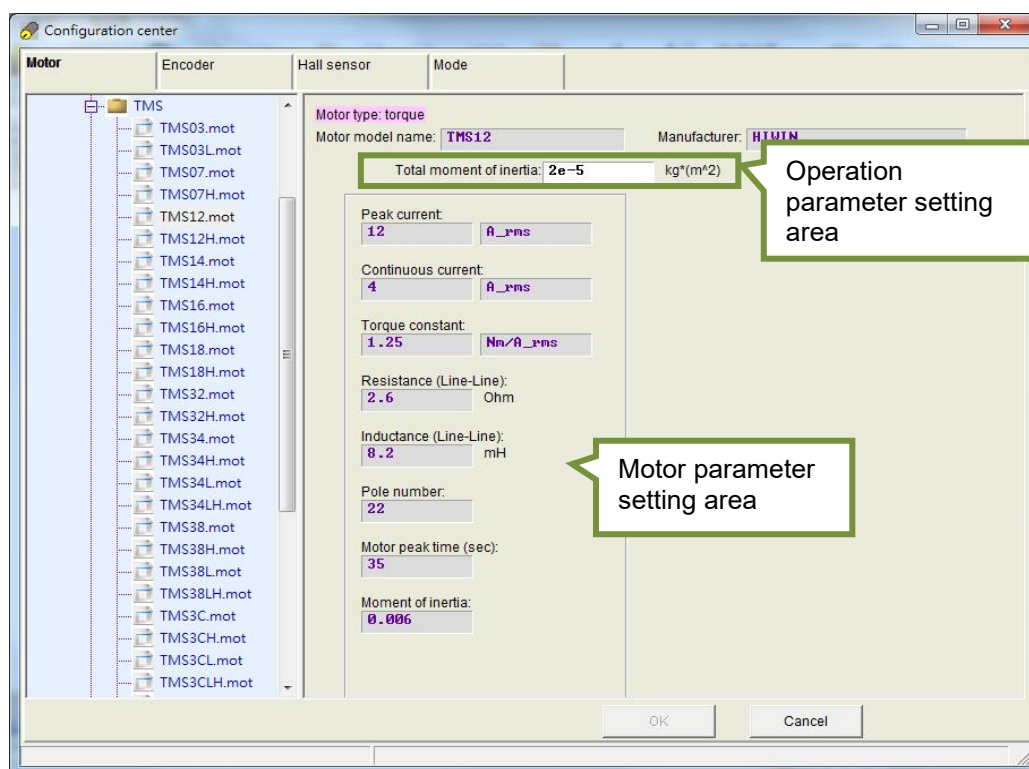


Figure5.2.1.3

(3) Customized motor

Input motor parameters of motors other than HIWIN standard models. For linear motor, click on **Linear** in figure 5.2.1.4 and click on **Customized Linear**. Input necessary parameters according to the motor specification. After parameters are set, the parameter settings can be saved as file (*.mot) and be loaded anytime.

A. Basic parameters of motor specification

- Peak current
The maximum instantaneous current that the motor can withstand (Unit: A_amp and A_rms)
- Continuous current
The maximum continuous current that the motor can withstand (Unit: A_amp and A_rms)
- Torque constant
Force or torque per unit current (Unit: N/A_amp, N/A_rms, Nm/A_amp and Nm/A_rms)
- Resistance (Line-Line)
Resistance among coils (Unit: Ohm)
- Inductance (Line-Line)
Inductance among coils (Unit: mH)
- Magnetic pole pair pitch
The distance between a pair of magnets (including one north pole and one south pole)
- Motor peak time
The maximum allowable time that the motor can withstand peak current (Unit: sec)

B. Operation parameter

- Moving mass:

Set the load mass of motor. (Unit: kg)

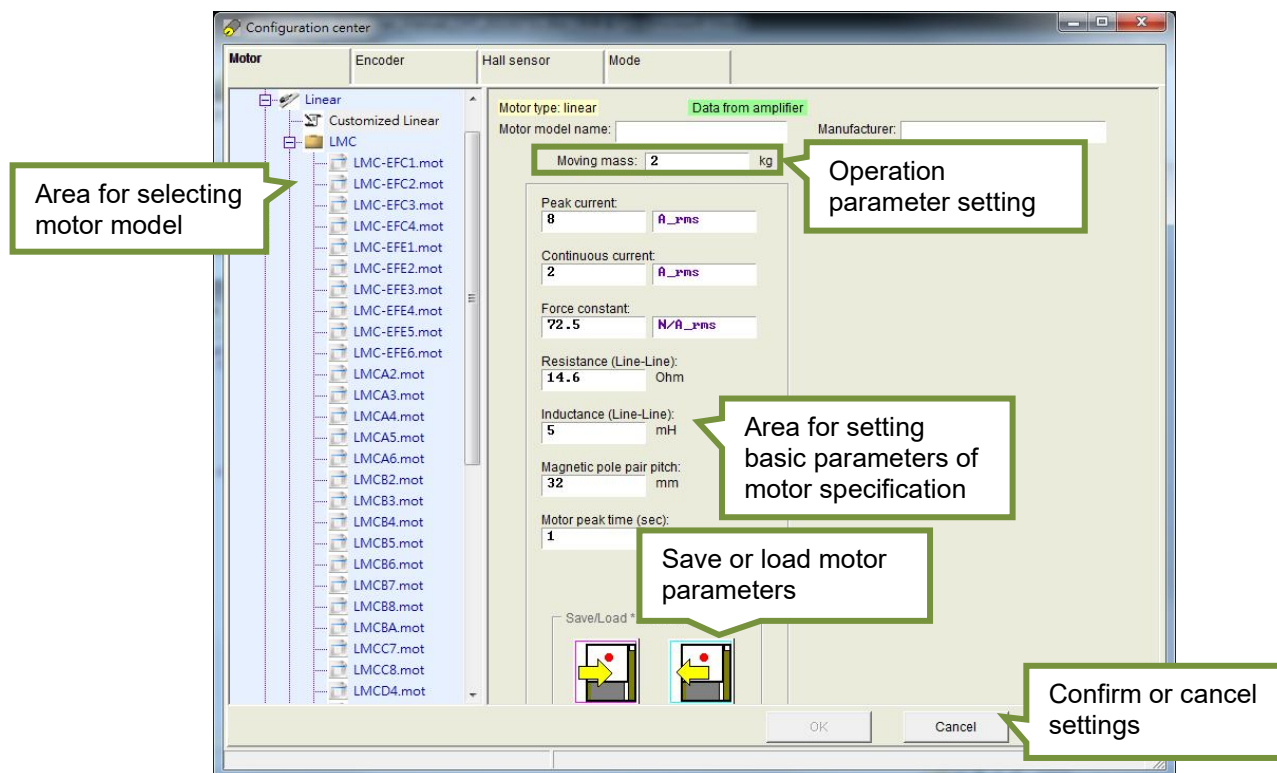


Figure5.2.1.4

5.2.2 Setting parameters of encoder

Servo drive receives feedback signal from encoder to perform servo control. The setting page for encoder is shown as figure 5.2.2.1. In this page, user is able to set encoder type and parameters. The commonly-used encoder parameters of HIWIN motors are already listed. User can also input parameters of other encoders. For instance, while using linear analog optical scale, click on **Linear** and select **Customized Linear Analog**. Input parameters according to the encoder specification. After parameters are set, the parameter settings can be saved as file (*.enc) and be loaded anytime.

D1 servo drive is able to detect encoder signal error. The default delay time is set to 200 ms. If some encoders require longer power on time, set suitable delay time in **Power-on time** field to avoid “Encoder error”.

D1 servo drive can be used with digital encoder and analog encoder, such as optical scale, magnetic scale, rotary encoder, etc. The supported encoders can be categorized into the following four types:

- (1) Linear-digital encoder
- (2) Linear-analog encoder
- (3) Rotary-digital encoder
- (4) Rotary-analog encoder

For commonly-used encoders of HIWIN, please refer to section 5.2.2.1. For user-defined encoder setting, please refer to section 5.2.2.2. To work with controller, D1 servo drive provides buffered encoder output and emulated encoder output to output encoder signal. When emulated encoder output is selected, the output resolution can be changed by adjusting scaling. For more information, please refer to section 5.2.2.3.

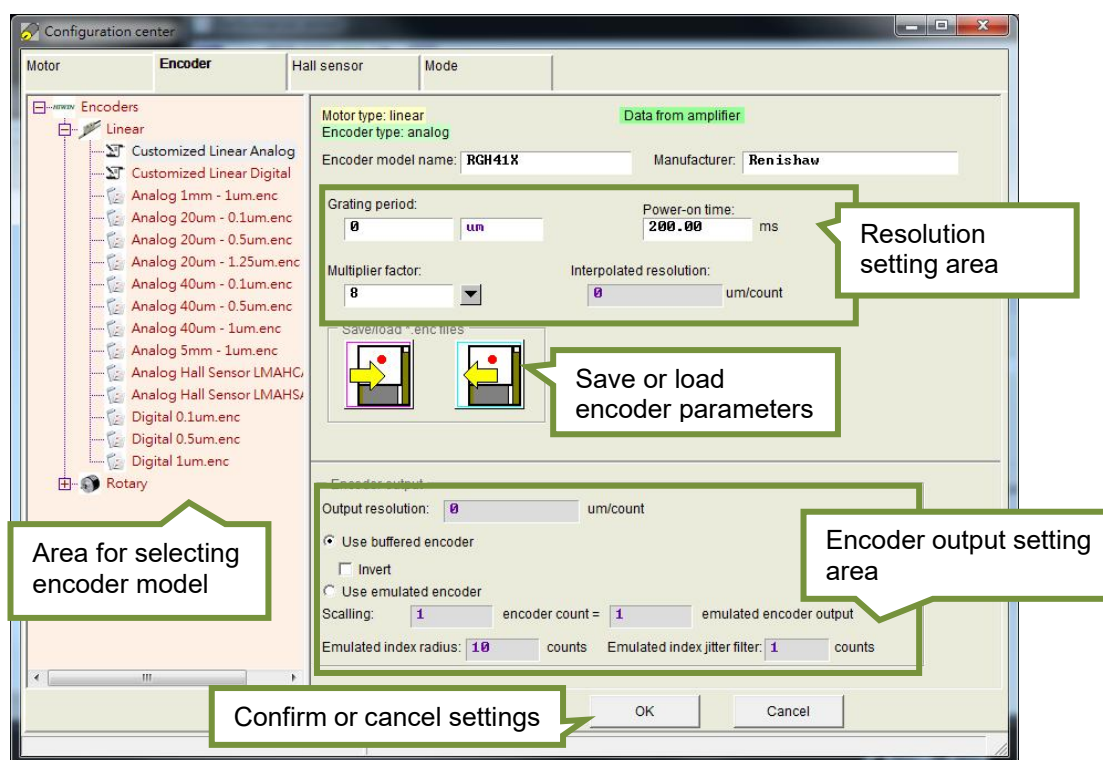


Figure5.2.2.1 Interface for encoder setting

5.2.2.1 HIWIN standard encoder

(1) Linear-digital encoder

Example: The resolution of digital magnetic scale PM-B-XX-XD-S-XX from HIWIN or digital optical scale RGH41X series from Renishaw is 1 μ m. If one of them is used, select **Linear** and **Digital 1 μ m** in the area shown in figure 5.2.2.1. If the desired resolution setting cannot be found, user is allowed to input encoder information by himself. For user-defined encoder setting, please refer to section 5.2.2.2.

(2) Linear-analog encoder

Example: The grating period of RGH41B analog optical scale from Renishaw is 40 μ m and interpolated resolution is 1 μ m. In the area shown in figure 5.2.2.1, select **Linear** and **Analog 40 μ m - 1 μ m**. If other multiplier factor or resolution is required, user is allowed to input encoder information by himself or select other selection. For user-defined encoder setting, please refer to section 5.2.2.2.

(3) Rotary-digital encoder

Example: If the resolution of rotary digital encoder is 10,000 counts/rev, select **Rotary** and **Digital 10000 cnt** in the area shown in figure 5.2.2.1. If the desired resolution setting cannot be found, user is allowed to input encoder information by himself. For user-defined encoder setting, please refer to section 5.2.2.2.

(4) Rotary-analog encoder

Example: HIWIN TMS32 torque motor uses rotary analog encoder. The rotary analog encoder has 3,600 sine waves per revolution which interpolates to 0.3 arc sec. In the area shown in figure 5.2.2.1, select **Rotary** and **Analog 3600 periods 0.3 arc sec**. The specifications of rotary analog encoders used by HIWIN TMS series are shown in table 5.2.2.1.1. If other multiplier factor or resolution is required, user is allowed to input encoder information by himself or select other selection. For user-defined encoder setting, please refer to section 5.2.2.2.

Table 5.2.2.1.1

Torque Motor Model	Grating Period/Rev
TMS03, TMS03L, TMS07, TMS07H	2048
TMS12, TMS14, TMS16, TMS18, TMS32, TMS32H, TMS34, TMS34H, TMS38, TMS38H, TMS3C, TMS3CL, TMS3CH	3600
TMS74, TMS74L, TMS76, TMS7C, TMS7CH	5400

5.2.2.2 User-defined encoder setting

(1) Linear-digital encoder

Set encoder resolution in **Encoder resolution** field. The unit can be um/count or nm/count.



Figure5.2.2.2.1

(2) Linear-analog encoder

Set the grating period of analog encoder signal and multiplier factor. The setting value of multiplier factor must be the integer multiple of eight. The maximum setting value is 65,528. After multiplier factor is set, the interpolated resolution (Unit: um/count) will be automatically calculated and displayed.

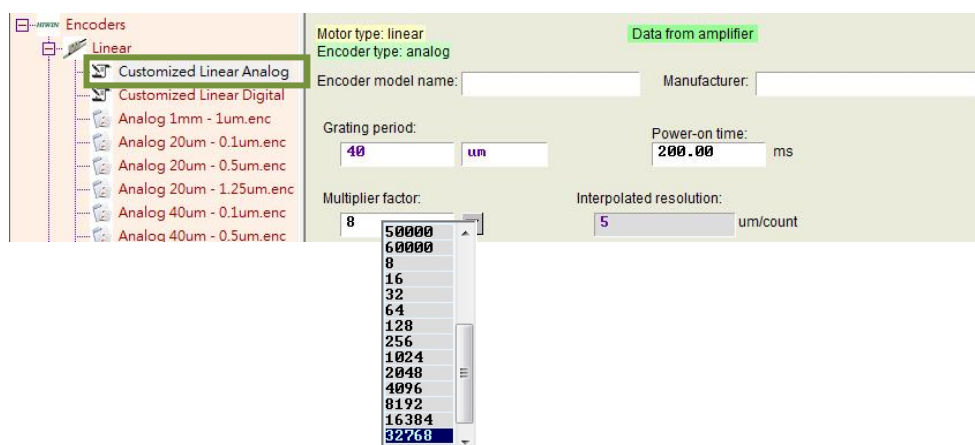


Figure5.2.2.2.2

(3) Rotary-digital encoder

Set the resolution per revolution (Unit: counts/rev). D1 servo drive calculates the linear resolution (Unit: um/counts) of the motor based on the screw pitch and encoder resolution set by user.

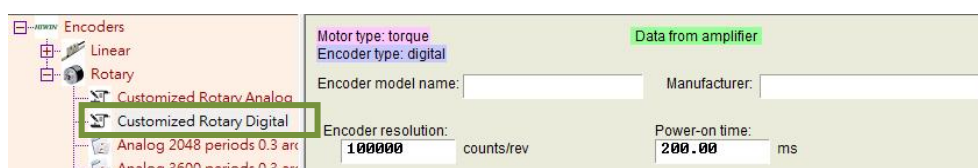


Figure5.2.2.2.3

(4) Rotary-analog encoder

Set the resolution per revolution. The setting value of multiplier factor must be the integer multiple of eight. The maximum setting value is 65,528. After multiplier factor is set, the interpolated resolution (Unit: counts/rev) will be automatically calculated and displayed. D1 servo drive also calculates the linear resolution of motor based on the interpolated resolution and screw pitch.

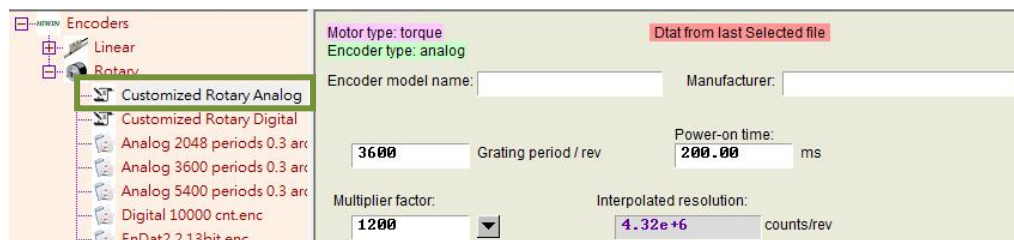


Figure5.2.2.2.4

5.2.2.3 Setting encoder output

D1 servo drive outputs AqB signal via CN2. If needed, connect to controller via CN2. In the encoder output setting area (figure 5.2.2.3.1), user is able to select **Use buffered encoder** or **Use emulated encoder**. The value in **Output Resolution** field will be updated.

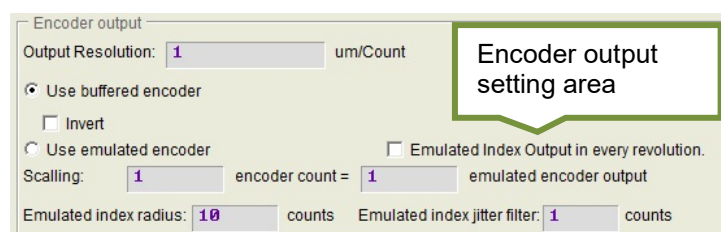


Figure5.2.2.3.1

(1) Buffered encoder output

When buffered encoder output is selected, the signals received from encoder will be directly output to controller. If needed, select **Invert** to invert the received signals before the signals are output to controller. The resolution of output signal will be shown in the same page.

Motor type: LINEAR
Encoder type: DIGITAL
Encoder Model Name: RGH41X Manufacturer: Renishaw
Encoder Resolution: 1 um / Count Power-on Time: 200 ms
Encoder output
Output Resolution: 1 um/Count
☒ Use buffered encoder
☐ Invert

Figure5.2.2.3.2

(2) Emulated encoder output

When emulated encoder output is selected, the signals received from encoder will be scaled before the signals are output to controller. In some cases, such as when controller cannot receive encoder signals sent at high frequency, the scaling can be set to 10:1 to let ten encoder counts equal one emulated encoder output. When the multiplier factor of analog encoder is set to a high value, scaling can also be used to lower the output resolution. If the scaling is set to 1 encoder count = -1 emulated encoder output, the direction will be reversed. For instance, in figure 5.2.2.3.3, the grating period of analog encoder is 20 um and the interpolated resolution after setting the multiplier factor to 200 is 0.1 um/count. If the scaling is set to 10 encoder counts = 1 emulated encoder output, the output resolution becomes 1 um/count.

Note:

Emulated encoder output is not available while saving parameters to Flash.

Motor type: LINEAR
Encoder type: ANALOG
Encoder Model Name: RGH22A,B Manufacturer: Renishaw
Grating period: 20 um Power-on Time: 200 ms
Multiplier factor: 200 Interpolated Resolution: 0.1 um/Count
Encoder output
Output Resolution: 1 um/Count
☐ Use buffered encoder
☐ Invert
☒ Use emulated encoder ☐ Emulated Index Output in every revolution.
Scaling: 10 encoder count = 1 emulated encoder output
Emulated index radius: 10 counts Emulated index jitter filter: 1 counts

Figure5.2.2.3.3

(3) Emulated Z-phase signal output

This function is supported in:

MD-36-SR, MD-18-SR (For TMX series motor), MD-36-S2-01, D1-36-T01, D1-△△-E△ and D1-△△-F△

This function can be used when:

When the bandwidth of controller is unable to receive Z-phase signal, this function can enlarge the output range of Z-phase signal to prevent the controller from missing Z-phase signal.

To use this function, select **Use emulated encoder** and set **Emulated index radius** and **Emulated index jitter filter**.

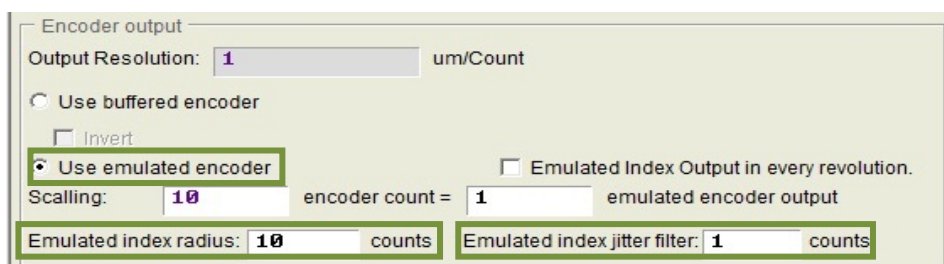


Figure5.2.2.3.4

- a Emulated index radius: Output range of emulated Z-phase signal, as figure 5.2.2.3.5.
- b Emulated index jitter filter: Suppress the bounce phenomenon of emulated Z-phase signal.

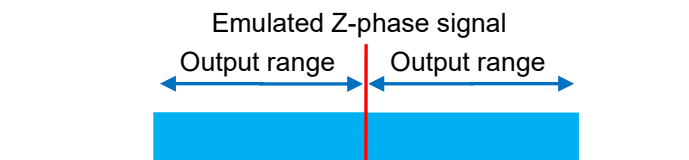


Figure5.2.2.3.5

When home offset is used in homing, the emulated Z-phase signal will move to the home position after home offset, as figure 5.2.2.3.6.

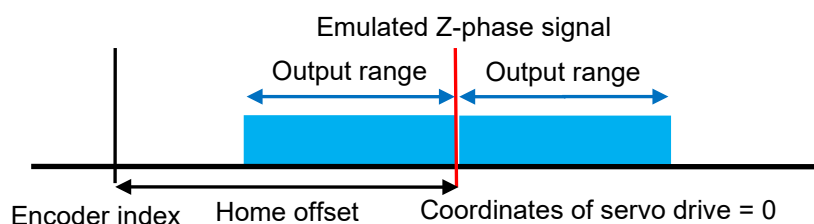


Figure 5.2.2.3.6

(4) Emulated Z-phase signal output in every revolution

This function can only be used with direct drive motor.

➤ When **Emulated Index Output in every revolution** is not selected

The servo drive outputs Z-phase signal when the index position is reached in the first revolution.

➤ When **Emulated Index Output in every revolution** is selected

The servo drive outputs Z-phase signal every time when the index position is reached.

Note:

- (1) For firmware version before D1 MDP 0.247 and D1COE MDP 0.327, if emulated encoder output function is enabled when digital encoder is used, emulated Z-phase signal will be output when the index position is reached in the first revolution. The signal width will be twice the set emulated index radius. For firmware version after D1 MDP 0.247 and D1COE MDP 0.327, emulated Z-phase signal is output every time when the index position is reached. The signal width is the set emulated index radius.
- (2) For linear motor, multiple index signal output only supports digital encoder.

5.2.3 Setting Hall sensor

Since D1 servo drive is able to complete phase initialization without Hall sensor, **None** is selected in the setting page shown in figure 5.2.3.1. Only when Hall sensor is used, the setting of Hall sensor is required. D1 servo drive supports both digital Hall sensor and analog Hall sensor. The setting of Hall sensor must be based on the actual application. If **Digital hall sensor** or **Analog hall sensor** is selected when no Hall sensor is used, it may cause abnormal operation of the servo drive or motor. If analog Hall sensor is used, the servo drive will regard it as encoder, so user does not need to install another encoder.

■ Hall phase check function

This function is only available when digital Hall sensor is used. If **Enable hall phase check** is selected, after phase initialization completes, the program will inspect if the commutation is correct or if there is abnormal disconnection. The error message “Hall phase check error” appears if an error occurs.

Note:

- (1) While using Hall phase check function, ensure the digital Hall sensor is not affected by electromagnetic interference, since electromagnetic interference may result in wrong inspection of the program.
- (2) It is not suggested to use Hall phase check function for application of short travel distance (within two pole pitches).

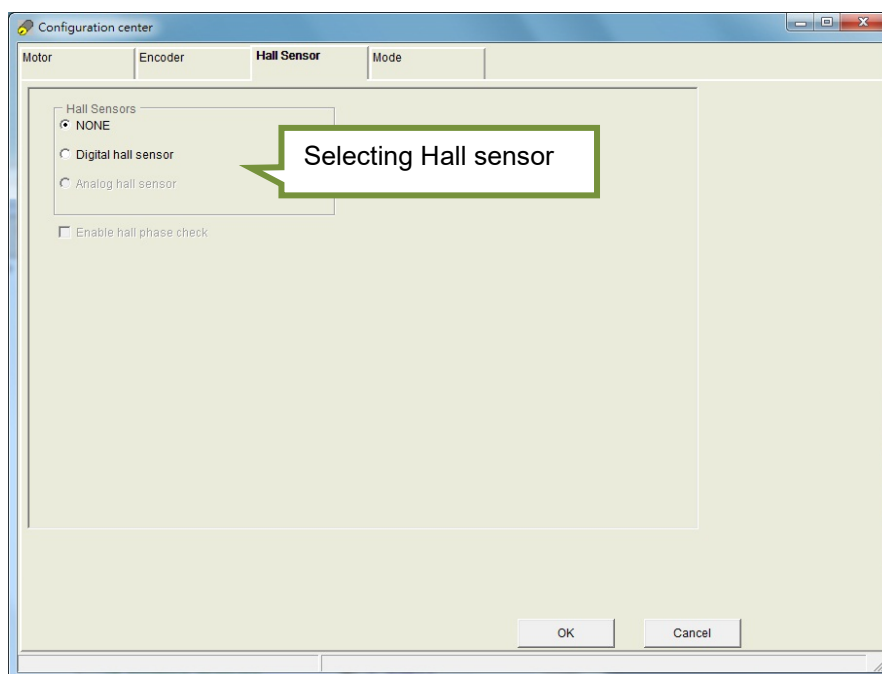


Figure5.2.3.1

5.2.4 Setting operation mode

The setting page for operation mode is shown as figure 5.2.4.1. The operation mode of the servo drive should be set after the parameters of motor, encoder and Hall sensor are set.

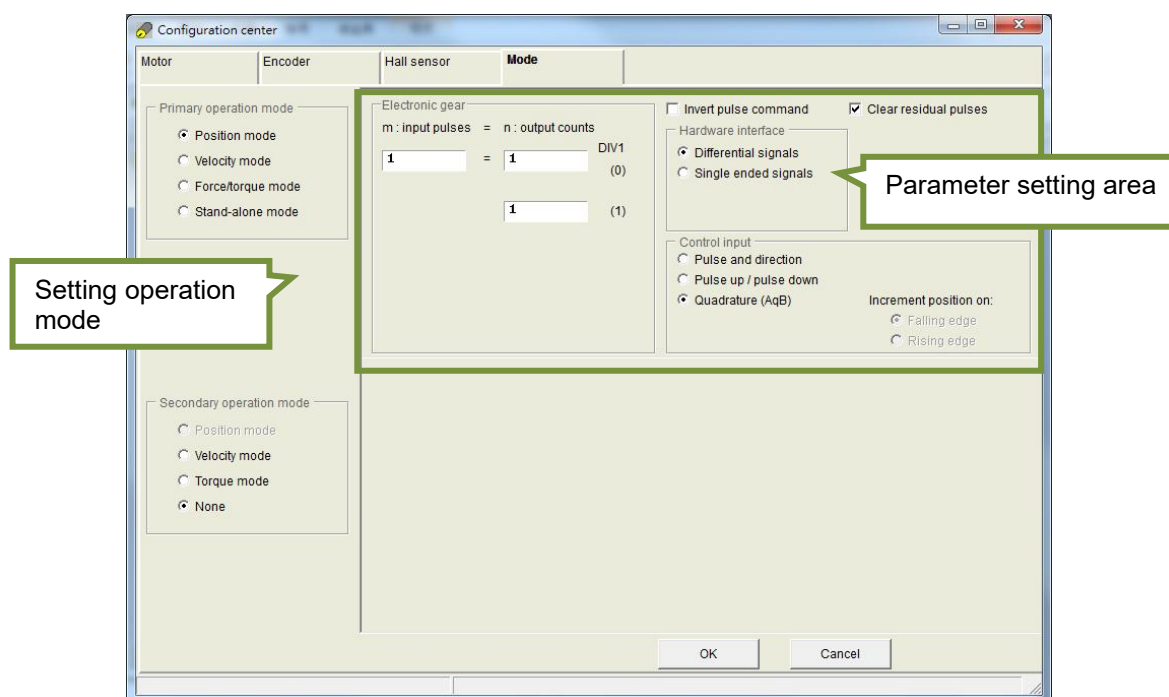


Figure5.2.4.1

(1) Position mode

For controller which only sends pulse command, select position mode to receive pulse command from the controller. The closed-loop control is handled by the servo drive. D1 servo drive supports three pulse types and two signal types. Electronic gear ratio is provided for application which requires fast movement. In position mode, digital inputs I9 and I10 are not general-purpose inputs. Check the checkbox of **Clear residual pulses** and the pulse signals which are not executed will be cleared as limit signal is triggered.

Note:

Pulse command from controller can only be accepted in servo ready state.

Figure5.2.4.2

(2) Velocity mode

For controller which sends analog command or PWM command, select velocity mode. The ratio (scaling) between external command and velocity can be set in the setting page in figure 5.2.4.3. Set 1 V equals what velocity in mm/s (linear motor) or rpm (torque motor). User can also set the corresponding velocity of full PWM. If a negative value is set for **Scaling**, the motor moves in negative direction.

Definition of dead band

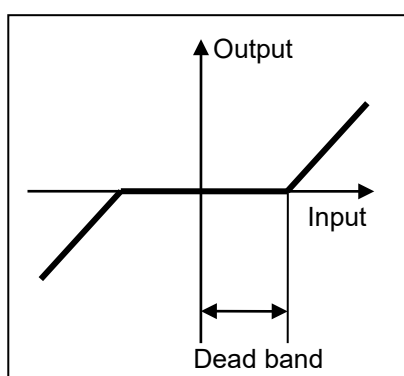


Figure5.2.4.3

(3) Force/torque mode

Another operation mode which can be used with controller sending analog command or PWM command is force/torque mode. The ratio (scaling) between external command and current can be set in the setting page in figure 5.2.4.4. Set 1 V equals what current in ampere (A). User can also set the corresponding current of full PWM. If a negative value is set for **Scaling**, the motor moves in negative direction.

Figure5.2.4.4

(4) Stand-alone mode

If user would like the servo drive to be tested alone or operated without controller, please select stand-alone mode. In this mode, all loops are controlled by the servo drive.

5.2.5 Saving configuration

After the settings described in sections 5.2.1 to 5.2.4 are completed, click on **OK** button. Then the page in figure 5.2.5.1 will appear and display the parameters of previous setting and current setting. Ensure the parameters are correct and click on **Send to RAM** button to save these parameters to the servo drive RAM. Click on **Cancel** button to return to Configuration center.

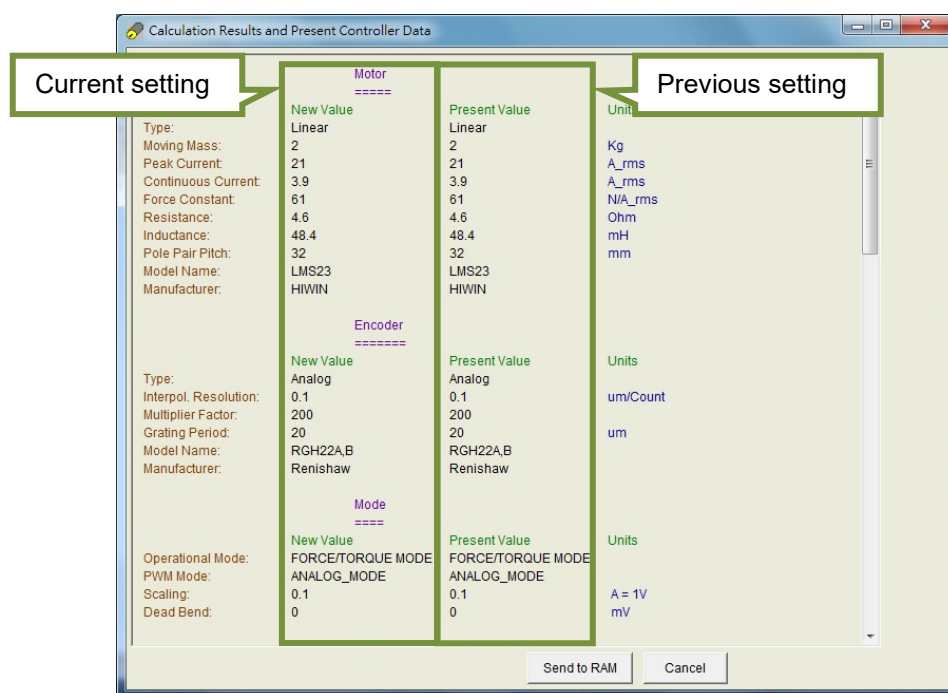




Figure5.2.5.1

If user would like to save the setting to Flash, click on  (Save parameters from amplifier RAM to Flash) on the toolbar. The setting will still be accessible after the 24 V power for the servo drive is turned off. If user would like to save the setting as file, click on  on the toolbar (Save parameter from amplifier RAM to File). The file extension of that file is .prm.

5.3 Auto phase center

Click on  on the toolbar or select **Auto phase center** from the submenu of **Conf./Tune** to open Auto phase center.

Note:

While performing phase initialization, the motor speed must be lower than $1/6 * (\text{pole pair pitch})/\text{s}$.

(1) Phase initialization mode: Use digital Hall sensor

Select this mode when digital Hall sensor is used. Digital Hall sensor must be set in Configuration center, please refer to section 5.2.3.

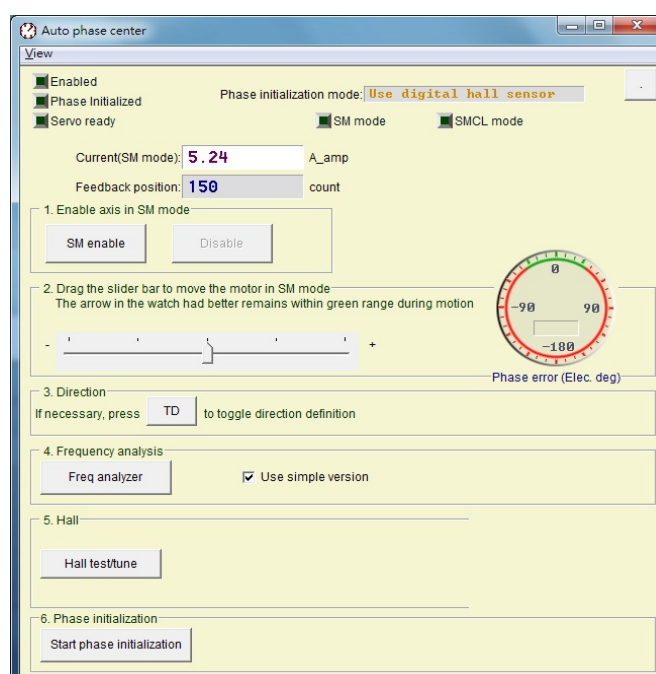


Figure 5.3.1 Phase initialization mode: Use digital Hall sensor

(2) Phase initialization mode: SW method 1

For SW method 1, Hall sensor is not required and motor only needs to move for a small distance to complete phase initialization. Two parameters, `st_cg` and `st_vpg`, must be adjusted before using SW method 1, please refer to section 11.2. If load is changed, these parameters need to be adjusted again.

While using operation mode other than stand-alone mode, external command is suggested to be sent after controller receives servo ready signal from the servo drive. If controller is unable to receive servo ready signal, wait at least three seconds before sending external command (For Lightening 0.181 or later version). If the checkbox of **Check the accuracy offset** is checked, Lightening will check whether the found electrical angle is correct or not before phase initialization.

Note:

For Lightening 0.180 or previous version, wait at least two seconds before sending external command.

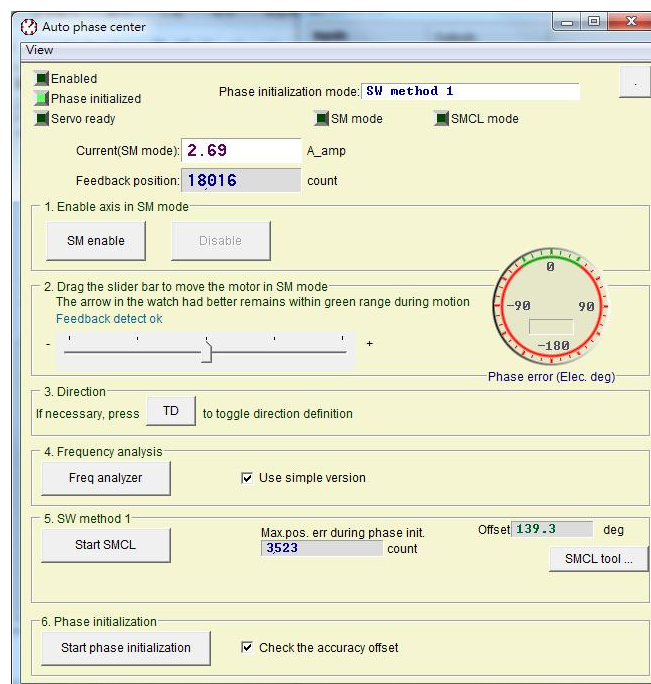


Figure 5.3.2 Phase initialization mode: SW method 1 (without Hall sensor)

(3) Phase initialization mode: SW method 5

For SW method 5, Hall sensor is not required and electrical angle detection is provided. To use SW method 5, the current for performing phase initialization must be set. SW method 5 requires longer execution time since electrical angle detection is performed during the process.

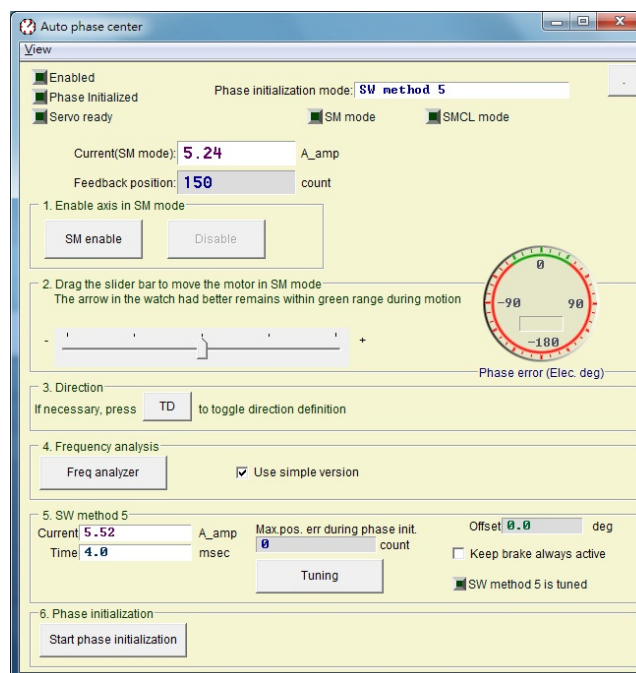


Figure 5.3.3 Phase initialization mode: SW method 5 (without Hall sensor)

(4) Phase initialization mode: STABS

STABS is for using absolute resolver to perform phase initialization.

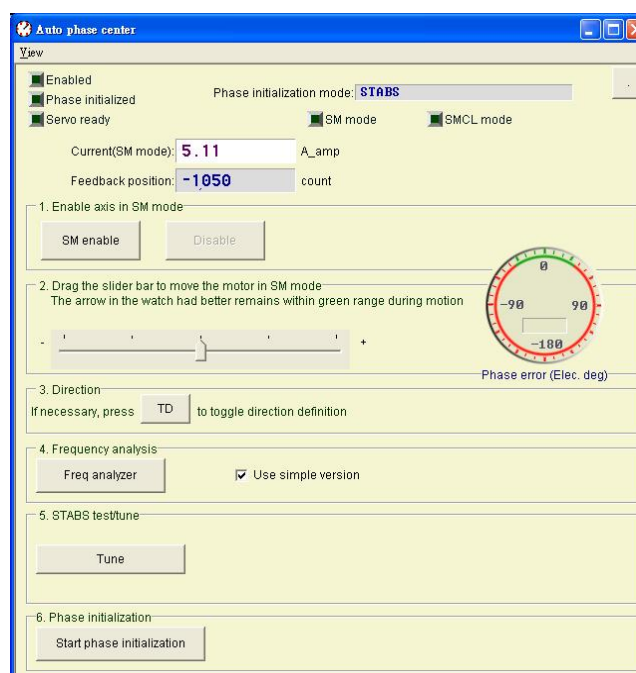


Figure 5.3.4 Phase initialization mode: STABS

5.3.1 Inspection before auto phase initialization

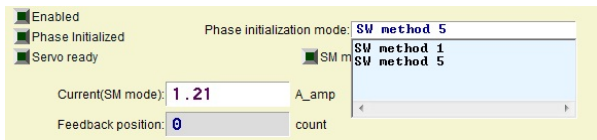
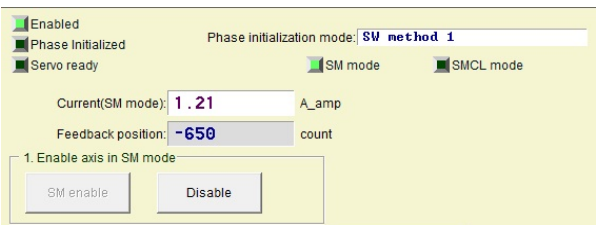
Check the following items before auto phase initialization.

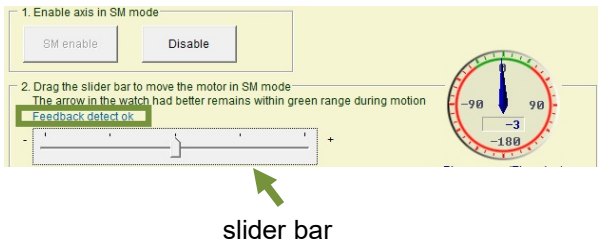
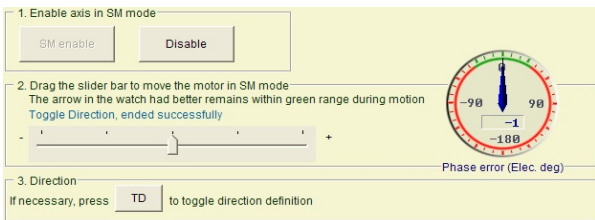
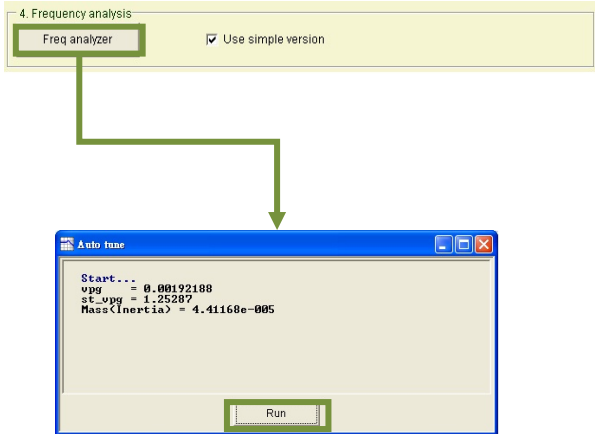
- (1) Check if motor power cable is correctly connected.
- (2) Check if encoder signal is normal.
- (3) Check if the servo drive receives hardware enable signal, please refer to chapter 12.
- (4) Check if over temperature cable is connected.
- (5) Check if AC main power is turned on.
- (6) Set and confirm the current setting for enabling. Set the required current (Unit: ampere (A)) for test run in SM mode in **Current (SM mode)** field. The setting value should be just enough for motor to move. The default setting value is 95% of the continuous current of motor.

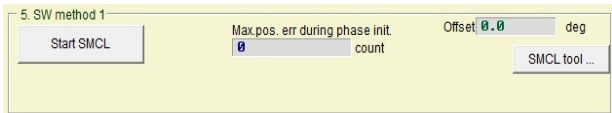
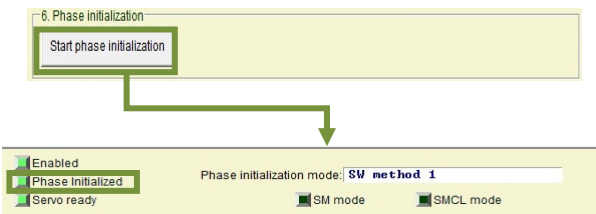
5.3.2 Operating procedures for auto phase initialization

The operating procedures of SW method 1 and SW method 5 are the same, refer to the table below. SW method 1 is used as an example in the table below.


Table5.3.2.1

Step	Figure	Description
1		Setting phase initialization mode: Select the desired phase initialization mode. The default phase initialization mode is SW method 5.
2		Enabling the motor in SM mode: Click on SM enable button and Enabled indicator becomes green. Note: (1) When the motor is enabled in SM mode, the servo drive outputs current according to the value set in Current (SM mode) field. To avoid overheating, the motor cannot be enabled for a long time in SM mode. (2) Enabling signal must be input from controller.

Step	Figure	Description
3		<p>Testing moving direction in SM mode: Drag the slider bar leftward and rightward to move the motor. The motor moves in positive direction while dragging the slider bar rightward. The motor moves in negative direction while dragging the slider bar leftward.</p> <p>Normally the pointer of Phase error (Elec deg) indicator should be between -30 degrees to +30 degrees (the range colored in green). After moving the motor by the slider bar, the message "Feedback detect ok" appears. Then user can proceed to next step. If the pointer moves randomly, release the slider bar and drag the slider bar to move the motor again.</p> <p>Note:</p> <ol style="list-style-type: none"> (1) If the pointer still moves randomly after moving the motor by the slider bar again, please check the following items: <ul style="list-style-type: none"> • The motor power cable and the encoder cable are correctly connected. • The setting of the encoder or motor, such as encoder resolution or pole pair number could be incorrect. Go to Configuration center and check again. (2) Enabling signal must be input from controller.
4		<p>Checking the definition of motion direction: If moving direction is inconsistent with what user has defined as positive or negative direction, click on TD button to reverse the definition of motion direction. After the message "Toggle Direction, ended successfully" appears, return to step 3 to check moving direction again.</p>
5		<p>Auto tuning: Select Use simple version and click on Freq analyzer button to show Auto tune window. Click on Run button to analyze frequency response and calculate parameters.</p> <p>This function can be used to easily set system loop gain. But in the following cases, the calculated parameter values may not be appropriate for the system.</p> <ol style="list-style-type: none"> (1) The stiffness of mechanism is too low. (2) The backlash of mechanism is too large. (3) The load has been changed. (4) The load inertia ratio is over 20. <p>Note:</p> <ol style="list-style-type: none"> (1) If mechanical resonance occurs during execution, stop inputting hardware enable signal or press F12 key in Lightning (Refer to section 6.1.3). (2) User is allowed to tune manually, please refer to section 11.3. For the descriptions of parameters vpg and st_vpg, please refer to sections 6.6.3 and 11.3.

Step	Figure	Description
6		<p>Adjusting phase initialization: The motor only needs to move for a small distance to complete phase initialization. After tuning in step 5 completes, check the tuning result by the following steps.</p> <p>Step 1: Click on Start SMCL button to find electrical angle.</p> <p>Step 2: Observe the values in the fields of Offset and Max. pos. err during phase init.. Offset shows the result of finding electrical angle and Max. pos. err during phase init. shows the largest movement during the process.</p> <p>Step 3: Repeat step 1 and 2 to observe if the offset is within +/- 15 degrees.</p> <p>Step 4: If offset is too large, click on SMCL tool... button for advanced tuning.</p>
7		<p>Executing phase initialization: Click on Start phase initialization button. After Phase Initialized indicator becomes green, it means phase initialization completes. The servo drive is able to control the motor to perform closed-loop control.</p>

■ Phase initialization when digital Hall sensor is used

Click on  to open the page for Hall sensor test and tuning. Click on **Start Hall tune** button. The servo drive starts to output current to drive motor. **Rotor angle (Elec. deg)** indicator shows electrical angle and Hall sensor information (0 to 5). After the motor stops, a message will appear to indicate the tuning has completed. Then, phase initialization can be started.

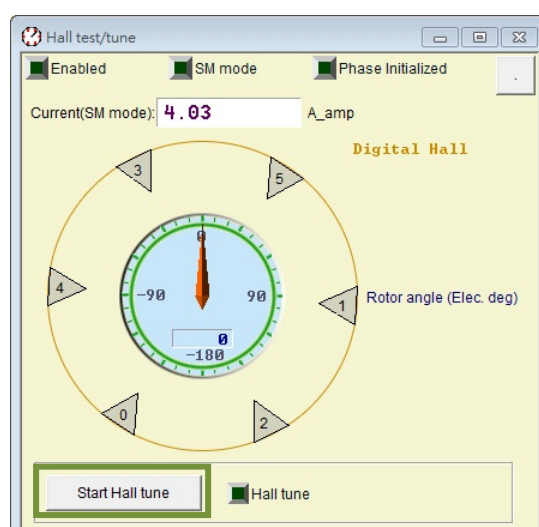


Figure5.3.2.1

■ Phase initialization when SW method 5 is used

When motor is used in vertical direction and is with mechanical brake, check the checkbox of **Keep brake always active** before phase initialization.

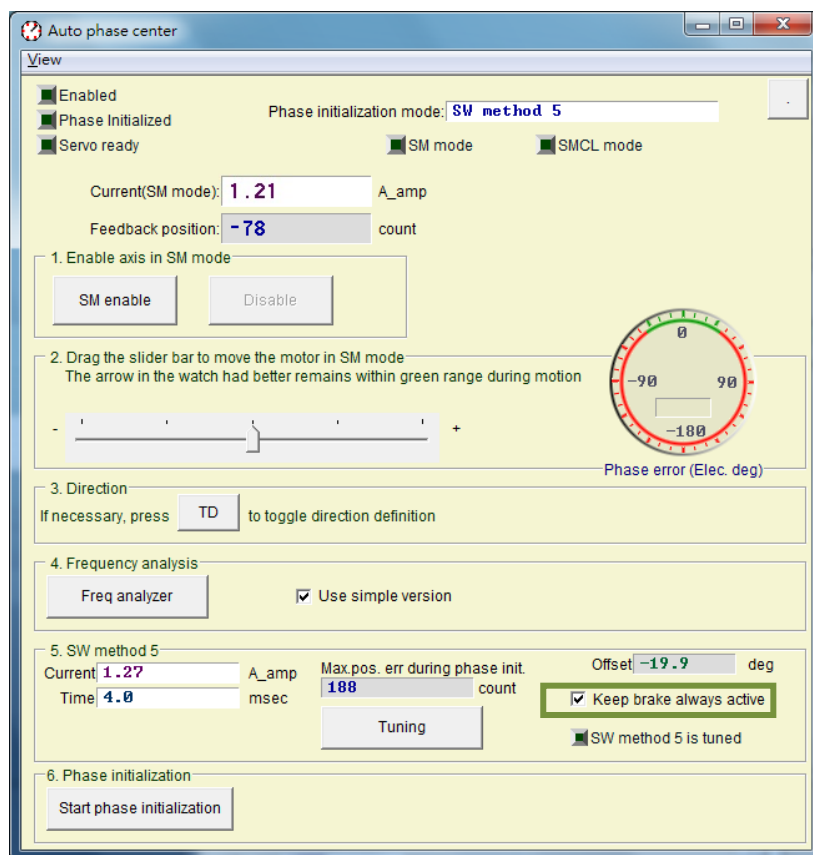


Figure5.3.2.2

■ Phase initialization when STABS is used

Click on **Tune** button in **5. STABS test/tune** to open **STABS test/tune** window and click on **Start** button. The servo drive starts to output current to drive motor. After the motor stops, a message will appear to indicate tuning has completed. Then, phase initialization can be started.

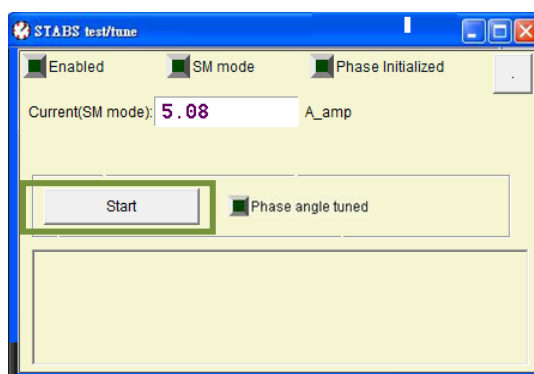


Figure5.3.2.3

5.3.3 Precautions for auto phase initialization

(1) The current for enabling

Pay attention to the following when setting the value in **Current (SM mode)** field in Auto phase center.

- The current must be less than the upper limit of the continuous current of motor. If user is not sure about the load, please start with small current first.
- If friction increases, larger current is required to move the load.
- If static friction is large, larger current is required.
- Motor may jog when static friction changes to dynamic friction as motor starts to move or when dynamic friction changes to static friction as motor stops.

(2) The moving direction of motor

Pay attention to the following when feedback detection fails in Auto phase center.

- Check the power for encoder and encoder signal.
- Check if differential encoder is used.
- Check if the grounding is appropriate.
- Check if motor brake is released.

(3) Moving motor

Pay attention to the following when motor cannot move.

- Check if motor is disabled.
- Check if there is any mechanical interference.
- Check if the mechanism can move smoothly and the mechanical resistance is low.
- Check if motor power cable is correctly connected.
- Check if the resistance of motor is appropriate.

(4) Hall sensor signal

- Check the cable for Hall sensor is correctly connected.
- Check the power for Hall sensor and Hall sensor signal.
- Check if the mechanism can move smoothly and the mechanical resistance is low.
- Check if the grounding is appropriate.

5.4 I/O setting

5.4.1 Digital inputs

D1 servo drive provides 10 digital inputs (I1~I6 and I9~I12). Nine digital inputs locate on connector CN2. I5 locates on connector CN3 for motor over temperature, but it can still be set for other function. The functions of I9 and I10 vary with the selected operation mode. In position mode, I9 and I10 cannot be used as general-purpose inputs.

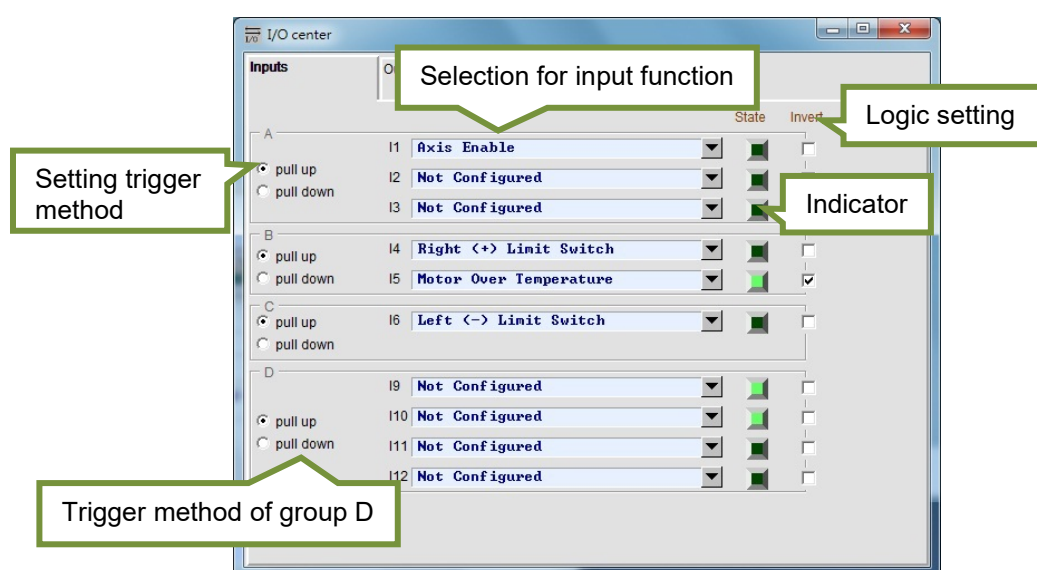



Figure5.4.1.1

(1) Setting trigger method

The digital inputs of D1 servo drive are divided into four groups, A, B, C and D group. Each group can be set as pull up or pull down. The setting must based on the wiring of the servo drive. Select **pull up** when the wiring is sink type. Select **pull down** when the wiring is source type. Refer to section 4.7.1 for wiring examples and pay special attention to the wiring of group D. In position mode, if controller is using optical coupler output (single-ended signal), the group must be set as pull up. Otherwise, the servo drive cannot receive pulse signal.

(2) Selection for input function

Click on , the drop-down list shown in figure 5.4.1.2 will appear.

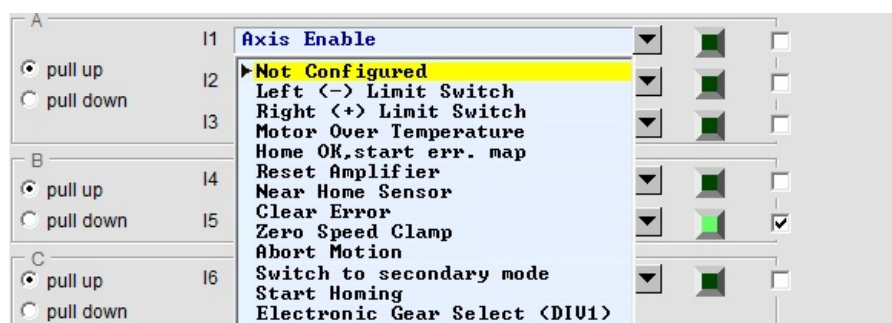


Figure5.4.1.2

Table5.4.1.1 Input functions

No.	Abbr.	Input Function	Description	Trigger Method
1	SVN	Axis enable	Enable or disable axis. Input I1 (Default)	Level triggered
2	LL	Left (-) limit switch	Left hardware limit Input I6 (Default)	Level triggered
3	RL	Right (+) limit switch	Right hardware limit Input I4 (Default)	Level triggered
4	MOT	Motor over temperature	Motor over temperature detection Input I5 (Default)	Level triggered
5	MAP	Home ok, start err. map	Activate error map function after homing completes.	Edge triggered
6	RST	Reset amplifier	Reset the servo drive.	Edge triggered
7	DOG	Near home sensor	Near home sensor	Level triggered
8	CE	Clear error	Clear error.	Edge triggered
9	ZSC	Zero speed clamp	Zero speed clamp In velocity mode, when this signal is received and the motor speed is slower than the setting value, the motor will be stopped at current position.	Level triggered
10	EMG	Abort motion	Emergency stop When this signal is received, the motor stops according to the emergency stop procedure.	Level triggered
11	MOD	Switch to secondary mode	Switch from first operation mode to second operation mode.	Level triggered
12	HOM	Start homing	Activate the built-in homing procedure in the servo drive.	Edge triggered
13	DIV1	Electronic gear select (DIV1)	Electronic gear ratio selection for position mode	Level triggered

Table5.4.1.2 Supported input functions in each operation mode

Input Function \ Operation Mode	Non-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
Motor over temperature	V	V	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	-
Zero speed clamp	-	V	V	-	-
Abort motion	-	-	-	V	-
Switch to secondary mode	V	V	V	V	-
Start homing	V	V	V	V	-
Electronic gear select (DIV1)	V	-	-	-	-

Note:

V means the input function is supported in the operation mode and can be assigned to I1~I12 (except I7 and I8).

Table5.4.1.3 Default input functions of D1 servo drive

Pull Up/Pull Down (Default)	Pin	Non-CoE Model	CoE Model	Invert
		Default Signal	Default Signal	
Group A: pull up	I1	Axis enable	Axis enable	No
	I2	Abort motion	Left (-) limit switch	No
	I3	Start homing	Right (+) limit switch	No
Group B: pull up	I4	Right (+) limit switch	Near home sensor	No
	I5 ^{Note}	Motor over temperature/Not configured	Motor over temperature/Not configured	No
Group C: pull up	I6	Left (-) limit switch	Not configured	No
Group D: pull up	I9	Not configured	Not configured	No
	I10	Not configured	Not configured	No
	I11	Not configured	Not configured	No
	I12	Not configured	Not configured	No

Note:

Depending on motor model, the default setting of I5 can be Motor over temperature or Not configured.

(3) Indicator

If indicator becomes green, it means the set function is activated. If not, it means the function is not activated.

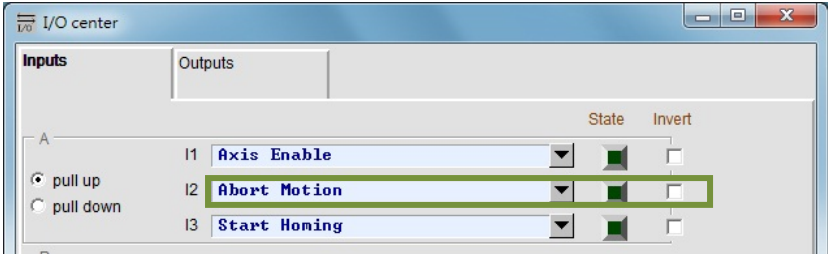
(4) Logic setting

If **Invert** is selected, the trigger condition is inverted.

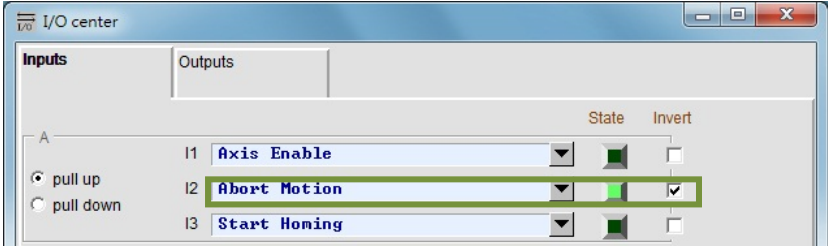
Input Function	Abort motion		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	EMG	Default Input	I2	Wiring Diagram	Refer to section 4.7.1.			

◆ **Function**
In stand-alone mode, when the input set for aborting motion is ON, the motor will decelerate at the speed set in Dec. kill to a stop. Dec. kill can be set in Performance center.

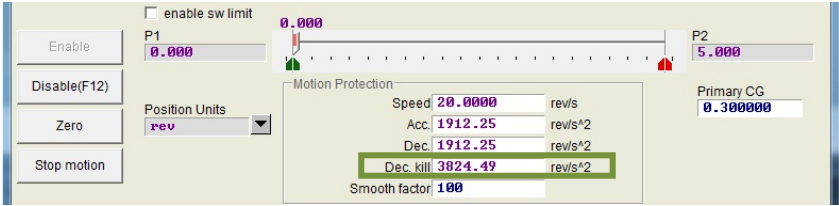
◆ **Description**
Set one input for aborting motion in I/O center. Use external signal to decelerate the motor at the speed set in Dec. kill to a stop. In the figure below, I2 is set for aborting motion.



After external signal is input, the motor decelerates at the speed set in Dec. kill to a stop.

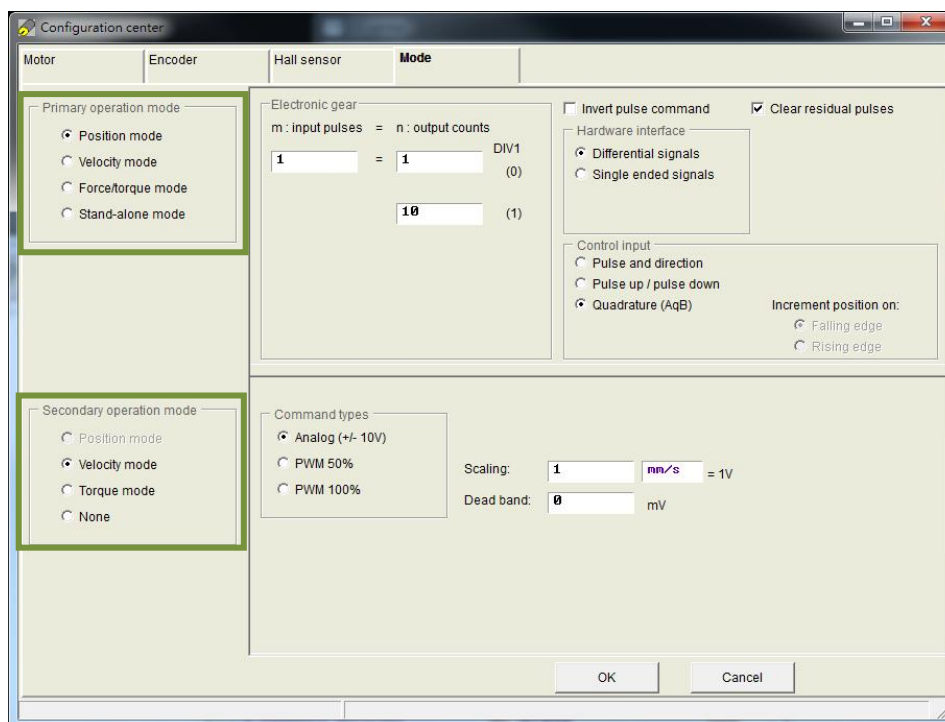


When **State** indicator becomes green, the servo drive ignores external pulse signal and decelerates the motor at the speed set in Dec. kill to a stop.

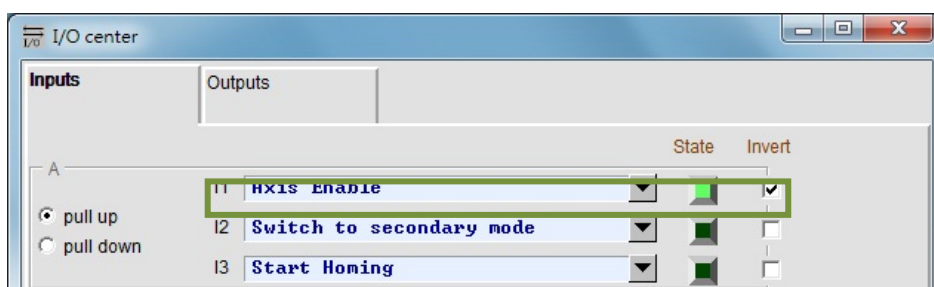


Input Function	Switch to secondary mode		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	MOD	Default Input	None	Wiring Diagram	Refer to section 4.7.1.			

- ◆ **Function**
Use I/O signal from controller to switch between operation modes.
- ◆ **Description**
Set primary operation mode and secondary operation mode in **Mode** tab in Configuration center.

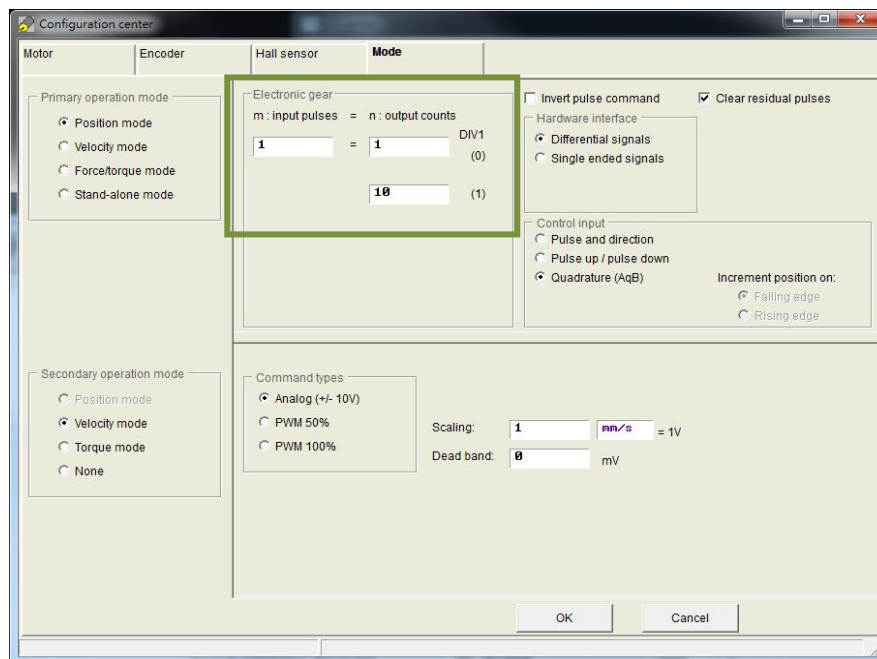


Set one input for switching to secondary operation mode in I/O center. In the figure below, I2 is set for switching to secondary operation mode. When the input signal is OFF, the mode set in **Primary operation mode** is used. When the input signal is ON, the mode set in **Secondary operation mode** is used. If **None** is selected for **Secondary operation mode**, stand-alone mode is used.



Input Function	Electronic gear select (DIV1)		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	DIV1	Default Input	None	Wiring Diagram	Refer to section 4.7.1.			

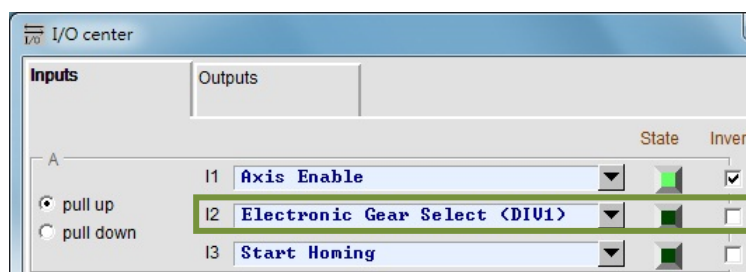
- ◆ **Function**
This input function is used to switch between two electronic gear ratios.
- ◆ **Description**
Select **Position mode** in **Mode** tab in Configuration center. Two electronic gear ratios can be set, please refer to below.



Select the required electronic gear ratio by the state of DIV1.

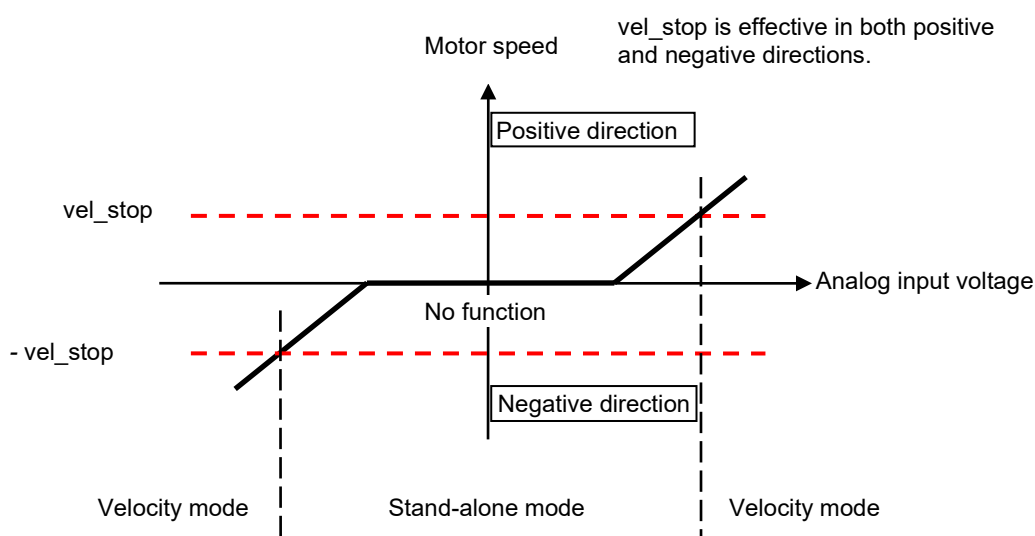
DIV1	Numerator
0	1 st
1	2 nd

Set one input to Electronic Gear Select (DIV1) in I/O center. In the figure below, I2 is set to Electronic Gear Select (DIV1). When the input signal is OFF, the first electronic gear ratio is used. When the input signal is ON, the second electronic gear ratio is used.

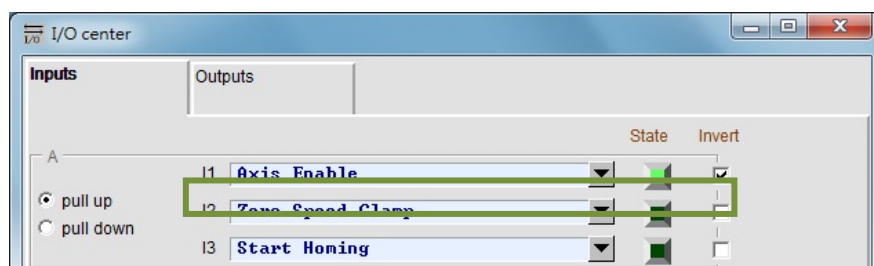


Input Function	Zero speed clamp		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	ZSC	Default Input	None	Wiring Diagram	Refer to section 4.7.1.			

- ◆ **Function**
This input function can only be used in velocity mode and is level triggered. When the input signal is ON and the motor speed is equivalent to or slower than the speed set for activating brake, the operation mode will be changed to stand-alone mode and the motor is stopped at current position. The operation mode is changed back to velocity mode and the motor starts to move as the motor speed is faster than the speed set for activating brake.

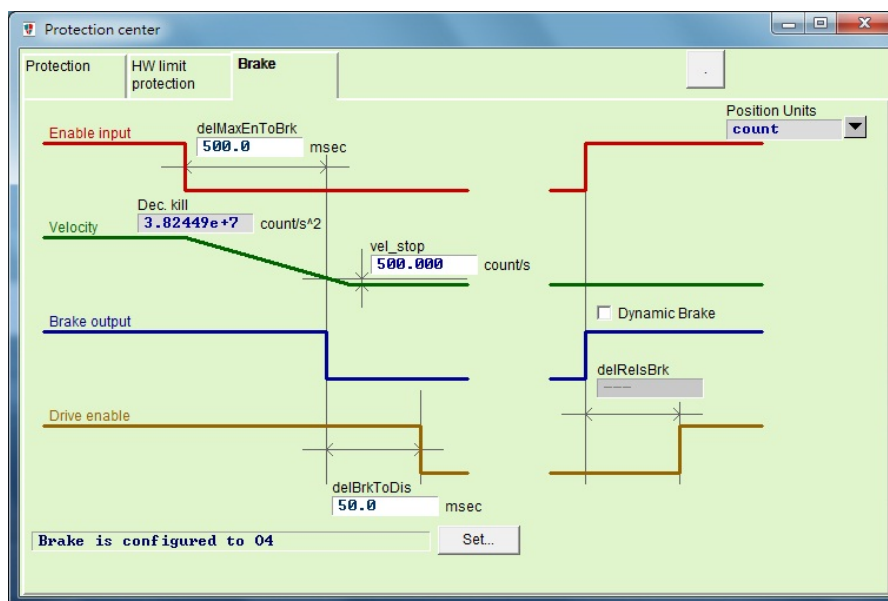


- ◆ **Description**
Set operation mode to velocity mode. Set one input to Zero Speed Clamp in I/O center. In the figure below, I2 is set to Zero Speed Clamp.



Go to Protection center and set the velocity for activating brake (vel_stop). The default setting value is 500 count/s.

Input Function	Zero speed clamp		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	ZSC	Default Input	None	Wiring Diagram	Refer to section 4.7.1.			



Zero speed clamp is activated when I2 is ON.

Input Function	Clear error		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	CE	Default Input	None	Wiring Diagram	Refer to section 4.7.1.			

- ◆ Function
Clear error.
- ◆ Description
When the input set for clearing error is from OFF to ON, error will be cleared.
After error is cleared, **Software Enabled** will be ON.

Input Function	Start homing		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	HOM	Default Input	I3	Wiring Diagram	Refer to section 4.7.1.			

- ◆ Function
Homing
- ◆ Description
When the input set for starting homing is from OFF to ON, homing will be executed according to the method set in Application center.

5.4.2 Digital outputs

D1 servo drive provides four sets of programmable digital outputs. Three outputs (O1 to O3) are general-purpose outputs which locate on connector CN2. One output (O4) which locates on the connector for 24 V power supply is for brake and can also be used as general-purpose output.

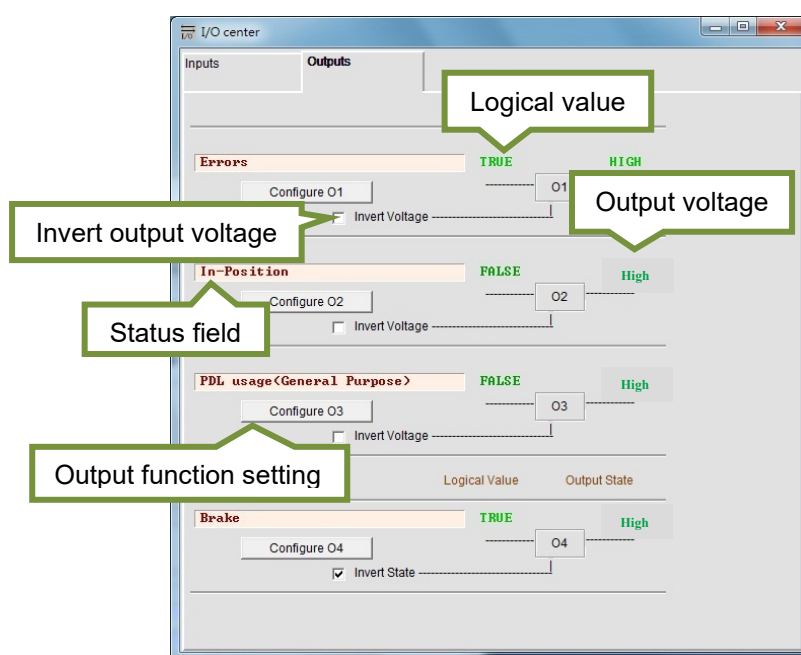


Figure5.4.2.1

(1) Output function setting

Each output has its corresponding setting button. For instance, the setting button of O1 is **Configure O1**. Click on **Configure O1** to show the setting window as figure 5.4.2.2. Output functions in figure 5.4.2.2 can be categorized into **Statuses**, **Errors** and **Warnings**. If two or more output functions are selected for one output, the output will be ON as either one of the selected output functions is triggered. Click on **Not Configured** to cancel the selection. Click on **Apply** to finish the setting or click on **Cancel** to cancel the setting. If **Set all errors** is clicked on, all the listed errors will be selected. For safety, it is suggested to select all the listed errors.

(2) Status field

When a function is set for an output, the name of that function will be displayed in the status field. If two or more functions are set for one output, the status field will display "Customized". If all the listed errors are selected, the status field will display "Errors" as figure 5.4.2.1. If no function is set, the status field will display "PDL usage (General purpose)".

(3) Logical value

The logical value of each output is displayed. The displayed value can be TRUE or FALSE.

(4) Invert output voltage

If needed, select **Invert voltage** to invert the polarity of output voltage. Please be noted the internal logical value of the servo drive will not be affected.

(5) Output voltage

The voltage level of the output pin will be displayed for user to check if the signal received by controller is correct.

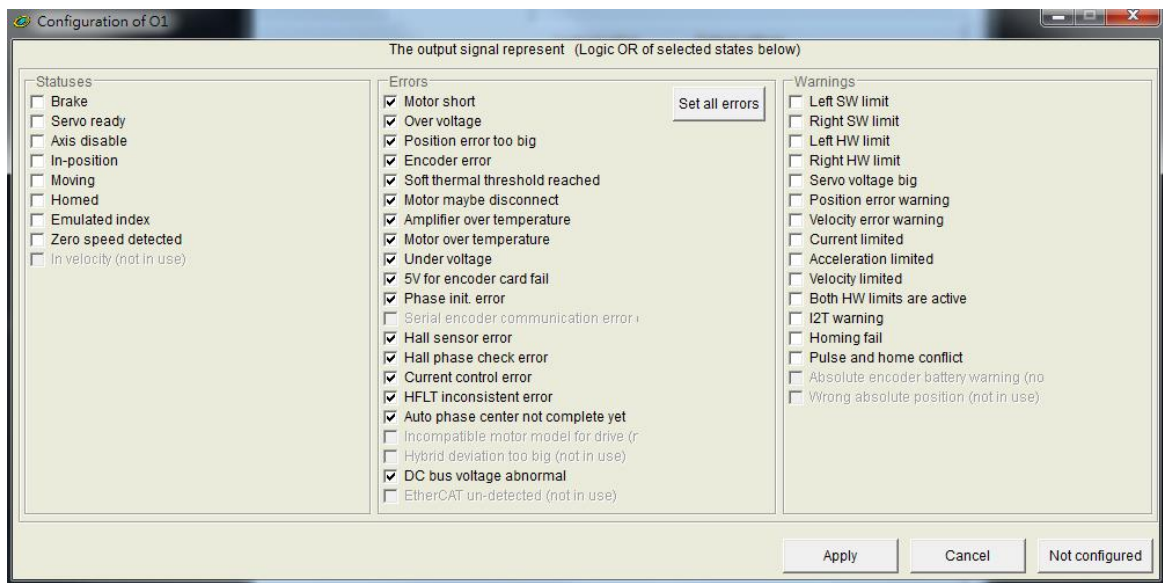


Figure5.4.2.2

Table5.4.2.1

Statuses			
Item	Abbr.	Output Function	Description
1	BRK	Brake	Brake signal If Brake is selected, other output functions cannot be set.
2	RDY	Servo ready	The motor is enabled.
3	DIS	Axis disable	The motor is disabled.
4	INP	In-position	In-position signal
5	MOV	Moving	The motor is moving.
6	HOMD	Homed	Homing completed.
7	EMI	Emulated index	Emulated Z-phase index signal
8	ZSPD	Zero speed detected	Zero speed detection signal
Errors			
Item	Abbr.	Output Function	Description
1	ALM	Errors	Normally all the selections in this category are set. (Click on Set all errors button.) User can also have his own setting

			depending on his need.
Warnings			
Item	Abbr.	Output Function	Description
1	LS	Left SW limit	Left software limit is triggered.
2	RS	Right SW 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 exceeds the setting value for warning.
6	PEW	Position error warning	Position error is greater than the setting value for warning.
7	VEW	Velocity error warning	Velocity error is greater than the setting value for warning.
8	CUL	Current limited	The motor peak current is reached.
9	ACL	Acceleration limited	Protection setting for acceleration is reached.
10	VL	Velocity limited	Protection setting for velocity is reached.
11	BOHL	Both HW limits are active	Both left and right hardware limits are triggered
12	I2T	I2T warning	Threshold of software over temperature protection has been exceeded.
13	HOMF	Homing fails	Homing failed.
14	PCHC	Pulse command and homing conflict	In position mode, both pulse command and homing command are received at the same time.

Table5.4.2.2 Default output settings of D1 servo drive

Pin	Non-CoE Model	CoE Model	Invert
	Trigger Condition	Trigger Condition	
O1	Errors	Errors	No
O2	In-position	In-position	No
O3	PDL usage (General purpose)	PDL usage (General purpose)	No
O4	Brake	Brake	Yes

Table 5.4.2.3 Supported output functions in each mode

Operation Mode Output Function	Non-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 the output function is supported.

Output Function	Zero Speed Detected		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	ZSPD	Default Output	O4	Wiring Diagram	Refer to section 4.7.2.			

◆

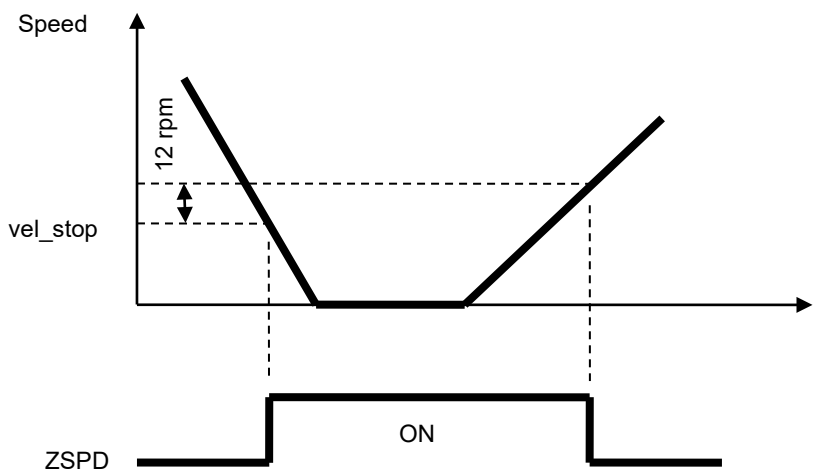
Function

This signal is output when motor speed is close to zero.

◆

Description

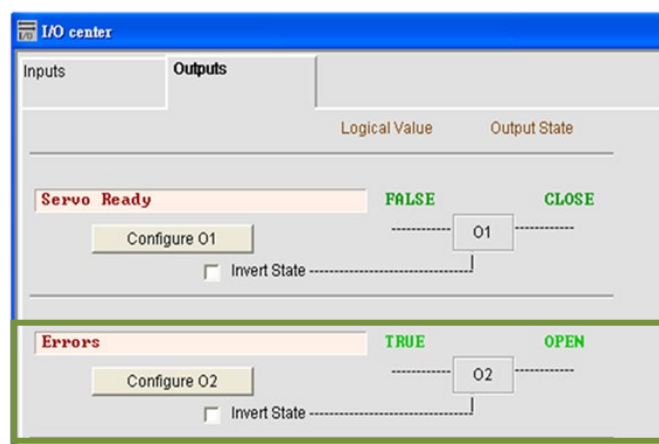
This signal is output when motor speed is slower than the value set for vel_stop. There is a 12 rpm delay to avoid signal bounce. For vel_stop, please refer to section 8.3.



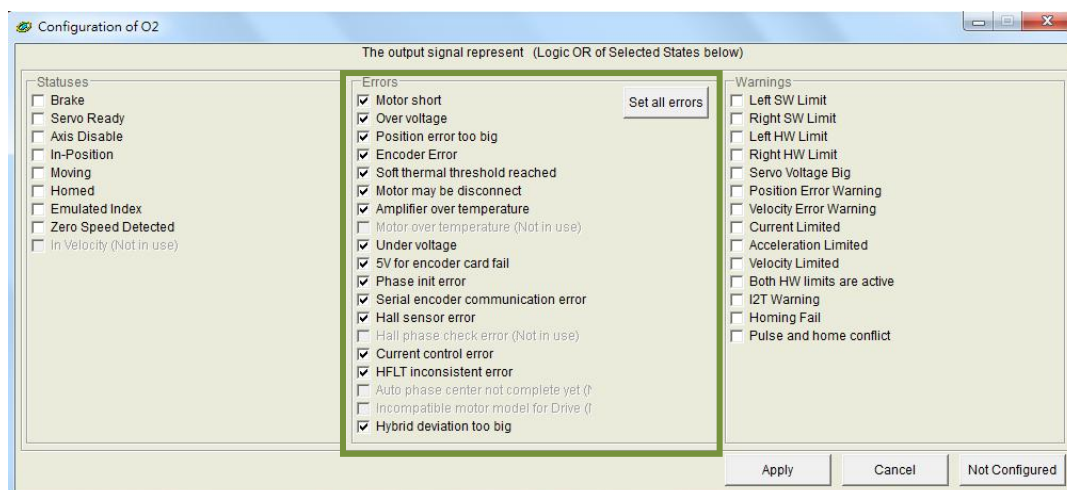
The graph illustrates the relationship between motor speed and the Zero Speed Detected (ZSPD) signal. The vertical axis represents Speed, and the horizontal axis represents time. A thick black line shows the speed profile: it starts at a high value, decreases linearly to zero, remains at zero for a short duration, and then increases linearly. A horizontal dashed line labeled 'vel_stop' is drawn across the graph. Two vertical dashed lines extend from the points where the speed curve intersects the 'vel_stop' line down to the ZSPD signal line. The ZSPD signal is shown as a thick black line that is low (OFF) when the speed is high, transitions to high (ON) as the speed drops below the 'vel_stop' threshold, and returns to low (OFF) as the speed rises above the 'vel_stop' threshold. A vertical double-headed arrow between the 'vel_stop' line and the speed curve indicates a 12 rpm delay.

Output Function	Errors		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	ALM	Default Output	O2	Wiring Diagram	Refer to section 4.7.2.			

- ◆ **Function**
User is allowed to output error statuses.
- ◆ **Description**
User can select **Errors** (Default output: O2) for one output in **Outputs** tab in I/O center.





Click on **Configure O2** button to show **Configuration of O2** window. Click on **Set all errors** button to select all the listed errors. The status field will display “Errors”. If not all the listed errors are selected, the status field will display “Customized”.



5.5 Setting in-position signal

In a servo system, position error exists between target position and encoder feedback position. The settling period as motor arrives at target position is called settling time. After that, motor goes into target radius. D1 servo drive supports in-position settings for user to set target radius and debounce time to observe if motor has reached target position. In-position settings are only available in position mode and stand-alone mode. User can set one output for in-position signal to notify controller that motor has arrived at target position.

■ Function setting

Click on  to go to Performance center. Click on **Position** tab to set in-position settings. If users would like to observe waveforms, click on  button. The default output of in-position signal is O2. For setting digital outputs, please refer to section 5.4.2.

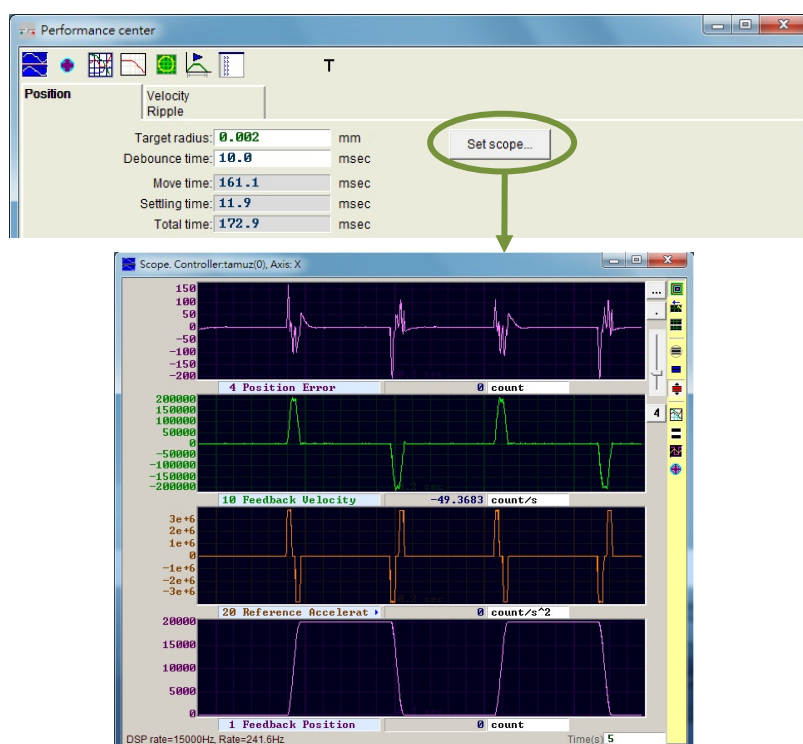


Figure5.5.1

Table 5.5.1

Parameter	Description
Target radius	Motor will be regarded as in-position after position error is within target radius. The default value is 100 times of encoder resolution.
Debounce time	Position error needs to be within target radius for the set debounce time for motor to be regarded as in-position.
Move time	Path planning time
Settling time	Settling time
Total time	Sum of move time and settling time

■ Debounce time setting

In-position signal could be unstable as the motor may overshoot during positioning. In this case, user can set debounce time to have stable in-position signal. In-position signal will only be sent after position error is within the target radius for the set debounce time. The larger the debounce time is, the more stable the in-position signal is. But setting larger debounce time could have longer time delay. Users can set appropriate debounce time by observing in-position signal in oscilloscope. For finding appropriate debounce time, please refer to below.

- (1) Set **Target radius** and set **Debounce time** to 0 ms. Let the motor move for a period of time and observe in-position signal from oscilloscope, as figure 5.5.2. When the motor is in-position, in-position signal is at high level. In figure 5.5.2, there are six protruding pulses as the motor moves close to the target position. Observe the time duration of protruding pulse.

Table 5.5.2

Protruding Pulse	Time Duration
1 st	1.5 ms
2 nd	1.4 ms
3 rd	1.4 ms
4 th	1.3 ms
5 th	1 ms
6 th	1 ms

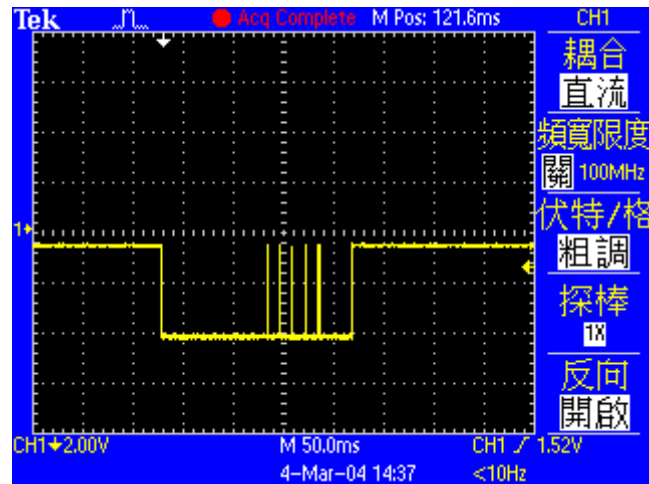


Figure 5.5.2 In-position signal when debounce time is set to 0 ms.

- (2) From figure 5.5.2, the longest time duration is 1.5 ms. Set debounce time to a value which is slightly larger than 1.5 ms. Considering safety factor, set debounce time to 3 ms. Let the motor move for a period of time. In-position signal becomes stable as figure 5.5.3.

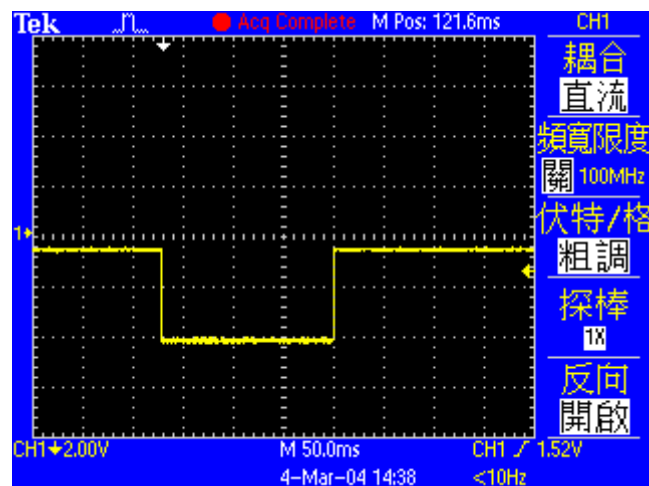



Figure 5.5.3 In-position signal when debounce time is set to 3 ms.

5.6 Homing

Click on  to go to Application center. The setting page for homing is in **Homing** tab, as figure 5.6.1. For standard digital encoder and analog encoder, refer to figure 5.6.1. For absolute resolver, refer to figure 5.6.2.

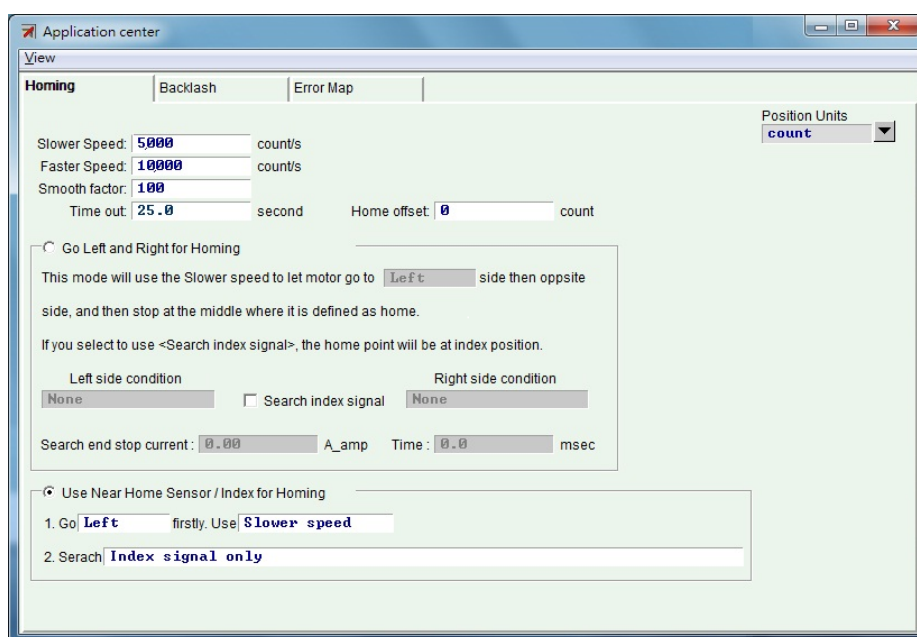


Figure 5.6.1 Homing setting (Standard digital encoder and analog encoder)

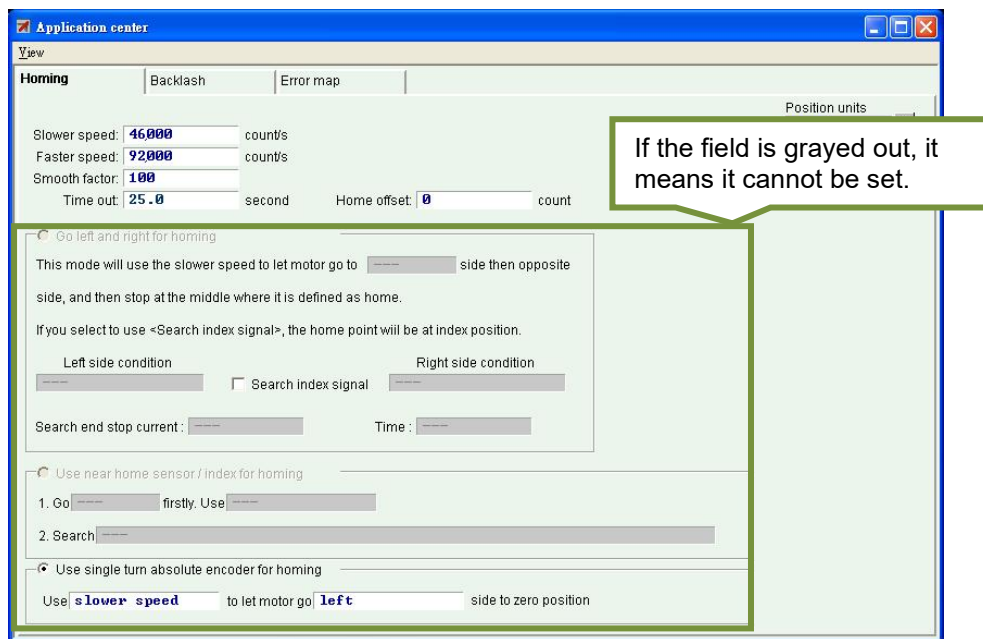


Figure5.6.2 Homing setting (Absolute resolver)

There are five basic parameters for homing.



Table5.6.1

Parameter	Description
Slower Speed	Homing at slower speed.
Faster Speed	Homing at faster speed.
Smooth factor	Smooth factor for homing (Setting range: 1 to 500)
Time out	The maximum search time of homing procedure
Home offset	Home offset

D1 servo drive provides four homing methods:

- (1) Homing by using left side and right side conditions, refer to section 5.6.1.
- (2) Homing by using near home sensor or index signal, refer to section 5.6.2.
- (3) Homing by using single-turn absolute encoder, refer to section 5.6.3.
- (4) Homing by using CiA 402 standard homing method, refer to section 5.6.4.

For motor with digital encoder or analog encoder, please use method (1) or (2). For motor with absolute resolver, please use method (3). For CoE model, please use method (4). Homing method (4) is supported in Lightening 0.185 or later version.

After homing method is set, click on **Home** button in Performance center. During homing, **Homed** indicator will keep flashing. If homing succeeds, **Homed** indicator becomes green (). If the time set for time out elapses, it means homing fails. Then **Homed** indicator becomes red ().

■ Home offset

(1) Motor stops at the position after home offset is applied

Applicable homing method:

- Homing by using left side and right side conditions
- Homing by using near home sensor or index signal
- Homing by using single-turn absolute encoder

When home offset is not zero, the position found by the selected homing method with home offset will be regarded as home position. Motor will move to this position. Refer to the figure below. In this figure, the left side and right side conditions are set. If home offset is positive, home position will be on the right of the position found by the selected homing method. If home offset is negative, home position will be on the left of the position found by the selected homing method.

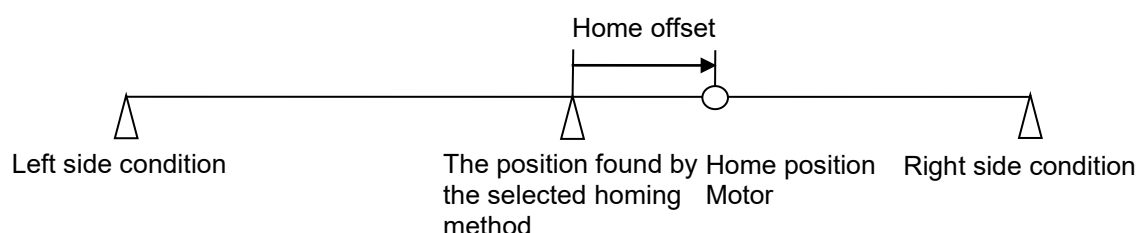


Figure5.6.3

(2) Motor stops at the position found by the selected homing method

Applicable homing method:

- Homing by using CiA 402 standard homing method

When home offset is not zero, the position found by the selected homing method will be set as the position after home offset is applied. Motor stops at the position found by the selected homing method. If home offset is positive, home position will be on the left of the position found by the selected homing method. If home offset is negative, home position will be on the right of the position found by the selected homing method.

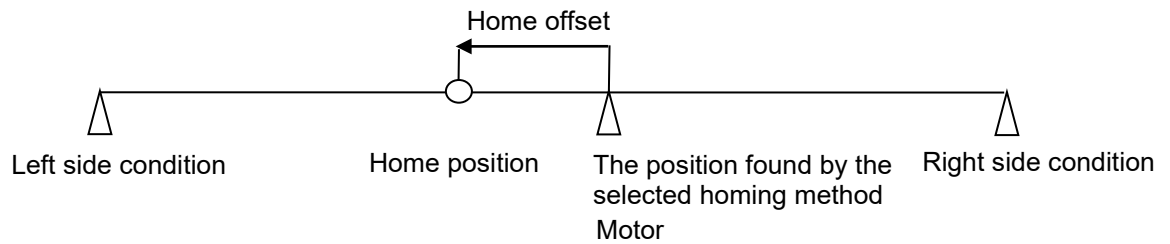


Figure5.6.4

5.6.1 Homing by left side and right side conditions

Homing by left side and right side conditions is a built-in homing method of D1 servo drive. Home position is the middle point of left side and right side conditions. The left side and right side conditions can be limit switches or end stops. The end stop is found by using the current generated by motor as it reaches hard stop. If the checkbox of **Search index signal** is checked, the index signal found during the process will be regarded as home position.

The homing method is described as below. In the figure below, the motor is set to move towards left at slower speed first (parameter ①) to find the left side condition. Then the motor moves towards the opposite direction to find the right side condition. Then the motor stops at the middle point. If the checkbox of **Search index signal** is checked, the index signal found during the process will be regarded as home position. The left side and right side conditions are set by parameters ② and ③.

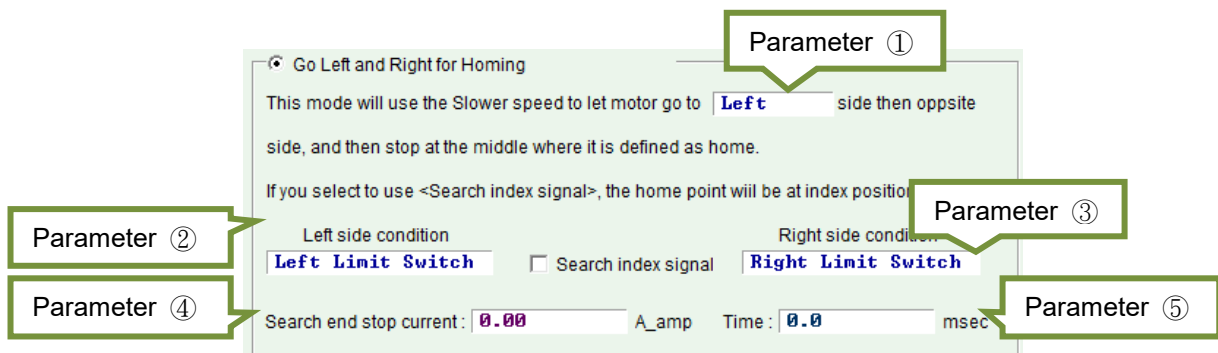


Figure5.6.1.1

Table5.6.1.1

Parameter No.	Parameter	Selection	Description
①	Initial moving direction	Left	Move to the left first.
		Right	Move to the right first.
②	Left side condition	None	Do not use left side condition.
		End stop	Move to the left to find end stop.
		Left limit switch	Move to the left to find limit switch.
③	Right side condition	None	Do not use right side condition.
		End stop	Move to the right to find end stop.
		Right limit switch	Move to the right to find limit switch.
④	Search end stop current		
⑤	Time		

The left side and right side conditions can be:

- (1) None
- (2) End stop
- (3) Limit switch

If the left side and right side conditions are end stops, parameters ④ and ⑤ must be set. Parameter ④ is the strength of the force while searching for end stop. Parameter ⑤ is the duration of the force. If parameter ⑤ is set to be too small, the servo drive may not correctly identify end stop. If parameter ⑤ is set to be too large, error “Soft-thermal threshold reached” could occur. To find proper value, please refer to the following.

Step 1: Open Scope, as figure 5.6.1.2. Set to observe the value of Actual Current.

Step 2: Let the motor move at slower speed for the total travel distance.

Step 3: Observe the value of Actual Current and record the maximum value, as figure 5.6.1.2. The maximum value is about 0.2 A, so **Search end stop current** can be slightly larger than 0.2 A. In this case, **Search end stop current** can be set to 0.23 A.

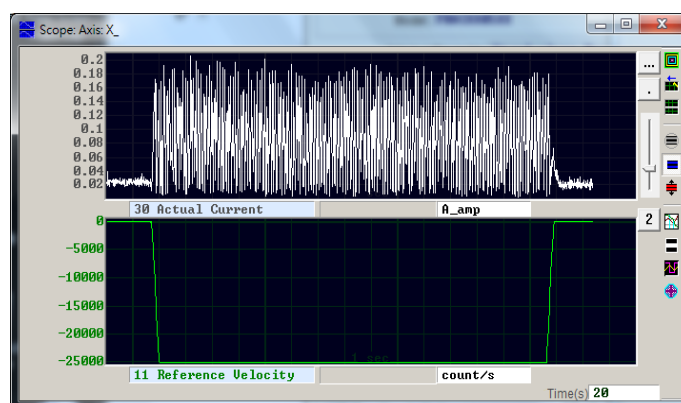


Figure5.6.1.2

Exception:

- (1) **Left side condition** is set to **None** and **Right side condition** is set to **End Stop** or **Right Limit Switch**. The initial moving direction (parameter ①) is set to left, as figure 5.6.1.3. The homing fails and **Homed** indicator becomes red.

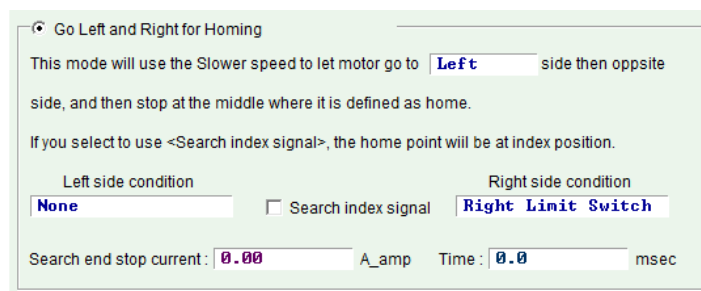


Figure5.6.1.3

- (2) The checkbox of **Search index signal** is checked, but there are multiple index signals in the travel distance. The index signal which is closest to end stop or right limit switch will be regarded as home position.

■ Homing example

Use the setting in figure 5.6.1.4 as an example. When homing procedure is activated, the motor moves towards negative direction at slower speed to find the negative limit switch. Then the motor moves towards positive direction to find the first Z-phase index signal it meets during the homing process. Refer to figure 5.6.1.5.

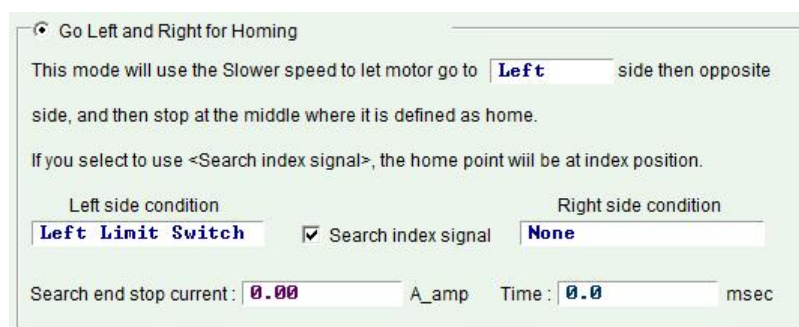


Figure5.6.1.4

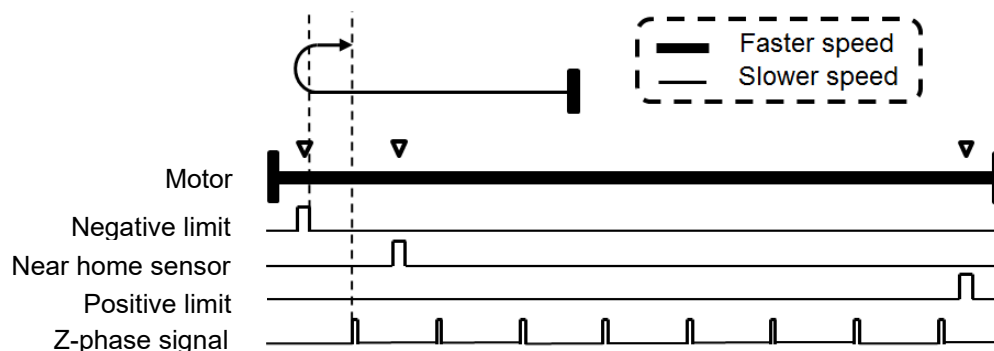


Figure5.6.1.5

5.6.2 Homing by near home sensor or index signal

D1 servo drive supports homing by near home sensor or index signal. Set input function **Near Home Sensor** in I/O center. This input function is triggered by external switch. After near home sensor is found, set to search for index signal in the left side or right side and use it as home position to have better accuracy.

The homing procedure is provided as below:

Search for near home sensor or index signal by using the initial moving direction (parameter ⑥) and initial moving speed (parameter ⑦) set by user.

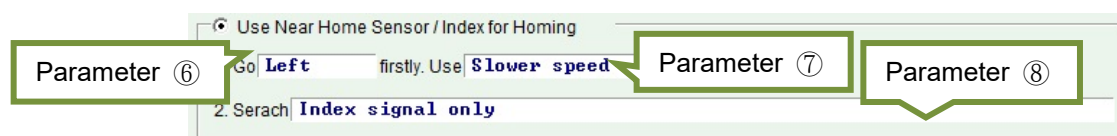


Figure5.6.2.1

Table5.6.2.1

Parameter No.	Parameter	Selection	Description
⑥	Initial moving direction	Left	Move to the left first.
		Right	Move to the right first.
⑦	Initial moving speed	Slower speed	Use slow homing speed. Refer to Slower Speed field in figure 5.6.1.
		Faster speed	Use fast homing speed. Refer to Faster Speed field in figure 5.6.1.
⑧	Homing method	Index signal only	Search for index signal.
		Near home sensor only	Search for near home sensor.
		Near home sensor then change to lower speed, move left, search index	After near home sensor is found, switch to slower speed to search for index signal on the left.
		Near home sensor then change to lower speed, move right, search index	After near home sensor is found, switch to slower speed to search for index signal on the right.

If user would like to perform homing by using near home sensor, connect photoelectric switch or mechanical switch to the digital input of the servo drive. Take I2 as an example in figure 5.6.2.2. Go to I/O center to set the input function of I2 as **Near Home Sensor**.

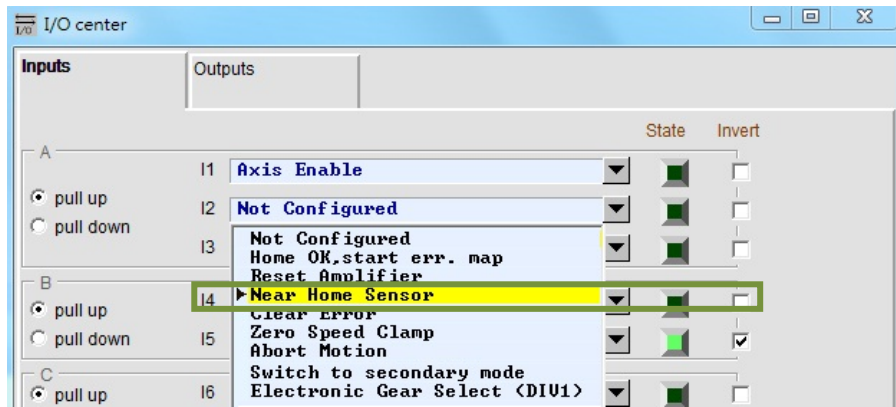


Figure5.6.2.2

■ Homing example

Use the setting in figure 5.6.2.3 as an example. When homing procedure is activated, the motor moves towards negative direction at faster speed to find the near home sensor. Then the motor moves towards negative direction to find the first Z-phase index signal it meets during the homing process. Refer to figure 5.6.2.4.

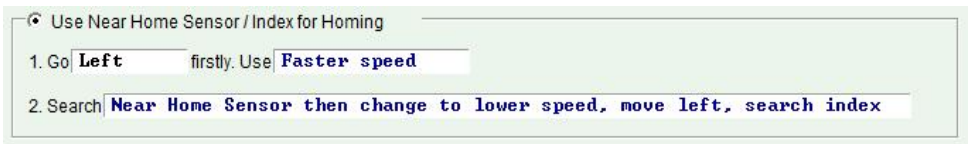


Figure5.6.2.3

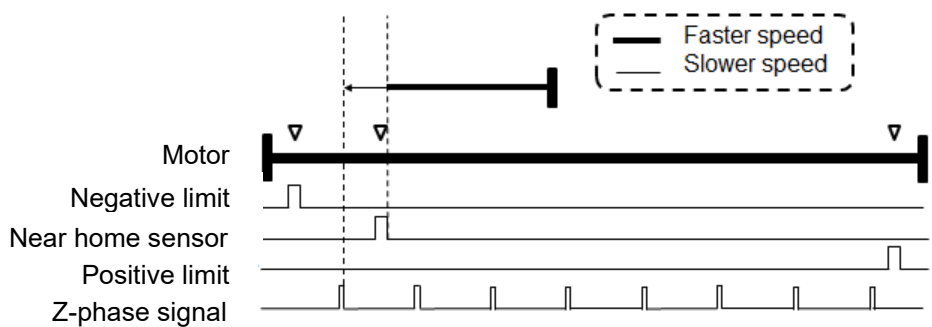


Figure5.6.2.4

5.6.3 Homing by single-turn absolute encoder

With single-turn absolute encoder, the servo drive is able to know the position of the motor within one revolution and how far the motor must move to reach the home position by calculation. User must decide to let motor move towards left side or right side, or along the shortest path for homing.

The homing procedure is provided as below:

Move towards the set direction (parameter ⑩) and at the set speed (parameter ⑨) for homing.

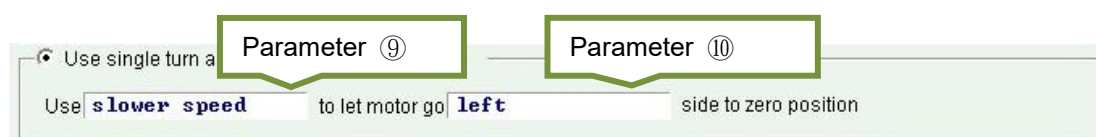


Figure5.6.3.1

Table5.6.3.1

Parameter No.	Parameter	Selection	Description
⑨	Moving speed	Slower speed	Use slow homing speed. Refer to Slower Speed field in figure 5.6.1.
		Faster speed	Use fast homing speed. Refer to Faster Speed field in figure 5.6.1.
⑩	Moving direction	Left	Move to the left first.
		Right	Move to the right first.
		Shortest path	Move along the shortest path.

5.6.4 Homing by CiA 402 standard homing method

Homing by CiA 402 standard homing method is supported in CoE model with Lightning version 0.185 (or later version). The setting window is as figure 5.6.4.1. In figure 5.6.4.1, green line means faster speed is used and orange line means slower speed is used. For the provided homing methods, please refer to table 5.6.4.1.

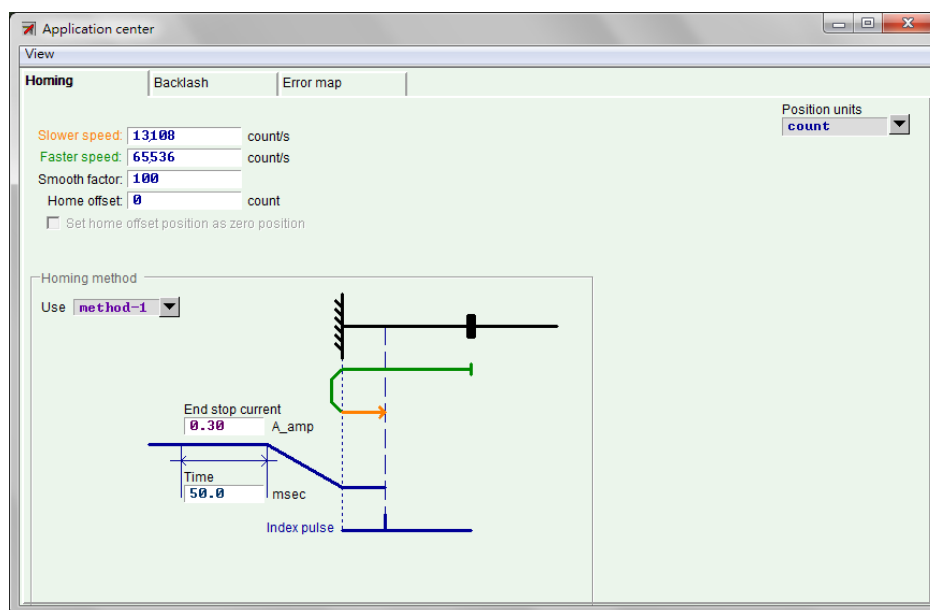


Figure5.6.4.1

Table5.6.4.1

Homing Method	Description	Figure
1	Homing with negative limit switch and index pulse, starting in negative direction. Search for negative limit switch at faster speed in negative direction. After the negative limit switch is found, search for index pulse at slower speed in positive direction.	
2	Homing with positive limit switch and index pulse, starting in positive direction. Search for positive limit switch at faster speed in positive direction. After the positive limit switch is found, search for index pulse at slower speed in negative direction.	

Homing Method	Description	Figure
7	<p>Homing with the rising edge of near home sensor signal and left index pulse, starting in positive direction.</p> <p>Outside near home sensor: Search for the rising edge of near home sensor signal at faster speed in positive direction. After it is found, search for left index pulse at slower speed in negative direction.</p> <p>Inside near home sensor: Search for the falling edge of near home sensor signal at faster speed in negative direction. After it is found, search for left index pulse at slower speed in negative direction.</p>	
8	<p>Homing with the rising edge of near home sensor signal and right index pulse, starting in positive direction.</p> <p>Outside near home sensor: Search for the rising edge of near home sensor signal at faster speed in positive direction. After it is found, search for right index pulse at slower speed in positive direction.</p> <p>Inside near home sensor: Search for the falling edge of near home sensor signal at faster speed in negative direction. After it is found, search for right index pulse at slower speed in positive direction.</p>	
9	<p>Homing with the falling edge of near home sensor signal and left index pulse, starting in positive direction.</p> <p>Outside near home sensor: Search for the falling edge of near home sensor signal at faster speed in positive direction. After it is found, search for left index pulse at slower speed in negative direction.</p>	
10	<p>Homing with the falling edge of near home sensor signal and right index pulse, starting in positive direction.</p> <p>Search for the falling edge of near home sensor signal at faster speed in positive direction. After it is found, search for right index pulse at slower speed in positive direction.</p>	

Homing Method	Description	Figure
11	<p>Homing with the rising edge of near home sensor signal and right index pulse, starting in negative direction.</p> <p>Outside near home sensor: Search for the rising edge of near home sensor signal at faster speed in negative direction. After it is found, search for right index pulse at slower speed in positive direction.</p> <p>Inside near home sensor: Search for the falling edge of near home sensor signal at faster speed in positive direction. After it is found, search for right index pulse at slower speed in positive direction.</p>	
12	<p>Homing with the rising edge of near home sensor signal and left index pulse, starting in negative direction.</p> <p>Outside near home sensor: Search for the rising edge of near home sensor signal at faster speed in negative direction. After it is found, search for left index pulse at slower speed in negative direction.</p> <p>Inside near home sensor: Search for the falling edge of near home sensor signal at faster speed in positive direction. After it is found, search for left index pulse at slower speed in negative direction.</p>	
13	<p>Homing with the falling edge of near home sensor signal and right index pulse, starting in negative direction.</p> <p>Search for the falling edge of near home sensor signal at faster speed in negative direction. After it is found, search for right index pulse at slower speed in positive direction.</p>	
14	<p>Homing with the falling edge of near home sensor signal and left index pulse, starting in negative direction.</p> <p>Search for the falling edge of near home sensor signal at faster speed in negative direction. After it is found, search for left index pulse at slower speed in negative direction.</p>	

Homing Method	Description	Figure
33	Homing with index pulse, starting in negative direction. Search for index pulse at slower speed in negative direction.	Use <input type="text" value="method33"/>
34	Homing with index pulse, starting in positive direction. Search for index pulse at slower speed in positive direction.	Use <input type="text" value="method34"/>
37	Set current position as home position.	Use <input type="text" value="method37"/>
-1	Homing with hard stop and right index pulse, starting in negative direction. Search for left hard stop at faster speed in negative direction. After it is found, search for index pulse at slower speed in positive direction. (For the setting of finding hard stop, please refer to section 5.6.1.)	Use <input type="text" value="method-1"/>
-2	Homing with hard stop and left index pulse, starting in positive direction. Search for right hard stop at faster speed in positive direction. After it is found, search for index pulse at slower speed in negative direction. (For the setting of finding hard stop, please refer to section 5.6.1.)	Use <input type="text" value="method-2"/>

Homing Method	Description	Figure
-3	Homing with absolute position. This homing method is only available for motor with multiturn absolute encoder. (The ninth code of motor model is 4.) Set current position as absolute target position. The motor does not need to move.	
-4	Search for hard stop in positive direction and move for end stop offset in negative direction. Search for right hard stop at faster speed in positive direction. After it is found, move for end stop offset at slower speed in negative direction.	
-5	Search for hard stop in negative direction and move for end stop offset in positive direction. Search for left hard stop at faster speed in negative direction. After it is found, move for end stop offset at slower speed in positive direction. ^{Note}	

Note:

The function of setting home offset as zero position has no function when homing method -4 or -5 is set.

In both homing procedures, the motor will stop at the position with home offset and set that position to zero.

■ Searching for hard stop

When searching for hard stop, two parameters will be used: End stop current and Time. End stop current is the strength of the force while searching for hard stop. Time is the duration of the force. If Time is set to be too small, the servo drive may not correctly identify the hard stop. If Time is set to be too large, error “Soft-thermal threshold reached” could occur. To find proper value for End stop current, please refer to the following.

Step 1: Open Scope, as figure 5.6.4.2. Set to observe the value of Actual Current.

Step 2: Let the motor move at slow homing speed (Slower speed) for the total travel distance.

Step 3: Observe the value of Actual Current and record the maximum value, as figure 5.6.4.2. The maximum value is about 0.2 A. End stop current can be slightly larger than 0.2 A. In this case, End stop current can be set to 0.23 A.

Note:

To avoid error “Position error too big” while searching for hard stop, the setting values of Slower speed and Time must satisfy the following formula.

$$\text{Slower Speed} \times \text{Time} < \text{Maximum Pos Error}$$

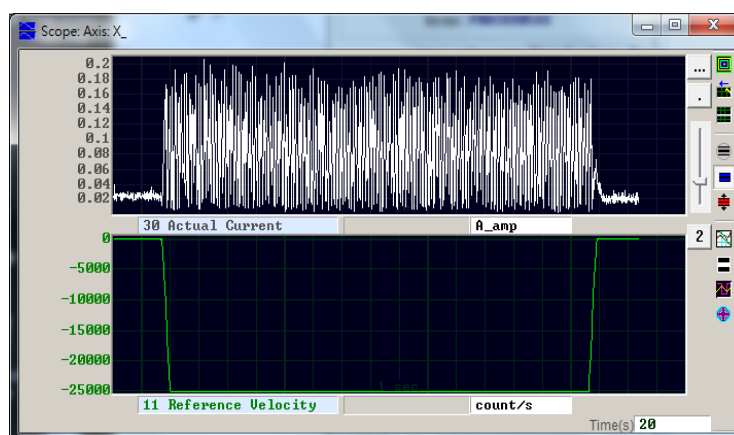



Figure 5.6.4.2

5.7 Save parameters to Flash and set to factory default

5.7.1 Save parameters to Flash

Click on  (Save parameters from amplifier RAM to Flash) to save current parameters to Flash. The parameters will still be accessible after the servo drive is turned off. Please pay attention to the following.

- (1) Emulated encoder output is temporarily not available while saving parameters to Flash. Position information during this time could be incorrect.
- (2) Values for error map function will not be saved to Flash. Go to **Error map** setting page in Application center to save error map settings to Flash.

5.7.2 Set parameters to factory default

Click on **Tools** on the menu bar and select **Set parameters to factory default** to set parameters to factory default, as figure 5.7.2.1. **Set drive to factory default** window appears as figure 5.7.2.2 (Lightening version 0.180 to 0.185A). If user would like to clear error map table at the same time, please select **Clear error table in flash then reset drive** and click on **Yes** button. When **Clear error table in flash then reset drive** is selected, a message dialog shown in figure 5.7.2.3 will appear informing user that before clearing error map table, the default settings will be saved to the servo drive and the servo drive will be reset. Click on **Yes** button and the system will proceed accordingly. Click on **No** button to return to **Set drive to factory default** window. After the parameters are set to factory default, the servo drive will be automatically reset.

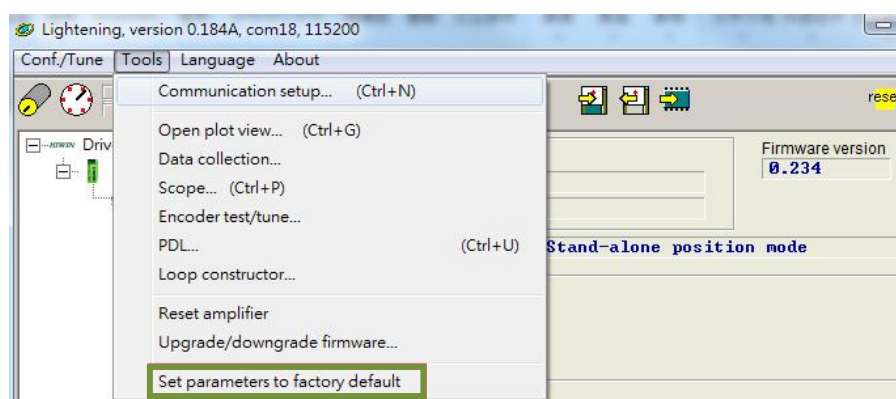


Figure5.7.2.1

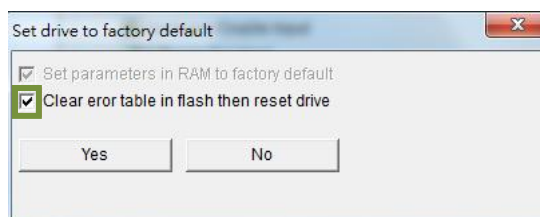


Figure5.7.2.2

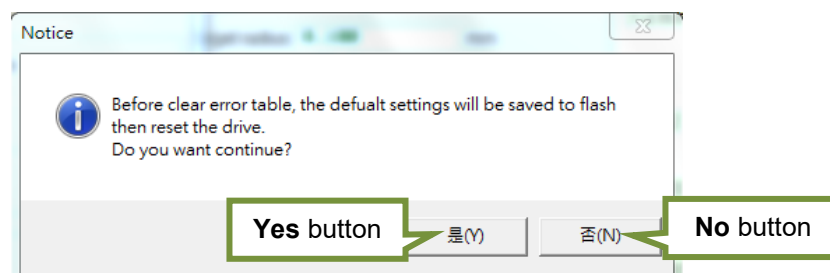


Figure5.7.2.3

If user is using Lightning version 0.186 or later version, click on **Tools** and select **Set amplifier to factory default** from the submenu. **Set amplifier to factory default** window appears as figure 5.7.2.4. Lightning will set parameters to factory default and windows other than the main window will be closed. Select **Clear error table in flash and reset drive** to clear error map table at the same time. Select **Clear user PDL** to clear user.pdl at the same time. A notice window will appear informing user that user.pdl will be cleared, as figure 5.7.2.5. Click on **Yes** button and the system will proceed accordingly. Click on **No** button to return to **Set amplifier to factory default** window. After the parameters are set to factory default, the servo drive will be automatically reset.

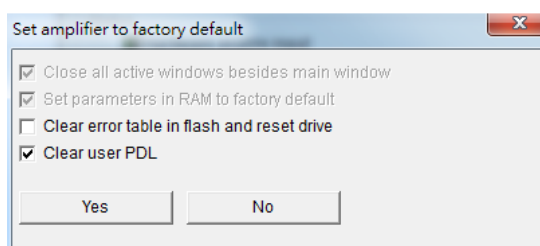


Figure5.7.2.4

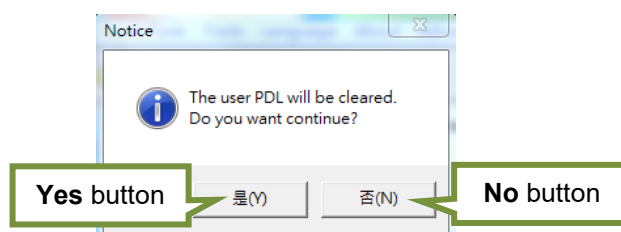


Figure5.7.2.5

5.8 Setting operation mode via Lightening


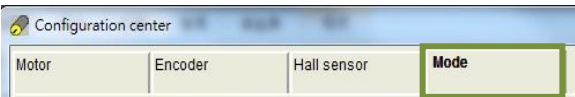
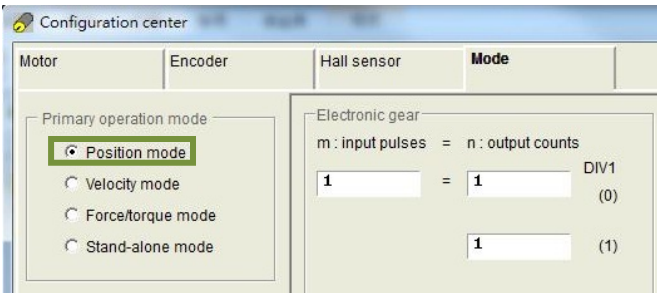
5.8.1 Position mode

In position mode, when pulse command is received from controller, the servo drive will move the motor for a corresponding distance. For further information of position mode, please refer to section 3.1.1. The setting of position mode should include mode selection, pulse type selection, electronic gear ratio setting and smooth factor setting. After setting, please save parameters to Flash.

(1) Mode selection

For mode selection, please refer to below.

Table5.8.1.1

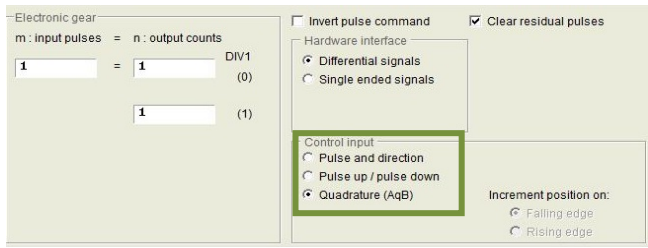
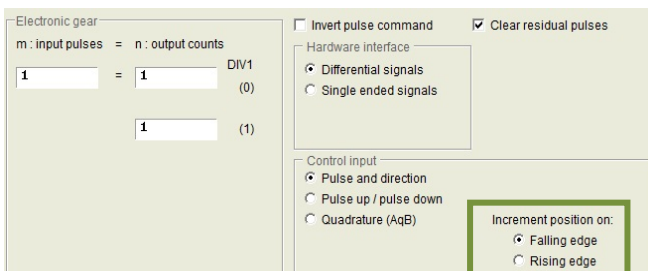
Step	Figure	Description
1		After Lightening is opened, click on the icon of Configuration center on the toolbar. Or click on Conf./Tune on the menu bar and select Configuration center .
2		In Configuration center, click on Mode tab.
3		In the setting page of Mode , select Position mode .

(2) Pulse type selection

D1 servo drive supports three pulse types. For more information, please refer to section 3.1.1.

For pulse type selection, please refer to below.

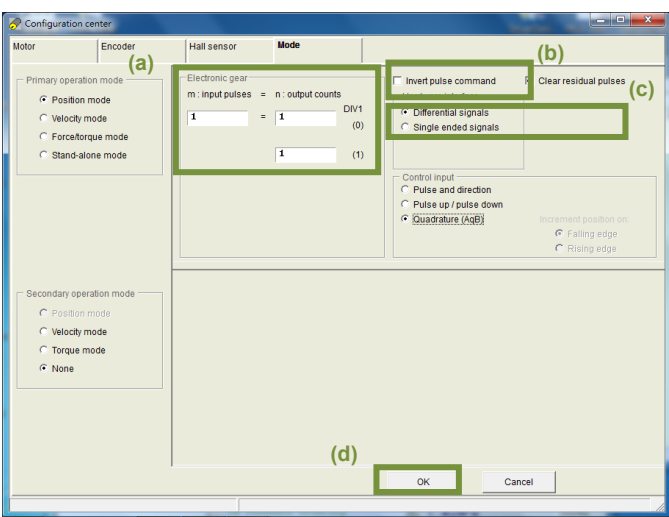
Table5.8.1.2

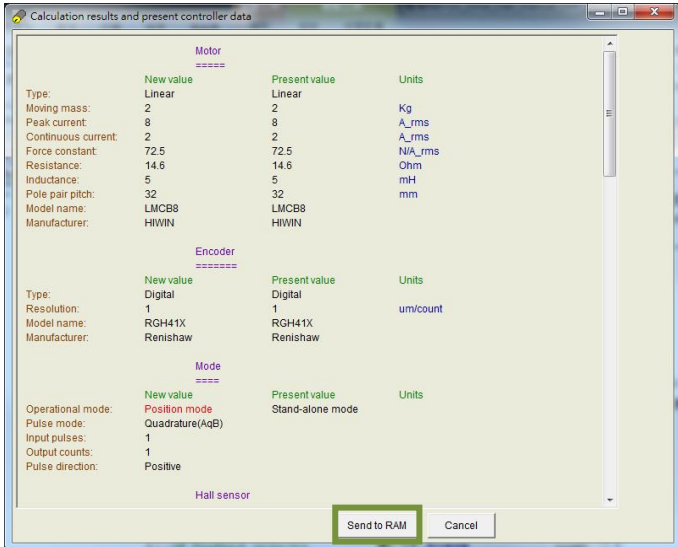
Step	Figure	Description
1		In the setting page of Mode , select pulse type in the setting area of Control input .
2		In the setting page of Mode , select trigger method in the setting area of Increment position on . Note: This setting is required only when Pulse and direction or Pulse up/pulse down is selected.

(1) Electronic gear ratio setting

D1 servo drive supports two electronic gear ratios. For more information, please refer to section 5.4.1. For setting electronic gear ratio, please refer to below.

Table5.8.1.3


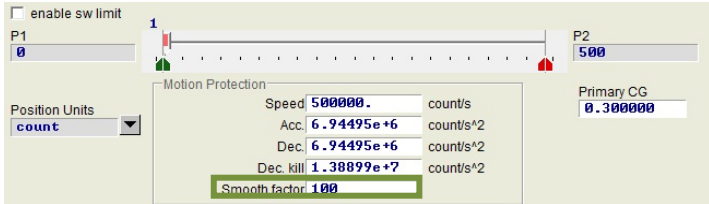
Step	Figure	Description
1		In the setting page of Mode , user can set electronic gear ratio in the setting area of Electronic gear which is indicated by (a) in the left figure.
2		In the setting page of Mode , user can set to invert pulse command in the setting area of Invert pulse command which is indicated by (b) in the left figure.
3		In the setting page of Mode , select Differential signals or Single ended signals based on the wiring in the setting area of Hardware interface . It is indicated by (c) in the left figure.
4		After settings, click on OK button which is indicated by (d) in the left figure.

Step	Figure	Description
5		Click on Send to RAM button to save parameters to RAM.

(2) Smooth factor setting

D1 servo drive allows user to set smooth factor. For more information, please refer to section 3.4. For smooth factor setting, please refer to below.

Table5.8.1.4

Step	Figure	Description
1		Click on the icon of Performance center on the toolbar. Or click on Conf./Tune on the menu bar and select Performance center .
2		Set smooth factor in Performance center.


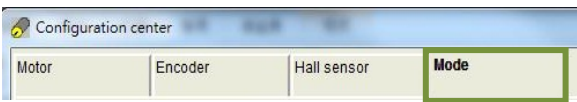
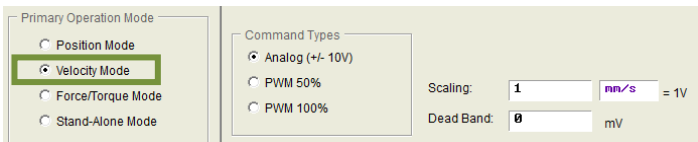
5.8.2 Velocity mode

D1 servo drive is able to transform voltage command and PWM command into velocity command. For more information, please refer to section 3.1.2. The setting of velocity mode should include mode selection and format setting of command input. After setting, please save parameters to Flash.

(1) Mode selection

For mode selection, please refer to below.

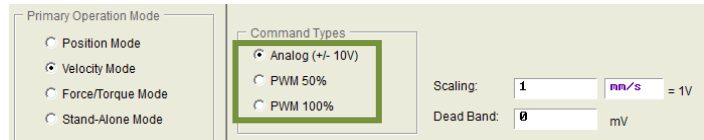
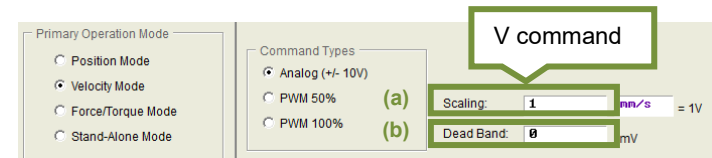
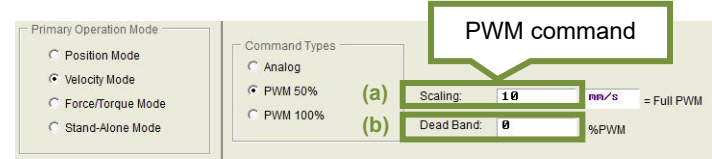
Table5.8.2.1

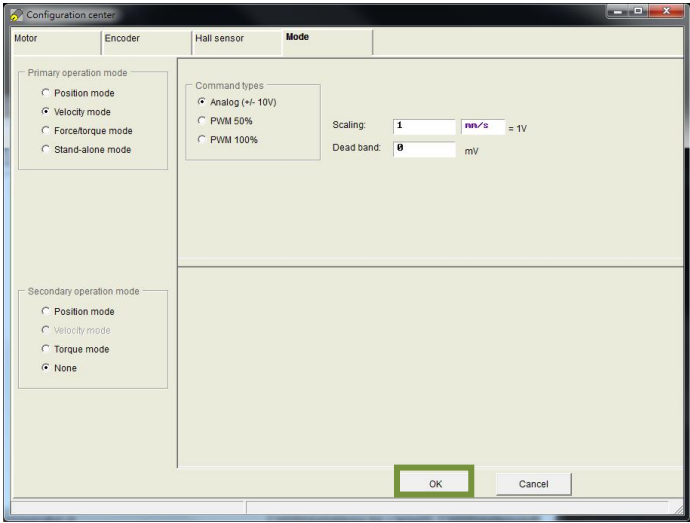
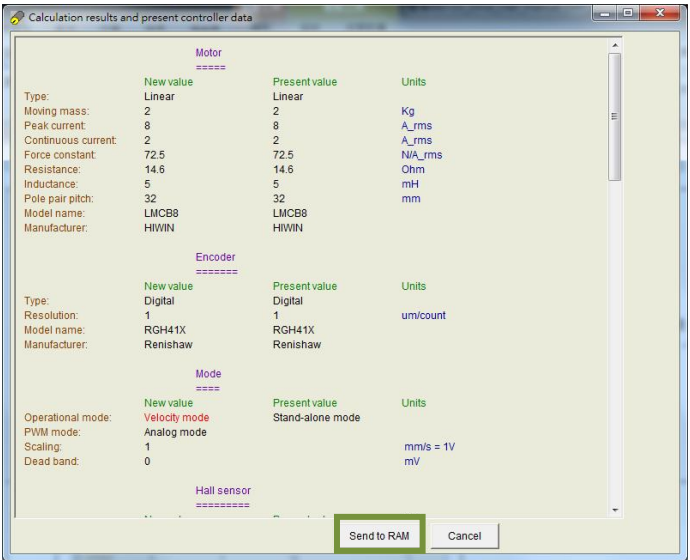
Step	Figure	Description
1		After Lightening is opened, click on the icon of Configuration center on the toolbar. Or click on Conf./Tune on the menu bar and select Configuration center .
2		In Configuration center, click on Mode tab.
3		In the setting page of Mode , select Velocity mode .

(2) Format setting of command input

For format setting of command input, please refer to below.

Table5.8.2.2

Step	Figure	Description
1		In the setting page of Mode , set command type in the setting area of Command Types .
2		In the setting page of Mode , set the ratio (scaling) between external command and velocity. Set 1 V equals what velocity in mm/s or rpm. Or set the corresponding maximum velocity of full PWM command.
3		Set dead band in the setting page of Mode . For the definition of dead band, please refer to figure 5.2.4.3.

Step	Figure	Description
4		After setting, click on OK button.
5		Click on Send to RAM button to save parameters to RAM.


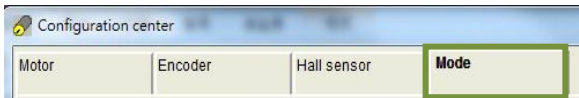
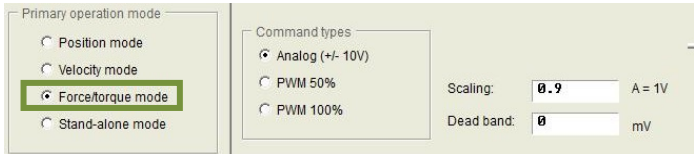
5.8.3 Force/torque mode

D1 servo drive is able to transform voltage command and PWM command into current command. For more information, please refer to section 3.1.3. The setting of force/torque mode should include mode selection and format setting of command input. After setting, please save parameters to Flash.

(1) Mode selection

For mode selection, please refer to below.

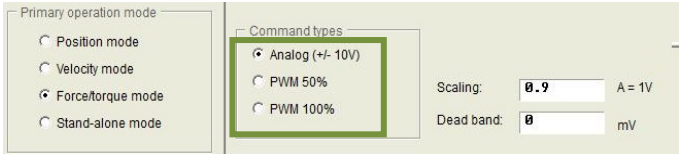
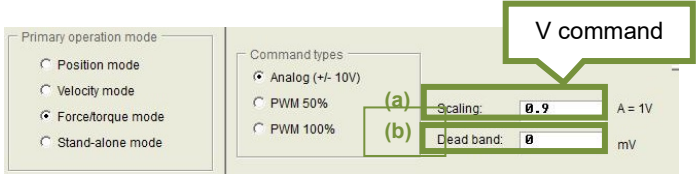
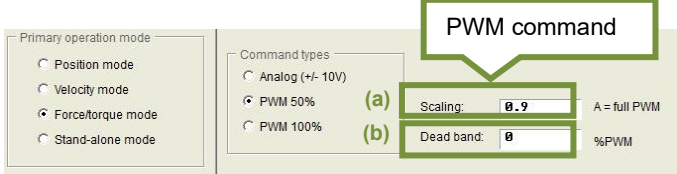
Table5.8.3.1

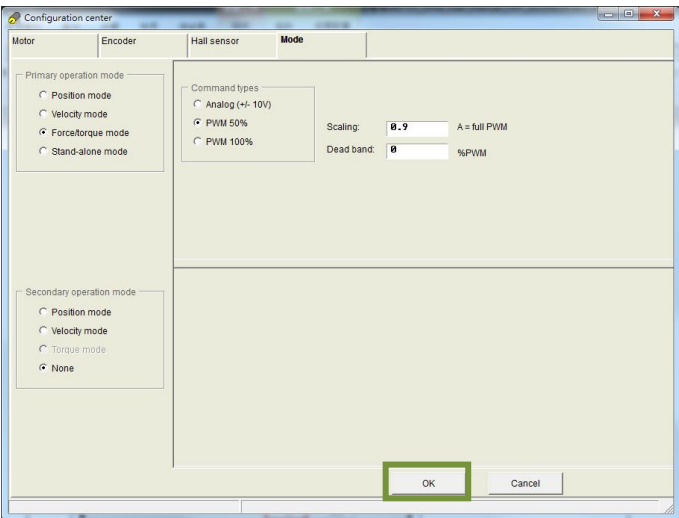
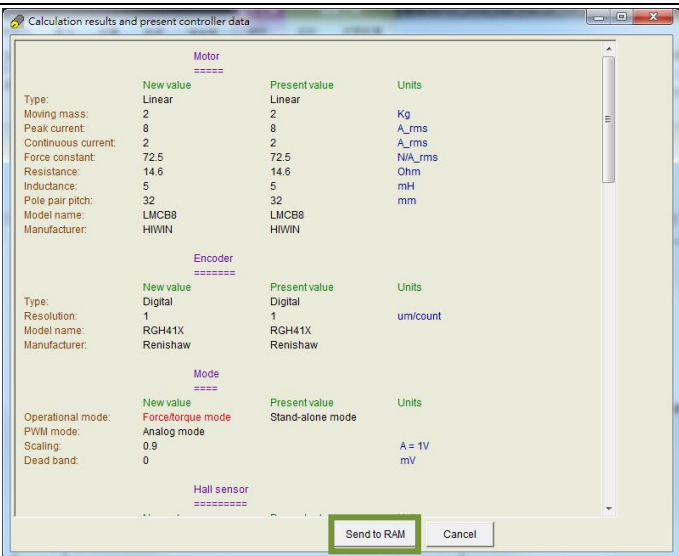
Step	Figure	Description
1		After Lightning is opened, click on the icon of Configuration center on the toolbar. Or click on Conf./Tune on the menu bar and select Configuration center .
2		In Configuration center, click on Mode tab.
3		In the setting page of Mode , select Force/torque mode .

(2) Format setting of command input

For format setting of command input, please refer to below.

Table5.8.3.2

Step	Figure	Description
1		In the setting page of Mode , set command type in the setting area of Command types .
2		In the setting page of Mode , set the ratio (scaling) between external command and current. Set 1 V equals what current in ampere (A). Or set the corresponding maximum current of full PWM command.
3		Set dead band in the setting page of Mode . For the definition of dead band, please refer to figure 5.2.4.3.

Step	Figure	Description
4		After setting, click on OK button.
5		Click on Send to RAM button to save parameters to RAM.


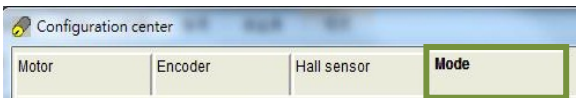
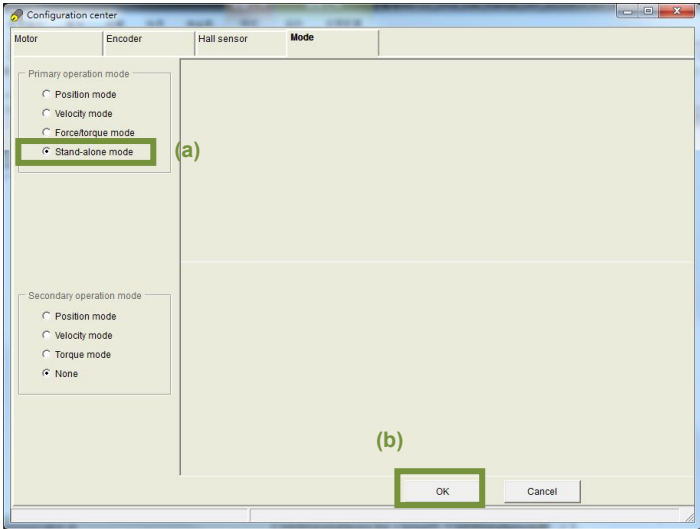
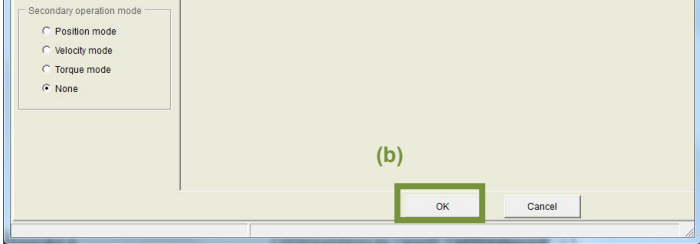

5.8.4 Stand-alone mode

In stand-alone mode, the servo drive will drive motor by using internal path planning. For more information, please refer to section 3.1.4. The setting of stand-alone mode should include mode selection. After setting, please save parameters to Flash.

(1) Mode selection

For mode selection, please refer to below.

Table5.8.4.1

Step	Figure	Description
1		After Lightening is opened, click on the icon of Configuration center on the toolbar. Or click on Conf./Tune on the menu bar and select Configuration center .
2		In Configuration center, click on Mode tab.
3		In the setting page of Mode , select Stand-alone mode .
4		After setting, click on OK button.
5		Click on Send to RAM button to save parameters to RAM.

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6. Tuning

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6.1 Status display and Quick view

In Lightening, status display and Quick view are two essential tools which allow user to know the status of the servo drive and the physical quantities for motion control.

6.1.1 Status display

There are two status display areas in Lightening. One is in the main window and the other one is in Performance center, please refer to figure 6.1.1.1. These status display areas show the status and the error/warning message of the servo drive.

■ Status

- Hardware Enable Input: Indicates if hardware enable signal is input.
- Software Enabled: Indicates if software enable is activated.
- Servo ready: Indicates if motor is enabled.
- Phase Initialized: Indicates if phase initialization has completed.
- Moving: Indicates if motor is moving.
- Homed: Indicates if homing has completed.
- SM mode: Indicates if motor is enabled in SM mode.

■ Error and warning messages

- Last error: Display the latest error message.
- Last warning: Display the latest warning message.

For more information, please refer to chapter 9.

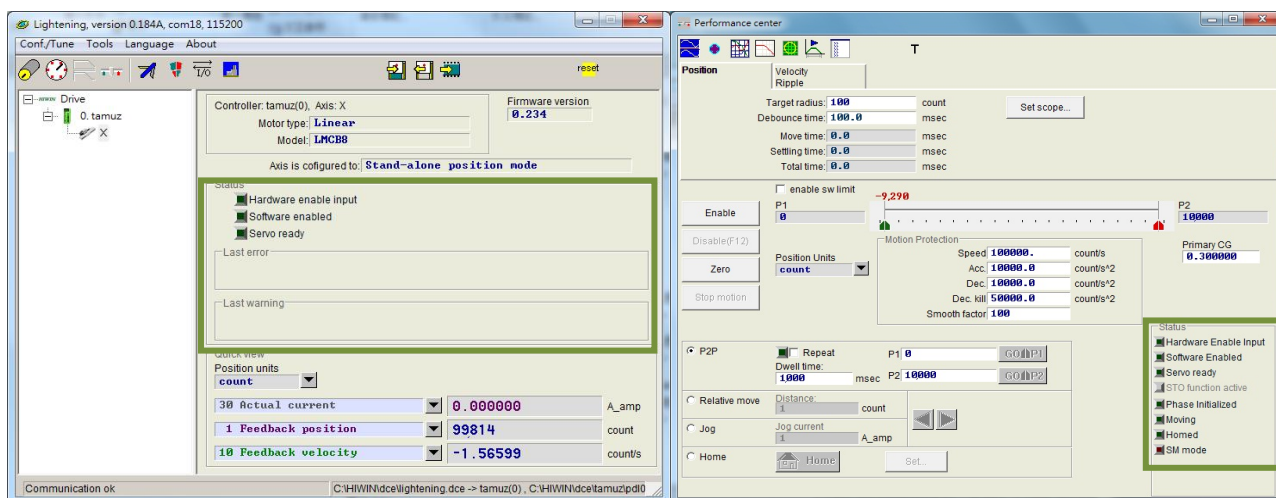


Figure 6.1.1.1 Status display

6.1.2 Quick view

In the main window, there is an area called Quick view as figure 6.1.2.1. Quick view can display three user-defined physical quantities. The values of these physical quantities will be updated for user to observe and analyze the system. For supported physical quantities, please refer to section 3.11.

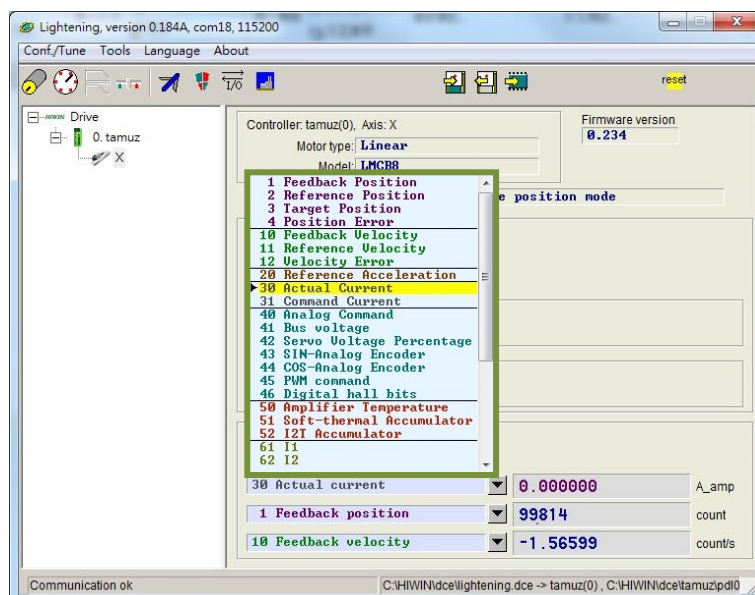


Figure 6.1.2.1 Selection of physical quantities

■ Unit setting

For physical quantities related to distance, user is allowed to select desired unit for displaying or setting physical quantities (such as position or velocity).

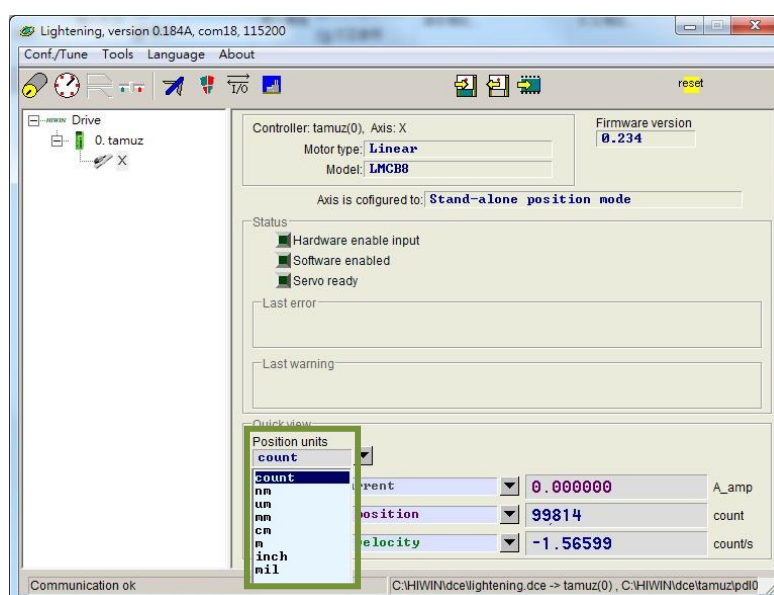


Figure 6.1.2.2 Unit setting

6.1.3 Function keys

Function keys **F6** and **F12** can be used when Lightening is in operation.

- **F6**: Move the main window of Lightening to the top.
- **F12**: **F12** function key is for emergency stop. Press **F12** key to stop motion (Refer to section 3.4.)
After the motion stops, the motor will be disabled.

6.2 Performance center

Tuning can be performed in Performance center. As phase initialization completes, user can proceed to perform test run. Performance center supports test run, tuning and tools for observing motion performance. Three motion types are provided for test run: (1) Point-to-point (P2P) motion (2) Relative move and (3) Jog. Motion parameters such as speed, acceleration, deceleration, Dec. kill and smooth factor can be set in Performance center.

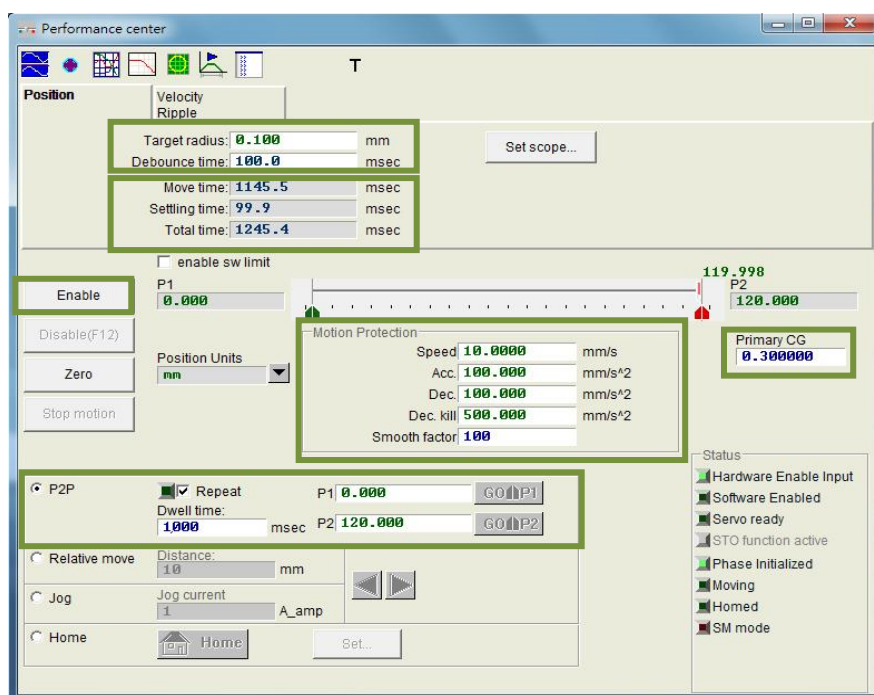


Figure6.2.1 Performance center

Below is the example of performing test run by point-to-point (P2P) motion.

Table6.2.1

Step	Figure	Description
1		Click on Enable to enable the motor.
2		Select P2P .
3		Set P1 and P2. (If software limits are used, ensure P1 and P2 are within Lower SW limit and Upper SW limit.
4		Set the desired speed, acceleration and smooth factor (Refer to section 3.4.) in Motion Protection area. If user has no special requirement, test run can be performed by using the default values.
5		Click on GO↑P1 , the motor moves to P1. Click on GO↑P2 , the motor moves to P2. If repeated point-to-point (P2P) motion is required, select Repeat and set dwell time. Then click on GO↑P1 or GO↑P2 to perform point-to-point (P2P) motion.

Settling time can be measured in Performance center. Target radius and debounce time can also be set in Performance center, please refer to section 5.5. During motion, primary CG can be adjusted to meet the requirement of settling time. Higher servo gain can have faster response and shorter settling time. User can observe the required time for entering target radius by move time, settling time and total time. (Refer to section 3.7.) Click on **Set scope...** to show Scope to observe the waveforms related to settling time. Velocity ripple can be measured in Performance center. User can observe velocity ripple by point-to-point (P2P) motion. **V max**, **V min**, **V avg** and **Velocity Ripple** show the maximum speed, minimum speed, average speed and velocity ripple of a constant speed phase. Click on **Set scope...** button to show Scope to observe the waveforms related to velocity ripple.

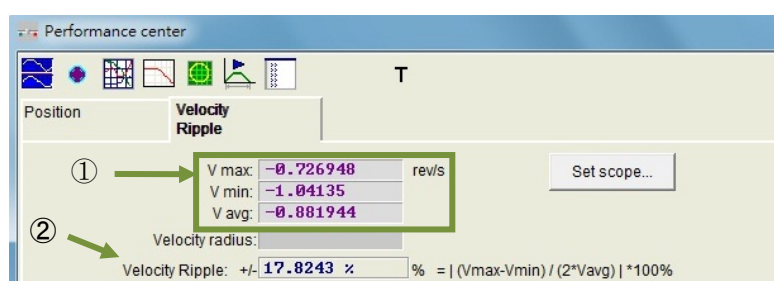


Figure 6.2.2 Performance center-Velocity Ripple page

①



V max: The maximum value of velocity ripple

V min: The minimum value of velocity ripple

V avg: The average value of velocity ripple

②

Velocity Ripple: Velocity ripple (Refer to section 3.9.)

For Relative move, user can set the desired travel distance. For Jog, press  or  to continuously jog motor in positive or negative direction. The motion parameters used for test run are also used for motion protection. After test run, please reset the parameters. Otherwise, motor may not reach the desired speed or acceleration when motion command is sent from controller.

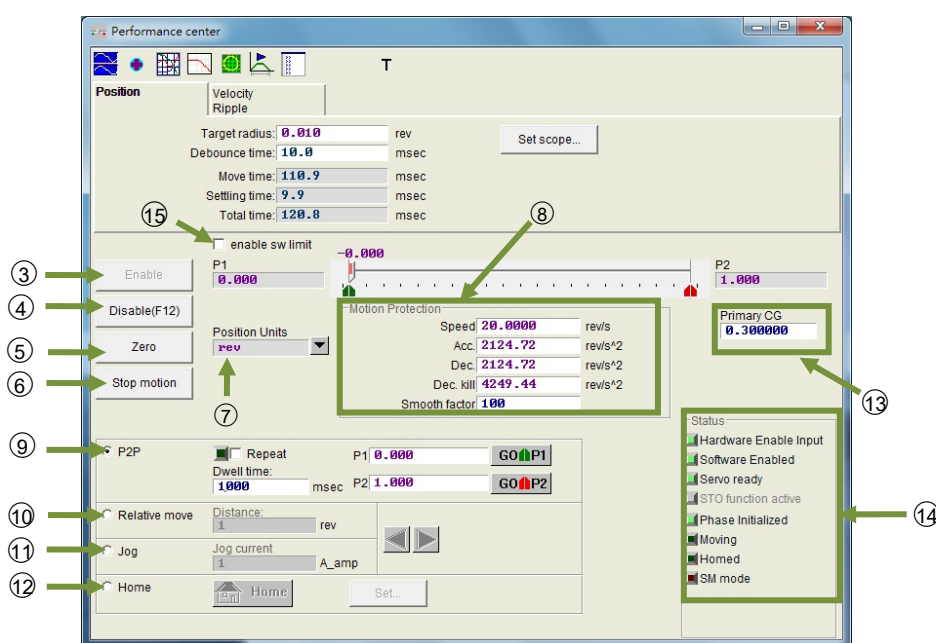


Figure 6.2.3 Performance center-Position page

- ③ Enable: Enable motor.
- ④ Disable: Disable motor.
- ⑤ Zero: Set current position as zero position.
- ⑥ Stop motion: Stop motor.
- ⑦ Position units: User is allowed to set the desired unit. The function is the same as the unit setting in Quick view.

- ⑧ Motion protection: Parameters for test run and motion protection, including speed, acceleration, deceleration, Dec. kill and smooth factor

User can use smooth factor to create S-curve velocity profile or T-curve velocity profile. The setting range is from 1 to 500. Increase the value of smooth factor to have S-curve velocity profile and decrease the value of smooth factor to have T-curve velocity profile. (Refer to section 3.4.)

- ⑨ P2P: Point-to-point motion

- ⑩ Relative move: Relative motion

- ⑪ Jog: Perform continuous motion. In current mode, current value is set for continuous motion of constant current.

- ⑫ Home: Homing




- ⑬ Primary CG: Servo gain

The higher the gain is, the greater the servo stiffness is. User can use primary CG to adjust servo stiffness. If servo stiffness is too strong, the system becomes unstable, causing vibration and electrical noise. At this time, this value must be decreased.

- ⑭ Status: Status display

- ⑮ Enable sw limit: Enable software limit. This function can limit the travel distance of motor.

6.3 Scope

D1 servo drive provides Scope for user to observe essential physical quantities during tuning. User can also use Scope to find out the cause when motor cannot be operated. Click on  in Performance center or  to open Scope. Click on  in **Position** page and **Velocity Ripple** page to show related physical quantities in Scope. As figure 6.3.1, after the desired parameter is selected, the waveform of the selected physical quantity can be observed.

Note:

The contents displayed in Scope are not real-time. To observe detailed information of physical quantity, please use oscilloscope or Data collection function. (Refer to section 6.4.)

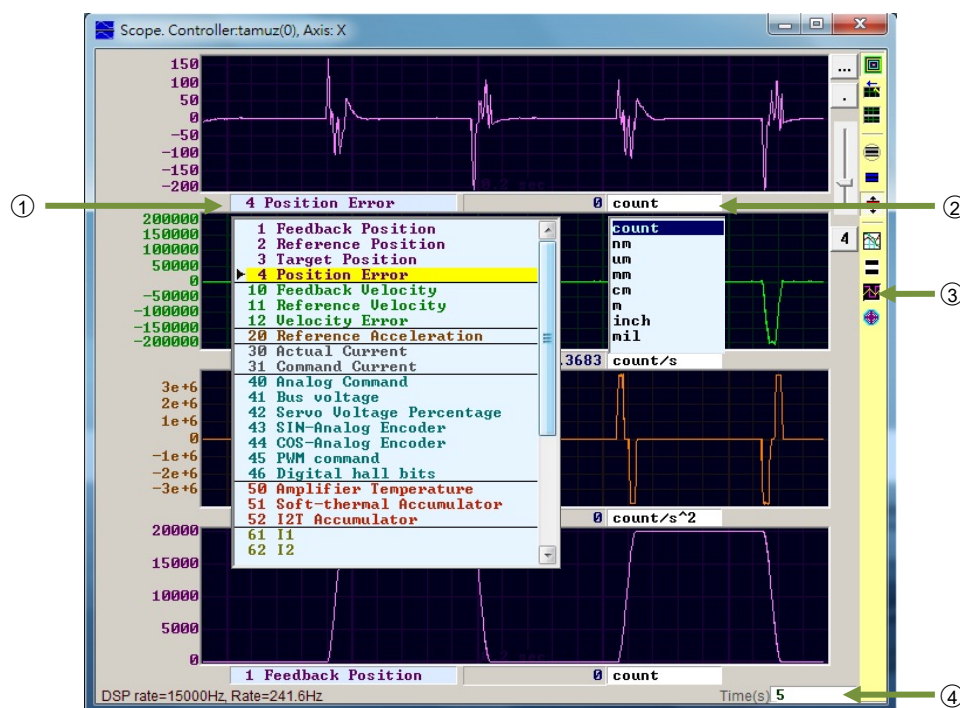


Figure6.3.1 Scope

- ① Physical quantity: Select the desired physical quantity to be observed. (Refer to section 3.11.)
- ② Unit: Select the unit for the selected physical quantity.
- ③ Channel: Select to display how many channels at the same time.(1 to 8)
- ④ Time range: Set the time length of horizontal axis. (Unit: second)


Table6.3.1

Icon	Name	Description
	Scope On/Off (PageDown)	Open/Close Scope. When Scope is closed and opened again, Scope will recapture data.
	View in paper mode (Ctrl+T)	Change display mode. The supported modes are Normal mode and Paper mode.
	Toggle scopes window (PageUp)	Display all the selected physical quantities in one screen. Click to switch among physical quantities.
	Fit graph to window	Adjust all physical quantities to appropriate scales.
	Fit graph to window dynamically	Adjust all physical quantities to appropriate scales dynamically.
	Fit graph to window dynamically + clip	The function is the same as above, but only the range of vertical axis will be extended.
	Show last data with plot view tool	Display the data of Scope with Plot view tools.
	Reset scope	Scope recaptures data.
	Show all plots in same window	Display all the selected physical quantities in one screen and they share the same vertical axis.
	Open recorder window	Set the physical quantities in Scope for Data collection.

6.4 Data collection

In addition to observing physical quantities in Scope, user can also use Data collection which provides more options for data capture, advanced graph display and processing function to observe physical quantities. Data collection allows user to set sampling time and event trigger to start or stop Data collection.

6.4.1 Function description

Click on  in figure 6.3.1. The physical quantities selected in Scope will be automatically set for Data collection.

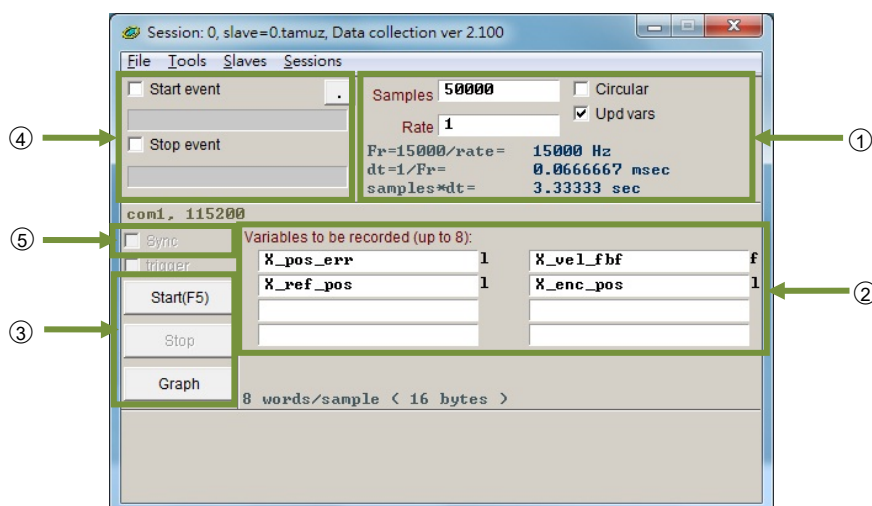


Figure6.4.1.1 Data collection window

① Rate and Samples

-Samples: The number of samples

-Rate:

User can set sampling frequency in **Rate**. For instance, if **Rate** is set to 1, the sampling rate is 15,000 Hz. If **Rate** is set to 2, the sampling rate is 7,500 Hz. The maximum sampling rate is 15,000 Hz. If user sets to collect too much data, it is possible that not all the requested data can be successfully collected due to the limit of communication bandwidth. At this time, users can decrease the number of physical quantities.

-Dt: Sampling time

-Samples*dt: The total time of Data collection

To increase the total time of Data collection, user can simply increase the value in **Samples**.

- ② The internal variable name of the selected physical quantity
 - ③ Click on **Start** button to start Data collection. Click on **Stop** button to stop Data collection. Click on **Graph** button and the collected data will be plotted as graph in Plot view.
 - ④ Set start event and stop event to start Data collection and stop Data collection.
 - ⑤ For more information of Sync function, please refer to section 6.4.2.
- Example 1: To capture the graph of one motion cycle
- Check the checkbox of **Start event** and set "X_run" in the field. Check the checkbox of **Stop event** and set "X_stop". After setting, click on **Start** button and Data collection will be on standby. Data collection starts as motor starts to move and stops as motor stops moving. When Data collection completes, click on **Graph** button to obtain the graph.
- Example 2: To capture the graph of one speed period
- Check the checkbox of **Start event** and set "X_vel_fb>0" in the field. Check the checkbox of **Stop event** and set "X_vel_fb<0" in the field. After setting, click on **Start** button and Data collection will be on standby. Data collection starts as motor speed is greater than 0 and stops as motor speed is less than 0. When Data collection completes, click on **Graph** button to obtain the graph.
- Example 3: To capture the graph from the time of enabling to the time of disabling
- Check the checkbox of **Start event** and set "I1" in the field. Check the checkbox of **Stop event** and set "~I1" in the field. After setting, click on **Start** button. When enabling (I1 = 1), Data collection starts. When disabling (I1 = 0), Data collection stops.

Note:

When the checkbox of **Upd vars** is not checked, Lightening stops updating variables. This can improve the bandwidth for Data collection. If Start event is triggered by I1 (such as example 3), it should be triggered by hardware I/O.

6.4.2 Data collection via PDL program

To be more precise on Data collection, user can use Sync function in figure 6.4.1.1 to have more flexible and real-time Data collection than event trigger. User needs to add a program fragment with title label “_RecordSync” and set trigger condition. Data collection starts as trigger condition is satisfied. The setting instructions are as below.

Step 1: An empty task is required for executing _RecordSync. Check if any task is available among task 0 to task 3.

Step 2: Add the contents below into PDL program.

_RecordSync:

till(); // Add trigger condition or status.

rtrs_act=1; // Start to record.

ret; // Add this line to repeat Data collection each time when trigger condition or status occurs.

Step 3: In the parentheses of till(), add trigger condition or status. For instance, input I4 in the parentheses. The default setting of I4 is right software limit.

Step 4: Check the checkbox of **Sync**.

Step 5: Click on **Start** button, the program will start to execute function _RecordSync and wait for the trigger condition or status. For instance, when I4 is ON, Data collection starts. If I4 is ON for more than once, only the last data will be collected.

Example:

#task/1;

_RecordSync:

till(I4); // I4 is ON.

rtrs_act=1; // Start to record.

ret;

6.5 Plot view

Data collected in **Data collection** window can be plotted as graph. **Plot view** window provides measurement and calculation functions for analysis. There are five areas in **Plot view** window: menu bar, toolbar, physical quantity display area, graph display area and timeline scrollbar, please refer to figure 6.5.1.

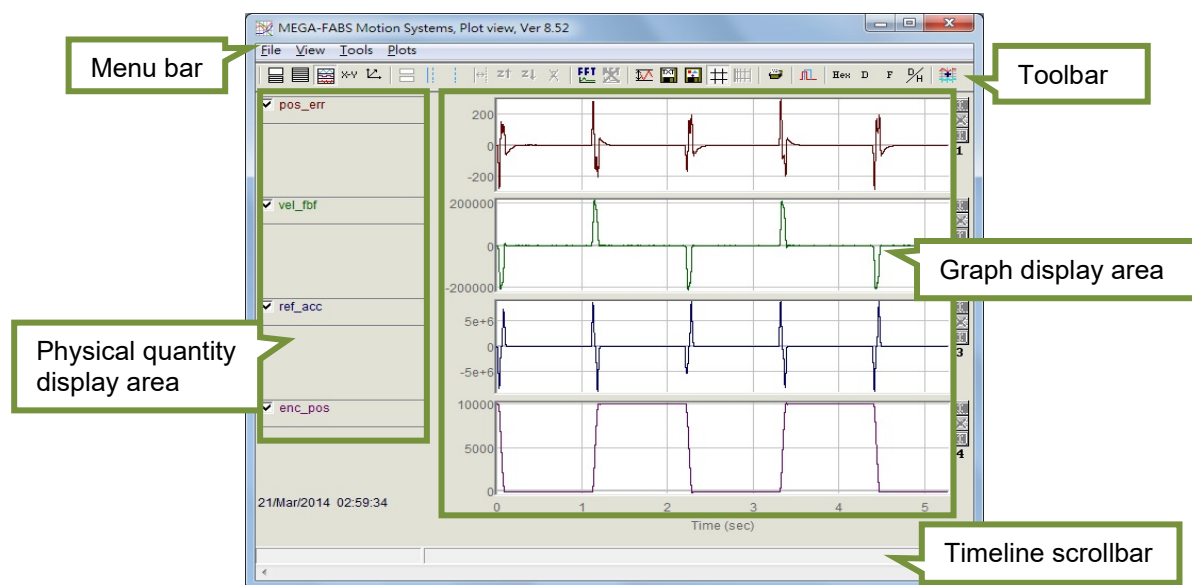


Figure6.5.1 Plot view

6.5.1 Display mode

(1) Number of display channels

The graphs of physical quantities will be displayed in graph display area. **Plot view** window displays the graphs of physical quantities captured in Scope or by Data collection. User can modify the number of display channels. The maximum number of display channels is eight. Icons in **Plot view** window are described as below.

- : Set the number of display channels.

- : Display one channel only.

If user would like to view two graphs at the same time, click on and select **2 graphs**. If user would like to view only one graph, click on and select the desired graph to be displayed, as figure 6.5.1.1. In figure 6.5.1.1, two physical quantities are captured in Scope or by Data collection.

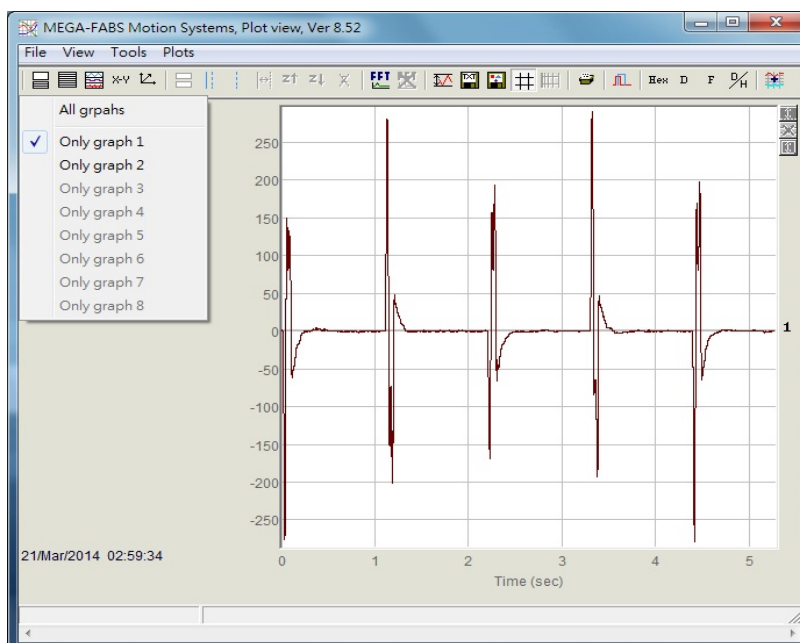


Figure6.5.1.1

(2) Show or hide physical quantities

Uncheck the checkbox of physical quantity to hide the graph of that physical quantity. For instance, in figure 6.5.1.2, the checkboxes of **pos_err** and **ref_acc** are unchecked. Icon in **Plot view** window is described as below.

: Click on this icon or press **Delete** key to hide all physical quantities.

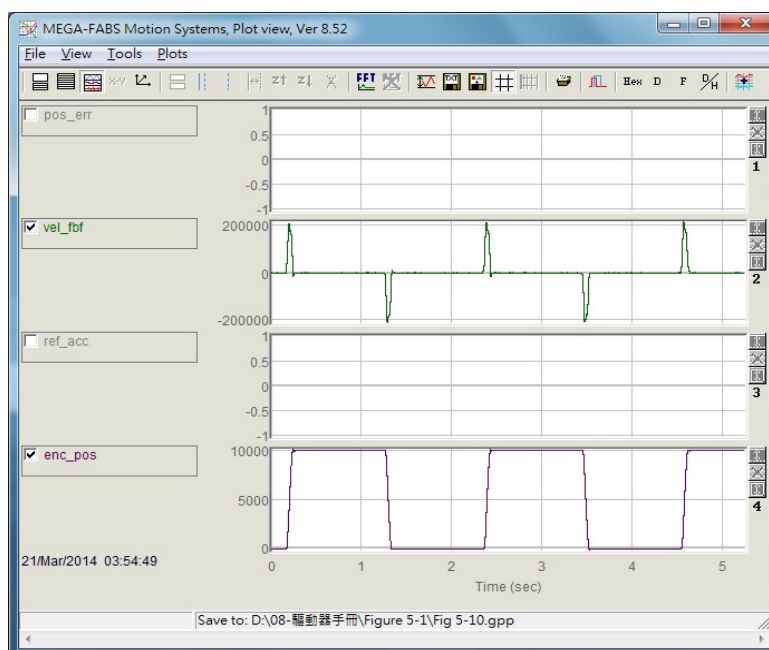












Figure6.5.1.2

(3) Zoom in and zoom out functions

Plot view window allows user to zoom in and zoom out on X axis and Y axis. If user would like to observe a certain segment of a graph, he can use reference lines to select the desired segment and zoom in. Icons on toolbar are described as below.

- : Zoom in on the segment selected by reference lines on X axis.
- : Undo zoom in function.
- : Redo zoom in function.
- : Cancel zoom in function.
- : Zoom in on the segment selected by reference lines on Y axis.
- : Cancel zoom in function on Y axis.

(4) Zoom in or zoom out on X axis

As figure 6.5.1.3, if user would like to zoom in on the segment between 2 seconds and 4 seconds, user can left click and right click on the graph to show two reference lines (blue line and blue dotted line) to select this segment. Click on  to zoom in, as figure 6.5.1.4. Repeat the above steps to see more closely on the segment between 2 seconds and 3 seconds. Click on  to go back to the segment between 2 seconds and 4 seconds. Click on  to return to the segment between 2 seconds and 3 seconds. Click on  to return to the original graph, as figure 6.5.1.3.

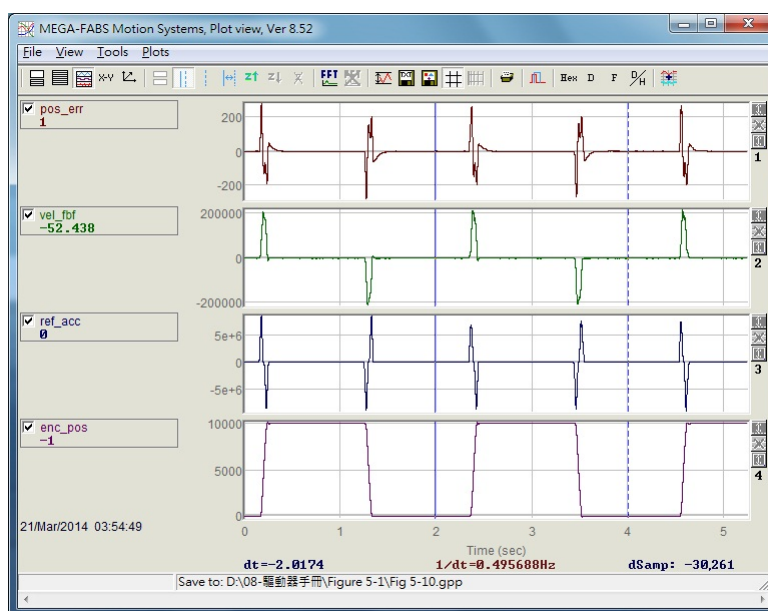


Figure6.5.1.3

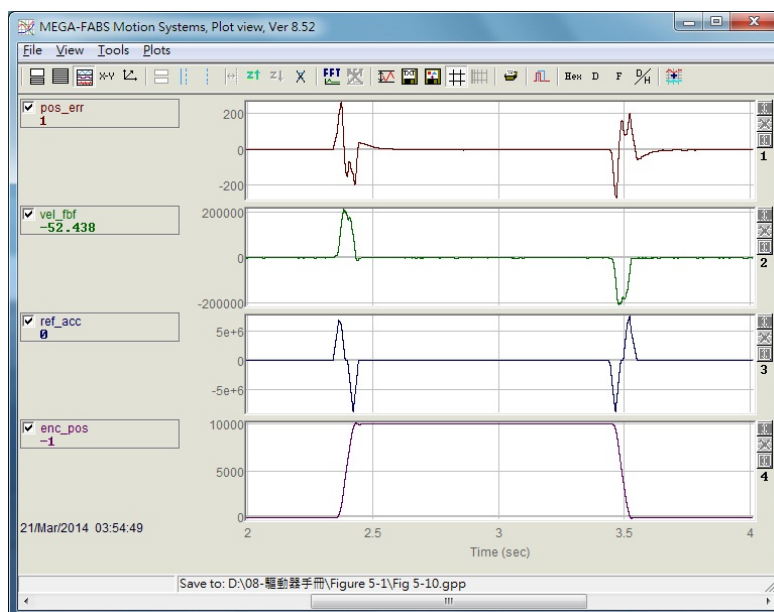




Figure6.5.1.4

(5) Zoom in or zoom out on Y axis

If user would like to zoom in on Y axis, user needs to press **Ctrl** key and left click or press **Ctrl** key and right click at the same time to show two reference lines (red line and red dotted line) to select a segment, as figure 6.5.1.5. Click on  to zoom in on the selected segment, as figure 6.5.1.6. At this time, the values on Y axis are locked and displayed in red. When scrolling the timeline scrollbar, the locked values on Y axis will not be updated, as figure 6.5.1.7. Click on  to return to the original graph, as figure 6.5.1.5.

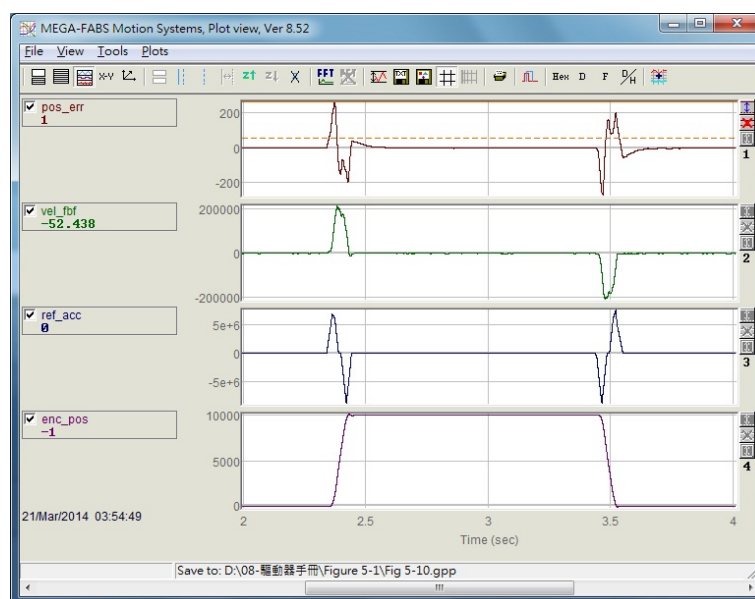


Figure6.5.1.5

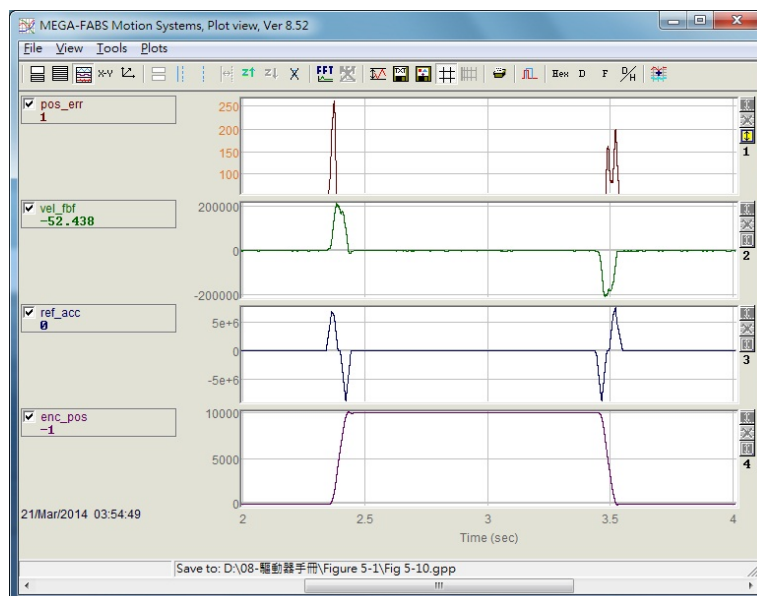


Figure6.5.1.6

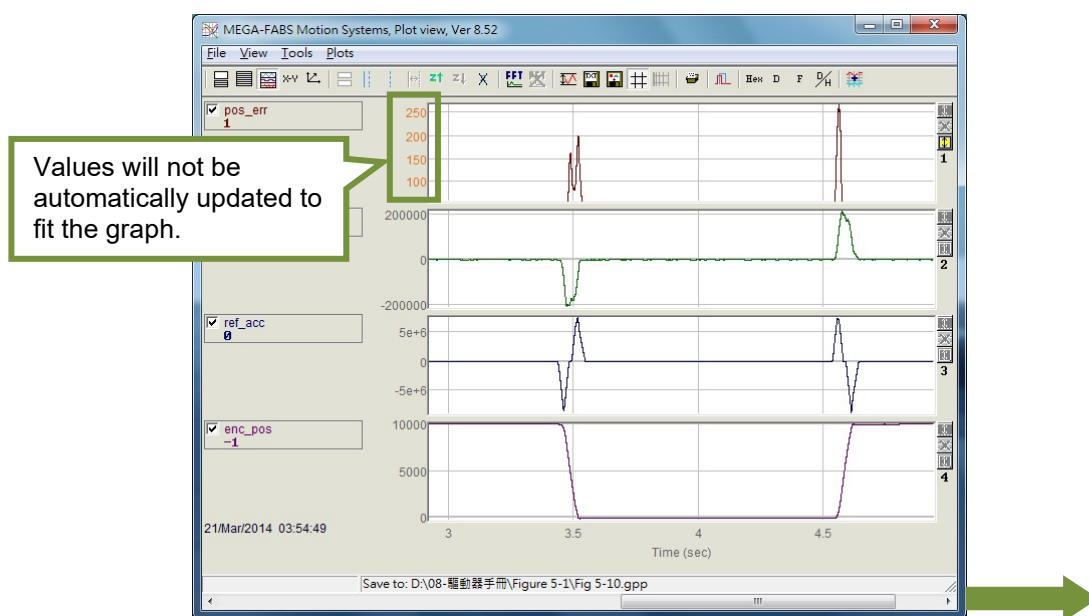


Figure6.5.1.7

(6) dt, 1/dt and dSamp

When the segment is selected by reference lines, three values (dt, 1/dt and dSamp) will be shown below the graph as figure 6.5.1.3.

dt: The time of the selected segment


dSamp: The number of the samples in the selected segment

(7) Display a graph in different channel

To display a physical quantity in a different channel, click and hold on the physical quantity until a dotted line box appears. Then drag the physical quantity to the desired channel.

(8) Display of physical quantity

To inspect the physical quantity of a specific point in the graph, move reference line (blue line) to that point. Its value will be shown in the bottom of the window. The value can be displayed in decimal or hexadecimal format.

- : Display the value in hexadecimal format.

- : Display the value in decimal format.

6.5.2 Save and open file

In **Plot view** window, the data can be saved as .txt file, .bmp file or .gpp file. .txt file saves the values of physical quantities. .bmp file saves the graphs of physical quantities. .gpp file is the only file type which can be opened in **Plot view** window. For saving data as .txt file or .bmp file, please refer to below.

- : Save the values of physical quantities as .txt file.

- : Save the graphs of physical quantities as .bmp file.

To save or open .gpp file, please click on **File** on the menu bar and select **Save** or **Open**.

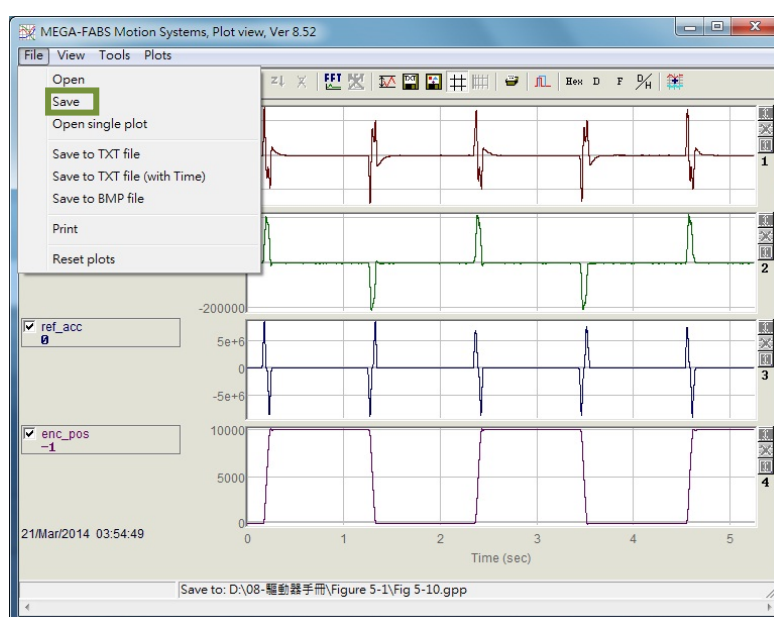



Figure 6.5.2.1 Save data as .gpp file

6.5.3 Calculation functions

Plot view window provides some calculation functions, such as integration, differentiation, addition and multiplication, etc. User can directly calculate in **Plot view** window. Besides, **Plot view** window also provides the maximum value, the minimum value, ripple calculation and spectrum analysis of physical quantity.

(1) Plot statistics window

Click on  to show **Plot statistics** window. The window will show the maximum value, the minimum value, average value, root mean square (Rms), Rip (standard deviation/average value) and RipA (the maximum value-the minimum value/average value) of the physical quantity in the selected segment.




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 Plot statistics window

(2) Calculation function

Click on **Tools** on the menu bar and select **Math operation** or click on  to open **Math operation** window, as figure 6.5.3.2. Take adding two physical quantities as an example here. Select **Linear** and select **pos_err** and **vel_fbf** from the drop-down list. Set name and color in **New plot name** field. After that, click on **Create** button to create a new graph, as figure 6.5.3.3.

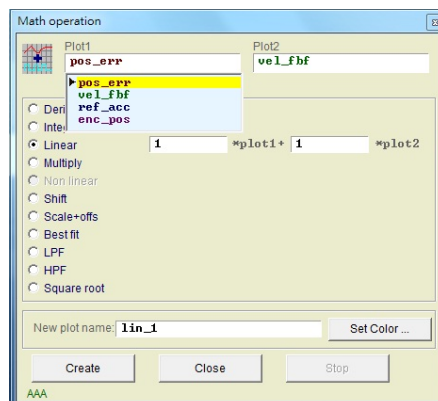


Figure6.5.3.2

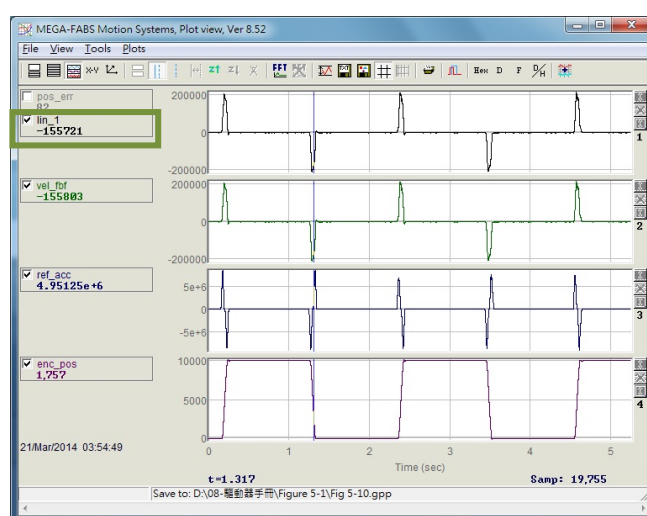




Figure6.5.3.3

(3) Fast Fourier transform (FFT)

Click on  to show **FFT** window as figure 6.5.3.4. Select physical quantity to do fast Fourier transform. Take pos_err as an example here. Click on **Run FFT** button to generate the graph as figure 6.5.3.5. To cancel fast Fourier transform, please click on .

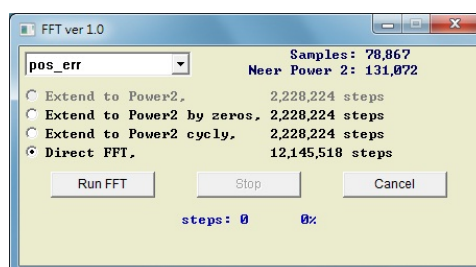


Figure6.5.3.4

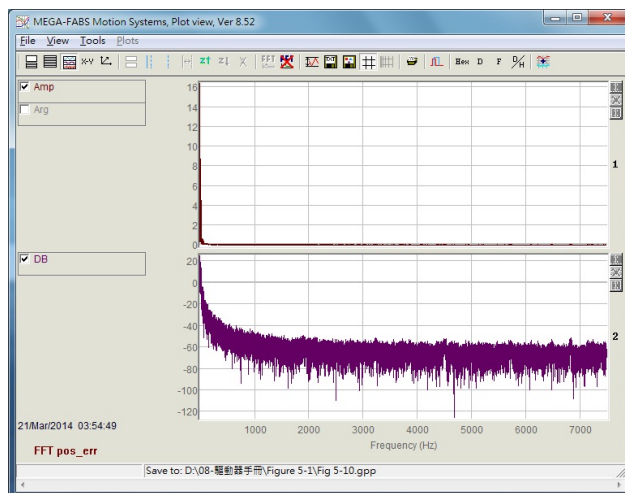



Figure6.5.3.5

(4) Natural logarithm

Click on  to display the values of X axis in logarithmic form. The function is only available after fast Fourier transform completes.

6.6 Advanced gain tuning

Reduced move and settling time, small position error and smooth velocity are often preferred while performing servo control via servo drive. The performance can be improved by gain and parameter tunings. For D1 servo drive, the simplest way to enhance the performance of motor is to adjust common gain (Primary CG). The greater the common gain is, the stronger the servo stiffness is. However, if servo stiffness is too strong, system vibration or electrical noise may occur. These phenomena may vary with mechanism.

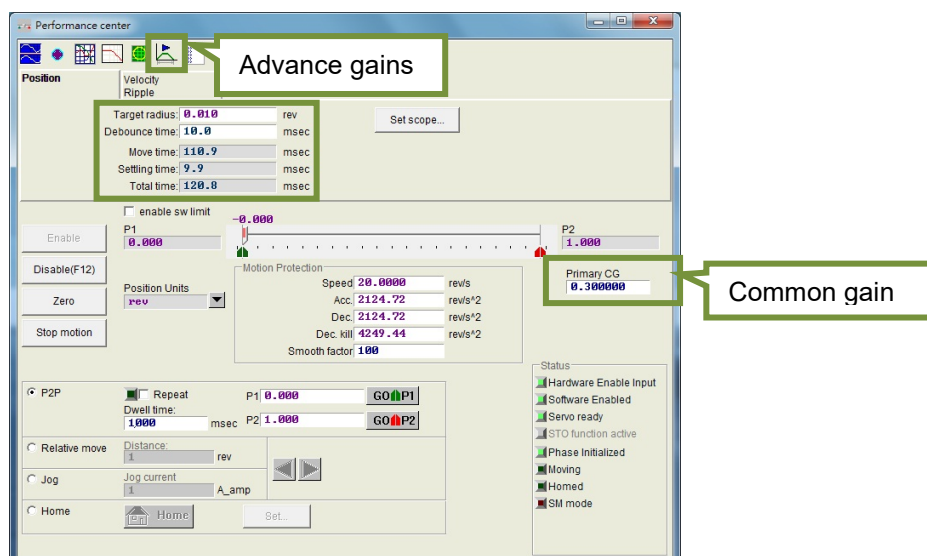


Figure6.6.1 Performance center

If the desired performance cannot be achieved by simply adjusting common gain, D1 servo drive also provides advanced gains for advanced tuning, including filter, acceleration feedforward (Acc feedforward), schedule gains and velocity loop gain (Schedule Gains + vpg), analog input correction and current loop.

6.6.1 Filter

Two filters are provided in the servo drive. They can be set as low-pass filters or notch filters to eliminate high-frequency vibration and deal with resonance frequency to enhance controlling performance. Frequency analyzer is commonly used to analyze system characteristics while configuring a filter. Click on **Bode...** in figure 6.6.1.1 to open simulation interface for Bode plot. The settings for low-pass filter and notch filter will be described as below.

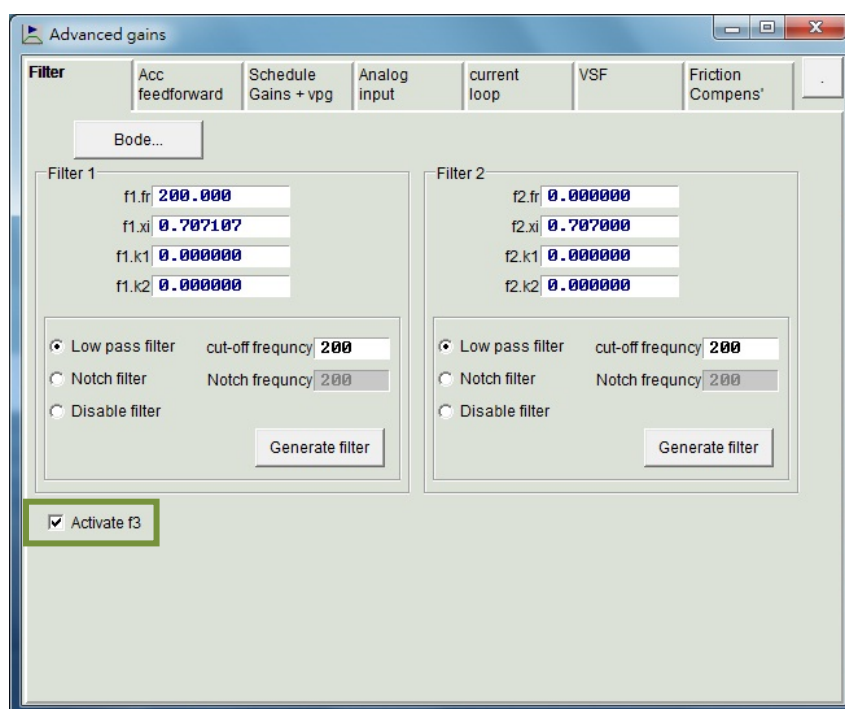


Figure6.6.1.1 Filter

(1) Low-pass filter

- ① fr: fr is the cutoff frequency (Unit: Hz). For normal application, user can set cutoff frequency to 500 Hz. For other application, user can consider decreasing the value of cutoff frequency. If the cutoff frequency is set to be too low, it may affect the controlling performance.
- ② xi: Damping ratio (Setting range: 0 to 1)
- ③ k1: 0
- ④ k2: 0

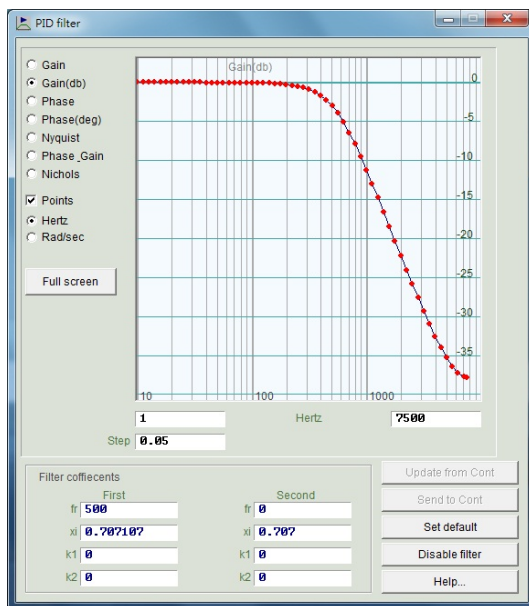


Figure6.6.1.2 Low-pass filter

(2) Notch filter

When resonance frequency (For instance, resonance frequency between 10 to 250 Hz) occurs and cannot be fixed by modification of mechanism or improvement of design, user can consider using notch filter. The setting of notch filter is usually based on the result of frequency analysis, please refer to section 6.6.3. For how to set a notch filter, please refer to below.

- ① fr: Cutoff frequency (Unit: Hz)
- ② xi: Damping ratio (Setting range: 0 to 1)

When the value is closer to 0, the filtering frequency band is narrower. When the value is closer to 1, the filtering frequency band is wider.

- ③ k1: 0
- ④ k2: 1

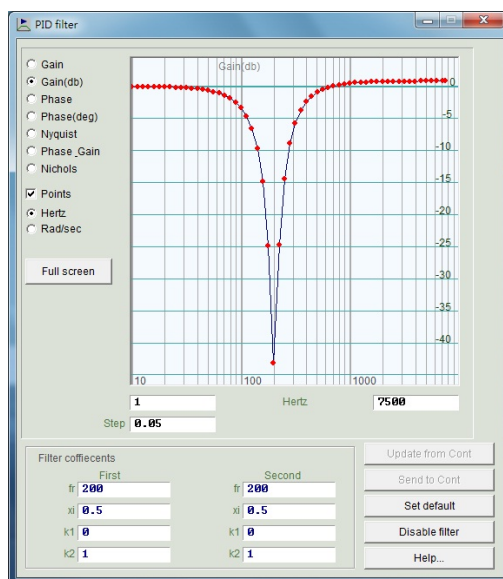



Figure6.6.1.3 Notch filter

(3) Automatic resonance suppression filter

Automatic resonance suppression filter (f3) will be automatically set and activated as auto gain tuning completes. If resonance cannot be suppressed by automatic resonance suppression filter (f3) after auto gain tuning, go to **Advanced gains** window and uncheck the checkbox of **Activate f3**, as figure 6.6.1.1. Manually adjust **Filter 1** and **Filter 2** to suppress resonance.

6.6.2 Acceleration feedforward

Position error is usually greater during acceleration or deceleration. In application with large moving mass or moment of inertia, this problem is more likely to occur. User can set acceleration feedforward parameter to effectively decrease position error during acceleration or deceleration. For how to adjust acceleration feedforward, please refer to below.

Step 1: Click on  to show **Scope** window.

Step 2: Set the value of **Acc feedforward gain** to 0.

Step 3: Perform point-to-point (P2P) motion at the desired maximum acceleration.

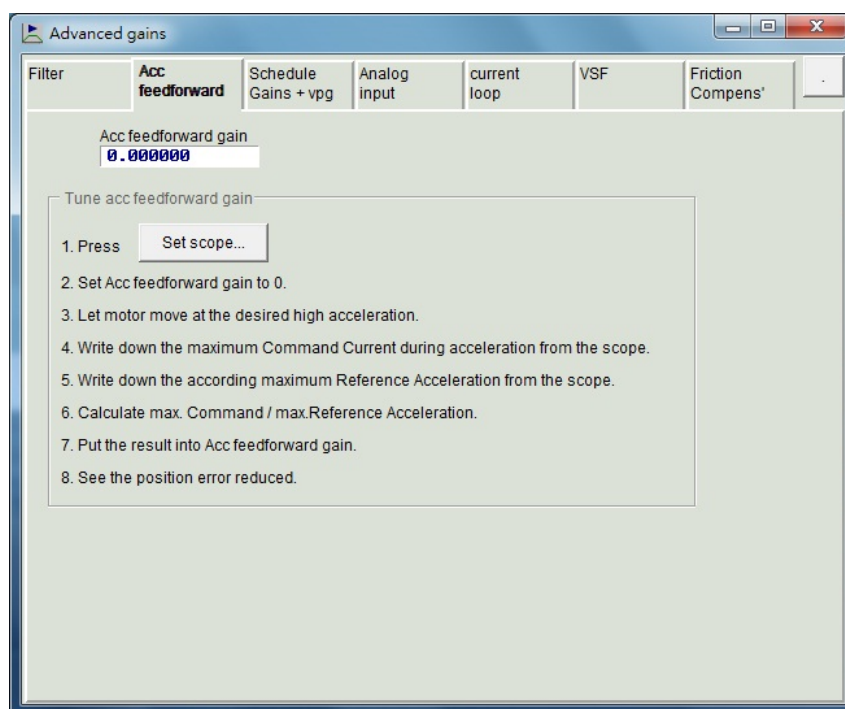


Figure6.6.2.1 Acceleration feedforward

Step 4: Record the maximum command current during acceleration. In figure 6.6.2.2, the maximum command current is 16. When the motor starts to move, Scope will be as figure 6.6.2.2. Use the icon indicated in figure 6.6.2.2 to show one physical quantity only. Repeatedly click on the icon to display the graph of command current, reference acceleration or position error.

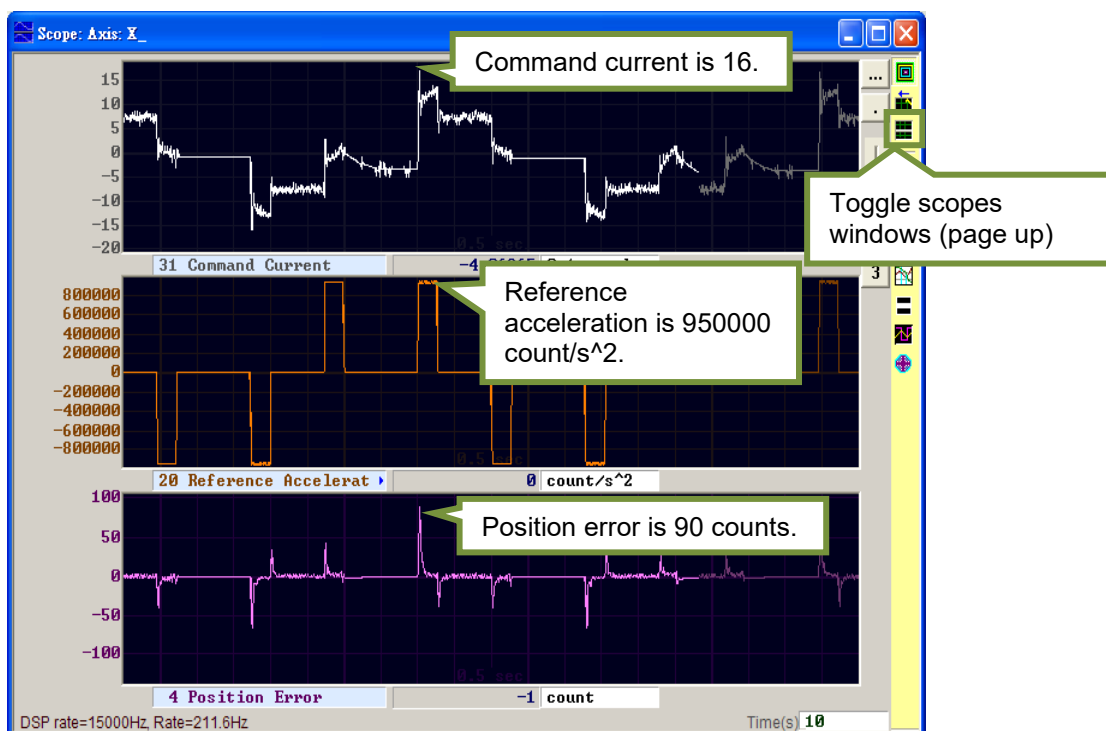


Figure6.6.2.2 The motion trajectory of motor

Step 5: Record the maximum reference acceleration during acceleration. In figure 6.6.2.2, the maximum reference acceleration is 950,000 count/s².

Step 6: Divide command current by reference acceleration.

$$\text{Acc feedforward gain} = \text{command current} / \text{reference acceleration} = 16 / 950,000 = 1.68421\text{e-}5$$

Step 7: Input the result of step 6 into the field of **Acc feedforward gain**, as figure 6.6.2.3.

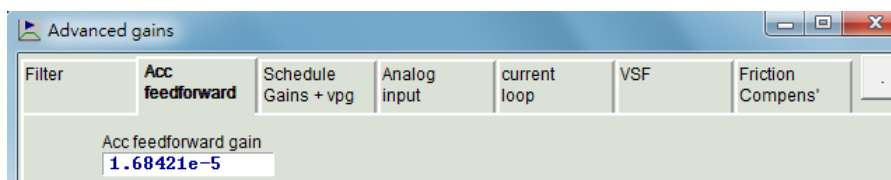


Figure6.6.2.3 Acceleration feedforward gain

Step 8: Observe if the position error has decreased. In figure 6.6.2.4, the position error has decreased from 90 counts to 65 counts.



Figure6.6.2.4 After adding acceleration feedforward gain

6.6.3 Schedule gains and velocity loop gain

(1) Schedule gains

A complete motion can be divided into three phases. (Refer to section 3.7)

- ① Move: From the start to the end of path planning
- ② Settling: From the end of path planning to in-position
- ③ In-position: In-position signal is sent.

Schedule gains are used to adjust the gains of different phases (Move, Settling and In-position). Gains will be adjusted in proportion to common gain (CG). When the setting is 1, it means the original common gain (CG) will be used. When the setting is less than 1, it means the gain is decreased. The corresponding parameter of each phase is listed below.

- ① Moving: sg_run
- ② Settling: sg_stop
- ③ In-position: sg_idle

If common gain (CG) is set to 0.5 and sg_run is set to 1.2, the gain will be changed to $0.5 \times 1.2 = 0.6$. Schedule gain can help to change gain to fit different phase.

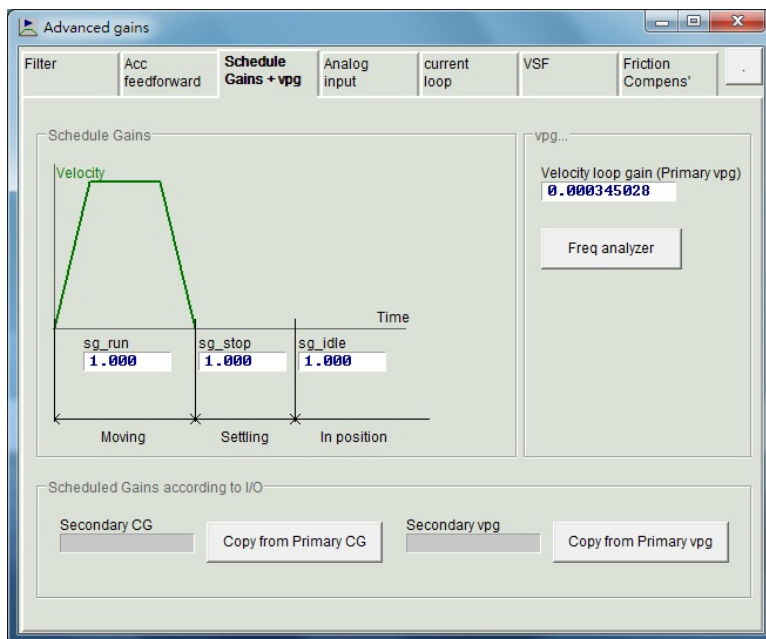


Figure6.6.3.1

(2) Velocity loop gain (vpg)

Velocity loop gain (vpg) is an internal control parameter of D1 servo drive. The initial value of velocity loop gain is automatically calculated from the parameters set in Configuration center. Normally user does not need to modify the value. If needed, user can use Freq analyzer to adjust the value again, please refer to below.

Step 1: Click on **Freq analyzer** to show **Freq analyzer** window, as figure 6.6.3.2.

Step 2: Click on **Enable**.

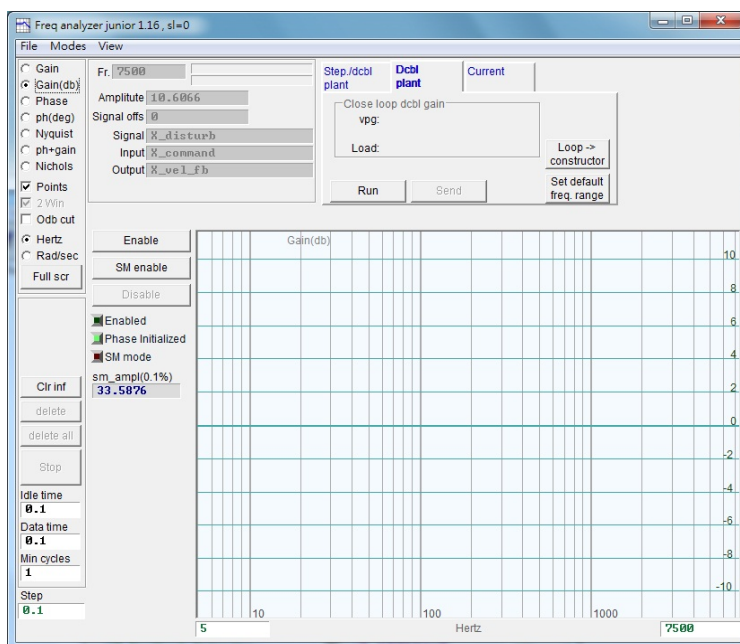


Figure6.6.3.2

Step 3: Click on **Run** to start frequency analysis. Motor will firstly vibrate at low frequency and then generate a high-frequency sound. A frequency response graph will appear as figure 6.6.3.3 after completion.

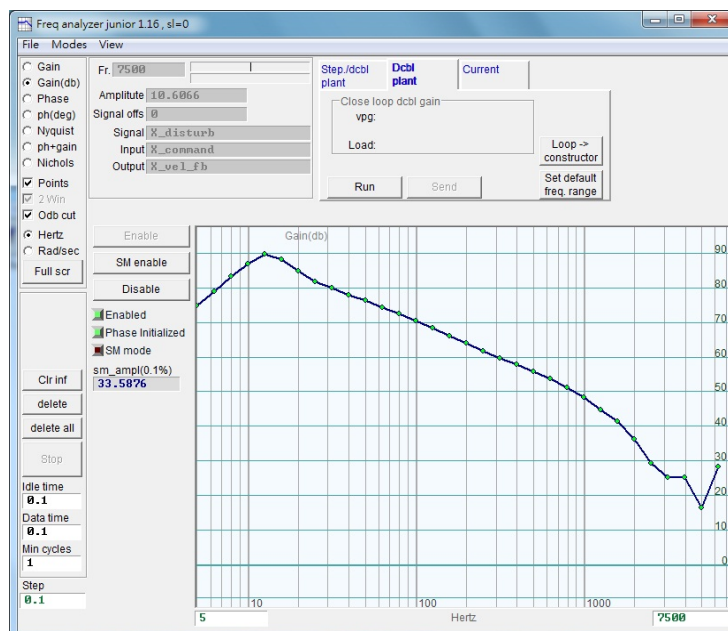


Figure6.6.3.3

Step 4: Left click on the graph to show a reference line (-20dB). Move the reference line to the frequency response line, as figure 6.6.3.4. The gain will be recalculated and updated in the field of **vpg**. The gain is increased when the reference line is moved downward. The gain is decreased when the reference line is moved upward.

Step 5: Click on **Send** to send velocity loop gain to the servo drive. If users would like the gain to be accessible after power off, please save it to the servo drive Flash.

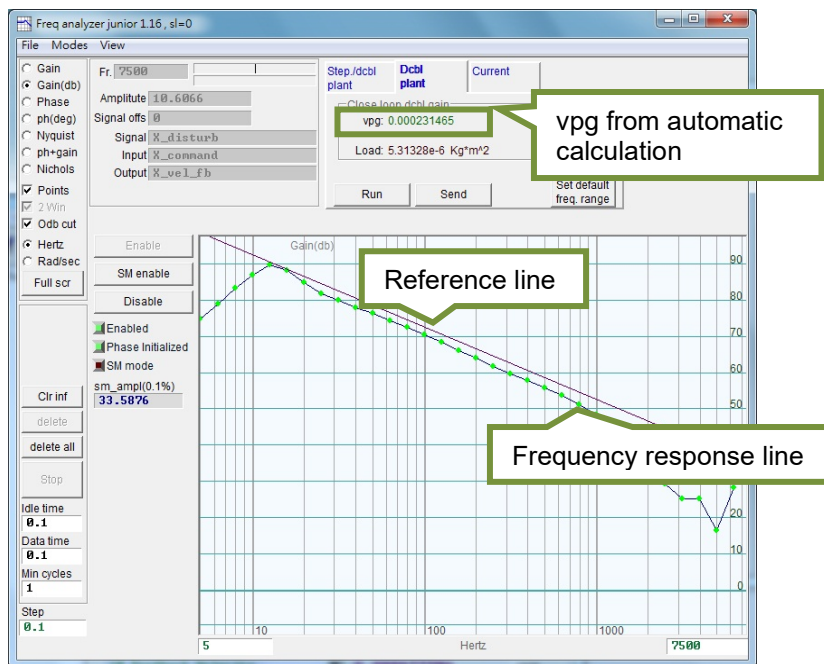


Figure6.6.3.4

6.6.4 Offset correction for analog input

While using voltage mode, the voltage command sent from controller could have DC bias. This could distort command and affect performance. D1 servo drive provides offset correction for analog input. Click on **Set Offset** to automatically measure offset and proceed offset correction.

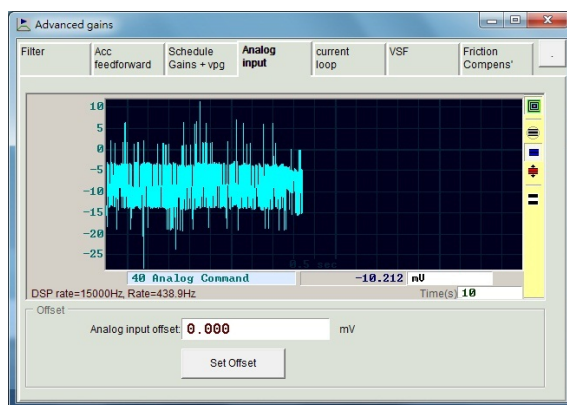


Figure6.6.4.1 Analog voltage input

6.6.5 Current loop

The gains (K_i and K_p) of current loop are calculated based on motor parameters when motor type is selected in Configuration center, and do not need to be adjusted again. However, if the motor parameters are not correctly set, user can use these gains for adjustment.

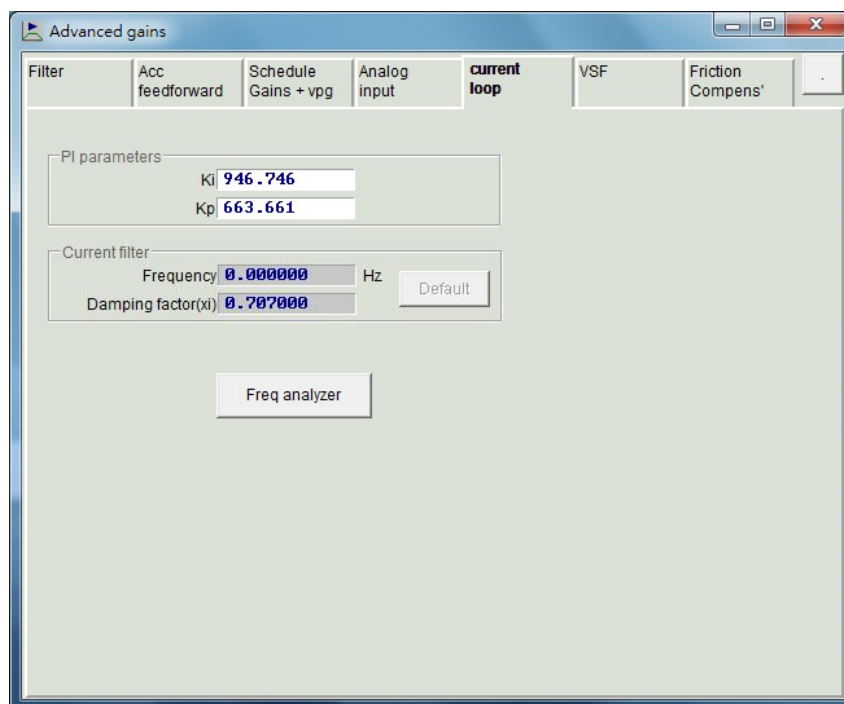



Figure6.6.5.1 Current loop

6.6.6 Vibration suppression filter

Vibration suppression filter (VSF) is used to suppress the vibration during motion. For instance, when motor is used with robotic arm with end effector, vibration could be greater during motion. User can set **Frequency** and **VSF factor** in **VSF** tab of **Advanced gains** window. Check the checkbox of **enable VSF** to suppress vibration. The setting range of **Frequency** is from 0.1 to 200 Hz. The setting range of **VSF factor** is from 0.7 to 1.5. Normally it is suggested to set VSF factor to 1.0, as the default value. Please be noted that do not check or uncheck the checkbox of **enable VSF** when motor is moving. Otherwise, unexpected vibration or error may occur. Below are the instructions of finding vibration frequency and enabling vibration suppression filter (VSF).

- Step 1: Set the desired acceleration, deceleration and travel distance. Perform point-to-point (P2P) motion.
- Step 2: Open Scope and observe position error and reference velocity, as figure 6.6.6.2.
- Step 3: Click on  (Plot view) in **Scope** window for analyzing waveforms.

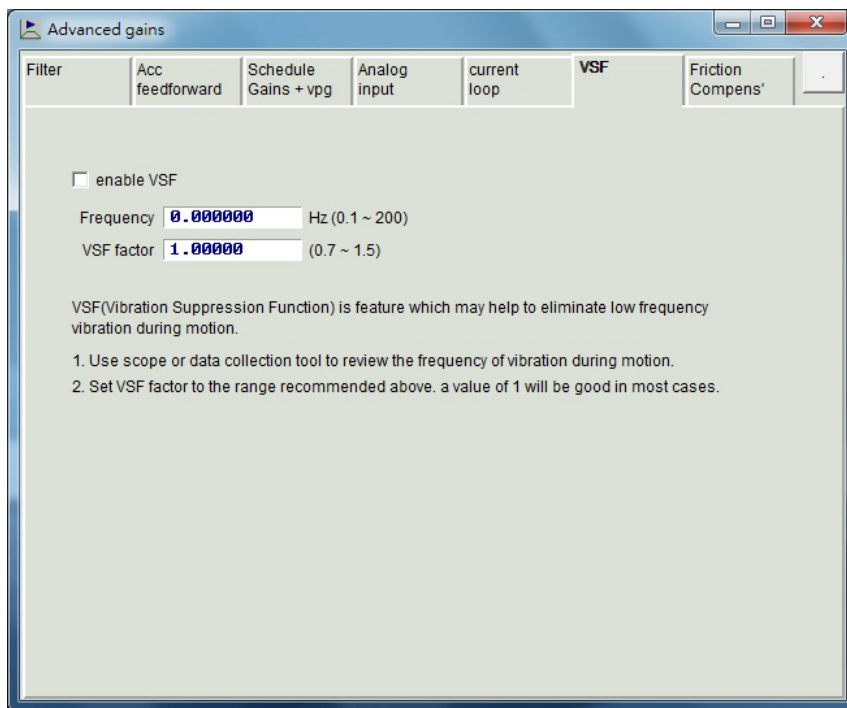


Figure6.6.6.1 Vibration suppression filter

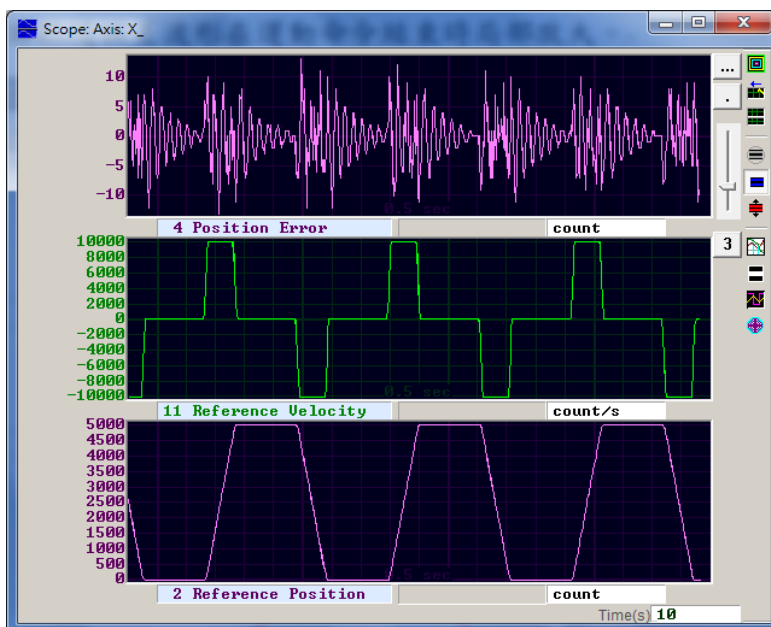



Figure6.6.6.2

Step 4: As motion command completes, enlarge the graph of position error. Select the desired segment, as figure 6.6.6.3. Click on  to zoom in on the segment. For related operation, please refer to section 6.5.

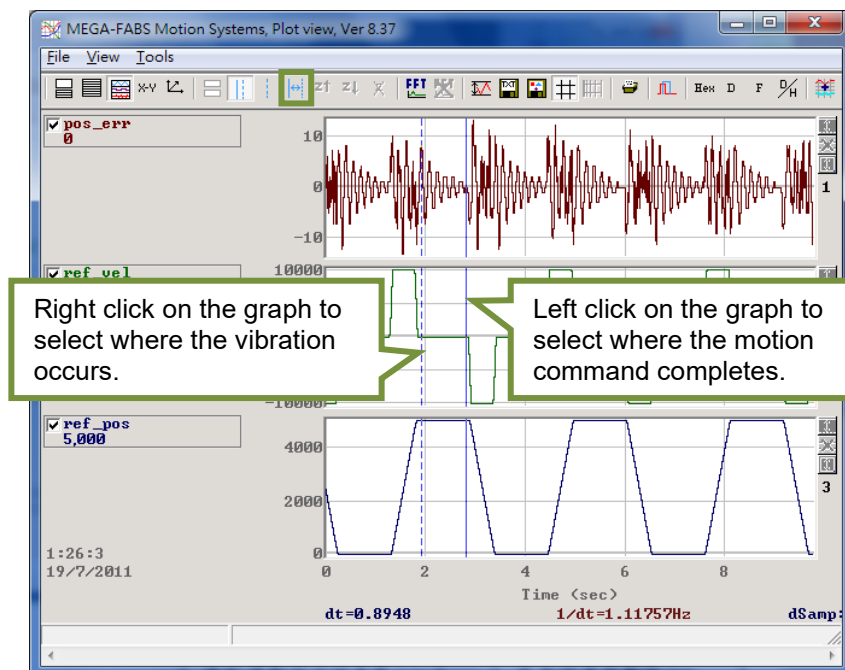



Figure6.6.6.3

Step 5: Click on  in **Plot view** window to do fast Fourier transform of pos_err, as figure 6.6.6.4.

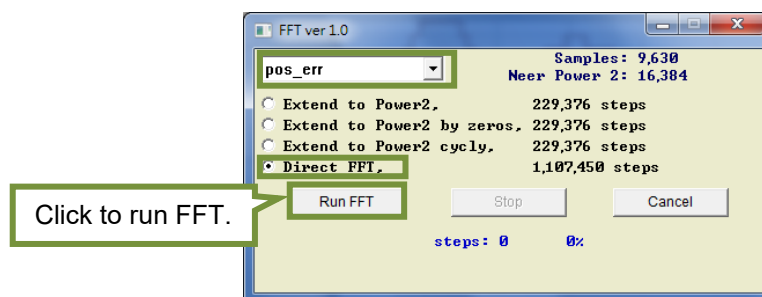


Figure6.6.6.4

Step 6: After fast Fourier transform completes, the graph will be shown as figure 6.6.6.5.

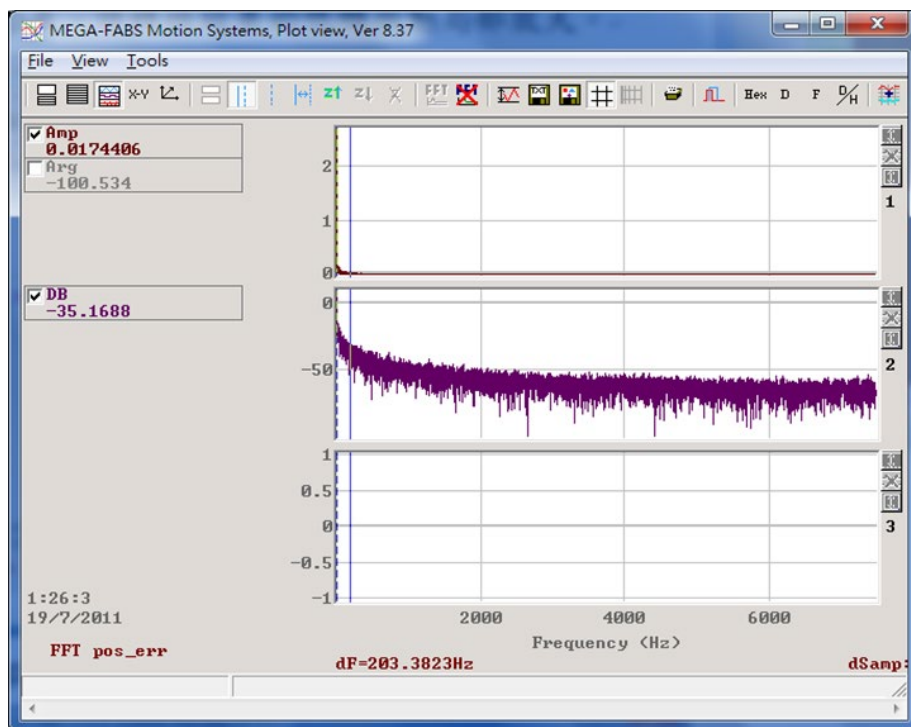


Figure6.6.6.5

- Step 7: Zoom in on the segment of low frequency and record the vibration frequency of the maximum amplitude, as figure 6.6.6.6.
- Step 8: Input the frequency of low-frequency vibration into **Frequency** field in **VSF** tab of **Advanced gains** window. In figure 6.6.6.6, the frequency of low-frequency vibration is 6.7 Hz.

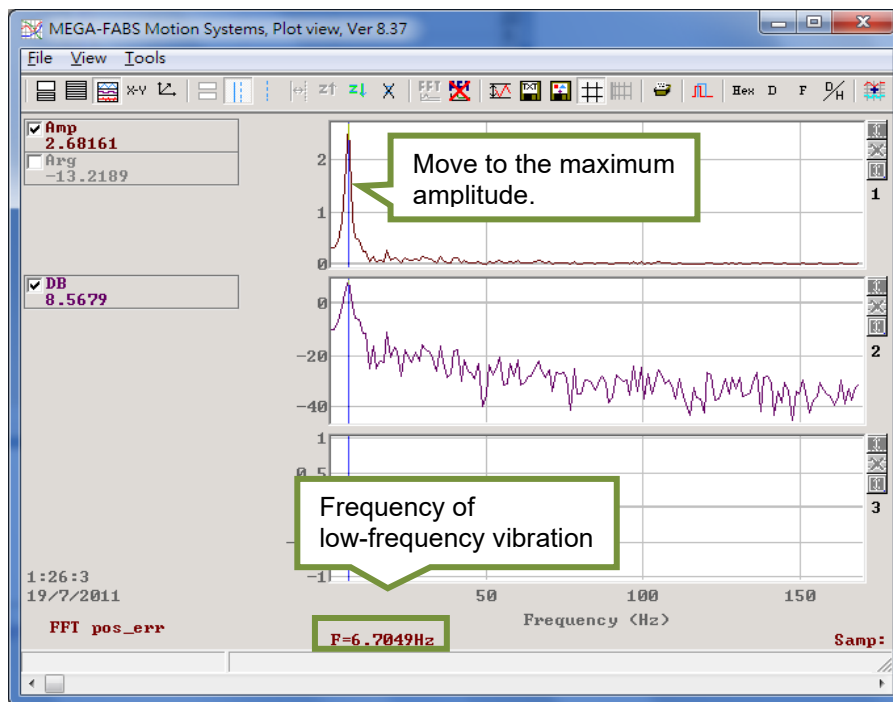


Figure6.6.6.6

Step 9: Check the checkbox of **enable VSF** to enable vibration suppression filter (VSF), as figure 6.6.6.7. Please be noted that do not check or uncheck the checkbox of **enable VSF** while the motor is moving.

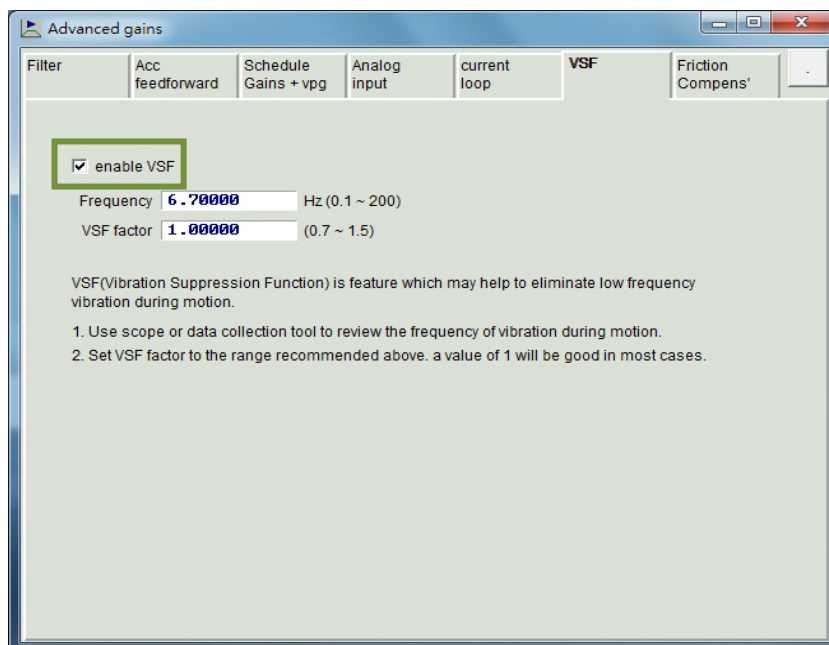
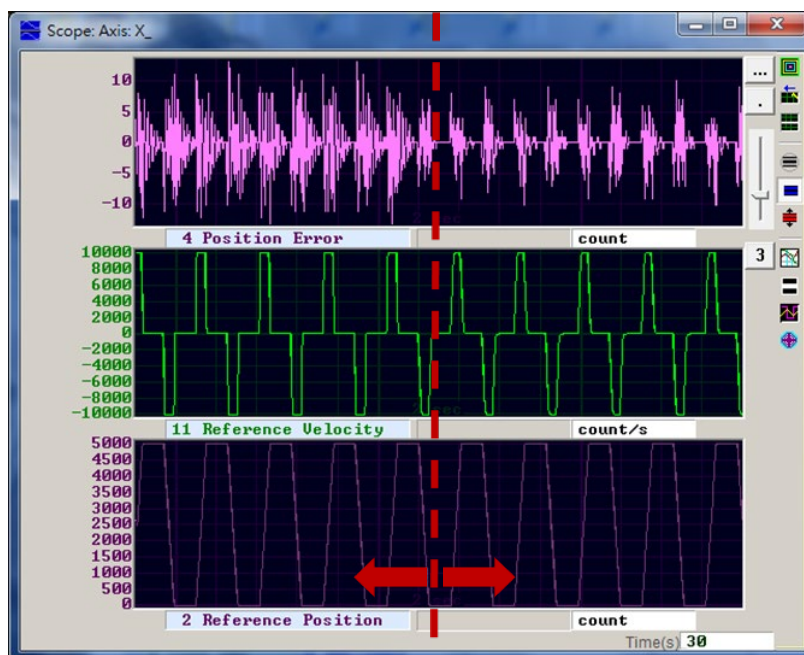


Figure6.6.6.7

Step 10: After vibration suppression filter (VSF) is enabled, the position error has decreased as the motor stops.



Vibration suppression filter (VSF) is not enabled. Vibration suppression filter (VSF) is enabled.

Figure6.6.6.8

6.6.7 Friction compensation

The efficiency and function of motion could be affected by the mechanical friction from transmission component. D1 servo drive provides friction compensation to reduce the effect of friction.

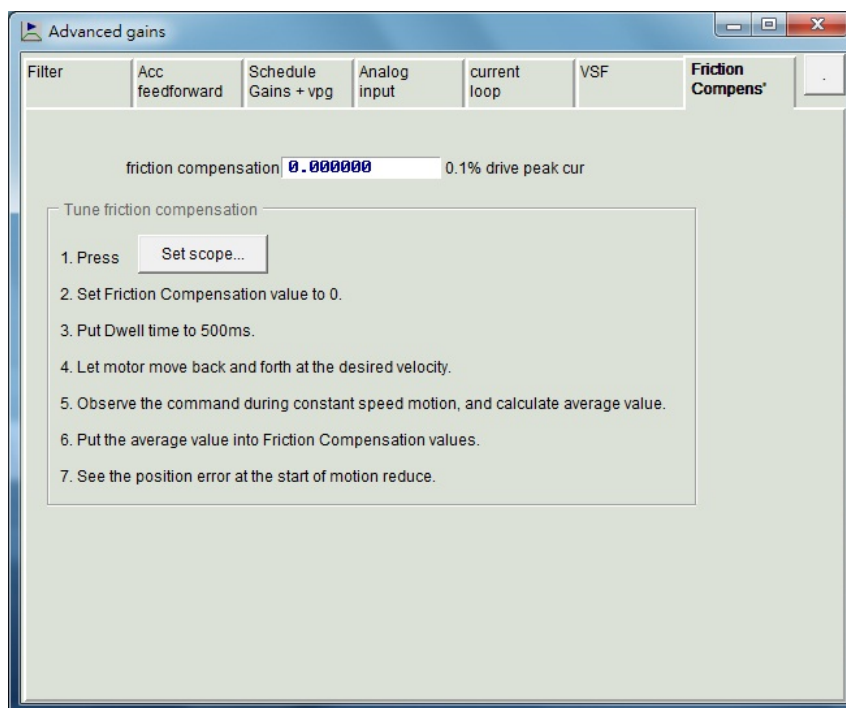


Figure6.6.7.1

For how to apply friction compensation, please refer to the instructions below.

- Step 1: Click on **Set scope...** button to show **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 perform point-to-point (P2P) motion. Observe position error in **Scope** window. It is suggested to apply friction compensation if position error is greater when motor starts to move, as the left part of figure 6.6.7.2.
- Step 5: Observe command current when the motor is moving at constant speed and calculate its average value. As figure 6.6.7.2, the average value of command current is 20.
- Step 6: Input the average value from step 5 into the field of **friction compensation**.
- Step 7: Observe if the position error when the motor starts to move has decreased, as the right part of figure 6.6.7.2. The position error has decreased after friction compensation is applied.

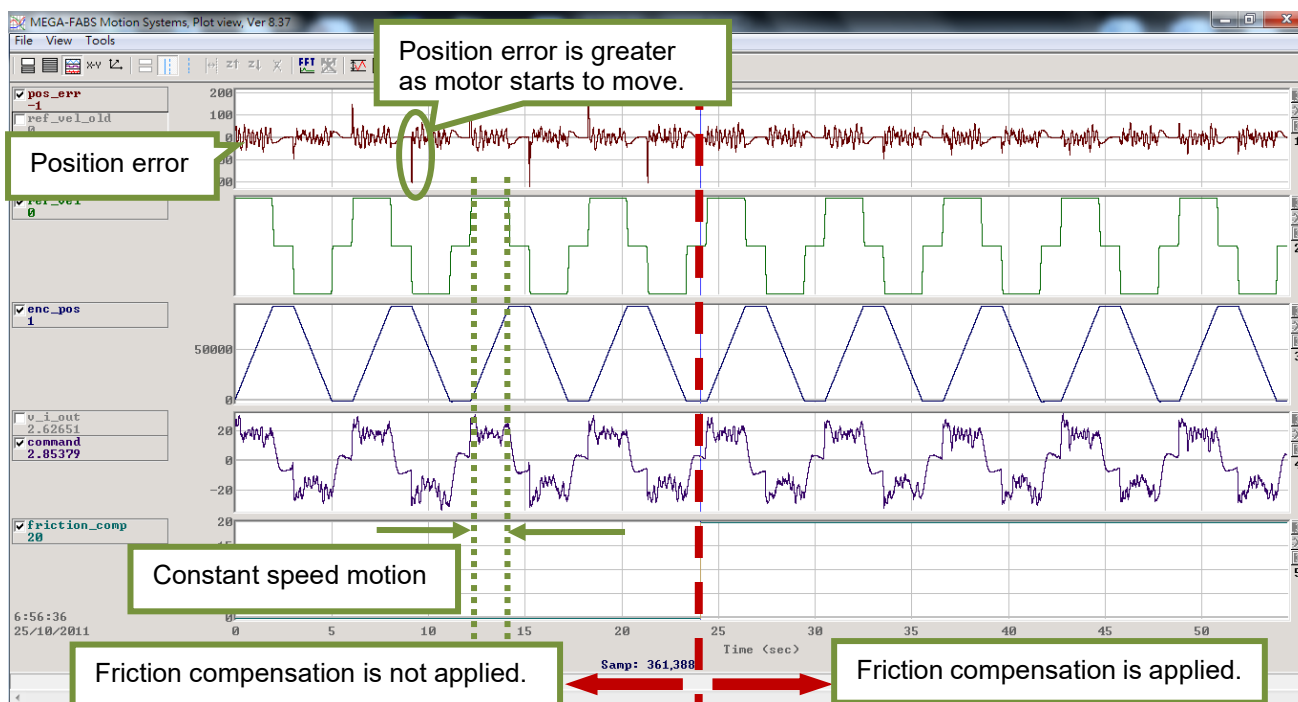


Figure6.6.7.2 Friction compensation

6.7 Loop constructor

In Loop constructor, user is able to check the stability of control system. Loop constructor supports spectrum analysis tools, such as Nyquist plot, Nichols plot and Bode plot and allows user to adjust filters and gains (vpg, vig, ppg and CG). User can directly observe the frequency response of control system and adjust parameters in Loop constructor. To open **Loop constructor** window, click on **Tools** on the menu bar and select **Loop constructor** from the submenu, as figure 6.7.1. The interface of Loop constructor is shown in figure 6.7.2.

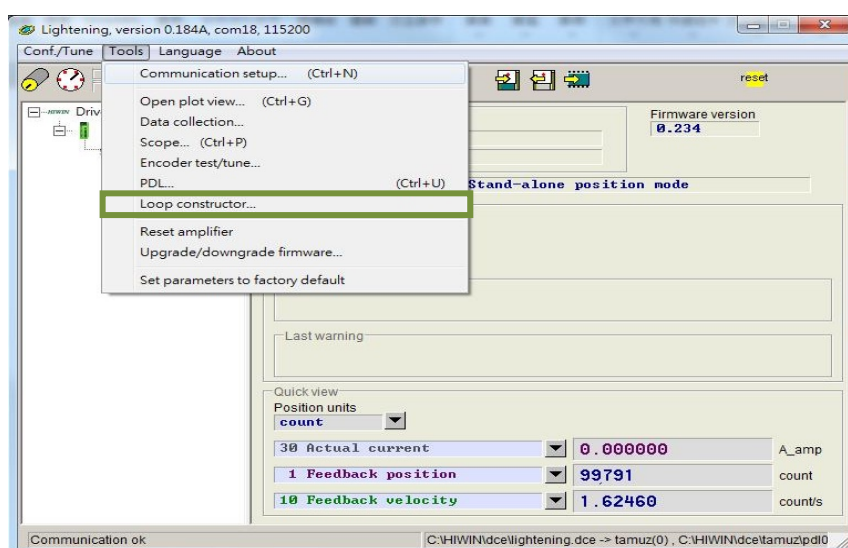


Figure6.7.1 Open Loop constructor

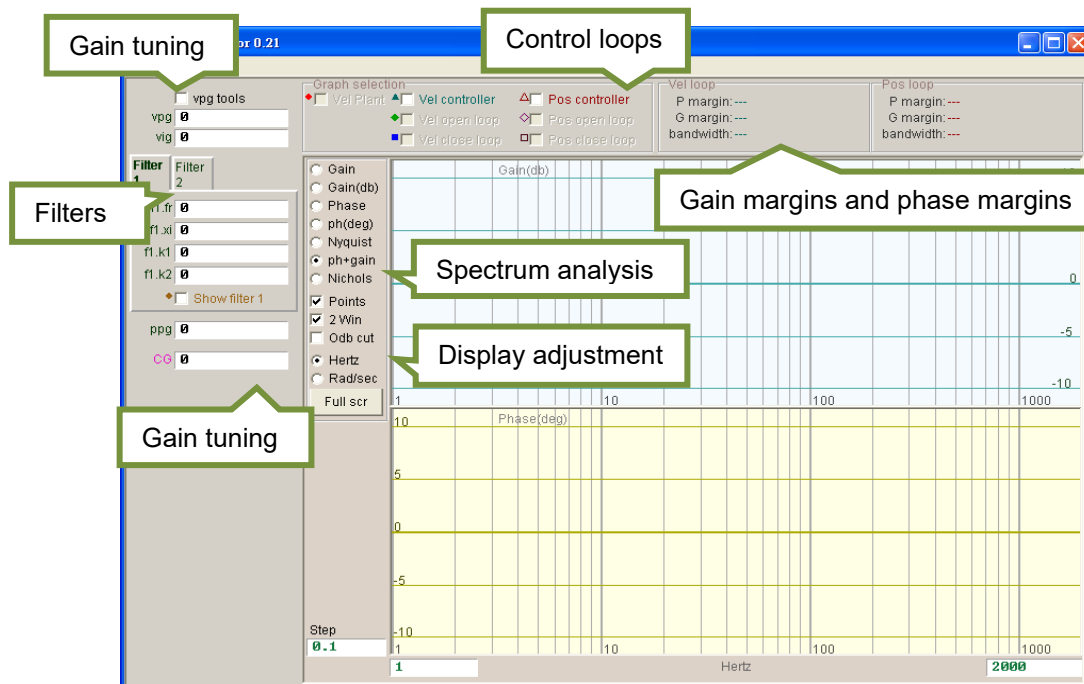


Figure6.7.2 Loop constructor interface

6.7.1 Load/save file

While using Loop constructor to analyze control system, the control system and gains must be loaded first. Click on **File** on the menu bar and select **Load** from the submenu. The three loading methods are described as below.

- (1) Load plant + gains from file...: Load .lop file. Control system and gains will be loaded.
- (2) Load plant from file...: Load .fgr file. Control system will be loaded.
- (3) Load gains from file...: Load .gns file. Control gains will be loaded.

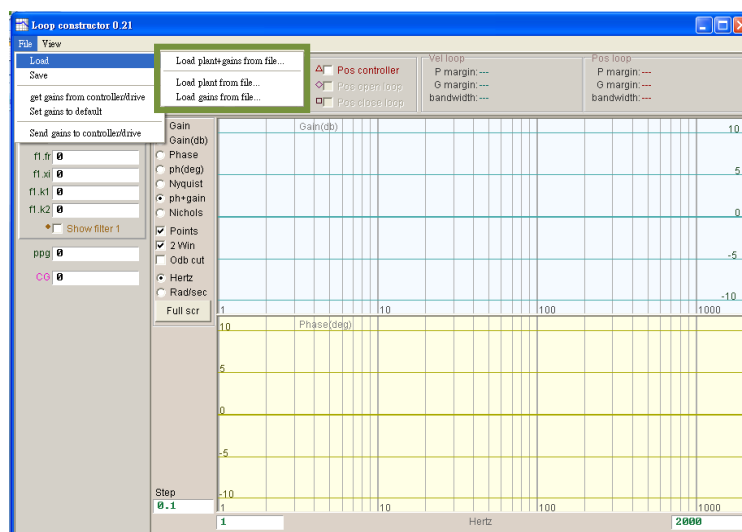


Figure6.7.1.1

After analyzing control system in Loop constructor, user can save the control system and gains. Click on **File** on the menu bar and select **Save** from the submenu. The three saving methods are described as below.

- (1) Save plant + gains to file...: Save as .lop file. Control system and gains will be saved.
- (2) Save plant to file...: Save as .fgr file. Control system will be saved.
- (3) Save gains to file...: Save as .gns file. Control gains will be saved.



Figure6.7.1.2

6.7.2 Tool

The spectrum analysis tools of Loop constructor can simulate and analyze the Nyquist plot, Bode plot and Nichols plot of control system. The frequency response of control system can be obtained by using spectrum analysis tools.

6.7.2.1 Frequency response function

Frequency response can be expressed by the transfer functions of dynamic system which show the relationship between input signals and output signals. The control architecture of the servo drive is shown in figure 6.7.2.1.1.

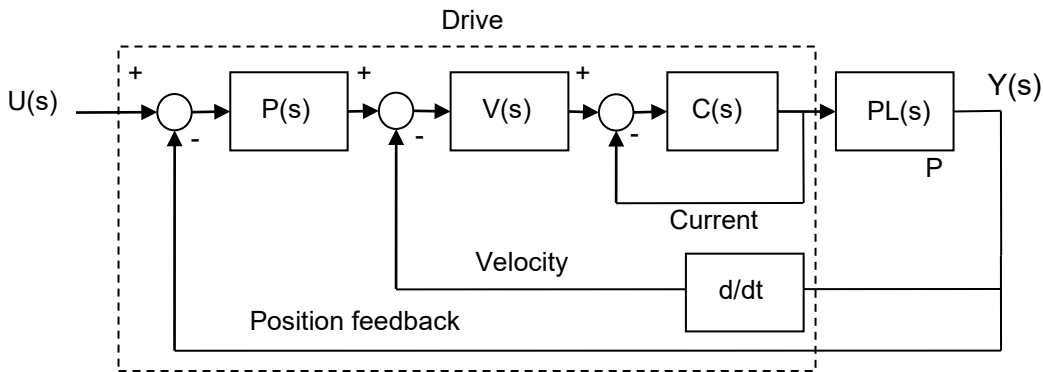


Figure 6.7.2.1.1 The control architecture of servo drive

- (1) $U(s)$: System input (Servo drive command)
- (2) $Y(s)$: System output (Position feedback of encoder)
- (3) Plant: $PL(s)$ is the relationship between servo drive command and feedback position. Plant includes mechanical platform, motor and feedback system.
- (4) Controller: $P(s)$ is the position loop controller. $V(s)$ is the velocity loop controller. $C(s)$ is the current loop controller.
- (5) Open loop: The transfer function of open loop system is $G(s) = P(s) \cdot V(s) \cdot C(s) \cdot PL(s)$. All feedback signals are ignored.
- (6) Closed loop: The transfer function of closed-loop system is $T(s) = \frac{P(s) \cdot V(s) \cdot C(s) \cdot PL(s)}{1 + P(s) \cdot V(s) \cdot C(s) \cdot PL(s)}$

6.7.2.2 Nyquist

Select **Nyquist** in **Loop constructor** window to simulate and analyze the frequency responses of velocity open loop (Vel open loop) and position open loop (Pos open loop) of control system. Check the checkbox of **Vel open loop** or **Pos open loop** to simulate and analyze its Nyquist plot. The checkboxes of **Vel open loop** and **Pos open loop** can be checked at the same time. The Nyquist plot of position open loop is shown in figure 6.7.2.2.1. Click on the curve to display frequency response value to analyze control system.

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

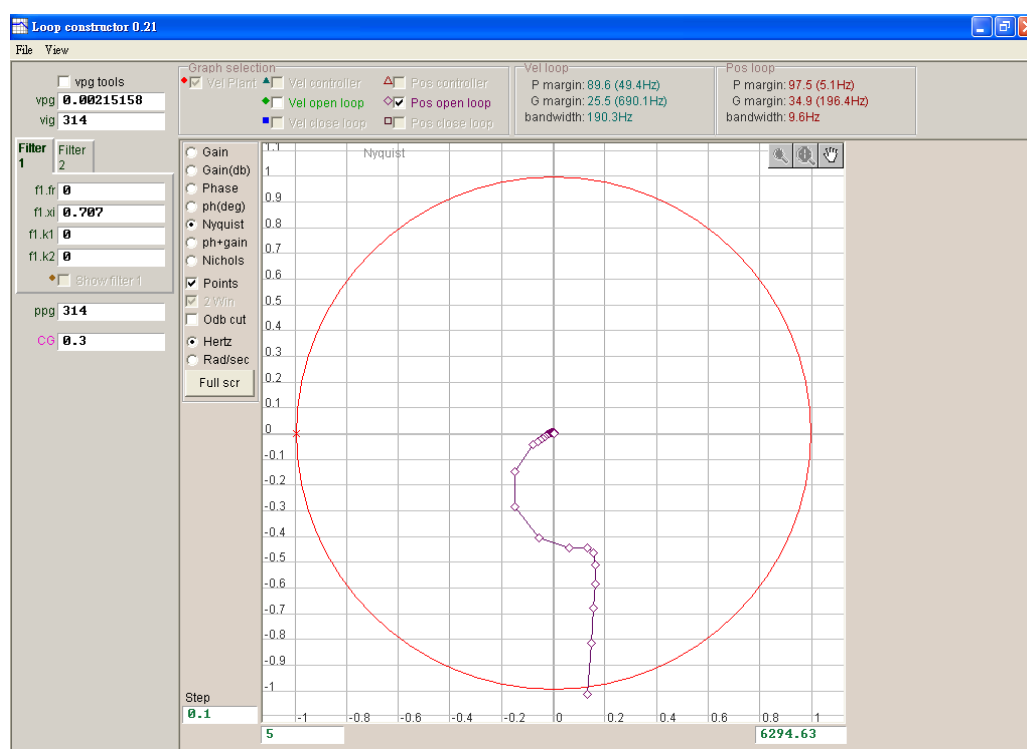


Figure6.7.2.2.1 Nyquist plot of position open loop

6.7.2.3 Bode

Select **ph+gain** in **Loop constructor** window to simulate and analyze the frequency responses of velocity controller (Vel controller), velocity open loop (Vel open loop), velocity closed loop (Vel close loop), position controller (Pos controller), position open loop (Pos open loop) and position closed loop (Pos close loop). Check the checkbox of the desired item to simulate and analyze its Bode plot. The above six items can be simulated and analyzed at the same time. Click on the curve to display frequency response value to analyze control system.

- (1) Vel controller (Velocity controller): Frequency response of velocity controller
- (2) Vel open loop (Velocity open loop): Frequency response of velocity open loop
- (3) Vel closed loop (Velocity close loop): Frequency response of velocity closed loop
- (4) Pos controller (Position controller): Frequency response of position controller
- (5) Pos open loop (Position open loop): Frequency response of position open loop
- (6) Pos closed loop (Position close loop): Frequency response of position closed loop

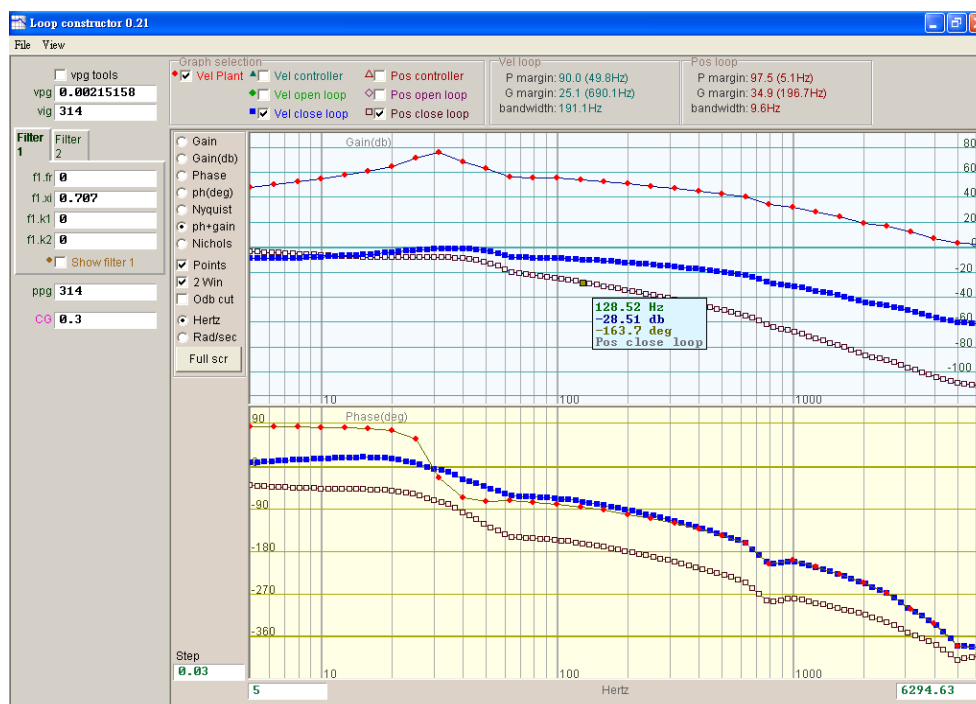


Figure6.7.2.3.1 Bode plots of velocity closed loop and position closed loop

6.7.2.4 Nichols

Select **Nichols** in **Loop constructor** window to simulate and analyze the frequency responses of velocity open loop (Vel open loop) and position open loop (Pos open loop). Check the checkbox of **Vel open loop** or **Pos open loop** to simulate and analyze its Nichols plot. The checkboxes of **Vel open loop** and **Pos open loop** can be checked at the same time, as figure 6.7.2.4.1. Click on the curve to display frequency response value to analyze control system.

- (1) Vel open loop (Velocity open loop): Frequency response of velocity open loop
- (2) Pos open loop (Position open loop): Frequency response of position open loop

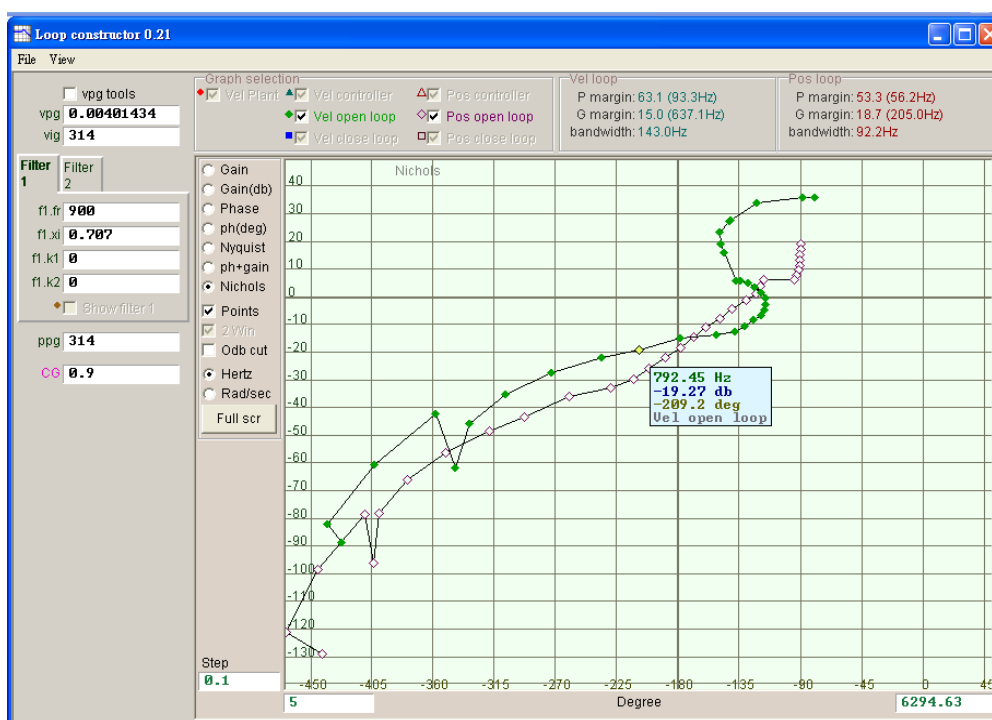


Figure 6.7.2.4.1 Nichols plots of velocity open loop and position open loop

6.7.3 Filter

Two filters are provided for the control loop of the servo drive to deal with high-frequency noise, machine vibration or insufficient structural stiffness.

6.7.3.1 Low-pass filter

Low-pass filter in control loop is used to suppress high-frequency noise or machine vibration. Figure 6.7.3.1.1 shows the Bode plot of low-pass filter. Modify the parameters of filter (fr and xi) to simulate how the filter affects the frequency response of control system.

- (1) fr: fr is the cutoff frequency (Unit: Hz). For normal application, user can set cutoff frequency to 500 Hz. For other application, user can consider decreasing the value of cutoff frequency. If the cutoff frequency is set to be too low, it may affect the controlling performance.
- (2) xi: Damping ratio (Setting range: 0 to 1)
- (3) k1: Low-pass filter = 0
- (4) k2: Low-pass filter = 0

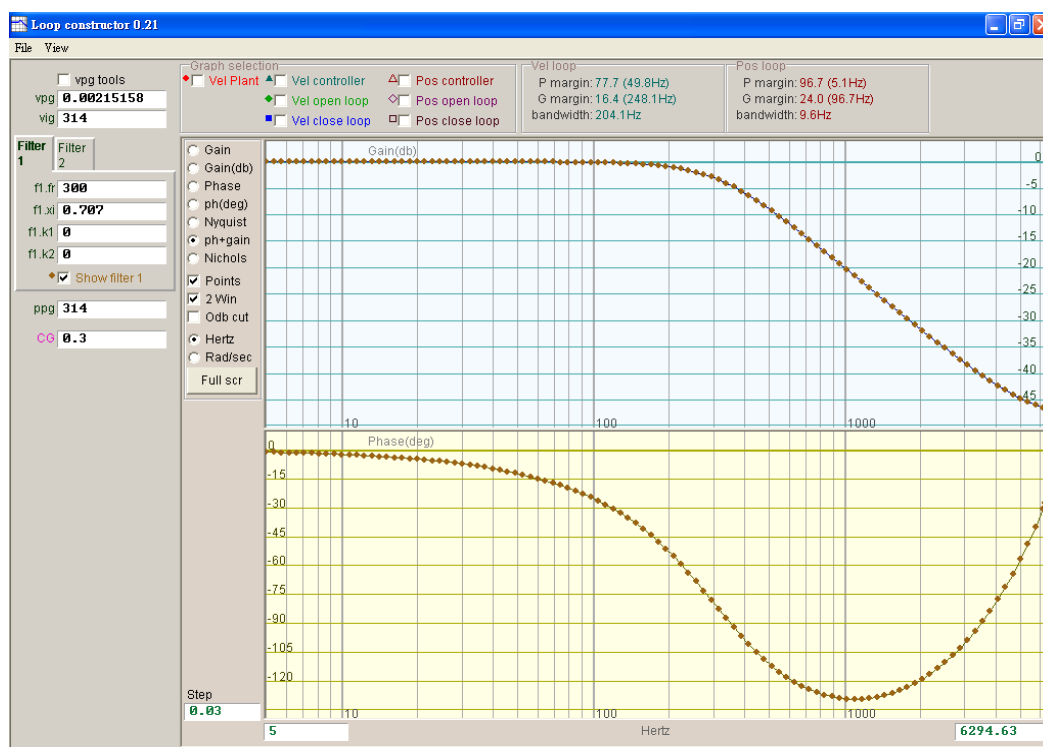


Figure6.7.3.1.1 Low -pass filter

6.7.3.2 Notch filter

When resonance frequency occurs and cannot be fixed by modification of mechanism or improvement of design, user can consider using notch filter. Figure 6.7.3.2.1 shows the Bode plot of notch filter. Modify the parameters of filter (fr and xi) to simulate how the filter affects the frequency response of control system.

- (1) fr: Cutoff frequency (Unit: Hz)
- (2) xi: Damping ratio (Setting range: 0 to 1)

When the value is close to 0, the filtering frequency band will be narrower; when the value is close to 1, the filtering frequency band will be wider.

- (3) k1: Notch filter = 0
- (4) k2: Notch filter = 1

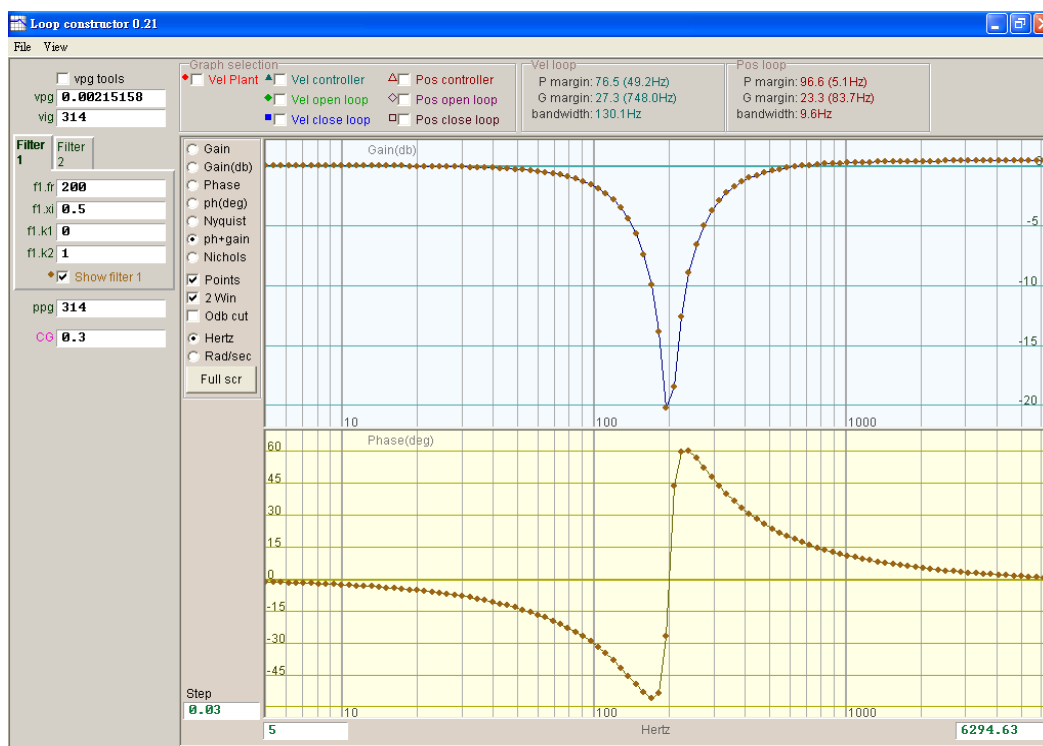


Figure 6.7.3.2.1

6.7.4 Gain tuning

Loop constructor allows user to adjust velocity loop gains (vpg and vig), position loop gain (ppg) and common gain (CG) to simulate the stability of control system after gain tuning.



Figure6.7.4.1 Gain tuning in Loop constructor

■ Velocity loop

The gains of velocity loop are vpg and vig. vpg is the proportional gain of velocity loop. vig is the integral gain of velocity loop.

- (1) vpg: Adjusting vpg will affect the transient response of velocity loop and increase the bandwidth of velocity loop.
- (2) vig: Adjusting vig will affect the steady-state error of velocity loop. The system may become unstable if vig is set to be too high.

■ Position loop

The gain of position loop is ppg. ppg is the proportional gain of position loop.

- (1) Adjusting ppg will affect the transient response of position loop and increase the bandwidth of position loop.

6.7.5 Spectrum analysis

The gain margins, phase margins and bandwidth of velocity loop and position loop are provided in **Loop constructor** window for user to adjust gains to simulate the stability of control system after gain tuning. In **Loop constructor** window, **P margin** means phase margin and **G margin** means gain margin. For further information of gain margin and phase margin, please refer to section 3.6.




Figure6.7.5.1 P margins and G margins in Loop constructor

6.8 Checking encoder signal

Encoder provides the servo drive with information such as position and angle to complete servo loop control. User can check if encoder signal is normal or not via Lightning.

(1) Checking encoder signal

Click on  in **Performance center** window or select **Encoder test/tune** from the submenu of **Tools** to open the window for checking encoder signal. The windows for digital encoder and analog encoder are different.

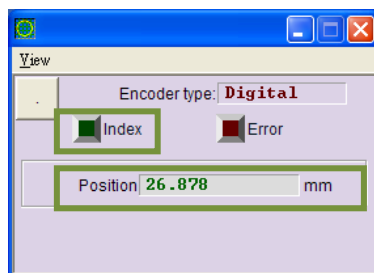


Figure6.8.1 Digital encoder

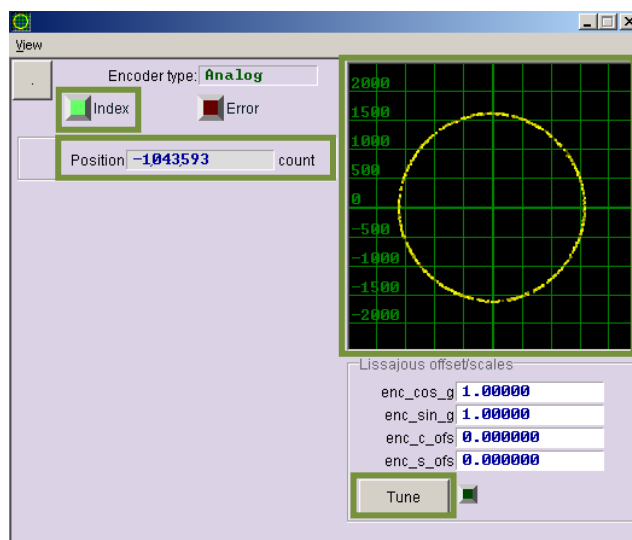


Figure6.8.2 Analog encoder

(2) Checking encoder value

Digital encoder signal and analog encoder signal are digital pulse and sine wave signal with 90 degrees phase differences. Manually move motor for a known distance and check if the value in **Position** field is the same. While using analog encoder, use Lissajous figure to check if the signal is normal.

(3) Checking index signal

Use **Index** indicator in figure 6.8.1 or 6.8.2 to check if the Z-phase signal of encoder is normal. **Index** indicator blinks green as the servo drive receives Z-phase signal.

(4) Lissajous figure

While using analog encoder, use Lissajous figure to check if the signal is normal. Normally the Lissajous figure of analog encoder signal must be a circle. The radius of that circle should be 977.4 to 1,954.8. If the radius is not within this range, it means the signal is too strong or too weak and the encoder must be readjusted. To obtain Lissajous figure, motor must move to let the encoder output signal, as figure 6.8.2. If motor does not move, there will be no circle and only a dot will appear in the display area.

Besides, if Lissajous figure is not ideal due to different amplitudes of analog encoder signals or the center of the circle is not in the center of the display area due to zero level offset, click on **Tune** button for adjustment. To use this function, motor must move slowly and let the encoder outputs signals for at least 10 grating periods.

6.9 Error map function

The accuracy of linear motor is determined by the linear encoder installed on the positioning platform. Normally the positioning accuracy of positioning platform can be measured and corrected by using laser interferometer. With laser interferometer, the errors can be obtained. D1 servo drive provides a function called Error map function, which allows user to input the errors. With the information, the servo drive is able to calculate compensation value between fixed distances by linear interpolation to improve positioning accuracy. In **Error map** window, user needs to set **Interval** and **Total points** before inputting the errors.

Note:

1. The home position is the start position for Error map function to compensate in positive direction. Please perform homing before using Error map function.
2. If controller would like to receive feedback pulses from the servo drive and enable Error map function at the same time, select **Use emulated encoder** in **Encoder** tab.

6.9.1 Setting error map function

To use Error map function, please refer to the instructions below.

Step 1: Open Application center and select **Error Map** tab.

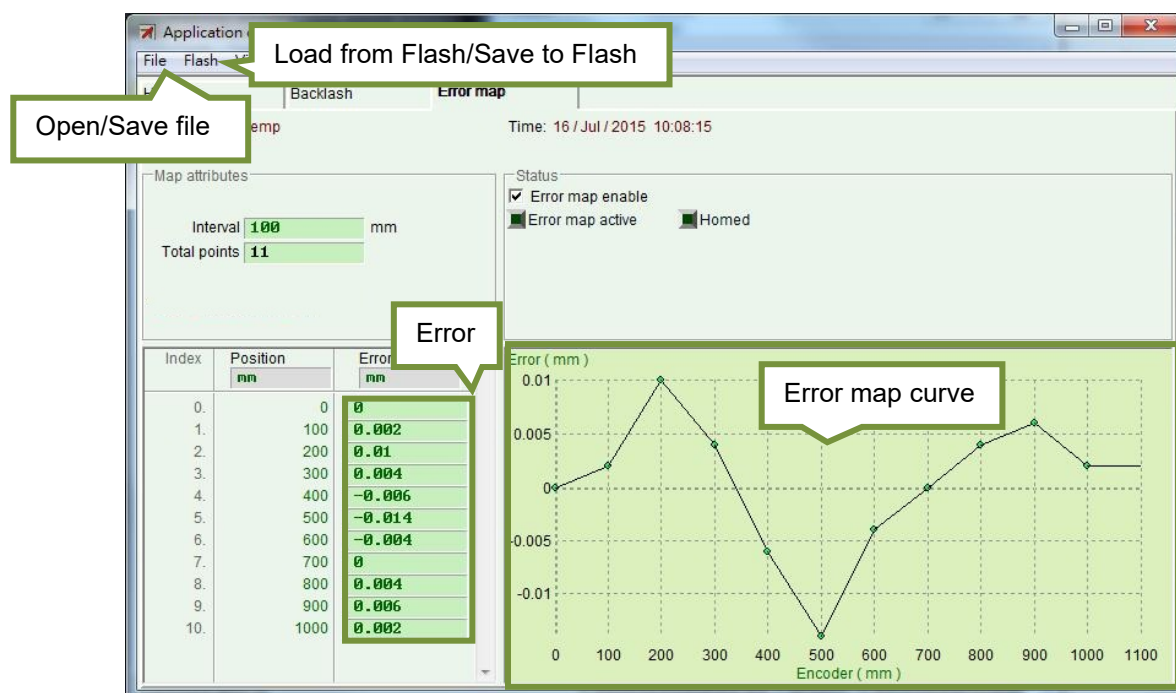


Figure6.9.1.1 Error map page

Step 2: Set **Interval** and **Total points**. Input the errors into the fields of **Error**. User is allowed to use different units. In figure 6.9.1.1, the compensation range is from 0 to 1,000 mm. **Interval** is set to 100 mm. **Total points** is set to 11. The errors in the fields of **Error** are obtained by laser interferometer. Each value represents the positioning error at each target position. For instance, for target position 100 mm, the actual position measured by laser interferometer is 100.002 mm.

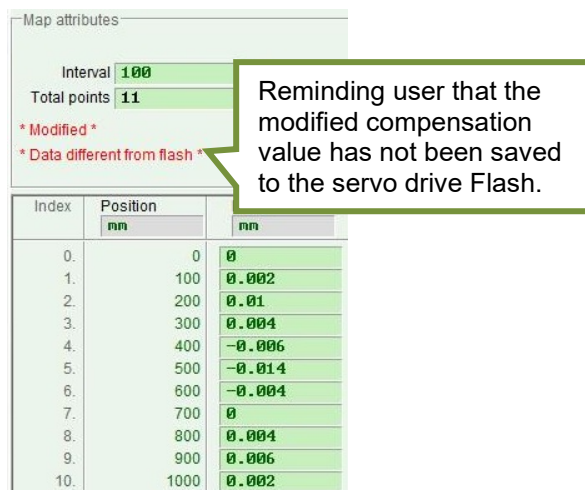


Figure6.9.1.2 Setting Error map function

Note:

1. After inputting errors into the fields of **Error**, the input values will be rounded to integer multiples of encoder resolution. For instance, if encoder resolution is 2 μm , input value 1 μm will be converted to 2 μm . If input value is 0.5 μm , it will be converted to 0 μm .
2. The smallest digit of displayed accuracy is in third decimal place. Please select appropriate units for **Position** and **Error**.
3. While using Error map function with torque motor, no matter how many revolutions the torque motor has run for, as long as the position is the same, the compensation value is the same. Set the compensation points for one revolution in the field of **Total points**. At this time, **Interval** cannot be set.

Step 3: Check the checkbox of ☒ **Error map enable**.

Step 4: Click on **Flash** on the menu bar and select **Send table to Flash**. If other parameters (parameters not related to Error map function) have been modified but have not been saved to the servo drive Flash, the window shown in figure 6.9.1.3 will appear. If not, please go to step 6.

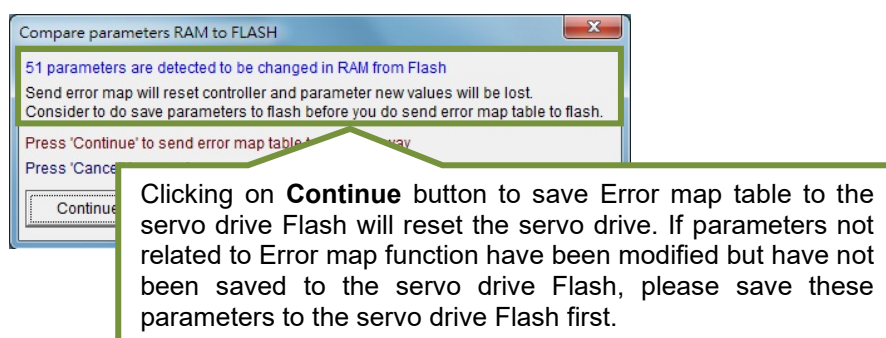


Figure6.9.1.3

- Step 5: Click on **Cancel** button to return to the main window. Save parameters to the servo drive Flash. Then go to step 4 again.
- Step 6: Click on **Yes** button to save Error map table to the servo drive Flash. After that, the servo drive will be automatically reset.



Figure6.9.1.4

6.9.2 Enabling error map function

After Error map table is set in the servo drive, the servo drive is able to compensate the errors after homing. D1 servo drive provides two ways of homing, please refer to below.

(1) Homing with controller

Set input function **Home OK, start err. map**. (Refer to section 5.4.) We assume the digital input of this input function is I2, as figure 6.9.2.1. The controller sends pulse command or voltage command to the servo drive to let the motor move to the home position. After that, the controller inputs signal via I2 to the servo drive to enable Error map function.

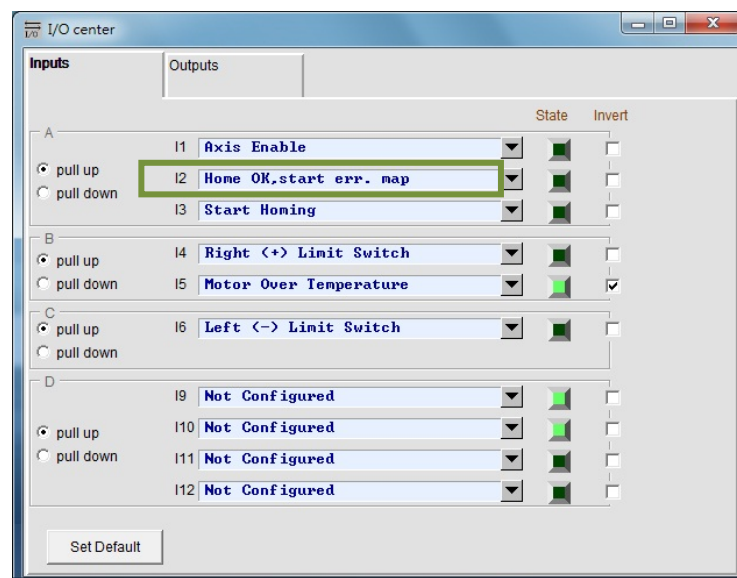



Figure6.9.2.1


(2) Homing in stand-alone mode

Open Performance center, click on  Home. (Refer to section 6.2.)

■ How to check if Error map function is enabled

If user would like to check if Error map function is enabled or not, go to **Error map** tab and check **Error map active** indicator. If **Error map active** indicator becomes green, it means Error map function is enabled.

6.9.3 Saving and opening error map table

The error compensation values set in **Error map** window can be saved to Flash or as file and that file can be opened in **Error map** window again, as figure 6.9.3.1. As described in section 6.9.1, select **Send table to flash** from the submenu of **Flash** to save Error map table to the servo drive Flash. Please be noted that  (Refer to section 5.7.1.) in the main window cannot save Error map table to the servo drive Flash.

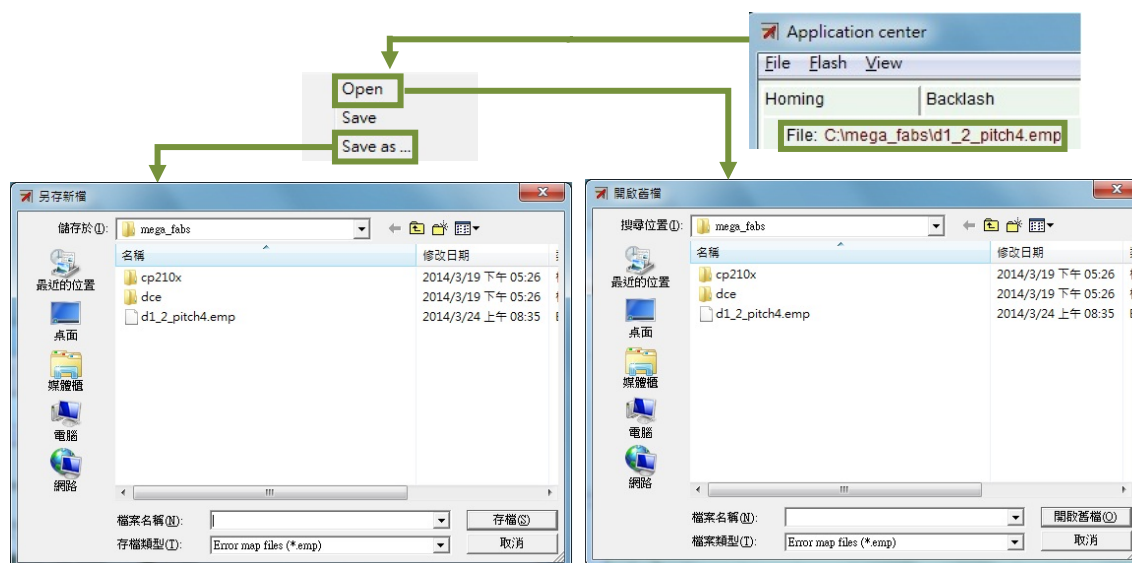


Figure6.9.3.1

6.9.4 Changing the start position of error map function

To change the start point of Error map function, click on **View** on the menu bar and select **Advanced** from the submenu. The setting page shown in figure 6.9.4.1 will appear. Input the desired start position into the field of **Start position**. Click on **Next** button and the motor will move for one interval in positive direction. Click on **Previous** button and the motor will move for one interval in negative direction. The value of **Error** in **Status** area will be updated to the corresponding error compensation value. The red dot on error compensation curve represents the value of **Encoder**. The value of **Feedback pos** equals the sum of **Encoder** and **Error** values.

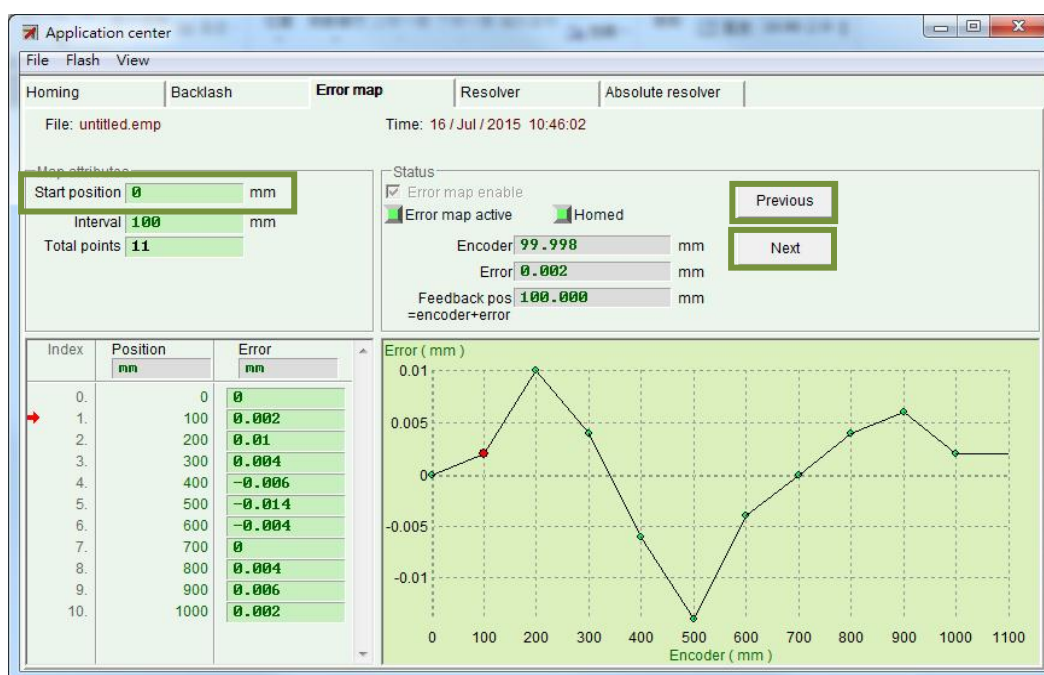


Figure6.9.4.1

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) When home offset = 0 and start position = 0

When home offset and start position are both zero, the effective range of Error map function is defined by index. Error map function is applied for operation in forward direction, starting from index. For operation in negative direction, Error map function is not applied.

Table 6.9.4.1

Home Offset	Start Position	Effective Range
0 mm	0 mm	

(2) When home offset ≠ 0 and start position = 0

When home offset is not zero and start position is zero, the effective range of Error map function is the same as the one when home offset and start position are both zero.

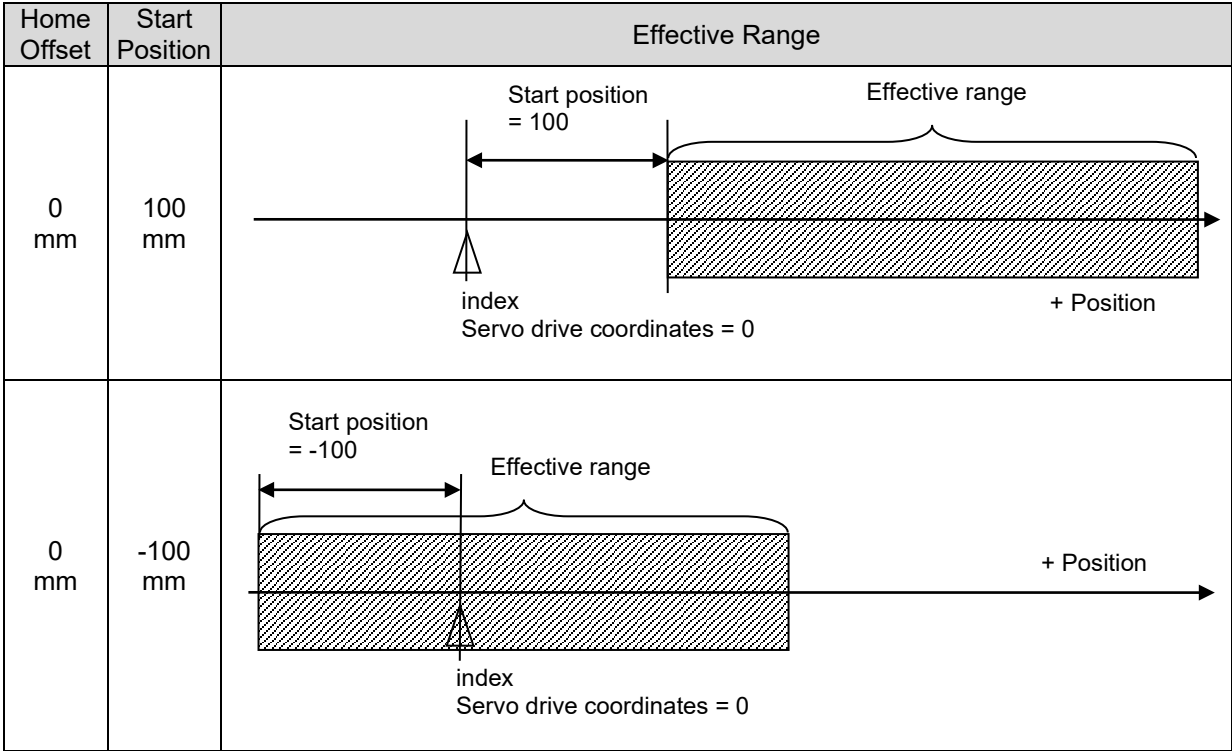
Table 6.9.4.2

Home Offset	Start Position	Effective Range
100 mm	0 mm	
-100 mm	0 mm	

(3) When home offset = 0 and start position ≠ 0

When home offset is zero and start position is not zero, index will be regarded as reference for the effective range of Error map function. The effective range of Error map function varies with start position.

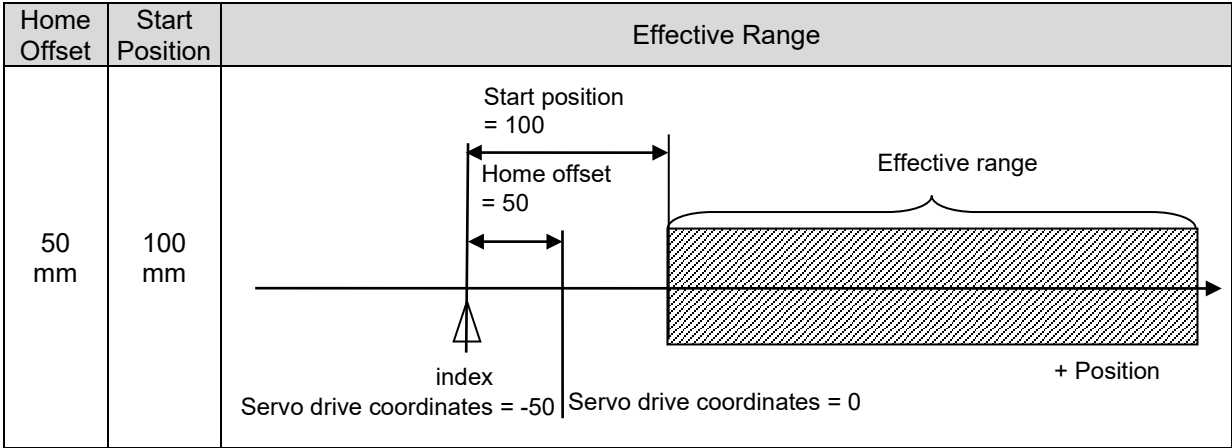
Table 6.9.4.3

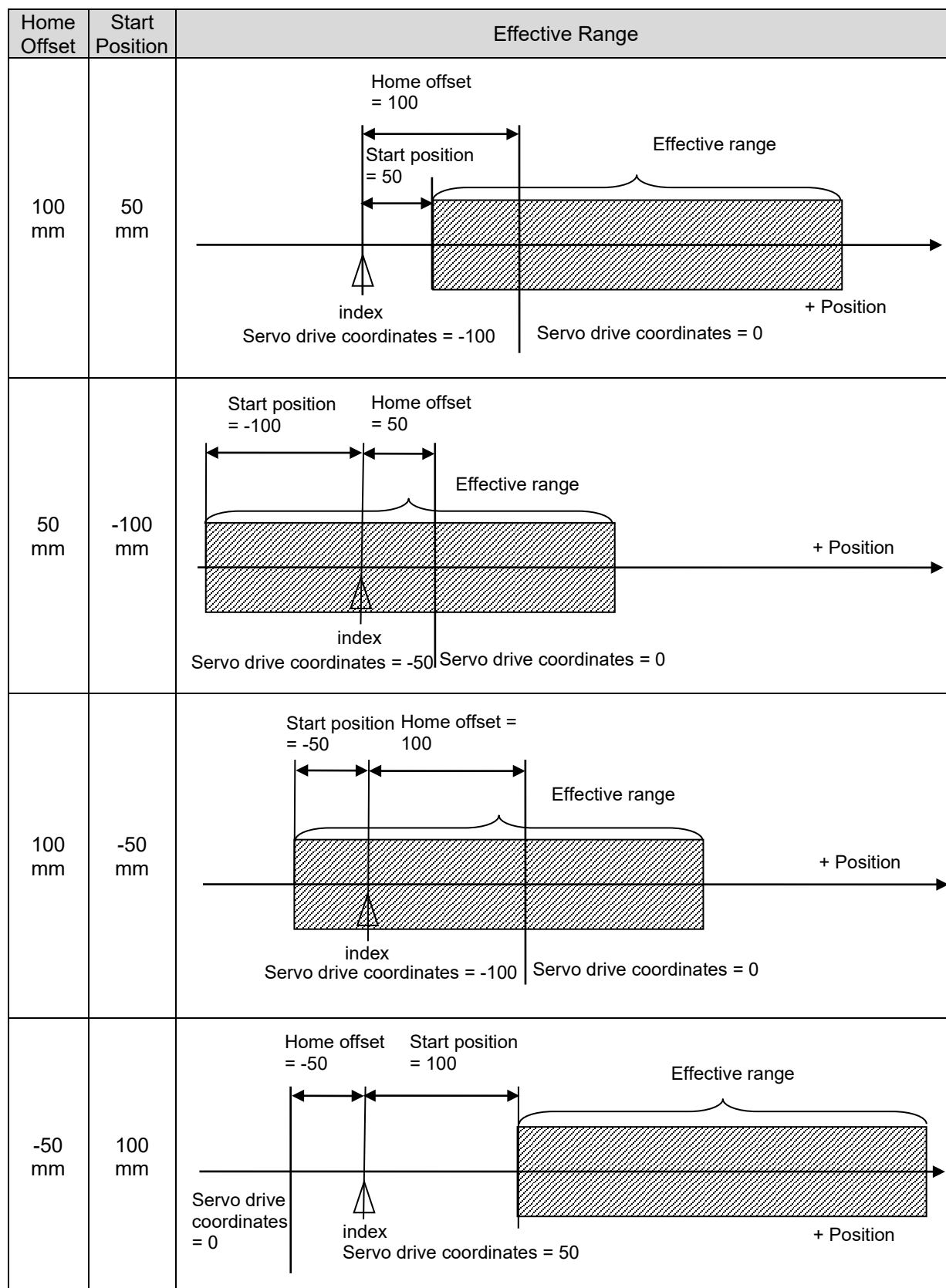


(4) When home offset ≠ 0 and start position ≠ 0

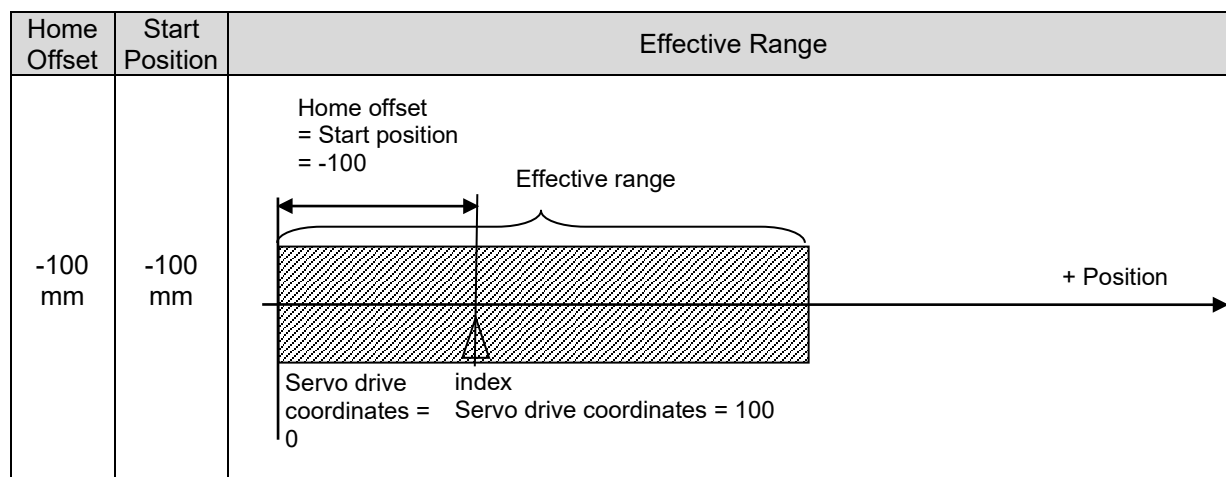
When home offset and start position are both not zero, the effective range of Error map function varies with start position. It does not vary with home offset.

Table 6.9.4.4





Home Offset	Start Position	Effective Range
-100 mm	50 mm	<p>Home offset = -100 Start position = 50</p> <p>Effective range</p> <p>Servo drive coordinates = 0 index Servo drive coordinates = 100</p> <p>+ Position</p>
-50 mm	-100 mm	<p>Start position = -100 Home offset = -50</p> <p>Effective range</p> <p>Servo drive coordinates = 0 index Servo drive coordinates = 50</p> <p>+ Position</p>
-100 mm	-50 mm	<p>Home offset = -100 Start position = -50</p> <p>Effective range</p> <p>Servo drive coordinates = 0 index Servo drive coordinates = 100</p> <p>+ Position</p>
100 mm	100 mm	<p>Home offset = Start position = 100</p> <p>Effective range</p> <p>index Servo drive coordinates = -100 Servo drive coordinates = 0</p> <p>+ Position</p>



6.10 Compensation function for resolver signal

The absolute accuracy of a resolver could be influenced by the quality of its signal. If its signal is properly compensated, the absolute accuracy can be enhanced. The compensation table for resolver signal is set for user and only needs to be reset when the servo drive or motor is changed.

Note:

The function can only be used when motor with resolver is used.

6.10.1 Operational description

To enable signal compensation function for resolver signal, please refer to below.

Step 1: Open Application center. Select **Advanced** from the submenu of **View** on the menu bar. **Resolver** tab appears as figure 6.10.1.1.

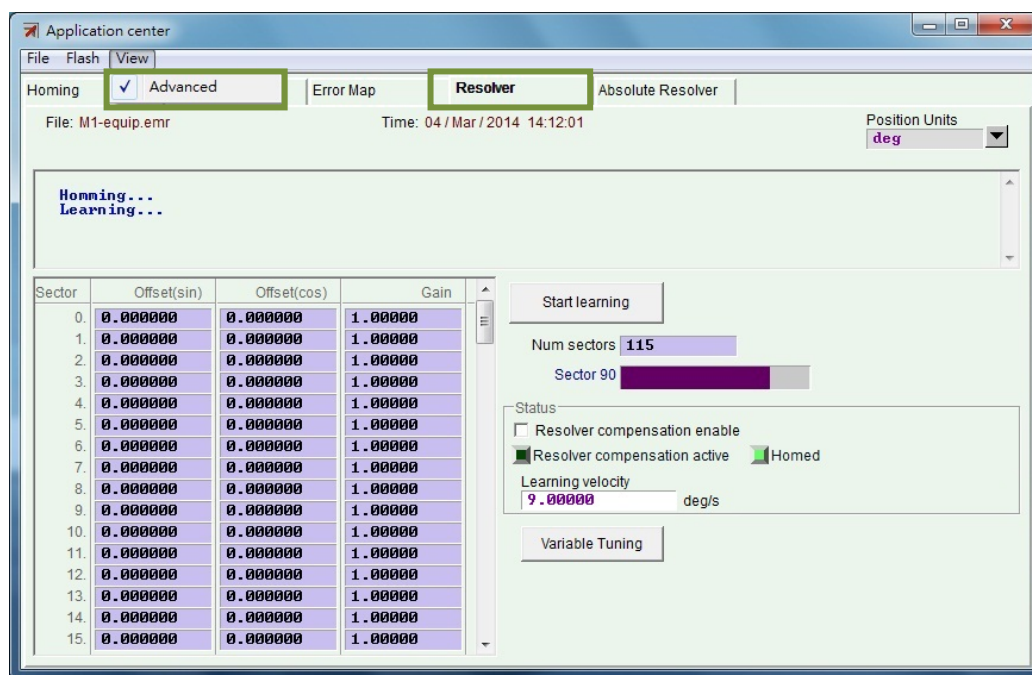


Figure6.10.1.1

Step 2: Set learning velocity. The default setting is 9 deg/s. The suggested setting range is from 9 deg/s to 18 deg/s.

Step 3: Click on **Start learning** button to create signal compensation table. The motor starts homing, and then the signal compensation table will be created. After the signal compensation table is created, the motor moves to the home position again. This may take around two to four minutes. After homing completes, message “go back home ok.” appears, as figure 6.10.1.2.

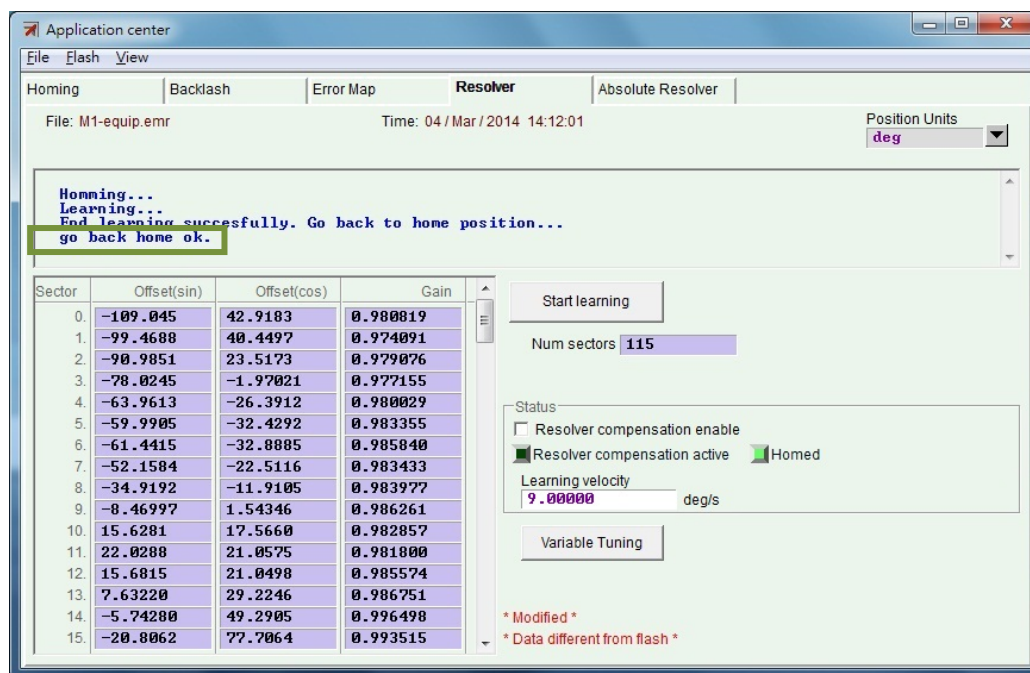



Figure6.10.1.2

- Step 4: Check the checkbox of ☒ Resolver compensation enable .
- Step 5: Save the signal compensation table to Flash, please refer to step 4 to step 6 of setting Error map function in section 6.9.1.
- Step 6: Click on **Variable Tuning** button in **Resolver** tab of Application center. The servo drive will drive the motor to find proper parameters. The velocity stability can be improved. This may take around two minutes.
- Step 7: Go to the main window of Lightening and click on  to save parameters to Flash.

6.10.2 Enabling signal compensation function

The method of enabling signal compensation function is the same as the one of enabling Error map function. Please refer to section 6.9.2.

6.10.3 Saving and opening signal compensation table

The methods of saving and opening signal compensation table are the same as the ones of saving and opening Error map table. Please refer to section 6.9.3. The file extension of signal compensation table is .emr.

6.11 Compensation function for absolute resolver signal

The compensation table for absolute resolver signal is set for user and needs to be reset only when the servo drive or motor is changed. Before resetting the compensation table for absolute resolver signal, please initialize the absolute resolver first. After that, start to perform compensation function on absolute resolver signal.

Note:

- (1) The function is only available for the servo drive which supports absolute resolver.
- (2) Before performing this function, please completes homing first.

6.11.1 Operational description

To enable compensation function for absolute resolver signal, please refer to below.

- Step 1: Open Auto phase center and complete phase initialization.
- Step 2: Enable the motor and move the motor to home position.
- Step 3: Open **Homing** tab in Application center. Ensure **Home offset** is set to 0 count.
- Step 4: Select **Advanced** from the submenu of **View** on the menu bar. **Absolute Resolver** tab appears as figure 6.11.1.1.
- Step 5: Click on **Start Initialization** button in figure 6.11.1.1. The information and message automatically shows after completion.

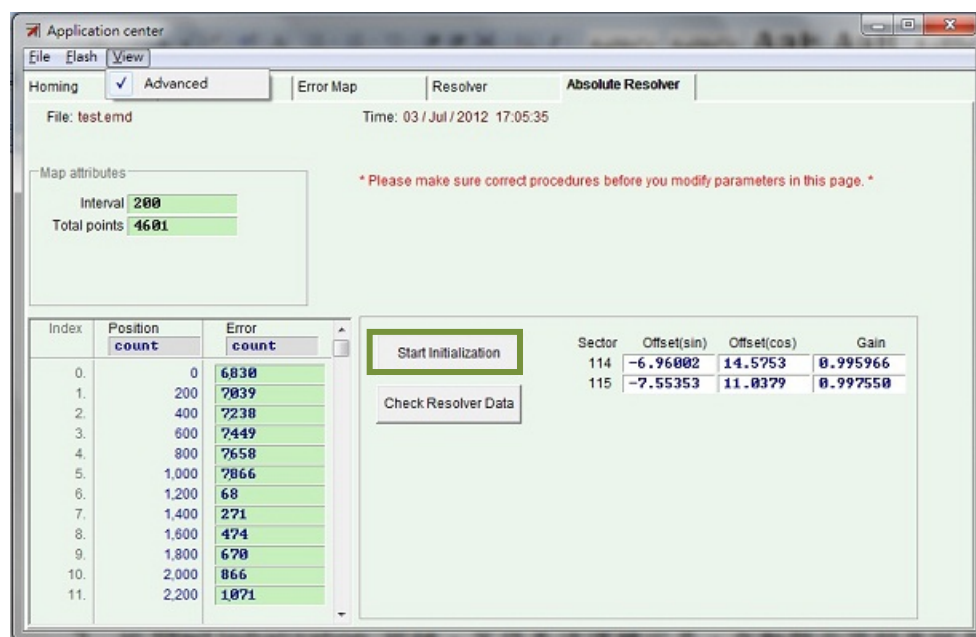


Figure6.11.1.1

Step 6: Click on **Check Resolver Data** button in figure 6.11.1.2. If the check is OK, **Data check** window appears as figure 6.11.1.3. If not, **Error** window appears as figure 6.11.1.4 and please repeat step 5. If the check fails for three times, go to **Resolver** tab and decrease the value of **Learning velocity**. Then repeat step 5.

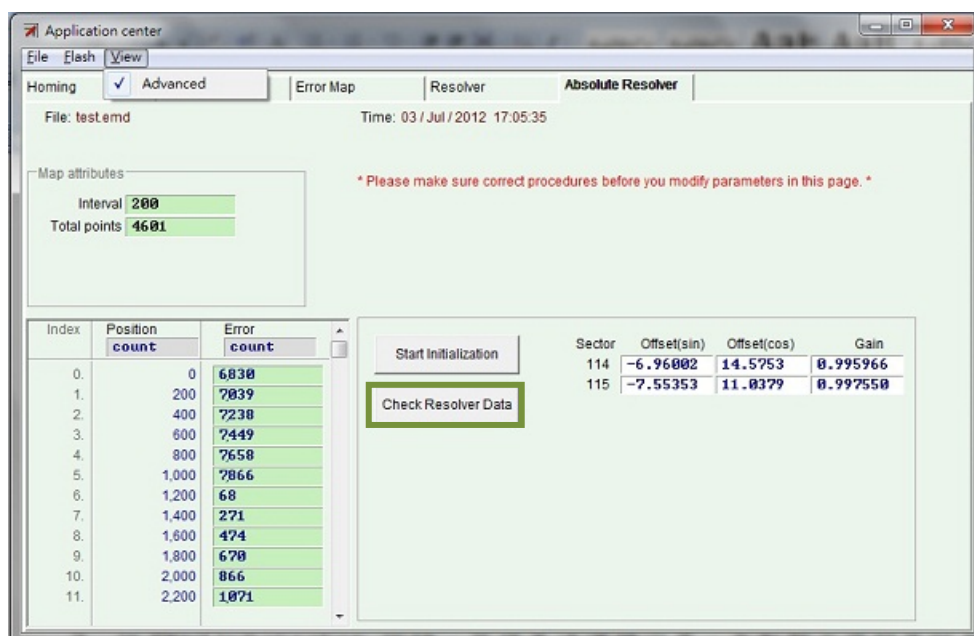


Figure6.11.1.2



Figure6.11.1.3

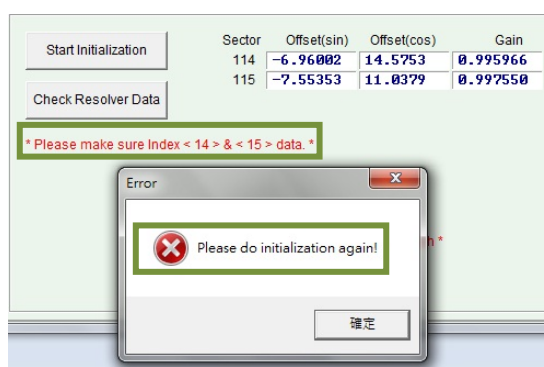



Figure6.11.1.4

- Step 7: Go to the main window of Lightening and click on  to save parameters to Flash.
- Step 8: Save the signal compensation table to Flash, please refer to step 4 to step 6 of setting Error map function in section 6.9.1.
- Step 9: Open Auto phase center and perform phase initialization again.
- Step 10: For creating signal compensation table, please refer to section 6.10.1.

6.11.2 Enabling signal compensation function

The method of enabling signal compensation function is the same as the one of enabling Error map function. Please refer to section 6.9.2.

6.11.3 Saving and opening signal compensation table

The methods of saving and opening signal compensation table are the same as the ones of saving and opening Error map table. Please refer to section 6.9.3. The file extension of signal compensation table is .emr.

7. LCD display

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7.1 LCD panel

7.1.1 Description

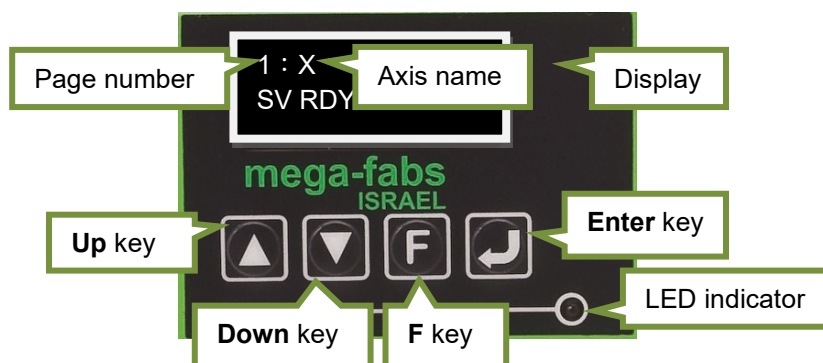


Figure7.1.1.1 LCD panel

Table7.1.1.1 Function description

Name	Function
Display	Displays parameter name, value, status and motion.
Page number	There are four pages in the LCD display. The current page number is displayed in the upper left corner.
Axis name	Axis name is displayed in the home page. Axis name can be modified in the main window of Lightening, please refer to section 5.1.3. If an error or a warning occurs, its message will be shown here as well.
LED indicator	Displays servo drive status, please refer to section 9.4.1.
Cursor	Static cursor: A blinking underline means the parameter can be edited. Dynamic cursor: A solid blinking square cursor means the parameter is being edited or the motor is jogging. No cursor: Displays parameter only.
Up key	Select selection, set parameter value and jog the motor.
Down key	Select selection, set parameter value and jog the motor.
F key	Switch among four operation modes and switch among editing modes while setting parameter value.
Enter key	Enter status display selection, save parameter value and confirm motion.

Note:

The LCD panel of CoE model can only be used to monitor servo drive status.

7.1.2 Description of operation page

There are four pages in the LCD display:

- (1) Home page
- (2) Display parameters page
- (3) Change parameters page
- (4) Actions page

Press **F** key to switch among modes. For the structure of the LCD display, please refer to figure 7.1.2.1.

Note:

The LCD display of CoE model only shows home page.

- (1) Home page

The home page displays the enabling or disabling status of motor, error message, warning message and axis name.

- (2) Display parameters page

The display parameters page displays parameters, such as motor feedback position, position command, position error, feedback velocity, velocity command, I/O status and motor status (phase initialization, moving, homing and error map function).

- (3) Change parameters page

Go to change parameters page to modify servo gain, velocity loop gain, operation mode, pulse type, advanced parameters and save parameters from RAM to Flash.

- (4) Actions page

Go to actions page to enable or disable motor, jog motor, move to absolute target position, clear coordinates to 0, perform auto tuning and set motor model.

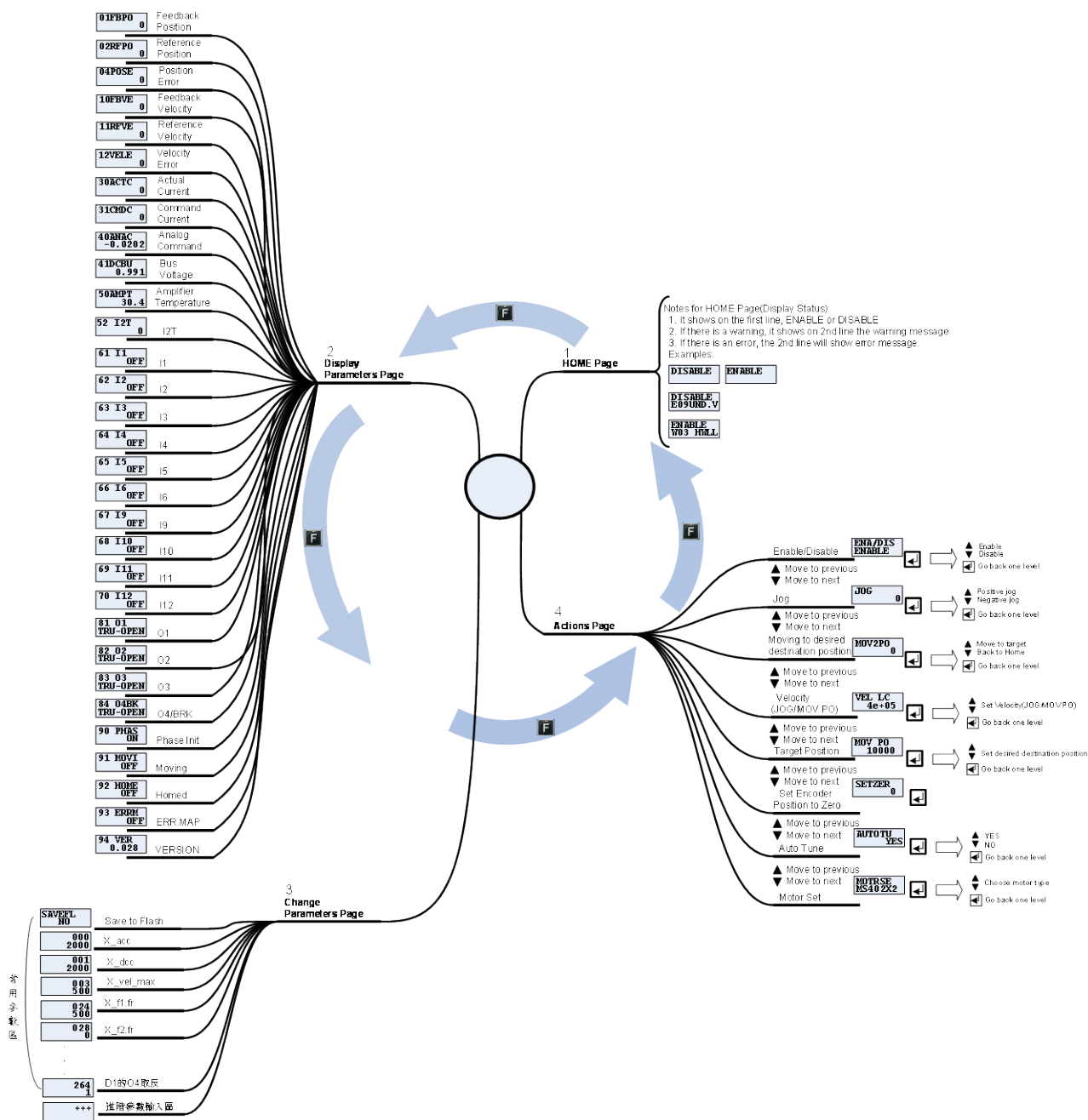


Figure7.1.2.1 The structure of the LCD display

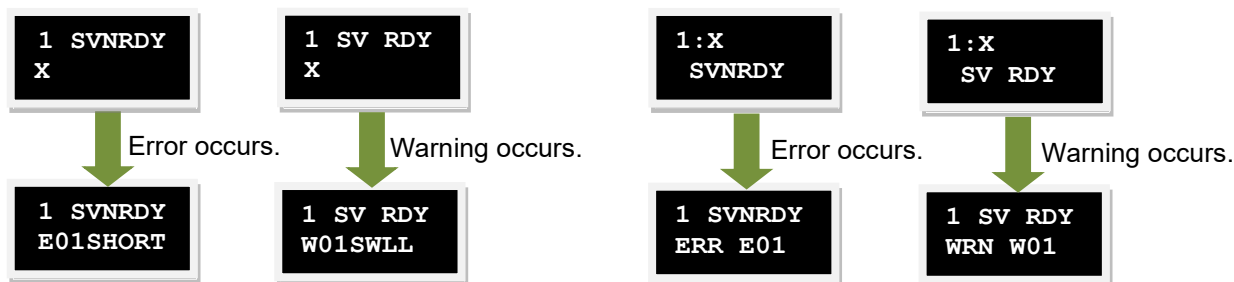
7.2 Home page

When power is supplied to the servo drive, the LCD display shows the enabling status of the connected motor. For the displayed abbreviation, please refer to below.

Table7.2.1 Enabling status

Displayed Abbreviation	Description
SV RDY	The motor is enabled.
SVNRDY	The motor is not enabled.

If an error or a warning occurs, the error message or warning message will be shown in the second line, as figure 7.2.1. For the description of error message or warning message, please refer to tables 7.2.2 and 7.2.3. For D1 firmware version 0.234, D1 CoE firmware version 0.314 and previous version, the LCD display shows the abbreviation of error message or warning message. For D1 firmware version 0.235, D1 CoE firmware version 0.315 and later version, the LCD display shows error code or warning code.



(a) Abbreviations of error message and warning message

(b) Error code and warning code

Figure7.2.1

Table7.2.2

No.	Abbreviation of Error Message	Error Code	Error Message in Lightning
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
8	E08M.HOT	ERR E08	Motor over temperature sensor activated
9	E09UND.V	ERR E09	Under voltage detected
10	E10V5ERR	ERR E10	5 V for encoder card fail
11	E11PHINI	ERR E11	Phase initialization error

No.	Abbreviation of Error Message	Error Code	Error Message in Lightning
12	E12SER.E	ERR E12	Serial encoder communication error
13	E13HAL.E	ERR E13	Hall sensor error
14	E14PHERR	ERR E14	Hall phase check error
15	E15CURER	ERR E15	Current control error
19	E19HFLT	ERR E19	HFLT inconsistent error
20	E20ATOPH	ERR E20	Auto phase center not completed error
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

Note:

- (1) For D1 firmware version 0.234, D1 CoE firmware version 0.314 and previous version, the LCD display shows the abbreviation of error message or warning message.
- (2) For D1 firmware version 0.235, D1 CoE firmware version 0.315 and later version, the LCD display shows error code or warning code.

Table7.2.3

No.	Abbreviation of Warning Message	Warning Code	Warning Message in Lightning
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
12	W12I2T	WRN W12	I2T warning
13	W13HOM.E	WRN W13	Homing fails
14	W14HOM.C	WRN W14	Pulse command and homing conflict

Note:

- (1) For D1 firmware version 0.234, D1 CoE firmware version 0.314 and previous version, the LCD display shows the abbreviation of error message or warning message.
- (2) For D1 firmware version 0.235, D1 CoE firmware version 0.315 and later version, the LCD display shows error code or warning code.

7.3 Display parameters page

Press **Up** key or **Down** key in display parameters page to switch among parameters, please refer to figure 7.3.1. The first line on the LCD display is parameter name. The second line is its value and status.



Figure7.3.1

Table7.3.1 Descriptions of abbreviations

Displayed Abbreviation	Physical Quantity	Description	Unit
01FBPO	Feedback position	Feedback position	count
02RFPO	Reference position	Position command	count
04POSE	Position error	Position error	count
10FBVE	Feedback velocity	Feedback velocity	LM: count/s DD: rpm
11RFVE	Reference velocity	Velocity command	LM: count/s DD: rpm
12VELE	Velocity error	Velocity error	LM: count/s DD: rpm
30ACTC	Actual current	Actual current	A_amp
31CMDC	Command current	Current command	A_amp
40ANAC	Analog command	Voltage command (From controller)	Volt
41DCBU	Bus voltage	Line voltage	Volt
50AMPT	Amplifier temperature	Servo drive temperature	°C
51SWTH	Soft-thermal accumulator	Software estimation for over temperature protection	-
52 I2T	I2T accumulator	I2T estimation	%
61 I1	I1	Input 1	-

Displayed Abbreviation	Physical Quantity	Description	Unit
62 I2	I2	Input 2	-
63 I3	I3	Input 3	-
64 I4	I4	Input 4	-
65 I5	I5	Input 5 (Motor over temperature signal)	-
66 I6	I6	Input 6	-
67 I9	I9	Input 9 (Pulse command)	-
68 I10	I10	Input 10 (Pulse command)	-
69 I11	I11	Input 11	-
70 I12	I12	Input 12	-
81 O1	O1	Output 1	-
82 O2	O2	Output 2	-
83 O3	O3	Output 3	-
84O4BK	O4/BRK	Output 4 (Brake signal)	-
90PHAS	Status: phase initialized	The status of phase initialization	-
91MOVI	Status: moving	Motion status	-
92HOME	Status: homed	Homing status	-
93ERRM	Status: error map active	The status of error map function	-
94 VER	Status: MDP version	The status of MDP version	-

The status displays of O1 to O4 are described in figure 7.3.2. The abbreviations of statuses are provided in table 7.3.2.

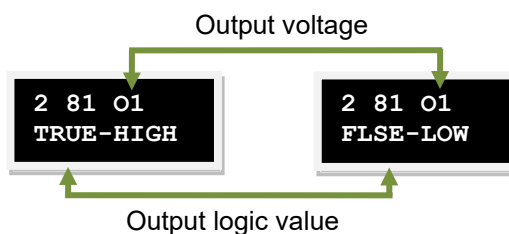


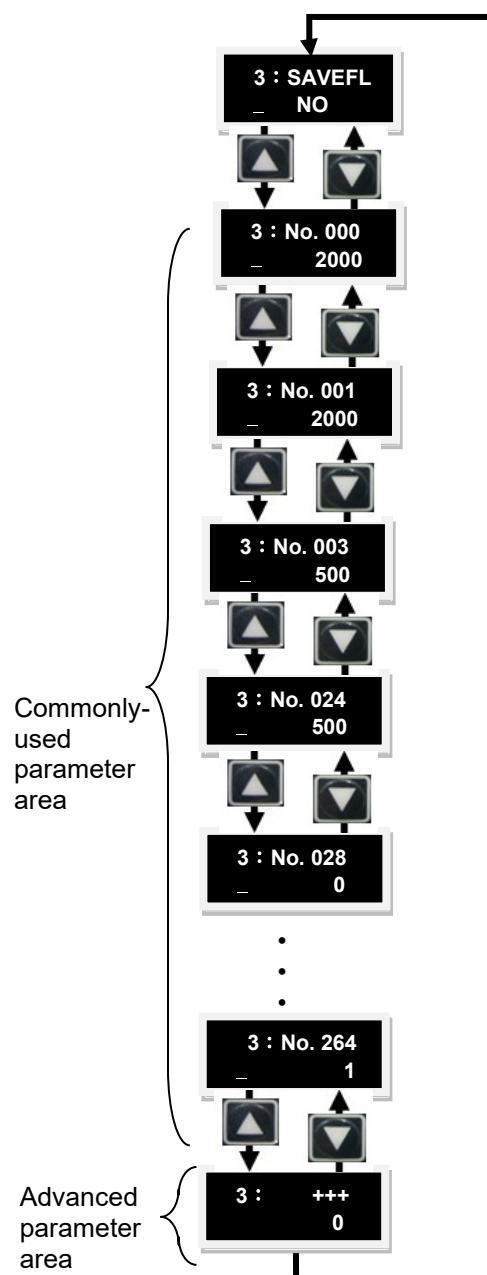
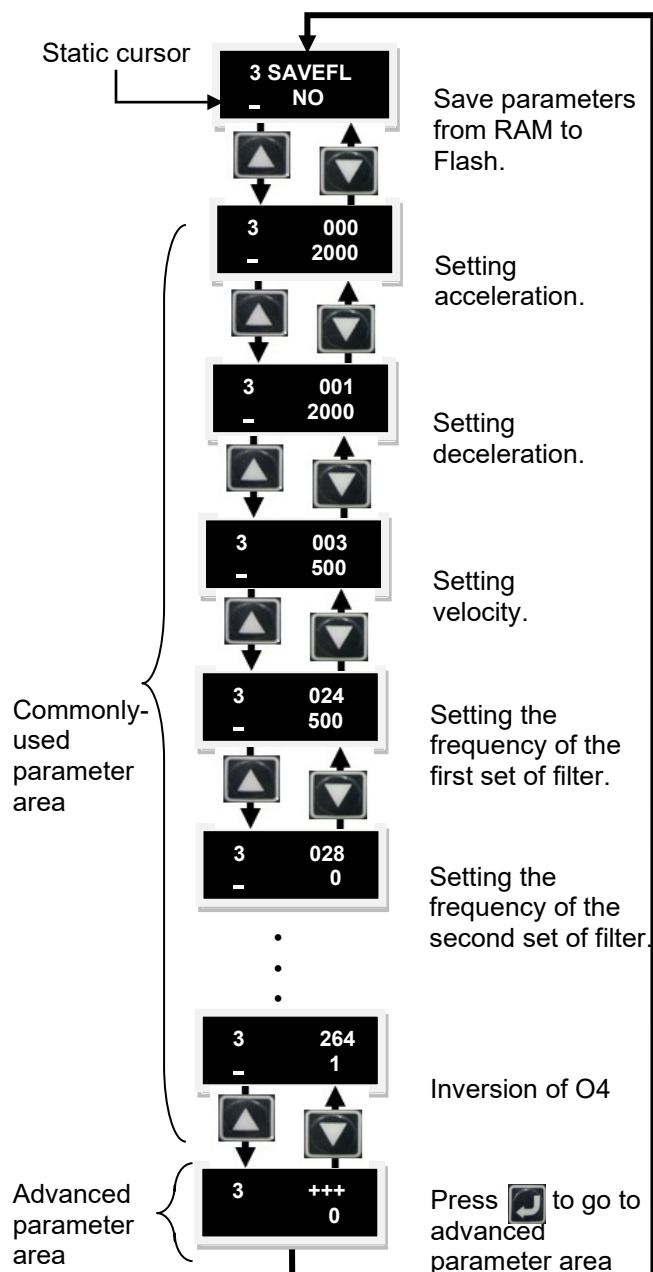
Figure7.3.2 Output status display

Table7.3.2 The abbrevaitions of output statuses

Displayed Abbreviation	Description
TRUE	True
FLSE	False
HIGH	High voltage
LOW	Low voltage

7.4 Change parameters page

The third page in the LCD display is change parameters page which is used for setting parameters. There are two areas, commonly-used parameter area and advanced parameter area, please refer to tables 7.4.1 and 7.4.3.1. In change parameters page, press **Up** key or **Down** key to switch among parameters, please refer to figure 7.4.1.



Note: Static cursor (blinking underline): The parameter can be edited.

(a) Displayed abbreviation

(b) Displayed code

Figure 7.4.1 Modifying parameters

Table 7.4.1 Table of commonly-used parameters (Set parameters based on actual situation.)

LCD No.	Function	Description
000	Acceleration	Set the maximum output acceleration of motor during motion.
001	Deceleration	Set the maximum output deceleration of motor during motion.
003	Velocity	Set the maximum velocity of motor during motion.
024	f1	Set the cutoff frequency of filter 1 in closed loop.
028	f2	Set the cutoff frequency of filter 2 in closed loop.
065	Servo gain	The servo stiffness is stronger as servo gain is higher. The servo stiffness is weaker as servo gain is lower.
081	The numerator of electronic gear ratio	The numerator of electronic gear ratio (output)
082	The denominator of electronic gear ratio	The denominator of electronic gear ratio (input)
083	Scaling of analog voltage command (velocity mode)	The scaling of velocity command Set the corresponding velocity of unit voltage.
085	Scaling of analog voltage command (force/torque mode)	The scaling of current command Set the corresponding current of unit voltage.
115	Smooth factor	Input range: 1~500 Larger smooth factor can have smoother motion profile.
129	Pulse type	0: Quadrature (AqB) 1: Pulse/Direction 2: Pulse up/Pulse down (CW/CCW)
130	Inversion of pulse command	0: Do not invert. 1: Invert.
212	Operation mode	0: Stand-alone mode 1: Position mode 2: Velocity mode 3: Force/torque mode
216	Switching between single-ended pulse signal and differential pulse signal	0: Single-ended 1: Differential
221	Inversion of I1	0: Do not invert. 1: Invert.
264	Inversion of O4	0: Do not invert. 1: Invert.

Note:

For the corresponding parameter of each LCD number, please refer to table 7.4.3.1.

7.4.1 Save to Flash

For how to save parameters from the servo drive RAM to Flash, please refer to below.

- Step 1: Press **Enter** key and select **SAVEFL** (There is a blinking cursor on the left of the second line.)
- Step 2: Press **Up** key or **Down** key to decide whether to save parameters from the servo drive RAM to Flash. Select **Yes** to proceed.
- Step 3: When motor is disabled, a message "PROCESS." appears when **Enter** key is pressed. This means parameters are being saved to Flash. A message "FINISH !" appears as the process completes, please refer to figure 7.4.1.1. If **Enter** key is pressed as motor is enabled, the motor will be disabled.

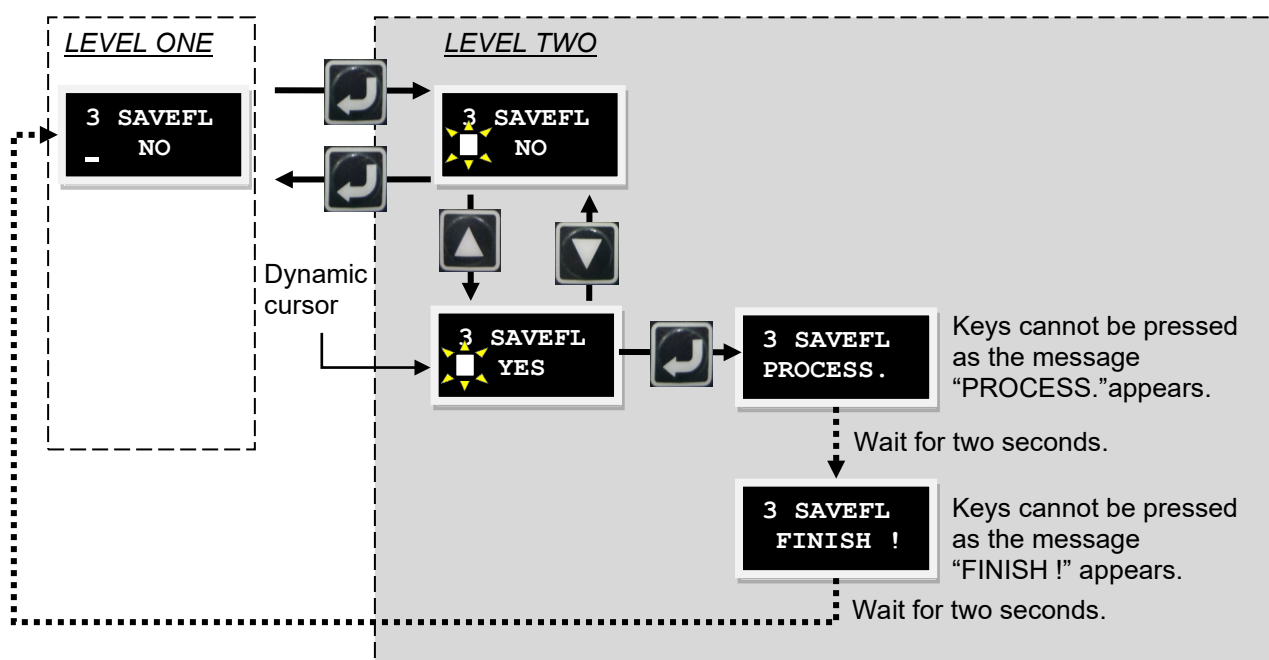


Figure7.4.1.1

7.4.2 Editing parameters

The parameters in the LCD display can be categorized into two types, enumerated type and non-enumerated type. The parameters marked with "#" in table 7.4.3.1 are enumerated type. For enumerated type, press **Enter** key to go to editing mode and set its value by pressing **Up** key or **Down** key. For non-enumerated type, user needs to input value by himself. At this time, **Up** key and **Down** key are used to move cursor or modify parameter value. Press **F** key to switch function. Take modifying common gain (CG, LCD No. 065) as an example here. We assume that CG must be changed from 0.5 to 1.2. Go to the page of LCD No. 065 and follow the steps below.

- Step 1: Press **Enter** key to go to the editing mode of LCD No. 065 (The dynamic cursor is on the left of the second line.)
- Step 2: Press **Down** key once to move the blinking cursor to the position of 0.
- Step 3: Press **F** key once (The function of **Up** key and **Down** key is to change parameter value.).
- Step 4: Press **Up** key twice to let the number become 1. For the switching sequence of numbers, please refer to figure 7.4.2.2.
- Step 5: Press **F** key once (The function of **Up** key and **Down** key changes to moving cursor.).
- Step 6: Press **Down** key twice to let the blinking cursor move to the position of 5.
- Step 7: Press **F** key once (The function of **Up** key and **Down** key changes to changing parameter value.).
- Step 8: Press **Down** key for four times to let the number become 2.
- Step 9: Press **Enter** key and CG has been changed to 1.2.

Note:

While using parameter editing function, please pay attention to the usage of **F** key.

- (1) When **F** key is pressed for less than one second, the function of **Up** key and **Down** key can be changed to moving cursor or changing parameter value.
- (2) When **F** key is pressed for more than two seconds, the display changes to LEVEL ONE and the changes will be ignored.

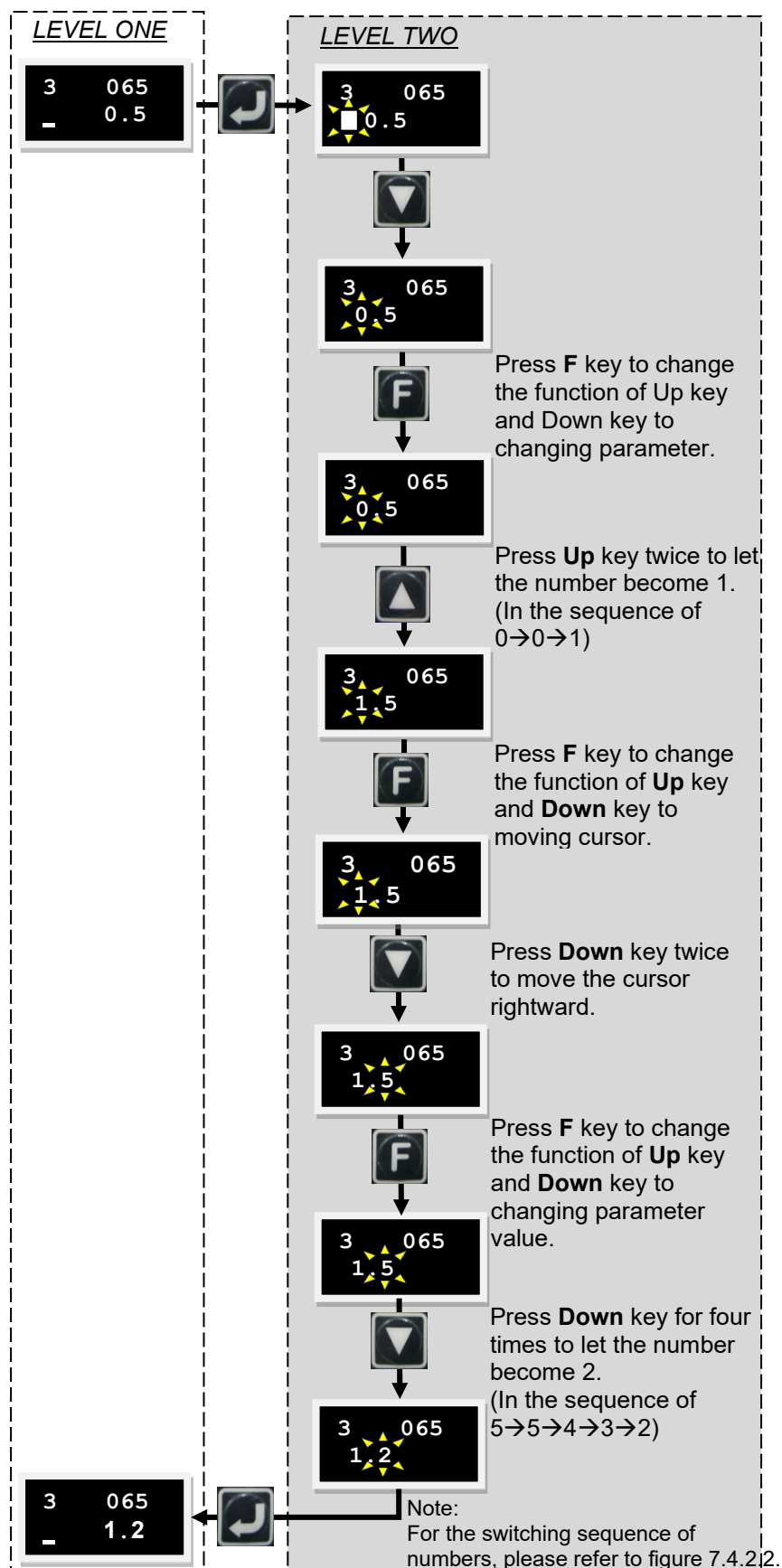


Figure7.4.2.1 Use changing common gain (LCD No. 065) as an example of parameter editing

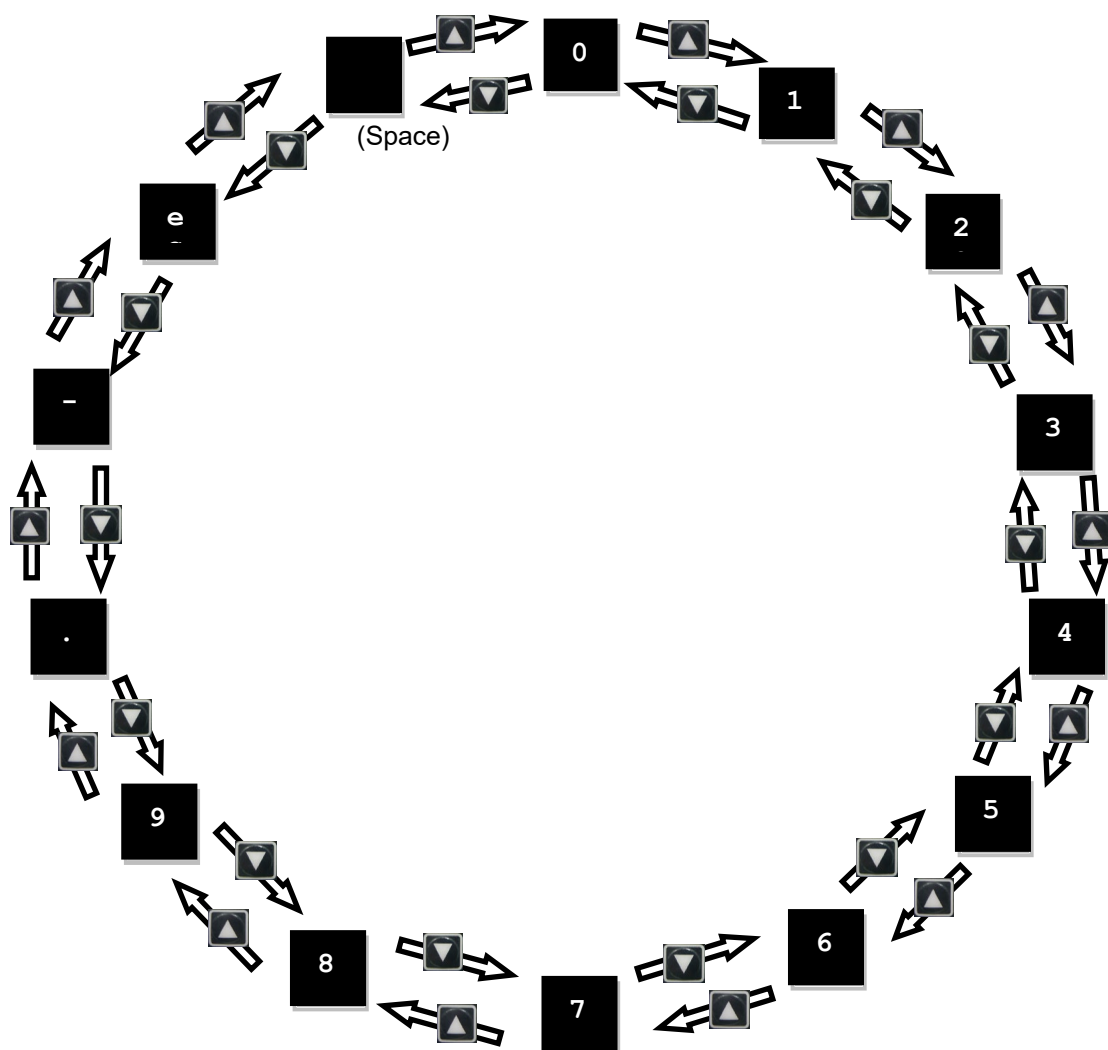


Figure7.4.2.2 The switching sequence of numbers

7.4.3 Advanced parameter area

To go to advanced parameter area, please follow the steps below.

Step 1: Press **Down** key until the LCD display shows “+++”. Press **Enter** key (There is a blinking cursor on the left of the second line.) to go to advanced parameter area. The advanced parameters are listed in table 7.4.3.1.

Step 2: The operation in advanced parameter area is the same as what is described in section 7.4.2.

Step 3: Press **Enter** key after editing parameter. The LCD display will show the modified parameter and its value. Press **F** key for two seconds to exit advanced parameter area. Please refer to the figure below.

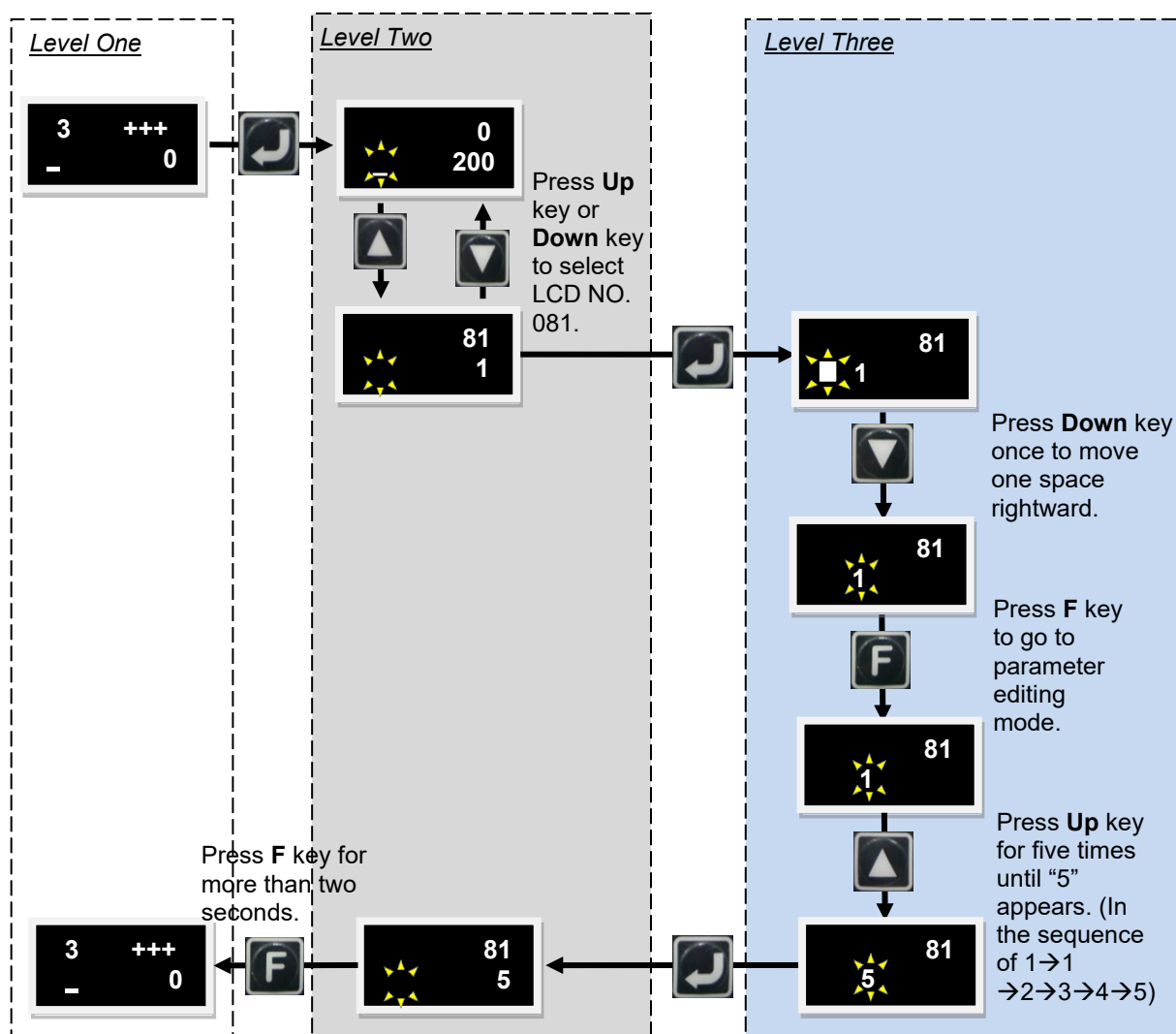


Figure7.4.3.1 Advanced parameter area

Table7.4.3.1 Advanced parameter table (Set parameters based on actual situation.)

LCD No.	Name	Definition	Unit	Default Value	Max.	Min.
000	X_acc	Set the maximum acceleration of motor during motion (Suggested value: Ten times of the maximum velocity of motor).	LM: count/s ² DD: rev/s ²	Refer to section 8.1.	2 ³¹ - 1	1
001	X_dcc	Set the maximum deceleration of motor during motion (Suggested value: Ten times of the maximum velocity of motor).	LM: count/s ² DD: rev/s ²	Refer to section 8.1.	2 ³¹ - 1	1
002	X_dcc_kill	The deceleration of motor for emergency stop (Suggested value: (1) Torque motor: Two times of the maximum deceleration (2) Linear motor: Ten times of the maximum deceleration)	LM: count/s ² DD: rev/s ²	Refer to section 8.1.	2 ³¹ - 1	1
003	X_vel_max	The maximum velocity of motor during motion (Suggested value: Do not exceed the rated velocity of motor)	LM: count/s DD: rpm	Refer to the catalogue of motor.	2 ³¹ - 1	1
007	X_p2p_pos1	Position 1 of point to point motion (P2P)	count	0	2 ³¹ - 1	- (2 ³¹ -1)
008	X_p2p_pos2	Position 2 of point to point motion (P2P)	count	10000	2 ³¹ - 1	- (2 ³¹ -1)
024	X_f1_fr	Cutoff frequency of filter 1 in closed loop	Hz	500	5000	0
028	X_f2_fr	Cutoff frequency of filter 2 in closed loop	Hz	0	5000	0
032	X_Upi_kp	Proportional gain of current loop (D axis)	-	Refer to section 6.6.5.	100000	1
033	X_Upi_ki	Integral gain of current loop (D axis)	-	Refer to section 6.6.5.	100000	0
039	X_index_vel	Homing speed (Slower speed)	count/s	10000	2 ³¹ - 1	1
040	X_index_tout	The maximum search time of homing procedure	66.67μs	25 sec	2 ³¹ - 1	1
048	X_st_vpg	Velocity gain of SW method 1 enabling	-	0.001	100	10 ⁻⁶
049	X_st_cg	Common gain of SW method 1 enabling	-	0.3	100	0.001
050	X_max_err	The maximum position error	count	1 pole pair pitch	2 ³¹ - 1	1
059	X_vpg	Velocity proportional gain of closed loop	-	0.001	1	10 ⁻⁶
064	X_affg	Acceleration feedforward gain of closed loop	-	0	1	0
065	X_CG	Servo gain	-	0.3	10	0.01
066	X_sg_run	Schedule gain (Gain during moving)	-	1	10	0.01
067	X_sg_idle	Schedule gain (Gain of in-position)	-	1	10	0.01
074	X_tr_time	Debounce time of in-position	66.67μs	100 ms	2 ³¹ - 1	0
075	X_tr	Target radius of in-position	count	100	2 ³¹ - 1	0
077	X_mass	Load mass of linear motor	Kg	2	2000	0.15
078	X_mInert	Moment of inertia of rotary motor	Kg*(m ²)	0.00002	50	10 ⁻⁶

LCD No.	Name	Definition	Unit	Default Value	Max.	Min.
079	X_gearRatyio	Gear ratio of AC servo motor	-	1	100	1
080	Vcmd_offs	Offset correction of analog input	Volt	0	10	-10
081	X_cmd_ext_N	The numerator of electronic gear ratio (output)	-	1	$2^{31} - 1$	1
082	X_cmd_ext_M	The denominator of electronic gear ratio (input)	-	1	$2^{31} - 1$	1
083	X_cmd_ext_v_sc	The scaling of velocity command The corresponding velocity of unit voltage (Suggested value: Rated velocity/10)	LM: mm/s DD: rpm	1 mm/s	3.4×10^{38}	-3.4×10^{38}
084	X_cmd_ext_v_dz	Deadband of velocity command When input voltage is smaller than this setting value, velocity command is 0.	Volt	0	10	0
085	X_cmd_ext_i_sc	The scaling of current command The corresponding current of unit voltage	A_amp/V	Motor peak current/10	3.4×10^{38}	-3.4×10^{38}
086	X_cmd_ext_i_dz	Deadband of current command When input voltage is smaller than this setting value, current command is 0.	Volt	0	10	0
088	X_pos_err_warn_win	Warning threshold of position error	count	0.5 pole pair pitch	$2^{31} - 1$	1
089	X_vel_err_warn_win	Warning threshold of velocity error	count/s	10^8	3.4×10^{38}	1
090	X_Resistance	Resistance of motor (Line-Line)	ohm	Refer to the catalogue of motor.	50	0.01
091	X_Inductance	Inductance of motor (Line-Line)	mH	Refer to the catalogue of motor.	250	0.01
092	X_vel_stop	Velocity for activating brake	count/s	0.05 mm/s	3.4×10^{38}	1
093	X_delMaxEnToBrk	Delay time for activating brake	66.67μs	500 ms	$2^{31} - 1$	1
094	X_delBrkToDis	Action time of brake	66.67μs	50 ms	$2^{31} - 1$	1
095	X_index_offs	Home offset	count	0	$2^{31} - 1$	0
114	X_Aenc_mulF _{ac}	Multiplier factor of analog encoder	-	8000	8000	1
115	X_new_sm_fa _c	Smooth factor	-	100	500	0
129#	X_pulse_mode	Pulse type 0: Quadrature(AqB) 1: Pulse/Direction 2: Pulse up/Pulse down (CW/CCW)	-	0	2	0
130#	X_pulse_dir	Invert pulse command. 0: Do not invert. 1: Invert.	-	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	Command input type in velocity mode and force/torque mode 0: Analog 1: PWM 50%	-	0	2	0

LCD No.	Name	Definition	Unit	Default Value	Max.	Min.
		2: PWM 100%				
133	out_config[0]	Setting O4 output signal.	-	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]	Setting O1 output signal.	-	49346	$2^{15} - 1$	0
138	out_config[5]		-	32828	$2^{15} - 1$	0
139	out_config[6]		-	98	$2^{15} - 1$	0
140	out_config[7]		-	135	$2^{15} - 1$	0
141	out_config[8]	Setting O2 output signal.	-	8	$2^{15} - 1$	0
142	out_config[9]		-	0	$2^{15} - 1$	0
143	out_config[10]		-	0	$2^{15} - 1$	0
144	out_config[11]		-	0	$2^{15} - 1$	0
145	out_config[12]	Setting O3 output signal.	-	0	$2^{15} - 1$	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
152#	X_StldmotTOv r	Setting motor over temperature signal. 0: No setting 80~85: I1~I6 86~87: I11~I12 88~89: I9~I10	-	84	89	0
155#	X_sw_pos_pro t_en	Enable/Disable software limits. 0: Disable software limits. 1: Enable software limits.	-	0	1	0
156#	X_hw_lim_prot _en	Enable/Disable hardware limits. 0: Disable hardware limits. 1: Enable hardware limits.	-	1	1	0
157	X_emu_N	The numerator of emulated encoder output	-	1	$2^{31} - 1$	1
158	X_emu_M	The denominator of emulated encoder output	-	1	$2^{31} - 1$	1
164	X_emu_i_radi us	Index radius of emulated encoder	count	10	$2^{31} - 1$	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
179	X_home_vel	Homing speed (Faster speed)	count/s	20000	$2^{31} - 1$	1
180#	X_home_option	Homing mode 0: Go left or right for homing. 1: Homing by searching for near home sensor or index signal.	-	1	1	0
181#	X_home_DIR	Start direction of homing	-	0	1	0

LCD No.	Name	Definition	Unit	Default Value	Max.	Min.
		0: Left 1: Right				
182#	X_home_opt0_index	Set whether to search for index when first homing mode is used. 0: Home position is at the middle of travel distance. 1: Home position is at index.	-	0	1	0
183#	X_home_left_SW	Left side condition 0: None 1: End stop 2: Limit switch	-	0	2	0
184#	X_home_right_SW	Right side condition 0: None 1: End stop 2: Limit switch	-	0	2	0
185	X_home_wall_CurrThrshld	The current for finding end stop (Note: curr_drv_peak is the peak current of the servo drive.)	(A_amp×1000)/(curr_drv_peak)	0	2 ³¹ - 1	1
186	X_home_wall_CurrTime	The time for finding end stop	msec	0	2 ³¹ - 1	1
187#	X_home_select_Speed	The initial speed of the second homing mode 0: Slower speed 1: Faster speed	-	0	1	0
188#	X_home_search_option	The homing method of the second homing mode 0: Search for index only. 1: Search for near home sensor 2: After near home sensor is found, move leftward and search for index. 3: After near home sensor is found, move rightward and search for index.	-	0	3	0
189	X_backlash	Backlash	count	0	2 ³¹ - 1	0
190#	X_r_compensation	Enable/Disable resolver signal offset compensation 0: Disable compensation table. 1: Enable compensation table.	-	0	1	0
209#	X_Use_DynamicBrk	Dynamic brake 0: Do not use dynamic brake. 1: Use dynamic brake.	-	0	1	0
212#	X_oper_mode1	Primary operation mode 0: Stand-alone mode 1: Position mode 2: Velocity mode 3: Force/torque mode	-	0	3	0
213#	X_oper_mode2	Secondary operation mode 0: Stand-alone mode 1: Position mode 2: Velocity mode 3: Force/torque mode	-	0	3	0
216#	LCD.sing_or_diff	Switch between single-ended pulse signal and differential pulse signal. 1: Single-ended pulse input 0: Differential pulse input	-	0	1	0

LCD No.	Name	Definition	Unit	Default Value	Max.	Min.
217#	LCD.buff_inv	Invert buffered encoder output. 0: Do not invert. 1: Invert.	-	0	1	0
218#	LCD.emu_or_buff	Switch between buffered encoder output and emulated encoder output 0: Buffered encoder output 1: Emulated encoder output	-	0	1	0
221#	LCD.I1_inv	Invert input I1. 0: Do not invert. 1: Invert.	-	0	1	0
222#	LCD.I2_inv	Invert input I2. 0: Do not invert. 1: Invert.	-	0	1	0
223#	LCD.I3_inv	Invert input I3. 0: Do not invert. 1: Invert.	-	0	1	0
224#	LCD.I4_inv	Invert input I4. 0: Do not invert. 1: Invert.	-	0	1	0
225#	LCD.I5_inv	Invert input I5. 0: Do not invert. 1: Invert.	-	0	1	0
226#	LCD.I6_inv	Invert input I6. 0: Do not invert. 1: Invert.	-	0	1	0
229#	LCD.I9_inv	Invert input I9. 0: Do not invert. 1: Invert.	-	0	1	0
230#	LCD.I10_inv	Invert input I10. 0: Do not invert. 1: Invert.	-	0	1	0
231#	LCD.I11_inv	Invert input I11. 0: Do not invert. 1: Invert.	-	0	1	0
232#	LCD.I12_inv	Invert input I12. 0: Do not invert. 1: Invert.	-	0	1	0
261#	LCD.O1_inv	Invert output O1. 0: Do not invert. 1: Invert.	-	0	1	0
262#	LCD.O2_inv	Invert output O2. 0: Do not invert. 1: Invert.	-	0	1	0
263#	LCD.O3_inv	Invert output O3. 0: Do not invert. 1: Invert.	-	0	1	0
264#	LCD.O4_inv	Invert output O4. 0: Do not invert. 1: Invert.	-	1	1	0
300#	LCD.pullA_down_up	Group A-Switch between high level and low level (Pull A). 0: High level 1: Low level	-	0	1	0
301#	LCD.pullB_down_up	Group B-Switch between high level and low level (Pull B). 0: High level 1: Low level	-	0	1	0

LCD No.	Name	Definition	Unit	Default Value	Max.	Min.
302#	LCD.pullC_down_up	Group C-Switch between high level and low level (Pull C). 0: High level 1: Low level	-	0	1	0
303#	LCD.pullD_down_up	Group D-Switch between high level and low level (Pull D). 0: High level 1: Low level	-	0	1	0
349#	X_VOF.FB_Switch	Enable/Disable velocity observer. 0: Disable velocity observer. 1: Enable velocity observer.	-	0	1	0
350	X_delRelsBrk	The delay time to turning on servo drive circuit after brake deactivates.	66.67μs	0	2 ³¹ - 1	0
353#	X_latch_err_tdrv	Latch error message "over temperature". 0: Disable 1: Enable	-	1	1	0
354#	X_latch_err_underv	Latch error message "undervoltage". 0: Disable 1: Enable	-	0	1	0
355#	X_mult_emu_index	Output emulated index signal in every revolution. 0: Disable 1: Enable	-	0	1	0
356	X_encPwrOnTime	Delay time for encoder power on	ms	200	2 ³¹ - 1	0

Note:

The parameters marked with "#" are enumerated type. To change this type of parameter by LCD panel, press **Enter** key to go to editing mode and set its value by pressing **Up** key or **Down** key.

7.5 Actions page

Actions page allows user to perform functions such as enabling, disabling, jog, absolute motion and set current position to zero. Motion velocity and target position can also be set in this page. Press **Up** key or **Down** key to select the required function, please refer to figures 7.5.1 and 7.5.2. The detailed operating procedures are provided in the following sections. (Take LCD display which shows abbreviations as the example here.)

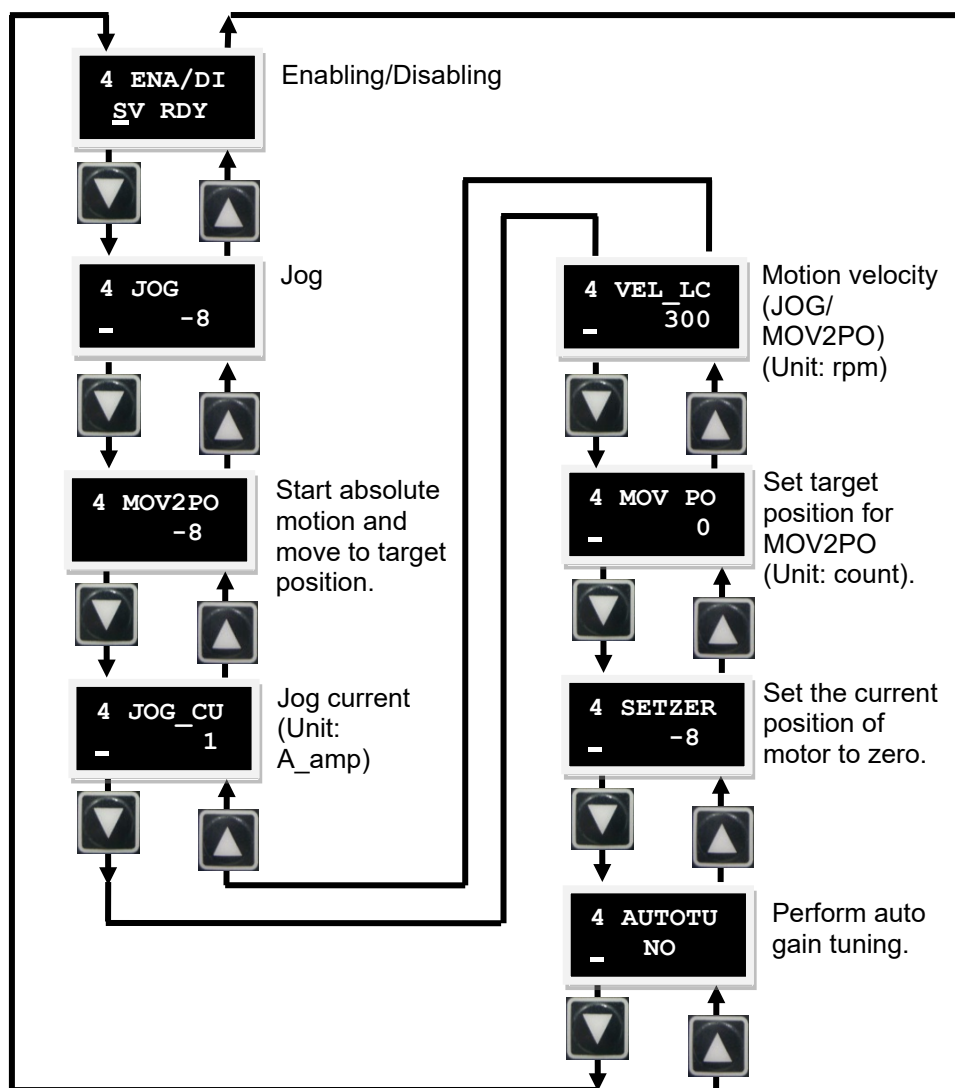


Figure7.5.1 Operation flow chart (Take LCD display which shows abbreviations as the example here.)

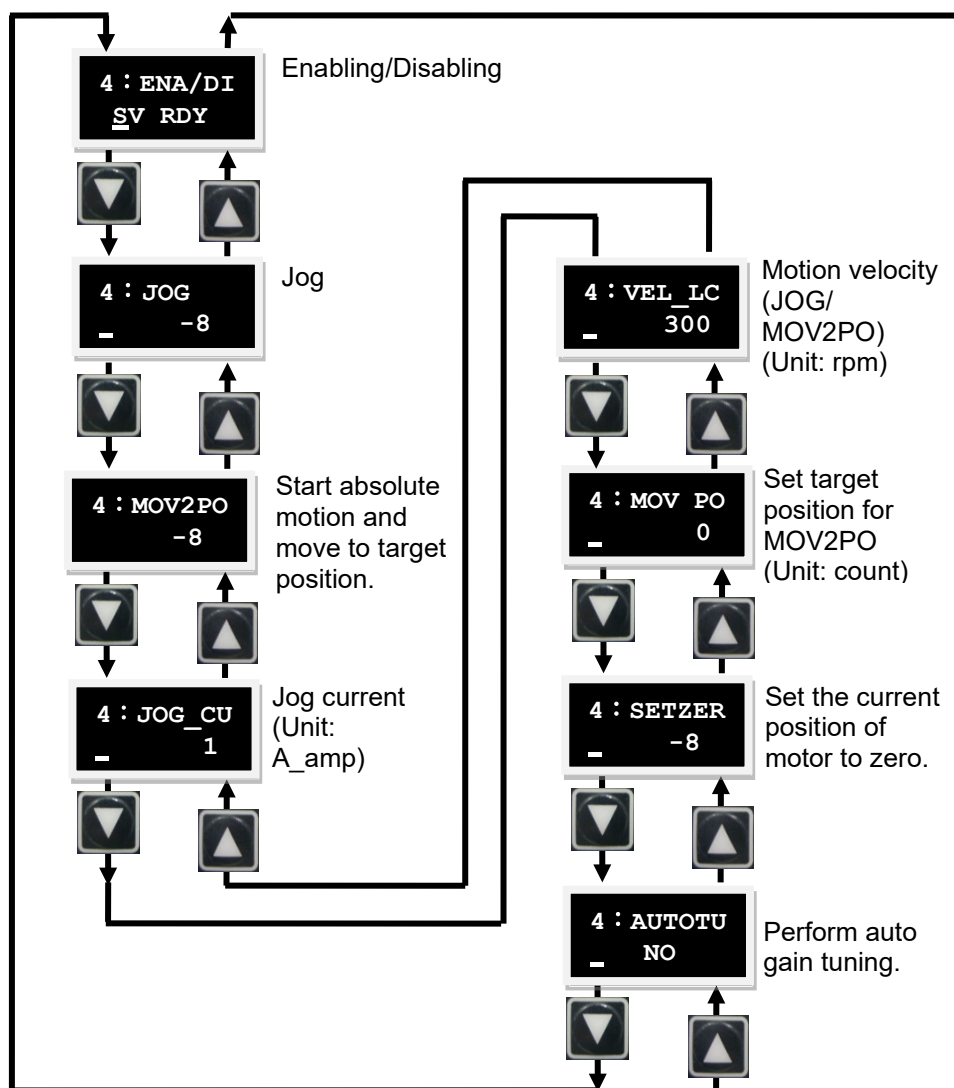


Figure7.5.2 Operation flow chart (Take LCD display which shows codes as the example here.)

7.5.1 Enabling and disabling

Before using this function to enable or disable motor, ensure external enable signal is input to the servo drive or whether LCD No. 221 (Invert input I1.) is 1. The default setting of I1 is for the input of axis enable signal. Follow the steps below to enable or disable motor. The operation flow chart is provided in figure 7.5.1.1.

- Step 1: Press **Enter** key to show **ENA/DI** (The static cursor is on the left of the second line.).
- Step 2: Press **UP** key or **Down** key to select **ENABLE** or **DISABLE**.
- Step 3: Press **Enter** key to complete setting.

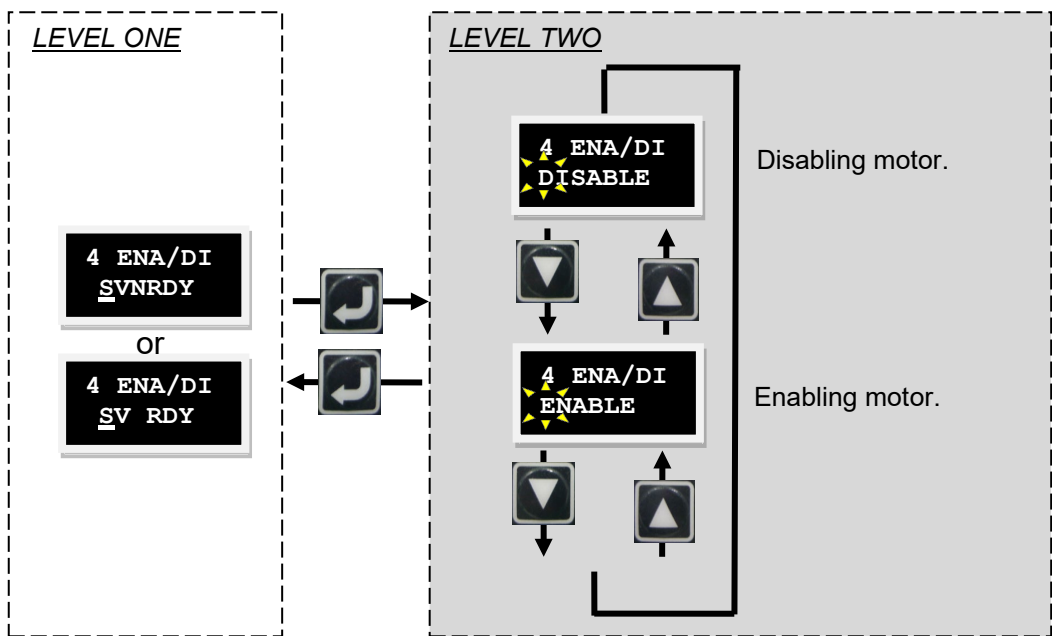


Figure7.5.1.1 The operation flow chart of enabling or disabling motor

7.5.2 Jog

Follow the steps below to perform jog. The operation flow chart is provided in figure 7.5.2.1.

Step 1: Press **Enter** key to show **JOG** (A solid blinking cursor is on the left of the second line.).

Step 2: Press **Up** key or **Down** key to move the motor towards positive direction or negative direction.

While the motor is moving, the feedback position is shown in the LCD display. The motor stops as the key is not pressed.

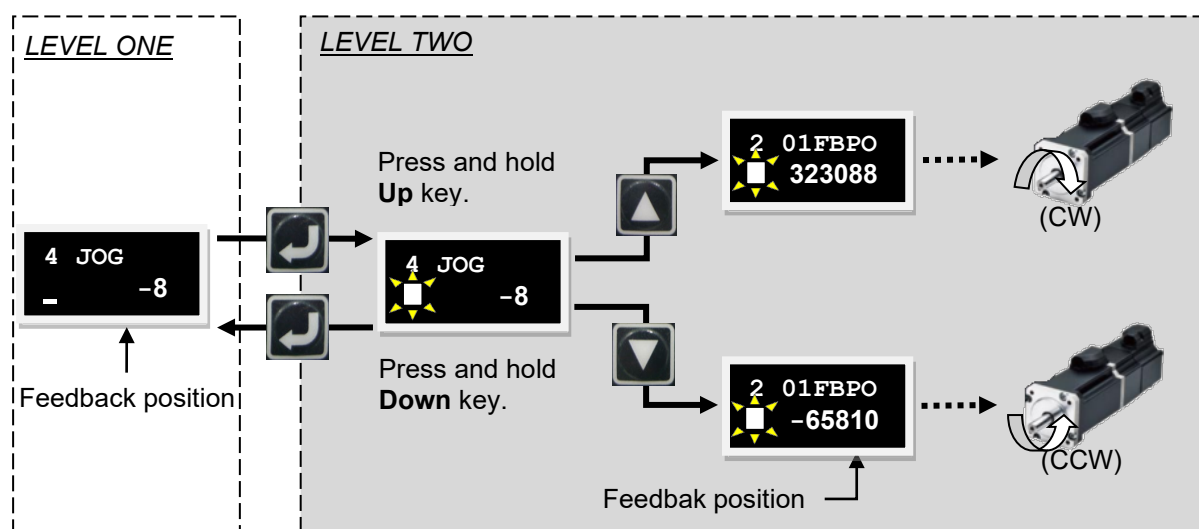


Figure 7.5.2.1 The operation flow chart of jog

Note:

In force/torque mode, the jog speed is not based on the setting of VEL_LC, but it is based on the speed set for motion protection

7.5.3 Absolute motion

Follow the steps below to perform absolute motion. The operation flow chart is provided in figure 7.5.3.1. The absolute position of the example below is 2000.

- Step 1: Press **Up** key or **Down** key to show **MOV PO** for setting target position. For the setting method, please refer to section 7.4.2. Set the target position to 2000.
- Step 2: Move to option **MOV2PO** and press **Enter** key (A solid blinking cursor is on the left of the second line.) to display current position. At this time, the motor is not moving yet.
- Step 3: Press **Up** key to start motion. The motor moves to the target position set in **MOV PO** at the speed set in **VEL_LC**. During motion, the feedback position (01FB PO) will be shown in the second line of LCD display. If user would like to abort motion, press **Enter** key and the motor stops moving. Press **Up** key to continue moving to the target position.
- Step 4: Press **Enter** key to return to LEVEL ONE.

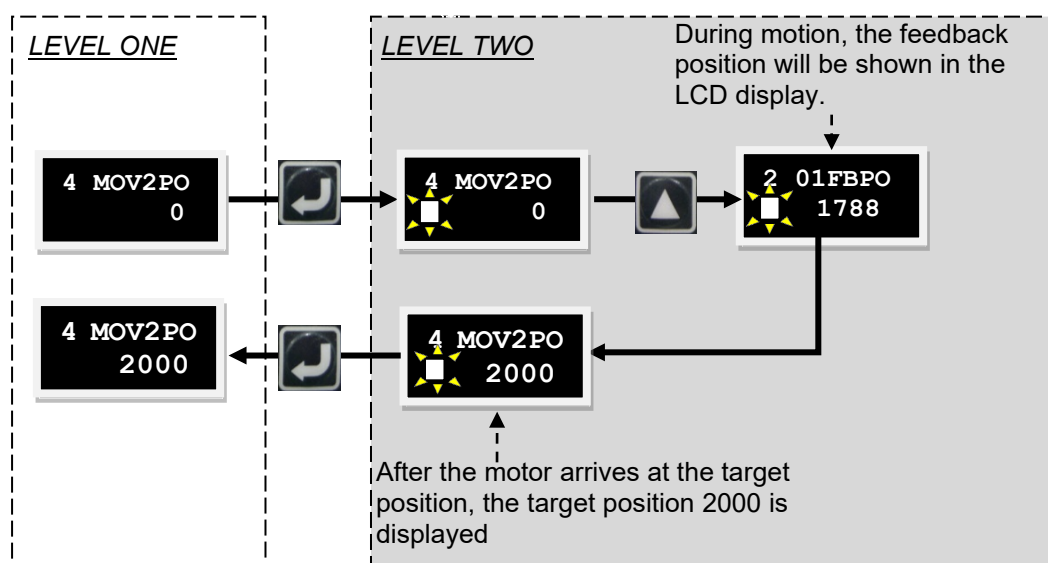


Figure7.5.3.1 The operation flow chart of absolute motion

7.5.4 Auto gain tuning

Follow the steps below to perform auto gain tuning (AUTOTU). The operation flow chart is provided in figure 7.5.4.1.

- Step 1: Press **Enter** key to show **AUTOTU** (A solid blinking cursor is on the left of the second line.).
- Step 2: Press **Up** key or **Down** key to select whether to perform auto gain tuning.
- Step 3: Select **AUTOTU YES** and press **Enter** key. Then the servo drive performs auto gain tuning. If **AUTOTU NO** is selected, the servo drive does not perform auto gain tuning.

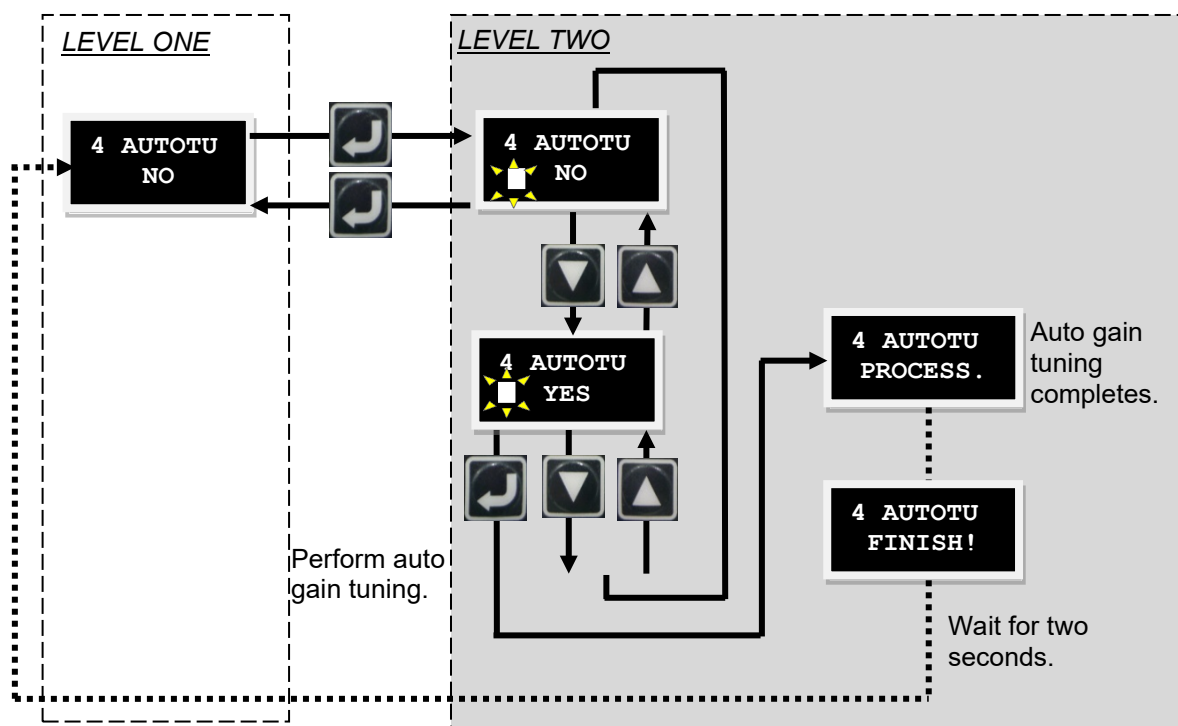


Figure7.5.4.1 The operation flow chart of auto gain tuning

7.5.5 Setting current position to zero

Follow the steps below to set current position to zero. The operation flow chart is provided in figure

7.5.5.1. Press **Up** key or **Down** key to show **SETZER**. Press **Enter** key to set current position to zero.

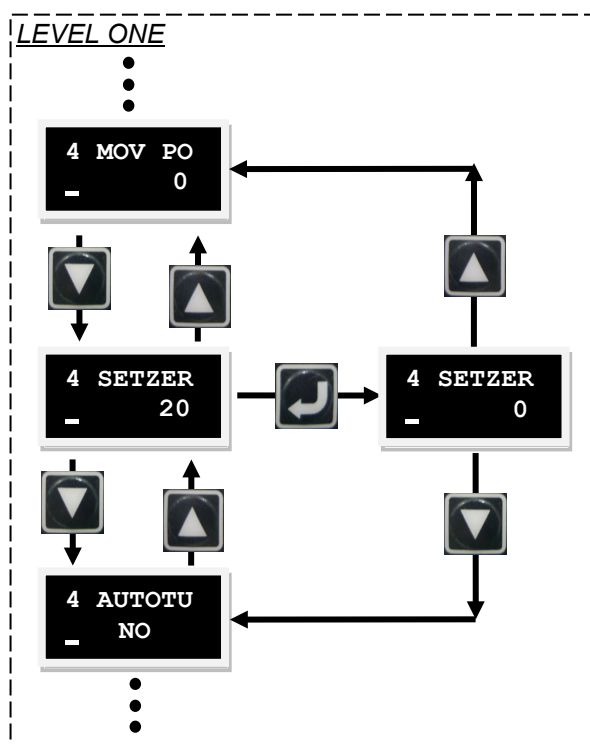


Figure7.5.5.1 The operation flow chart of setting current position to zero

7.6 Setting operation mode via LCD panel

The examples provided in the following sections use the LCD display which shows codes.

7.6.1 Position mode

In position mode, the motor moves for a corresponding distance after receiving pulse command. For detailed information, please refer to section 3.1.1.

The setting of position mode includes mode selection, pulse type selection, single-ended pulse signal/differential pulse signal setting, electronic gear ratio setting and smooth factor setting. After setting, save parameters to Flash by referring to section 7.4.1.

(1) Mode selection

The steps of setting position mode via LCD panel are provided in table 7.6.1.1.

Table7.6.1.1

Step	LCD Display	Key	Description
1			Open the parameter editing page of the LCD display.
2			Press and hold Down key to go to LCD No. 212 page (Refer to the note below.) which is the operation mode selection page.
3			Press Enter key to go to editing mode.
4			Press Up key once and set the parameter to 1 (Position mode).
5			Press Enter key to complete setting.

Note:

Refer to the table below for the parameter setting of operation mode.

Table7.6.1.2











LCD Number	Parameter	Definition	Initial Value
212	X_oper_mode1	Operation mode 0: Stand-alone mode 1: Position mode 2: Velocity mode 3: Force/torque mode	0

(2) Pulse type selection

D1 servo drive supports three pulse types. For detailed information, please refer to section 3.1.1.

The steps of setting pulse type via LCD panel are provided in table 7.6.1.3.

Table7.6.1.3

Step	LCD Display	Key	Description
1			Continue from the setting page of mode selection.
2			Press Down key twice to go to pulse type setting page (Refer to the note below.)
3			Press Enter key to go to editing mode.
4			Press Up key or Down key to select the required pulse type. Note: In this example, Pulse up/Pulse down (CW/CCW) is set.
5			Press Enter key to complete setting.

If user would like to set inversion of pulse command (LCD No. 130) and positive/negative logic switching of CW/CCW pulse (LCD No. 219), the setting method is the same as that of pulse type setting (LCD No. 129).

Note:

Refer to the table below for the parameter setting of pulse type.



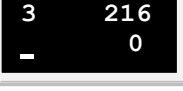





Table7.6.1.4

LCD Number	Parameter	Definition	Initial Value
129	X_pulse_mode	Pulse type 0: Quadrature (AqB) 1: Pulse/Direction 2: Pulse up/Pulse down (CW/CCW))	0
130	X_pulse_dir	Invert pulse command 0: Do not invert. 1: Invert.	0
219	LCD.cw_ccw_inv	Positive/negative logic switching of CW/CCW pulse 0: Do not invert. 1: Invert.	0

(3) Single-ended pulse signal/differential pulse signal setting

D1 servo drive supports both single-ended pulse signal and differential pulse signal. The steps of setting single-ended pulse signal input or differential pulse signal input are provided in table 7.6.1.5.

Table7.6.1.5

Step	LCD Display	Key	Description
1			Continue from the setting page of pulse type selection.
2			Press and hold Up key to go to LCD No. 216 page (Refer to the note below.) which is the setting page of single-ended pulse signal and differential pulse signal.
3			Press Enter key. Then press Up key once to change the parameter to 1. Note: In this example, differential pulse signal input is set.
4			Press Enter key to complete setting.

Note:

Refer to the table below for the parameter setting of single-ended pulse signal or differential pulse signal.

Table7.6.1.6

LCD Number	Parameter	Definition	Initial Value
216	LCD.sing_or_diff	Set single-ended pulse signal input and differential pulse signal input. 0: Single-ended 1: Differential	0

(4) Electronic gear ratio setting

D1 servo drive provides two sets of electronic gear ratios. For detailed information, please refer to section 5.4.1. The steps of setting electronic gear ratio are provided in table 7.6.1.7.

Table7.6.1.7

Step	LCD Display	Key	Description
1			Continue from the setting page of single-ended pulse signal and differential pulse signal.
2			Press and hold Down key to go to LCD No. 81 page (Refer to the note below.) which is the setting page of the numerator of electronic gear ratio (output).
3			Press Enter key. Then change the parameter from 1 to 3. Note: In this example, the gear ratio is set to 2:3. Two input pulses equal three encoder counts.
4			Press Enter key to complete the setting of encoder count.
5			Press Up key once to go to LCD No. 82 page (Refer to the note below.) which is the setting page of the denominator of electronic gear ratio (input).
6			Press Enter key. Then change the parameter from 1 to 2.
7			Press Enter key to complete input pulse setting.

Note:

Refer to the table below for the parameter settings of electronic gear ratio and pulse input method.

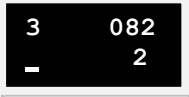

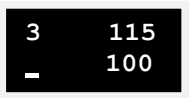

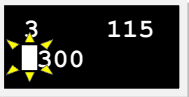

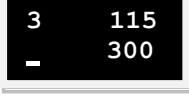

Table7.6.1.8

LCD Number	Parameter	Definition	Initial Value
81	X_cmd_ext_N	The numerator of electronic gear ratio (output)	1
82	X_cmd_ext_M	The denominator of electronic gear ratio (input)	1

(5) Smooth factor setting

Use smooth factor to create S-curve velocity profile or T-curve velocity profile. The setting range is 0~500. For detailed information, please refer to section 3.4. The steps of setting electronic gear ratio are provided in table 7.6.1.9.

Table7.6.1.9

Step	LCD Display	Key	Description
1			Continue from the setting page of electronic gear ratio.
2			Press and hold Up key to go to LCD No. 115 page (Refer to the note below.) which is the setting page of smooth factor.
3			Press Enter key. Then set smooth factor according to your requirement.
4			Press Enter key to complete setting.

Note:

Refer to the table below for the parameter setting of smooth factor.

Table7.6.1.10

LCD Number	Parameter	Definition	Initial Value
115	X_new_sm_fac	Smooth factor	100

7.6.2 Velocity mode

D1 servo drive is able to convert voltage command and PWM command into velocity command. For detailed information, please refer to section 3.1.2. The setting of velocity mode includes mode selection and command input type setting. After setting, save parameters to Flash by referring to section 7.4.1.

(1) Mode selection

The steps of setting velocity mode via LCD panel are provided in table 7.6.2.1.

Table7.6.2.1











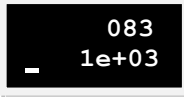









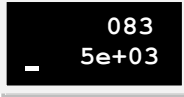




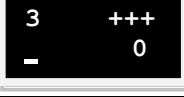




Step	LCD Display	Key	Description
1			Open the parameter editing page of the LCD display.
2			Press and hold Down key to go to LCD No. 212 page which is the operation mode selection page.
3			Press Enter key to go to editing mode.
4			Press Up key twice and set the parameter to 2 (Velocity mode).
5			Press Enter key to complete setting.

(2) Command input type setting

The steps of setting command input type via LCD panel are provided in table 7.6.2.2.

Table7.6.2.2

Step	LCD Display	Key	Description
1			Continue from the setting page of mode selection.
2			Press and hold Down key to go to LCD No. +++ page which is the advanced parameter area.
3			Press Enter key to go to the advanced parameter area.
4			Press and hold Up key to go to LCD No. 132 page which is the command input type selection page for velocity mode and force/torque mode (Refer to the note below.).

Step	LCD Display	Key	Description
5		   	Press Up key or Down key to set command input type. Note: In this example, analog voltage command input is set.
6		   	Press Enter key to complete command input type setting.
7		   	Press and hold Down key to go to LCD No. 83 page which is the setting page for the scaling of velocity command (Refer to the note below.).
8		   	Press Enter key. Then set the scaling of velocity command. (To invert voltage command or PWM command, add a negative sign in front of the scaling.)
9		   	Press Enter key to complete the setting of the scaling of velocity command.
10		   	Press and hold F key to go to LCD No. +++ page which is the commonly-used parameter area.

The setting method of the deadband of velocity command (LCD No. 084) is the same as that of the scaling of velocity command (LCD No. 083).

Note:

Refer to the table below for the parameter setting of command input type.

Table7.6.2.3

LCD Number	Parameter	Definition	Initial Value
132	X_cmd_pwm_mode	The command input type of velocity mode and force/torque mode 0: Analog 1: PWM 50% 2: PWM 100%	0
83	X_cmd_ext_v_sc	The scaling of velocity command Input the corresponding velocity of unit voltage or the corresponding maximum velocity of full PWM. (LM (DD) unit: mm/s (rpm) = 1V or mm/s (rpm) = full PWM)	1 mm/s
84	X_cmd_ext_v_dz	The deadband of velocity command Velocity command is 0 when input voltage is smaller than this setting value. (Unit: volt)	0

7.6.3 Force/torque mode

D1 servo drive is able to convert voltage command and PWM command into current command. For detailed information, please refer to section 3.1.3. The setting of velocity mode includes mode selection and command input type setting. After setting, save parameters to Flash by referring to section 7.4.1.

(1) Mode selection

The steps of setting force/torque mode via LCD panel are provided in table 7.6.3.1.

Table7.6.3.1











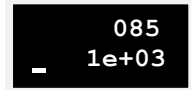




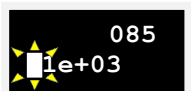




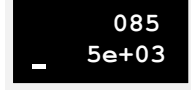




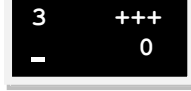




Step	LCD Display	Key	Description
1			Open the parameter editing page of the LCD display.
2			Press and hold Down key to go to LCD No. 212 page which is the operation mode selection page.
3			Press Enter key to go to editing mode.
4			Press Up key for three times and set the parameter to 3 (Force/torque mode).
5			Press Enter key to complete setting.

(2) Command input type setting

The steps of setting command input type via LCD panel are provided in table 7.6.3.2.

Table7.6.3.2

Step	LCD Display	Key	Description
1			Continue from the setting page of mode selection.
2			Press and hold Down key to go to LCD No. +++ page which is the advanced parameter area.
3			Press Enter key to go to the advanced parameter area.
4			Press and hold Up key to go to LCD No. 132 page which is the command input type selection page for velocity mode and force/torque mode (Refer to the note below.).

Step	LCD Display	Key	Description
5		   	Press Up key or Down key to set command input type. Note: In this example, analog voltage command input is set.
6		   	Press Enter key to complete command input type setting.
7		   	Press and hold Down key to go to LCD No. 85 page which is the setting page for the scaling of current command (Refer to the note below.).
8		   	Press Enter key. Then set the scaling of velocity command. (To invert voltage command or PWM command, add a negative sign in front of the scaling.)
9		   	Press Enter key to complete the setting of the scaling of current command.
10		   	Press and hold F key to go to LCD No. +++ page which is the commonly-used parameter area.

The setting method of the deadband of current command (LCD No. 086) is the same as that of the scaling of current command (LCD No. 085).

Note:

Refer to the table below for the parameter setting of command input type.

Table7.6.3.3

LCD Number	Parameter	Definition	Initial Value
132	X_cmd_pwm_mode	The command input type of velocity mode and force/torque mode 0: Analog 1: PWM 50% 2: PWM 100%	0
85	X_cmd_ext_i_sc	The scaling of current command Input the corresponding current of unit voltage or the corresponding maximum current of full PWM. (Unit: A_amp = 1 V or A_amp = full PWM)	Motor peak current/10
86	X_cmd_ext_i_dz	The deadband of current command Current command is 0 when input voltage is smaller than this setting value. (Unit: volt)	0

7.6.4 Stand-alone mode

In stand-alone mode, the servo drive performs path planning to drive motor. For detailed information, please refer to section 3.1.4. The setting of stand-alone mode includes mode selection. After setting, save parameters to Flash by referring to section 7.4.1.

(1) Mode selection

The steps of setting force/torque mode via LCD panel are provided in table 7.6.4.1.

Table7.6.4.1

Step	LCD Display	Key	Description
1			Open the parameter editing page of the LCD display.
2			Press and hold Down key to go to LCD No. 212 page which is the operation mode selection page. Note: In this example, the operation mode is changed from position mode to stand-alone mode.
3			Press Enter key to go to editing mode.
4			Press Down key once and set the parameter to 0 (Stand-alone mode).
5			Press Enter key to complete setting.

8. Protection function

8.	Protection function.....	8-1
8.1	Motion protection.....	8-2
8.2	Position and velocity error protection	8-5
8.2.1	Position error limit	8-5
8.2.2	Position error warning and velocity error warning.....	8-5
8.3	Brake protection	8-6
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8.6	Overvoltage protection	8-11

8.1 Motion protection

Motion protection limits or specifies the maximum speed, maximum acceleration, maximum deceleration and deceleration of emergency stop. When the requested speed or acceleration is too high, motion protection will be activated to constrain motion by values set for motion protection. Motion protection varies in different operation mode, please refer to table 8.1.1.



Table8.1.1

Limited Parameter Operation Mode	Speed	Acceleration	Deceleration	Deceleration of Emergency Stop (Dec. Kill)
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 motion protection is supported. “X” means motion protection is not supported.

(1) Set speed, acceleration and deceleration limits

Click on  to go to Performance center. The setting page for motion parameters is indicated in figure 8.1.1. Click on  to go to Protection center. The same motion parameters can be observed in **Protection** tab, but they are for display only and cannot be modified.

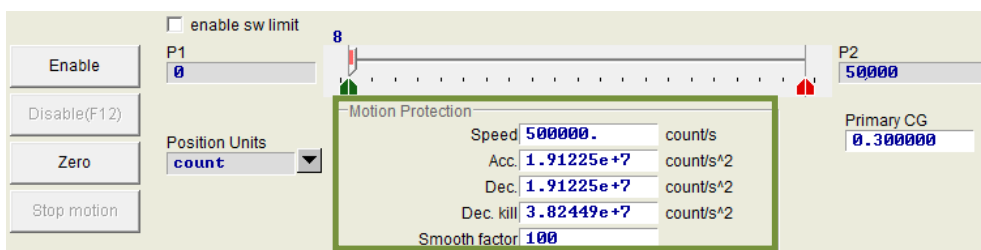


Figure8.1.1

Table8.1.2

Parameter	Description	Default Setting
Speed	Set the maximum speed of motor during motion.	Linear motor: 100 mm/s Torque motor: Rated speed
Acc.	Set the maximum acceleration of motor during motion.	Linear motor: $1/10 * (K_t * I_p / \text{Moving Mass})^{*1}$ Torque motor: $1/2 * (K_t * I_p / (10 * J_m))^{*2}$
Dec.	Set the maximum deceleration of motor during motion.	Linear motor: $1/10 * (K_t * I_p / \text{Moving Mass})^{*1}$ Torque motor: $1/2 * (K_t * I_p / (10 * J_m))^{*2}$
Dec. Kill	The deceleration of emergency stop	Linear motor: $10 * \text{Acc.}$ Torque motor: $2 * \text{Acc.}$
Smooth Factor	Smooth factor	Linear motor: 100 Torque motor: 100

Note:

- (1) *¹The maximum default setting of **Acc.** and **Dec.** of linear motor is 2 G.
- (2) *²J_m is the moment of inertia obtained from inertia estimation.

In figure 8.1.1, the maximum speed, maximum acceleration and maximum deceleration of motion can be set in the setting area of **Motion protection**. User can select preferred unit from the drop-down list of **Position units**. In addition to motion protection, these settings are also used for test run.

While performing point to point motion (P2P), relative move and jog in Performance center, ensure the parameters set in the area of **Motion protection** are for motion protection. In position mode or velocity mode, multiply the setting values of Acc. and Dec. by 10 to 100, so the performance will not be limited by motion protection function. If not, the performance could be limited.

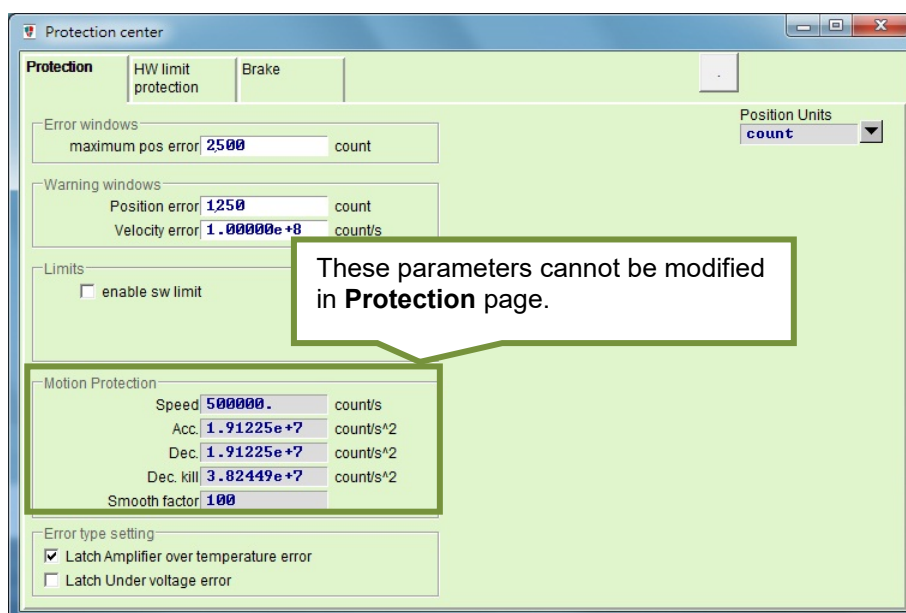


Figure8.1.2

(2) Cancel speed, acceleration and deceleration limits

In position mode, when smooth factor is set to 0, it means speed, acceleration and deceleration limits are cancelled. At this time, the motor moves exactly according to the path planned by the controller. User can decide whether to cancel the limit function of the servo drive.

(3) Applicable timing of deceleration of emergency stop (Dec. kill)

In the following occasions, deceleration of emergency stop will be used.

- A. In position mode or velocity mode, the motor is disabled and emergency stop is activated.
- B. While performing point to point motion (P2P) or relative move in Performance center, **Stop motion** button is clicked on.
- C. The deceleration after home position is found
- D. The deceleration used in jog.

(4) Smooth motion

Set smooth factor to reduce the impact of motor force to load during acceleration and deceleration. This parameter is designed by the number of samples in moving average filter, as shown in figure 8.1.3. The relationship between filter time constant and smooth factor is described as below.

- Models which do not support CoE communication: Filter time constant = Smooth factor × 0.5333 ms
- Models which support CoE communication: Filter time constant = Smooth factor × 0.5 ms

The setting range of smooth factor is from 0 to 500. Higher value means smaller impact. Set smooth factor to 1 to disable smooth function. Since the impact caused by motor force is decreased as smooth factor is increased, in some occasions, settling performance can be enhanced. However, smoother motion may have longer move time, please refer to section 3.7. Find suitable value for smooth factor by executing test run and tuning on your machine. When smooth factor is set to 0, the motion protection of the servo drive is disabled. In stand-alone mode, smooth factor cannot be 0.

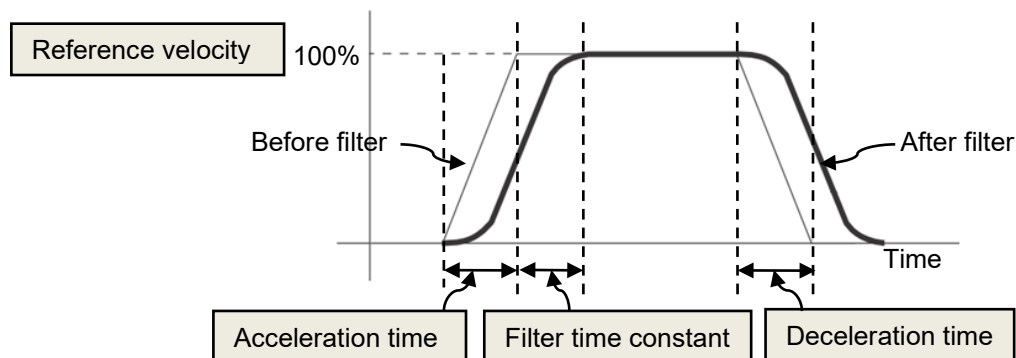


Figure8.1.3

8.2 Position and velocity error protection

8.2.1 Position error limit

In servo control, position error inevitably exists. Position error increases as motor moves, or due to other reasons such as friction from bearings or linear guideways, tight winding or cable tray, intrusion of foreign matter, reach of hard stop, abnormal encoder, interference, etc. To avoid excessive position error, D1 servo drive allows user to set error window. When position error exceeds the setting value of error window, error “Position error too big” occurs. Emergency stop will be activated. Brake signal will be output and motor will be disabled. The setting area for error window is shown in figure 8.2.1.1.



Figure8.2.1.1

Table8.2.1.1



Parameter	Description
Maximum pos error	Position error limit
Position error	Warning value of position error
Velocity error	Warning value of velocity error

8.2.2 Position error warning and velocity error warning

In addition to the position error limit described in section 8.2.1, D1 servo drive also provides warning function. When position error or velocity error exceeds the setting in **Warning windows**, a warning message will appear in the main window of Lightning to inform user.

8.3 Brake protection

D1 servo drive supports brake signal output to enable electromagnetic brake to protect motor and mechanism. This is often used for motor of Z axis. The timing of enabling brake is essential in such application. When motor moves in Z direction at high speed and the servo drive receives disabling command and commands the brake to engage directly, a huge vibration may occur and cause damage to the mechanism. If the motor is disabled too early, the motor and mechanism may possibly slip. Therefore, D1 servo drive provides brake parameters to avoid the above situations.

Click on  to go to Protection center. Click on **Brake** tab to open the setting page for the timing diagram of brake engagement. Click on  to set the output pin of brake signal. The default setting is O4. For setting method of digital output, please refer to section 5.4.2.

When the servo drive receives the disabling command from hardware or software, it will start the following procedures.

- Step 1: When the servo drive receives disabling command, the brake engages after the delay time set in **delMaxEnToBrk**. If the velocity of the motor is less than the value set in **vel_stop**, the brake also engages.
- Step 2: Then after the time set in **delBrkToDis**, the motor is disabled.

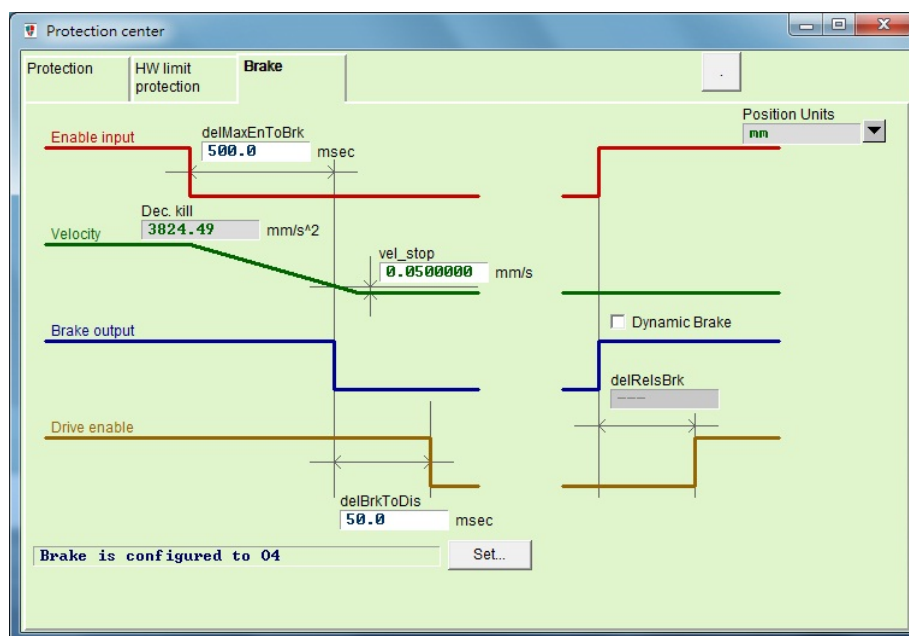


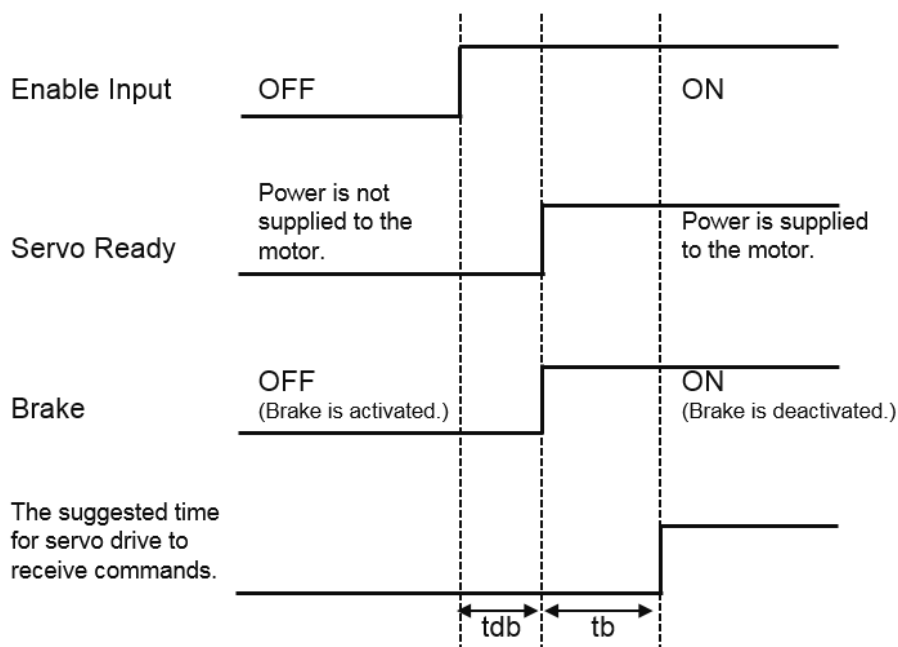
Figure8.3.1

Table8.3.1

Parameter	Description
Delay Time for Brake Engagement (delMaxEnToBrk)	Maximum time from the time when disabling command is received to the time when brake engages.
Deceleration of Emergency Stop (Dec. kill)	Deceleration of motor brake when emergency stop is activated. Refer to section 8.1.
Velocity for Brake Engagement (vel_stop)	After disabling command is received, brake engages as the motor reaches this velocity.
Brake Engagement Time (delBrkToDis)	Delay time from the time when brake engages to the time post-stage circuit is shut down.
Dynamic Brake Relay Delay Time (delRelsBrk)	The delay time to the completion of dynamic brake relay switching after brake disengages.

If the servo drive is connected to dynamic brake, in disabling state, the motor connects to brake resistor for braking. In enabling state, the motor needs to connect to the servo drive for enabling. The switch between the above two operation is done by relay. Therefore, the servo drive needs to wait for the motor to switch from the brake resistor to the servo drive before enabling. If the servo drive tries to enable the motor before it connects to the servo drive, error “Motor maybe disconnected” may occur. To avoid this problem, check the checkbox of **Dynamic Brake** and set proper delay time for relay.

To prevent the brake and the rotor of motor from abrasion due to delay in brake release, a time delay is required after the servo drive is in servo ready state and the brake is released.



Note:

- (1) **tdb** is the delay time for dynamic brake to switch relay (delRelsBrk).
- (2) **tb** is the delay time for mechanical brake to switch relay.


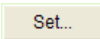
Refer to the release time of the motor brake for its setting.

Figure8.3.2

8.4 Limit protection

8.4.1 Hardware limit protection

D1 servo drive supports hardware limit protection. Hardware limit usually means the photoelectric switch or micro switch installed on positioning platform to identify travel distance. Hardware limit switch is usually a normally-closed sensor. When hardware limit switch is triggered, the servo drive decelerates the motor by the value set for emergency stop (Dec. kill). At this time, the servo drive only accepts motion command for moving the motor towards the opposite direction.

Click on  to go to Protection center. Select **HW limit protection** tab to open the setting page for hardware limit. Check the checkbox of **Enable HW limit** to enable hardware limit protection. Click on  to open the setting window of I/O center to set the input pin of hardware limit signal. For setting method of digital input, please refer to section 5.4.1.

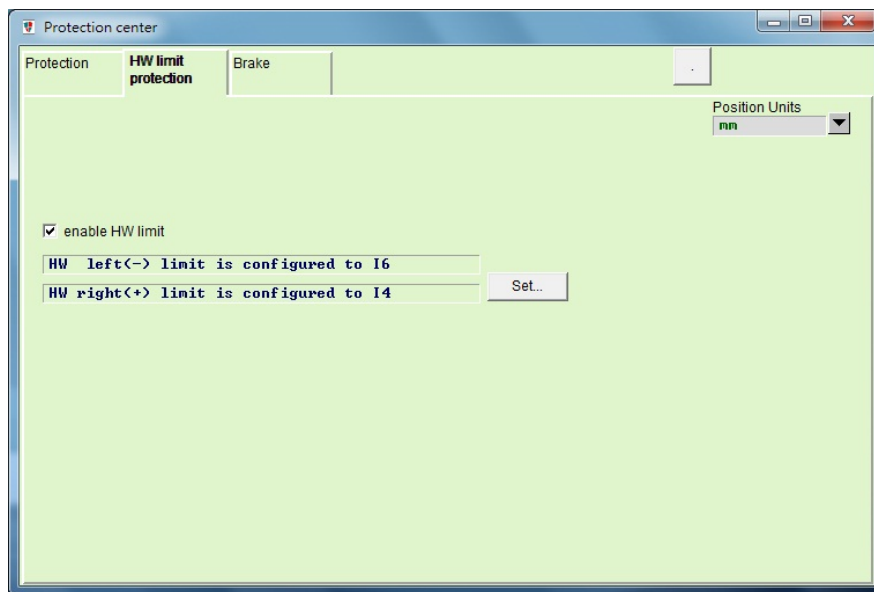



Figure8.4.1.1

8.4.2 Software limit protection

In addition to hardware limit protection, D1 servo drive also supports software limit protection. When motor reaches the position of software limit, the servo drive only accepts motion command for moving the motor towards the opposite direction.

Click on  to go to Protection center and select **Protection** tab. Software limits can be set in the setting area of **Limits**. Check the checkbox of **enable sw limit** to set software limits. Software limit protection can be enabled by checking the checkbox of **enable sw limit** in Performance center.

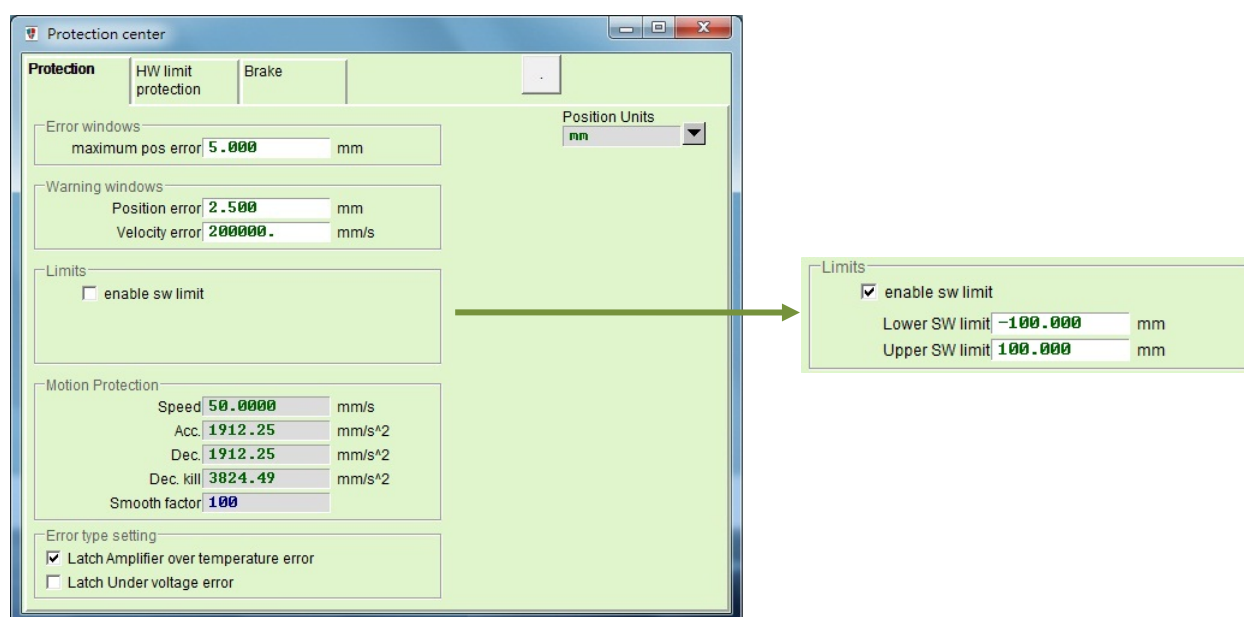


Figure8.4.2.1

Table8.4.2.1

Parameter	Description
enable sw limit	Set to enable or disable software limit protection.
Lower SW limit	Set the position of negative software limit.
Upper SW limit	Set the position of positive software limit.

8.5 Over temperature protection

8.5.1 Motor over temperature protection

Normally temperature switch will be installed inside motor to detect if the temperature is too high. Over temperature signal can be connected to the servo drive to protect motor. The default input pin of motor over temperature protection is I5. (I5 is on feedback connector CN3.) Temperature switch is usually normally-closed. When temperature is within normal range, temperature switch is closed. When temperature is too high, temperature switch is open. As temperature switch is activated, error message “Motor over temperature sensor activated” appears. Then the servo drive executes emergency stop procedure and disables the motor.

8.5.2 Software over temperature protection

In addition to motor over temperature protection, D1 servo drive is able to estimate motor temperature via software. The estimated temperature is obtained by evaluating the current output from the servo drive. If the estimated temperature reaches the threshold in the servo drive, error message “Soft-thermal threshold reached” appears. Then the servo drive executes emergency stop procedure and disables the motor. Select **Soft-thermal accumulator** in Quick view to check the current estimated temperature.

8.5.3 Servo drive over temperature protection

D1 servo drive is able to detect servo drive over temperature. When the temperature of the servo drive reaches 80 °C, error message “Amplifier over temperature” appears and the motor is stopped. Select **Amplifier temperature** in Quick view to check the current temperature of the servo drive.

8.6 Overvoltage protection

When motor decelerates, it generates energy. The energy returns to the capacitors of the servo drive. When the returned energy exceeds the capacity of the capacitors, regenerative resistor must be installed to protect the servo drive by absorbing the returned energy. For D1 servo drive, the voltage threshold for activating regenerative resistor is 390 Vdc; the voltage threshold for deactivating regenerative resistor is 380 Vdc. Regenerative resistors used in HIWIN standard products are listed in table 8.6.1. Connect them parallelly or serially based on your need.

Table8.6.1

Regenerative Resistor Model	HIWIN Part Number	Resistance	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 \pm 2 mm	150 \pm 2 mm	40 \pm 0.5 mm	5.3 \pm 0.5 mm	20 \pm 0.5 mm
RG2	215 \pm 2 mm	200 \pm 2 mm	60 \pm 1 mm	5.3 \pm 1 mm	30 \pm 1 mm
RG3	190 \pm 2 mm	175 \pm 2 mm	40 \pm 1 mm	5.2 \pm 1 mm	20 \pm 1 mm
RG4	390 \pm 2 mm	360 \pm 2 mm	60 \pm 1 mm	9 \pm 1 mm	28 \pm 1mm

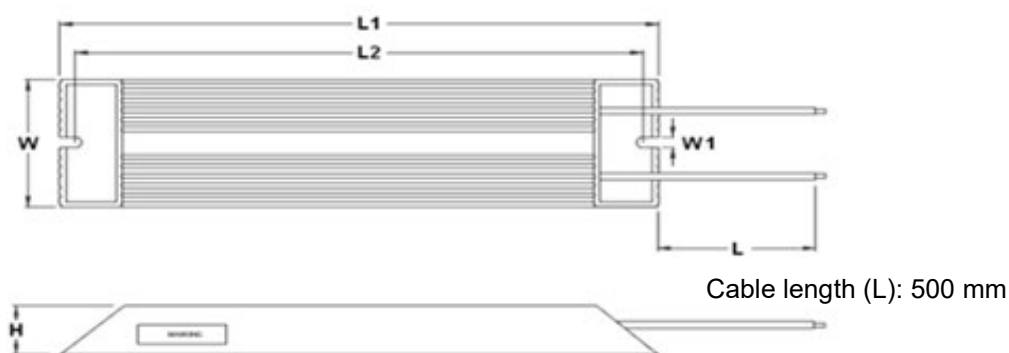


Figure8.6.1

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9. Errors and warnings

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9.1 Error messages and warning messages

If an error occurs, D1 servo drive will activate protection function and display error message in the area of **Last error**. If a warning occurs, warning message will be displayed in the area of **Last warning**.

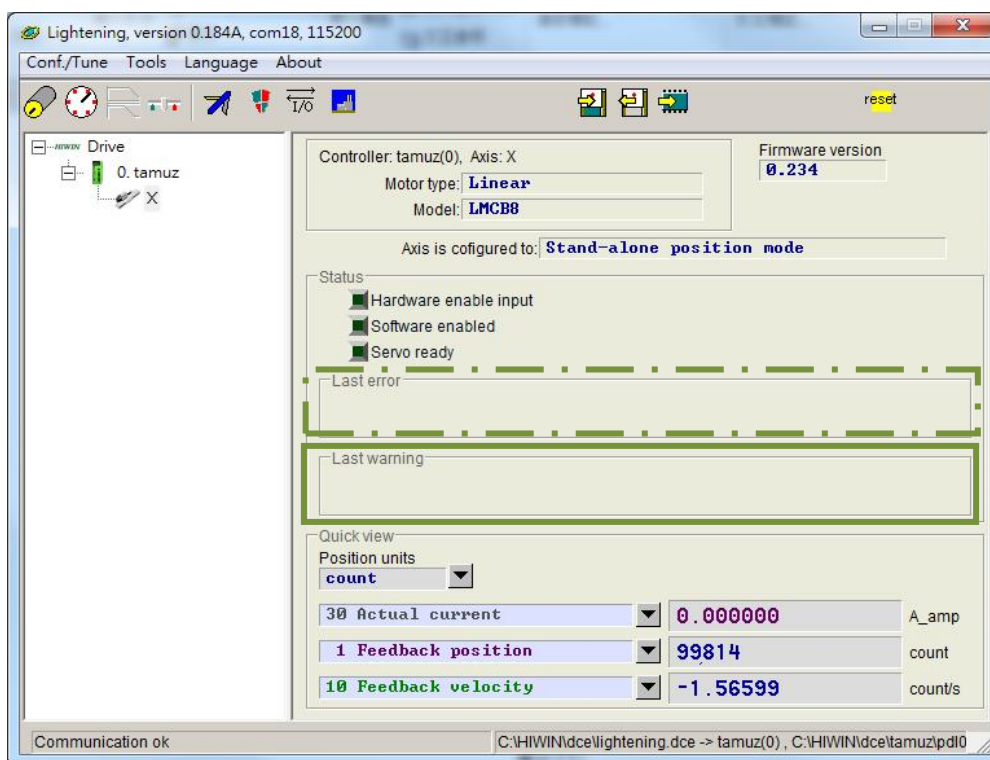


Figure9.1.1

The error messages of D1 servo drive and their meanings are listed in table 9.1.1.

Table9.1.1

No.	Error	Description
1	Motor short (over current) detected	Motor short circuit is detected.
2	Over voltage detected	The DC bus voltage inside the servo drive is too big.
3	Position error too big	Position error is greater than the value set for error.
4	Encoder error	(1) Digital encoder – Phase sequence error of A phase and B phase (2) Analog encoder – Sinusoidal signal is too weak when motor is not moving.
5	Soft-thermal threshold reached	The software detects motor over temperature.
6	Motor maybe disconnected	The motor power cable and the servo drive are not correctly connected.
7	Amplifier over temperature	Servo drive over temperature
8	Motor over temperature sensor activated	Motor over temperature sensor is activated.
9	Under voltage detected	The DC bus voltage inside the servo drive is too small.
10	5 V for encoder card fail	5 V voltage supplied to encoder interface card is abnormal.
11	Phase initialization error	Motor phase initialization fails.
12	Serial encoder communication error	Serial encoder communication error
13	Hall sensor error	Hall sensor is abnormal.
14	Hall phase check error	Error occurs while executing phase check by digital Hall sensor.
15	Current control error	Abnormal current control
19	HFLT inconsistent error	Hardware signal conflict
20	Auto phase center not completed error	Phase initialization is not completed yet.
22	DC bus voltage abnormal	DC bus voltage is abnormal. Check the input voltage.
23	EtherCAT interface is not detected	The servo drive does not detect EtherCAT interface.
24	CiA-402 homing error	An error occurs when performing CiA-402 homing and causes homing failure.

The warning messages of D1 servo drive and their meanings are listed in table 9.1.2.

Table9.1.2

No.	Warning	Description
1	Left SW limit	The left software limit is triggered.
2	Right SW limit	The right software limit is triggered.
3	Left HW limit	The left hardware limit is triggered.
4	Right HW limit	The right hardware limit is triggered.
5	Servo voltage big	The motor is close to the maximum velocity for operation.
6	Position error warning	Position error is greater than the setting value for warning.
7	Velocity error warning	Velocity error is greater than the setting value for warning.
8	Current Limited	Current reaches the maximum instantaneous current of motor specification.
9	Acceleration Limited	The value set for acceleration protection is reached.
10	Velocity Limited	The value set for speed protection is reached.
11	Both HW limits active	Both left and right hardware limits are triggered.
12	I2T Warning	The force of linear motor or torque motor exceeds the threshold of software over temperature protection.
13	Homing Fail	Homing fails.
14	Pulse command and homing conflict	In position mode, pulse command and homing command are both received.

9.2 Error and warning log

When D1 servo drive detects error or warning, the error or warning will be displayed in the main window of Lightening and will be saved in Errors and Warnings Log, as figure 9.2.1. To prevent user from missing the errors or warnings reported by the servo drive, the errors or warnings occur after power on (24 Vdc) are saved in Errors and Warnings Log. In **Time log** tab of **Errors and Warnings Log** window, errors and warnings occur after power on are recorded in time sequence. The time when each error or warning occurs will also be recorded.

Note:

The errors and warnings saved in Errors and Warnings Log are cleared after re-power on.

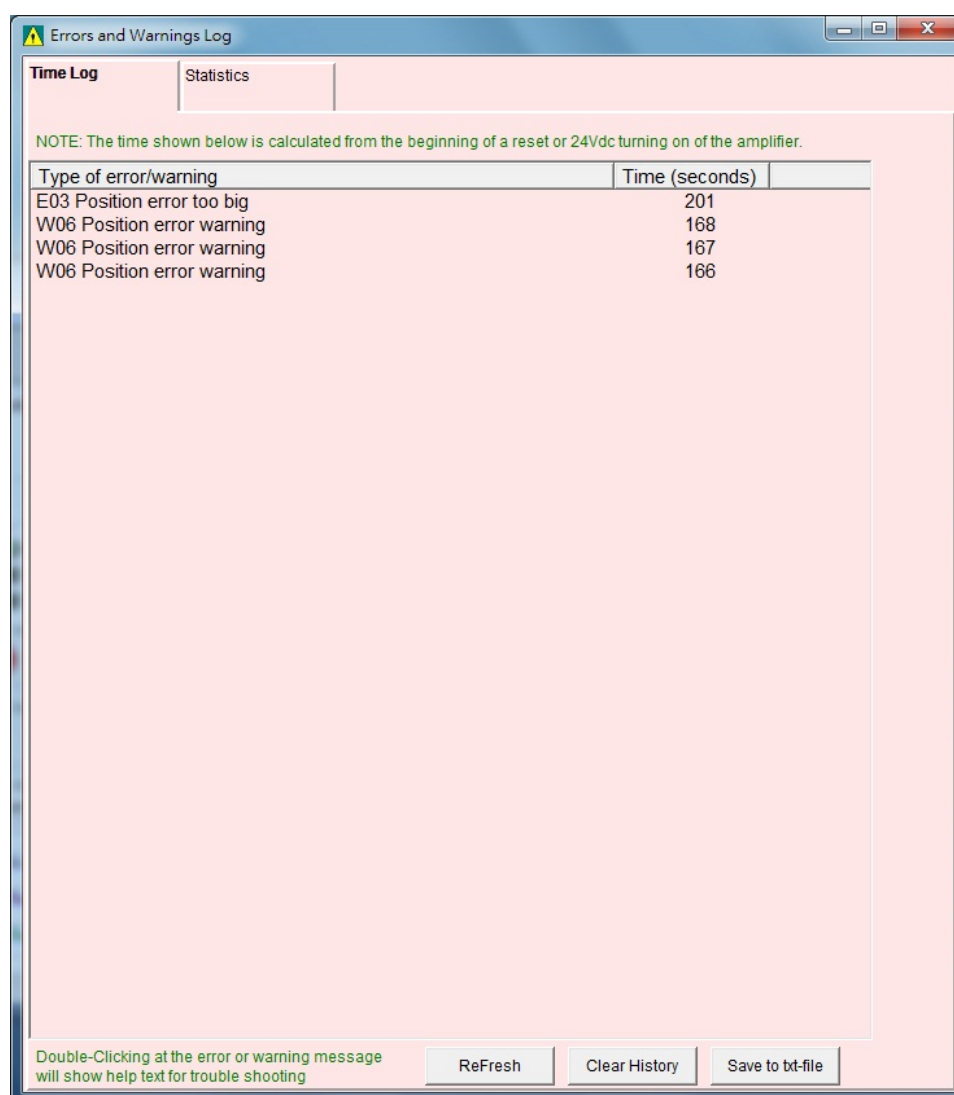


Figure9.2.1

The frequencies of occurring errors and warnings are saved in **Statistics** tab of **Errors and Warnings Log** window. User can know which error or warning frequently occurs.

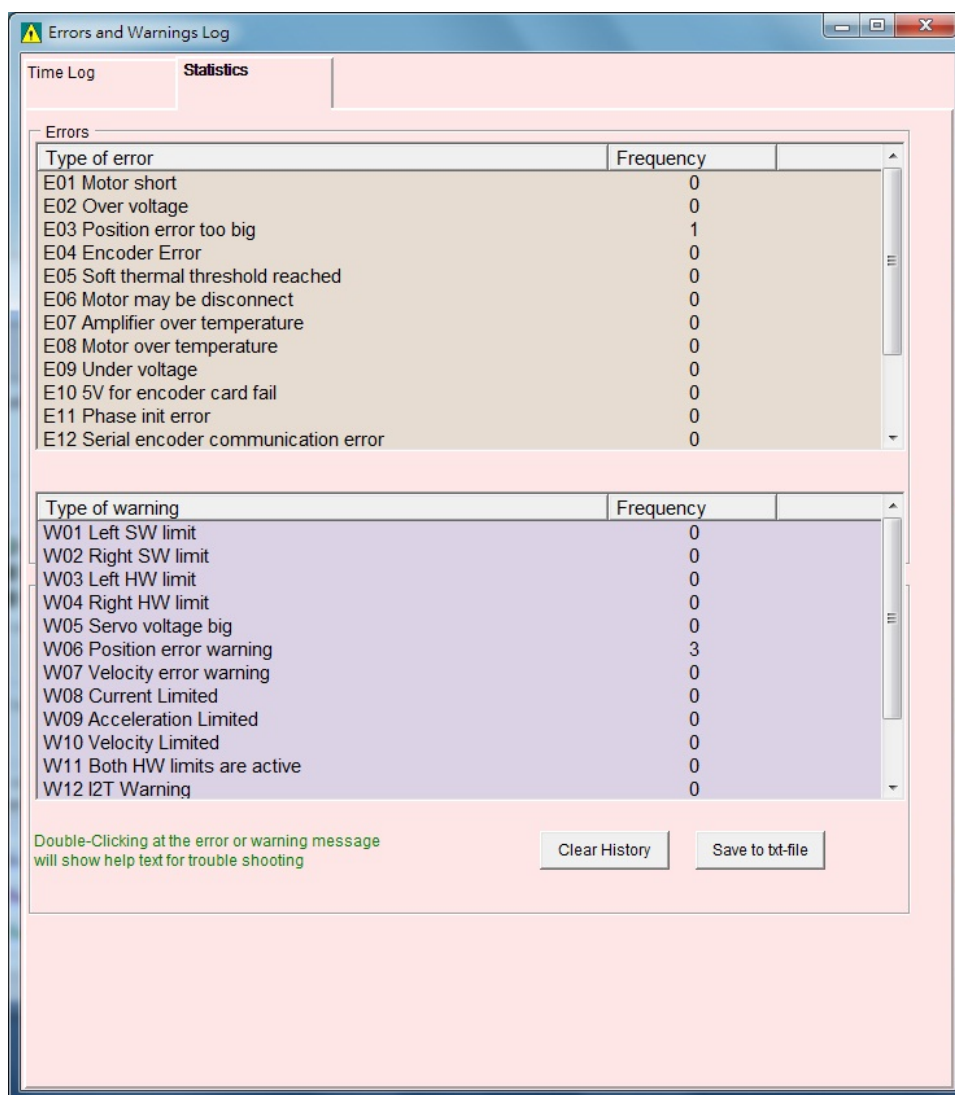


Figure9.2.2

Besides, user can double click on the error or warning in **Statistics** tab to show **Help tips** window which provides the cause and corrective action of the selected error or warning. For instance, in figure 9.2.3, the cause and corrective action of error “E03 Position error too big” is shown in **Help tips** window.

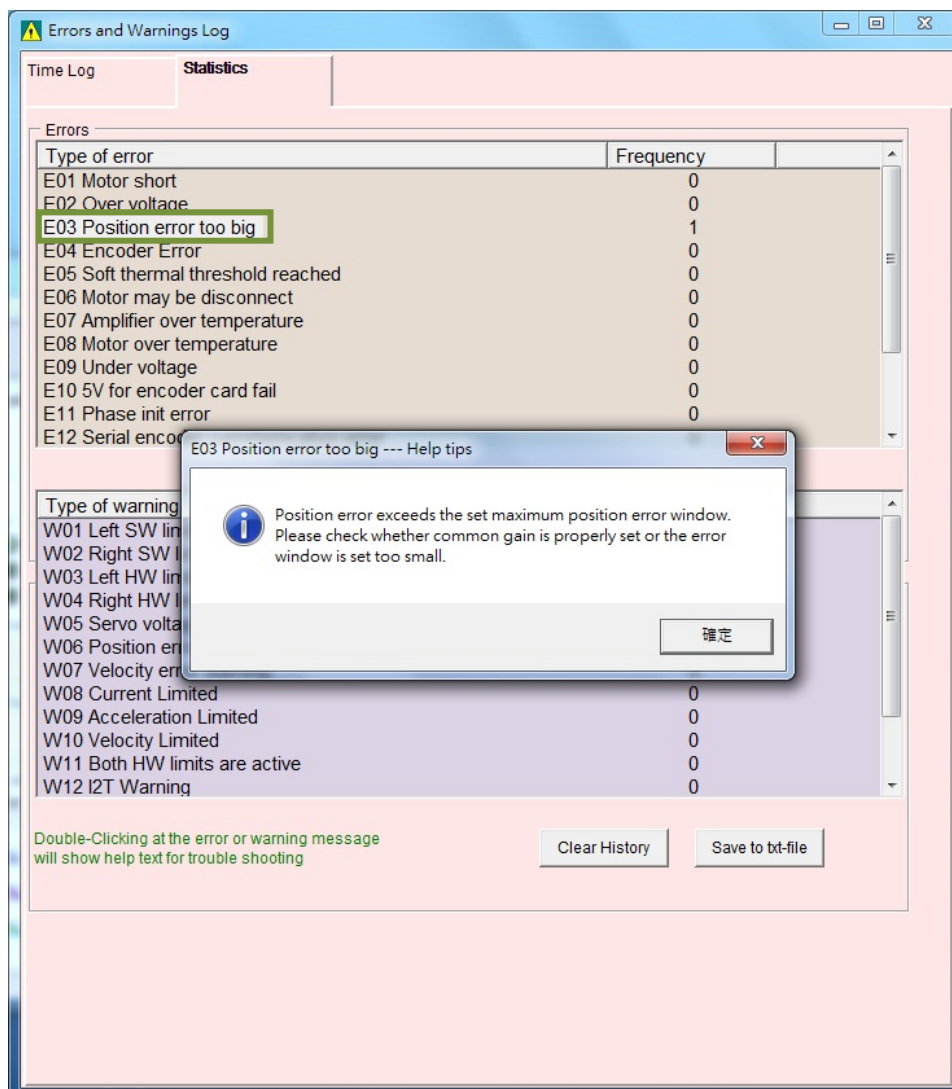


Figure9.2.3

9.3 Automatic error handling

D1 servo drive is able to report error and warning in Lightning. 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 the following error messages.

- (1) Amplifier over temperature
- (2) Under voltage detected

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** or **Latch Under voltage 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.

➤ Example 2

When error “Under voltage detected” occurs, it means AC main power is not correctly supplied to the servo drive. If user would like the motor to be enabled automatically after the cause of the error is cleared, uncheck the checkbox of **Latch Under voltage error**. If the AC main power for the servo drive is supplied normally, the motor will be enabled automatically.

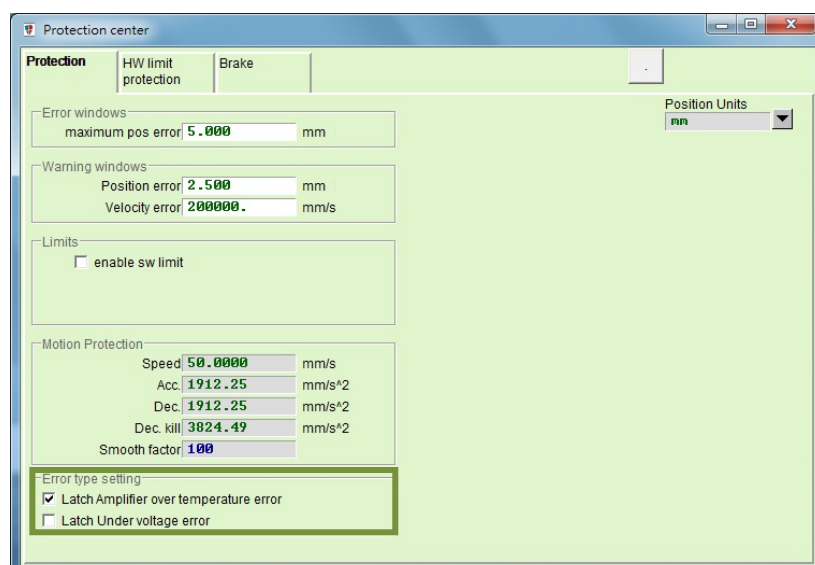



Figure9.3.1

■ Setting

Click on  to go to **Protection center** window. Click on **Protection** tab. In the setting area of **Error type setting**, uncheck the checkbox of **Latch Amplifier over temperature error** or **Latch Under voltage error** to enable automatic error handling function.

9.4 Troubleshooting

9.4.1 Status indicator

The status indicator of D1 servo drive is indicated in figure 9.4.1.1.

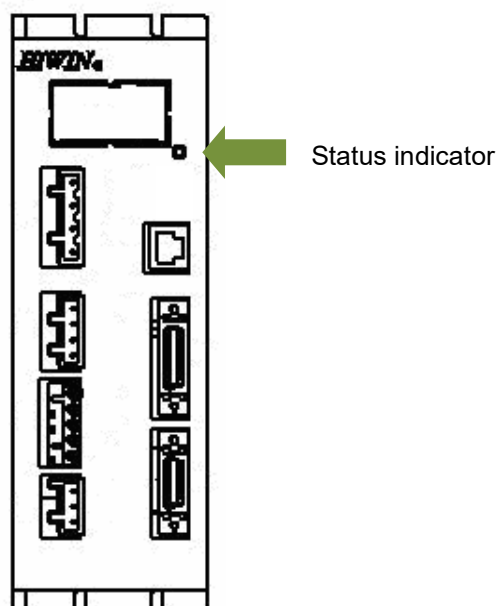


Figure9.4.1.1

Table9.4.1.1

Indicator	Servo Drive Status
No status	+24 Vdc power is not supplied.
Blinking red and green	The servo drive is powering on.
Blinking green	No power has been supplied to the motor.
Solid green	Power is being supplied to the motor.
Blinking green and solid red	No power has been supplied to the motor and an error occurs.

Note:


When the indicator turns red and green at the same time, the color looks like orange.

9.4.2 Error description and corrective action

Table 9.4.2.1

No.	Description	Error Message	Corrective Action
1	(1) Speed or acceleration is limited while sending pulse command or voltage command. (2) Controller already finishes sending pulse command, but motor is still moving to the target position slowly.	-	Check if the speed, acceleration and deceleration set for motion protection in Performance center are too small.
2	The moving direction of motor is opposite to the user-defined direction.	-	Redo auto phase initialization setting by referring to section 5.3. Use TD function to reset the moving direction of motor.
3	Error map function is not enabled.	-	Go to Error map page in Application center and check the following: (1) Check if the checkbox of Error map enable is checked. Refer to section 6.9. (2) Check if homing is completed or signals related to homing have been set in digital inputs.
4	Motor moves without receiving any command after it is enabled.	-	(1) Use Quick view or Scope to check if any pulse signal is received for Target Position. (2) Check if the pulse signal cable is connected properly. (3) Check if signal 0 V is connected to the shield or ground. (4) Check if the servo drive and machine are grounded. (5) Check if core should be added onto the pulse signal cable for filtering.
5	Motor does not move after command is sent from controller.	-	(1) Check if the command unit is correct. (2) Check if the speed or acceleration is 0. (3) Check if the software limits are enabled. Or check if the value set for Upper sw limit or Lower sw limit is correct. (4) Disable the motor and move it (forcer) manually to see if it runs smoothly.
6	The motor does not move after pulse command is sent from controller.	-	(1) Use Quick view or Scope to check if any pulse signal is received for Target Position. (2) Check if the pulse signal cable is connected properly. (3) Check if the electronic gear ratio is set to be too small.
7	Motor does not move after analog voltage command (V command) is sent from controller.	-	(1) Use Quick view or Scope to check if analog voltage command is received. (2) Set Analog input offset in Analog input tab of Advanced gains window.
8	Motor moves with a loud noise.	-	(1) Decrease the common gain (CG). (2) Set filters in Filter tab of Advanced gains window. Refer to section 6.6.1.
9	The servo drive is overheating.	Amplifier over temperature	(1) Check if the servo drive is installed in well-ventilated location. (2) Check if the ambient temperature is too high. (3) Wait till the servo drive cools down. (4) If the servo drive needs to be used for a long period of time, check if heat sink is needed.

No.	Description	Error Message	Corrective Action
10	The signal of position feedback sensor (reader) is abnormal.	Encoder error	<ol style="list-style-type: none"> (1) While using Renishaw optical position feedback system, check if the LED on the reader lights up. Normally, the LED should be green. If the LED does not light up, check if 5 V power is supplied or the signal cable is properly connected and is not short-circuited. If the LED is red, adjust the gap between the reader and scale and check if the scale is clean. (2) While using HIWIN magnetic scale, ensure the gap between the reader and scale is between 0.1 to 0.2 mm. Check if the signal cable is properly connected and is not short-circuited. Keep the scale away from strong magnet. (3) Check the reader is digital type or analog type. Ensure its model and resolution are correctly set. (4) Check if the phase sequence (A/B phase) of digital reader is incorrect. (5) When analog reader is not moving, check if the sinusoidal signal of the analog reader is too weak. (6) Check if the servo drive and machine are grounded, and the shield is grounded.
11	Motor (forcer) is overheating.	Motor over temperature sensor activated	<ol style="list-style-type: none"> (1) Check if the over temperature cable is connected. (2) Check if the temperature of the motor is too high. (3) Check if the continuous current and instantaneous current of the motor are within its specification. (4) Check if the duty cycle of the motor is too high.
12	DC bus voltage is too small.	Under voltage detected	<ol style="list-style-type: none"> (1) Check if the servo drive is connected to AC main power 100 or 240 Vac. (2) Use multimeter to check if AC main power 100 or 240 Vac is supplied.
13	DC bus voltage is too large.	Over voltage detected	<ol style="list-style-type: none"> (1) Check if the velocity, acceleration and load are within the specifications of the servo drive and motor. (2) If the motor needs to move at high speed, consider installing regenerative resistor. Select regenerative resistor based on your load and motion conditions. (3) Check if the load is too heavy. (4) Check if the speed is too high.
14	Position error is greater than the value set for maximum pos error .	Position error too big	<ol style="list-style-type: none"> (1) Check if the common gain (CG) is too small. (2) Open Protection tab in Application center and check if the value set in the field of maximum pos error is too small. (3) Check if the motor is obstructed during motion. (4) Check if the reader is normal. (5) Check if the optical scale is clean. (6) Check if the load is too heavy. (7) Check if the guideway has not been maintained for a long period of time. (8) Check if the cable tray is too tight.
15	There is short circuit among the U, V and W wires.	Motor short (over current) detected	<ol style="list-style-type: none"> (1) Ensure there is no short circuit among the U, V and W wires and the wiring is ideal. (2) Ensure there is no short circuit among the U, V and W wires and ground. (3) Ensure the resistances of U, V and W wires are the same.

No.	Description	Error Message	Corrective Action
			(4) Check if the motor power cable is too old.
16	The equivalent current that the servo drive outputs exceeds the maximum continuous current of motor.	Soft-thermal threshold reached	(1) Check if the continuous current and instantaneous current for the motor is within its specification. (2) Check if the acceleration command of path planning is greater than the rating of the motor. (3) Check if the motor is obstructed during motion. (4) Reset the servo drive and enable the motor again. (5) Check if the motor model and its current parameter is correctly set.
17	PC cannot communicate with the servo drive.	-	(1) Check if the driver for RS232 to USB converter is installed. Check if RS232 communication port appears in the device manager of Windows operating system. (2) Check if transmission rate (BPS) and communication port (Port) are correctly set. Refer to section 5.1. (3) Check if the pin assignment of RS232 cable is correct. Refer to section 4.6.
18	In position mode, the servo drive cannot receive the single-ended pulse signal sent from controller.	-	Check the output type of controller. If it is single-ended output (For example, Mitsubishi PLC module QD75P), ensure group D in I/O center is set as pull up. Refer to sections 4.7.3 and 5.4.1.
19	Controller receives incorrect position information while using emulated encoder function.	-	While saving parameters () to the servo drive Flash, the emulated encoder function is not available. Therefore, the position information sent to the controller during this time could be incorrect.
20	Fail to enable or disable digital output (O1 to O4) in PDL program.	-	Check if the digital output is set to "PDL usage" in I/O center.
21	Error "Hall sensor error" occurs while using digital Hall sensor.	Hall Sensor Error	Open Quick view or Scope in Lightening to observe physical quantity "46 digital hall bits". Move the motor manually to see if the value of this physical quantity changes. If the value does not change, check if the encoder cable is correctly connected. If the encoder cable is correctly connected, please replace it with another encoder cable. If the above method does not work, please replace the servo drive. If the above methods cannot clear this error, the digital Hall sensor could be broken, please replace the digital Hall sensor.

10. Servo drive thermal curve

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 - 10.2 Heat sink..... 10-3

10.1 Operating temperature and cooling

Figures 10.1.1 and 10.1.2 provide the information of D1 servo drive operating in its maximum allowable ambient temperature with different operating condition and cooling device. The cooling devices include heat sink D1-H1 and fan. The operating conditions are input voltage 120 Vac and 240 Vac.

■ Input voltage 120 Vac

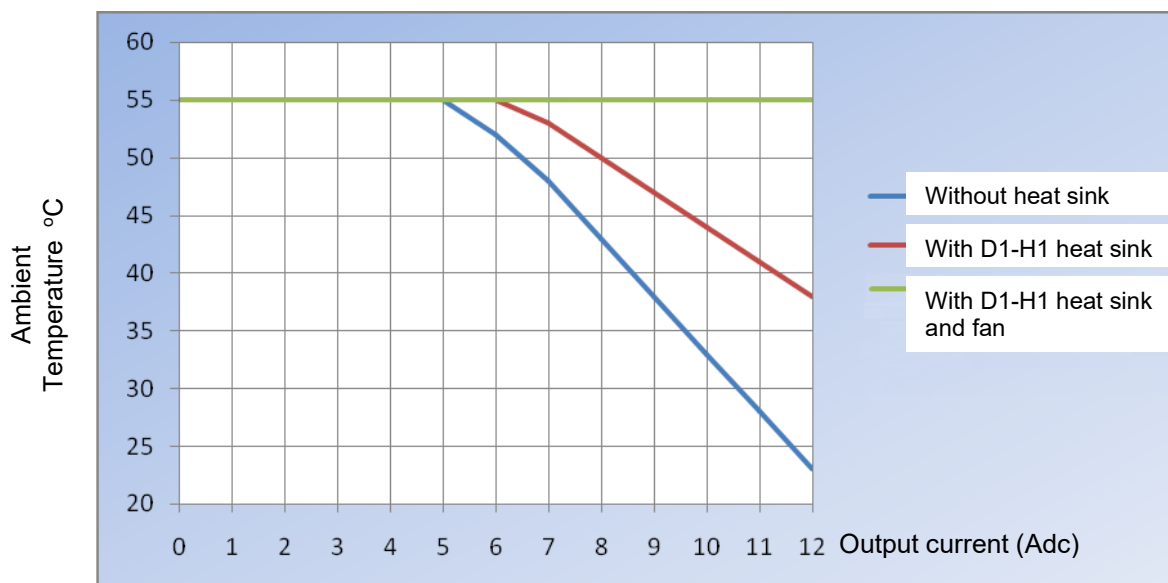


Figure10.1.1

■ Input voltage 240 Vac

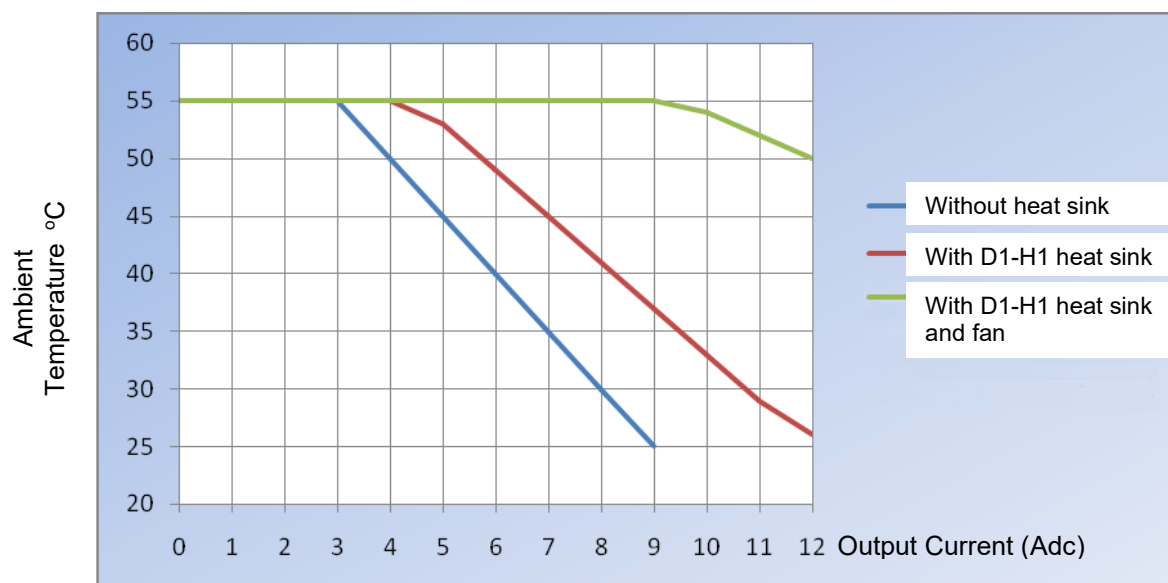


Figure10.1.2

■ Fan specifications

- (1) Air flow:153 (CFM)
- (2) Static pressure:0.43 (Inch-H₂O)

10.2 Heat sink

D1-H1 heat sink is shown in figure 10.2.1.

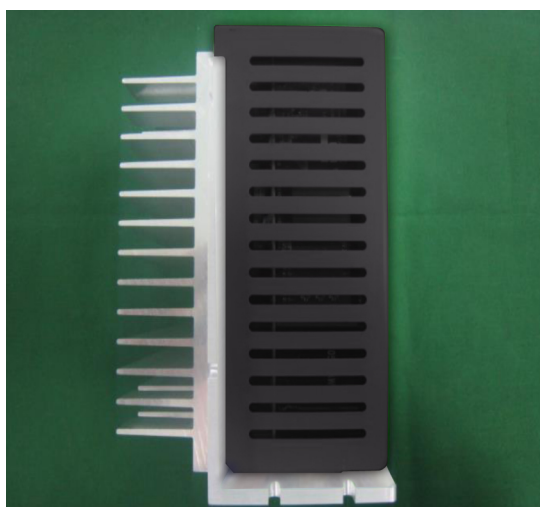


Figure10.2.1

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11. Advanced frequency analysis

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11.1 Advanced frequency analysis

Frequency analyzer is used for advanced frequency analysis when the values of v_{pg} and st_vpg calculated by the auto tuning function in section 5.3.2 cannot meet the requirement. Frequency analyzer measures the actual frequency response of the system and calculates the values of v_{pg} and st_vpg according to the application. With the generated frequency response figure, user is allowed to design filter to improve system performance.

To do advanced frequency analysis, do not check the checkbox of **Use simple version** and click on

 to open frequency analyzer.

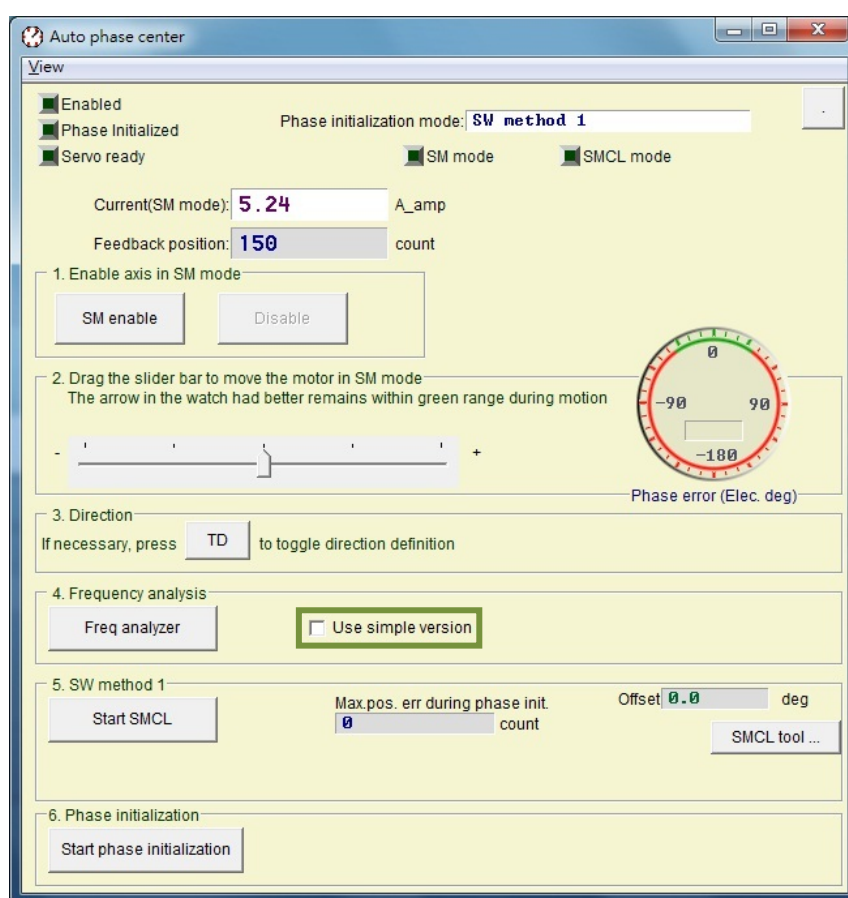



Figure11.1.1

11.2 Frequency analyzer

When frequency analyzer is opened, its default mode is “Stepper/Dcbl plant”. Click on **Run** to measure frequency. It is normal to have sound or vibration while measuring frequency. After the measurement completes, the result will be shown in the display area. Right click in the display area to open slope measurement tool. Select slope -20 dB/dec and move the cursor to the segment of the same slope. The program will automatically calculate the appropriate vpg and st_vpg. Click on **Send** to send these parameters to the servo drive. To save the parameters to the servo drive Flash, click on  in the main window of Lightning.

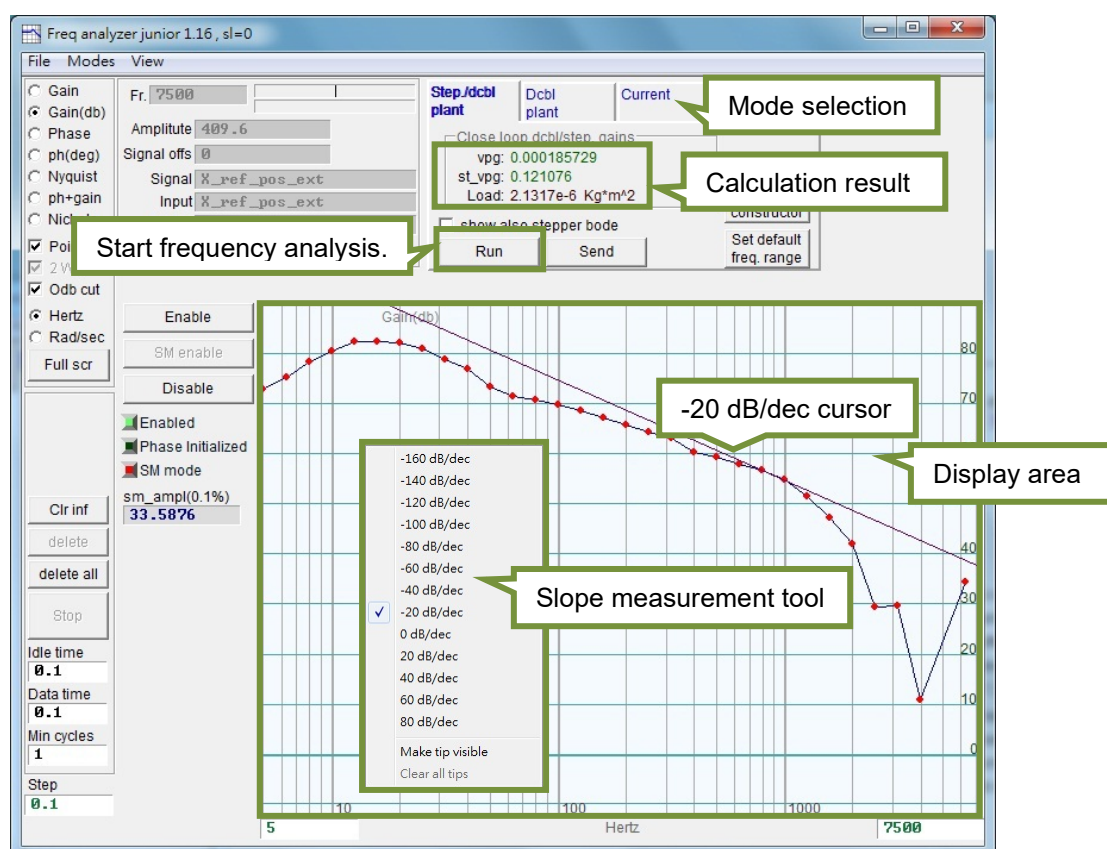


Figure11.2.1

When there are several -20 dB/dec segments in the curve, move the -20 dB/dec cursor to the segment which is closest to the top.

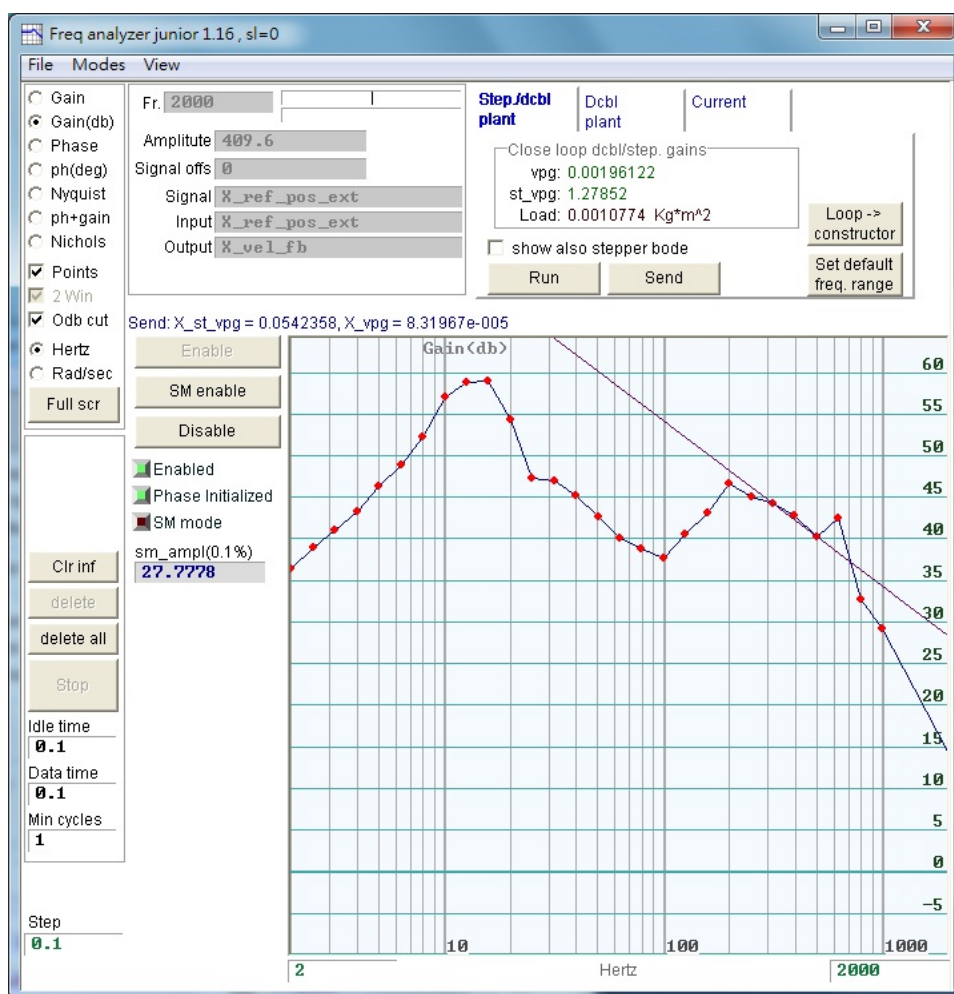


Figure11.2.2

11.3 SMCL tools

When SW method 1 is selected for phase initialization mode, use SMCL tools to adjust `st_cg` to minimize the movement while performing phase initialization. Click on **SMCL tool...** button in figure 11.1.1 to open SMCL tools, as figure 11.3.1. Increase `st_cg` to decrease the movement during phase initialization. If `st_cg` is set to be too large, it may cause vibration and unstable system. Click on **Start SMCL** button to check the movement during phase initialization and if there is vibration. Adjust `st_cg` and execute SMCL test repeatedly and check position error until the movement during phase initialization is acceptable.

Note:

Do not modify the value in **e_pointer** field.

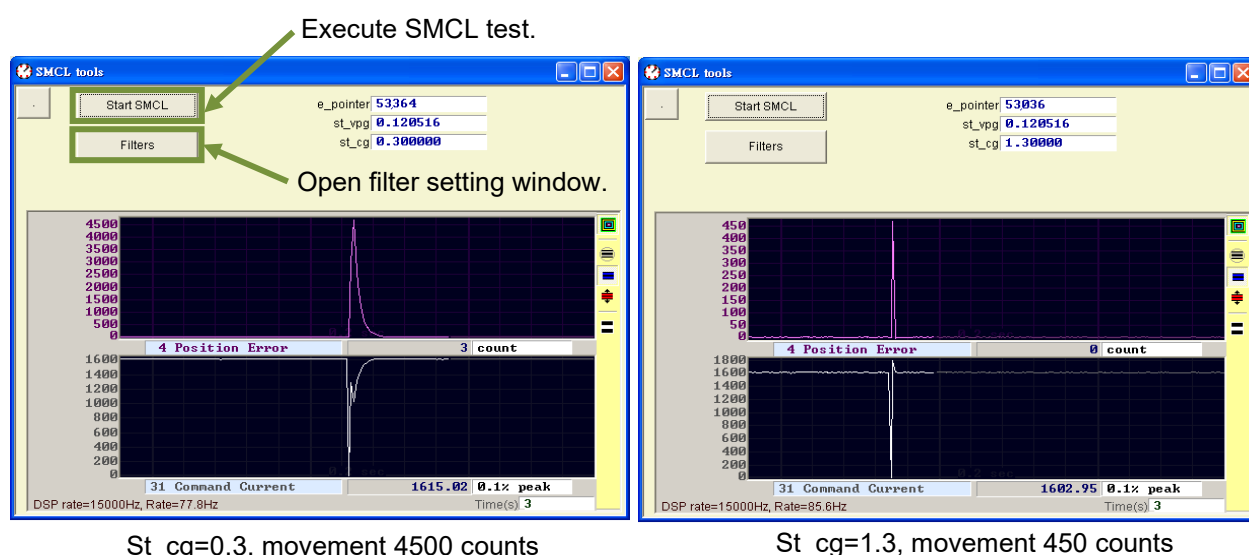


Figure11.3.1

■ SMCL parameters

(1) `st_cg`

`st_cg` is the proportional gain of control loop in SMCL mode. Normally `st_cg` must be as large as possible, but it is on the premise of not affecting the stability of the system. If `st_cg` is set to be too large, it may cause vibration and unstable system. At this time, `st_cg` must be decreased. `st_cg` is usually set to 0.2 to 1.5. But if the system is stable enough, `st_cg` could be more than 1.5.

(2) st_vpg

An initial value is calculated by using the physical parameters set in **Motor** page in Configuration center, such as load mass, moment of inertia, gear ratio and motor type, etc. If improper initial value of st_vpg is set, you may use frequency analyzer (Freq analyzer junior) to do frequency response test to obtain the appropriate value. Normally the st_vpg obtained from the frequency response test does not need to be adjusted again.

■ Filters

There are filters in SMCL tools. User may use the filters according to his requirement. For how to set filters, please refer to section 6.6.1.

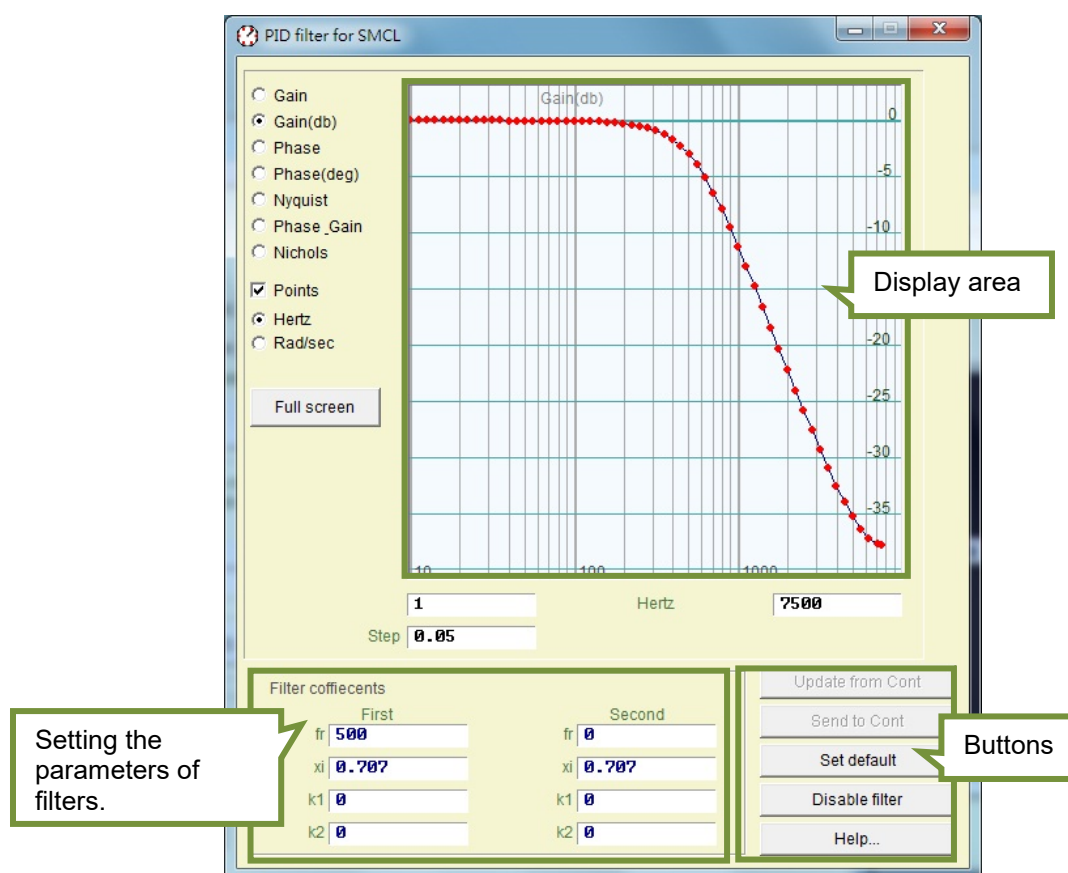


Figure11.3.2

12. Enabling motor

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12.1 Enabling method

■ Enable motor by controller

Normally motor is enabled by the command sent from controller via input port. Input function Axis enable is set in digital input I1 (section 5.4.1), as figure 12.1.1.

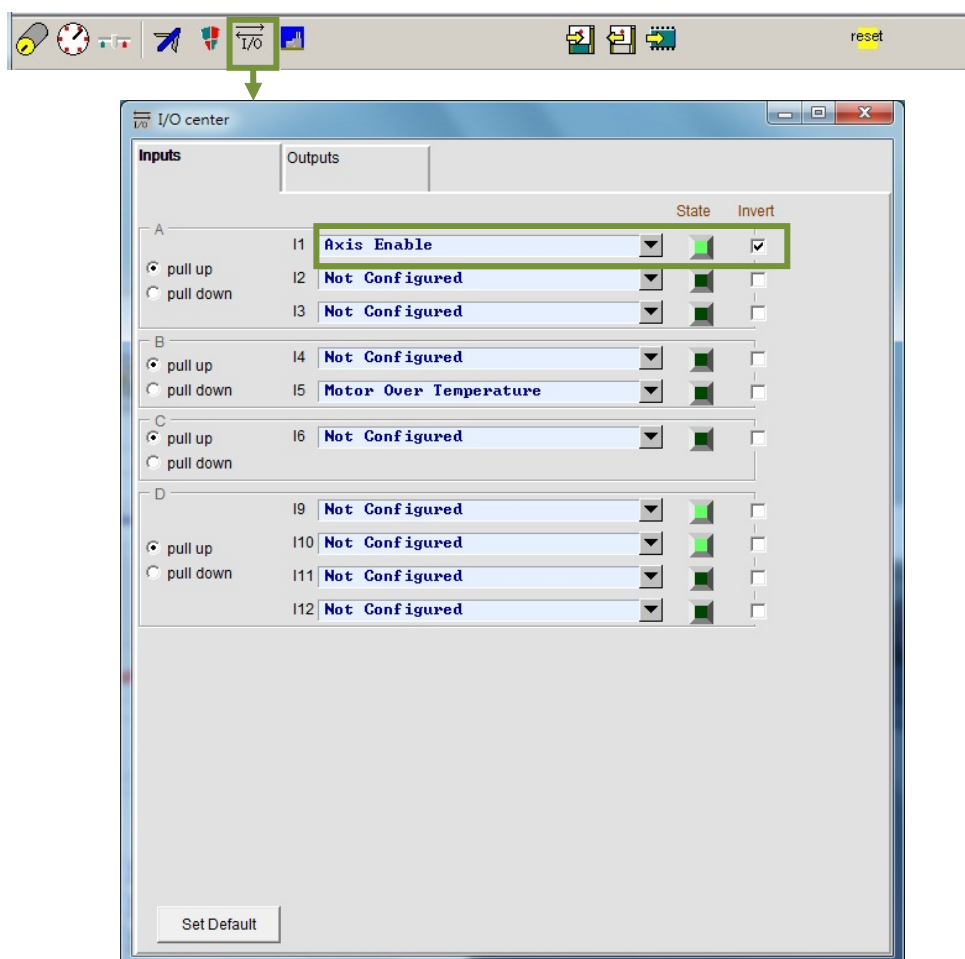



Figure12.1.1

■ Enable motor without controller

Without controller, hardware enable signal cannot be input into the servo drive. To simulate a hardware enable signal, click on  to open I/O center, as figure 12.1.1. Set I1 to I3 as pull up. Set I2 and I3 as **Not Configured**. Ensure the state indicator of **Axis Enable** becomes green. Normally I1 is for hardware enable signal. Check the checkbox of **Invert** to invert the logic. At this time, since the logic is inverted, I1 becomes ON when no signal is input. The state indicator becomes green which means hardware enable signal is received.

12.2 Checking enabling state from Lightening

When **Hardware Enable Input** indicator in Lightening becomes green, it means enabling signal is received from controller, as figure 12.2.1.

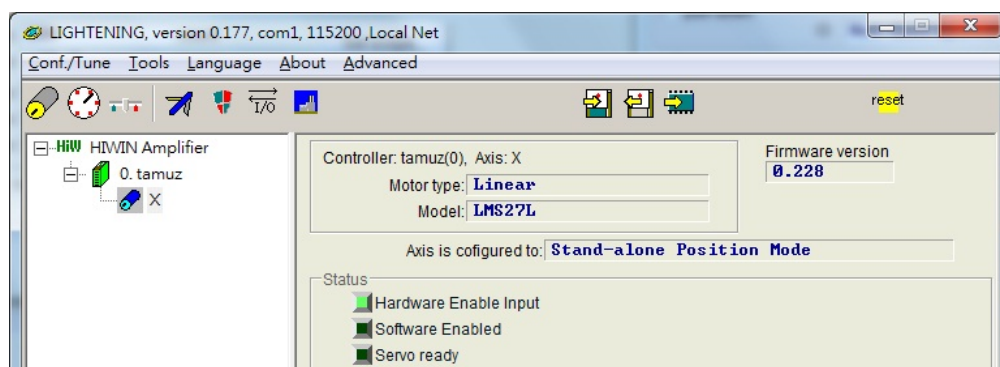


Figure12.2.1

Normally motor is enabled by axis enable signal from controller. Pay attention to the following:

- (1) When Lightening is an active window, clicking on **Disable (F12)** button can disable the motor. This is usually used for emergency.
- (2) Click on **Disable (F12)** button in Performance center of Lightening to disable the motor. To enable the motor again, click on **Enable** button (Note: **Hardware Enable Input** indicator must still be green.).

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13. Parameter comparison

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13.1 Comparing the parameters in RAM and Flash.....	13-2

13.1 Comparing the parameters in RAM and Flash

When motor parameters are modified but have not been saved to Flash, **Compare parameters RAM to FLASH** window appears as user is closing Lightning or saving error map parameters to Flash (Refer to section 6.9.1.), as figure 13.1.1. This window is to remind user that parameters are modified but have not been saved to Flash.

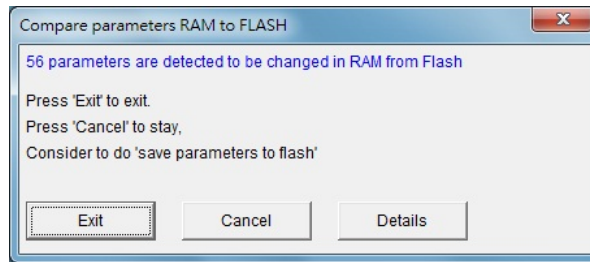


Figure13.1.1 Compare parameters RAM to FLASH window

Click on **Details** button to do further comparison. User is allowed to check which parameter has different settings in RAM and Flash. If the settings in RAM and Flash are not identical, the parameter and its value will be shown in blue.

The following two symbols may also appear in **Flash value** column.

- (1) =: The value saved in Flash is the same as the one in RAM.
- (2) **: User undid the parameter before. The value in RAM is changed to the one saved in Flash.

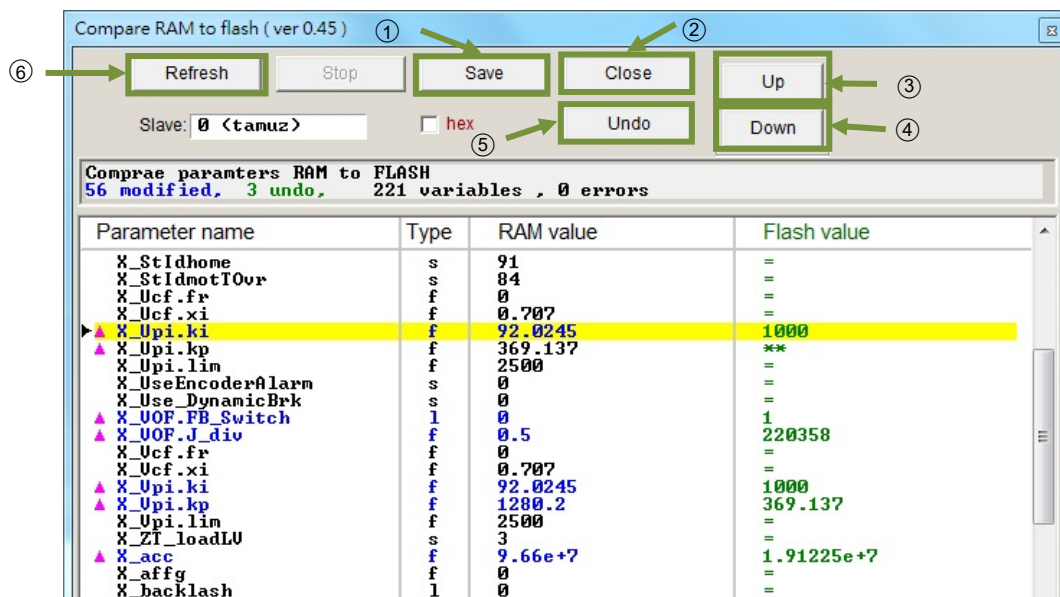


Figure13.1.2 Compare RAM to flash window

The buttons in **Compare RAM to flash** window are described as below:

- ① Save: Save parameter to the servo drive Flash.
- ② Close: Close the window.
- ③ Up: Go to the previous parameter which has different settings in RAM and Flash.
- ④ Down: Go to the next parameter which has different settings in RAM and Flash.
- ⑤ Undo: Change the value of the selected parameter. Its value in RAM is changed to the one saved in Flash.
- ⑥ Refresh: Compare the parameters in RAM and Flash again.
- ⑦ Redo: Cancel Undo of the selected parameter.

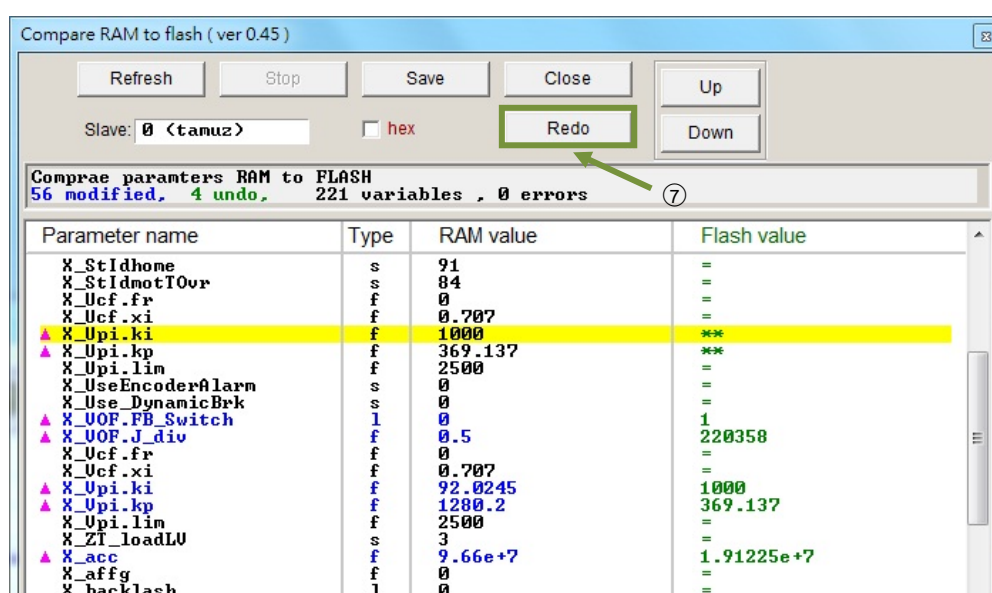


Figure13.1.3 Compare RAM to flash window

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14. Updating firmware and loading PDL

14.	Updating firmware and loading PDL	14-1
14.1	Updating servo drive firmware	14-2
14.2	Loading PDL program	14-4

14.1 Updating servo drive firmware

To update the firmware of the servo drive, click on **Tools** in the main window of Lightning. Select **Upgrade/Downgrade firmware** from the submenu, as figure 14.1.1. Then window in figure 14.1.2 appears.

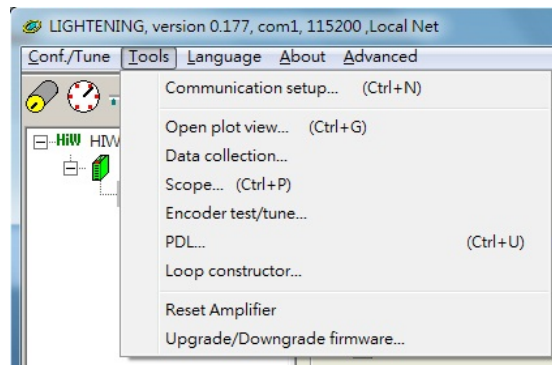


Figure14.1.1

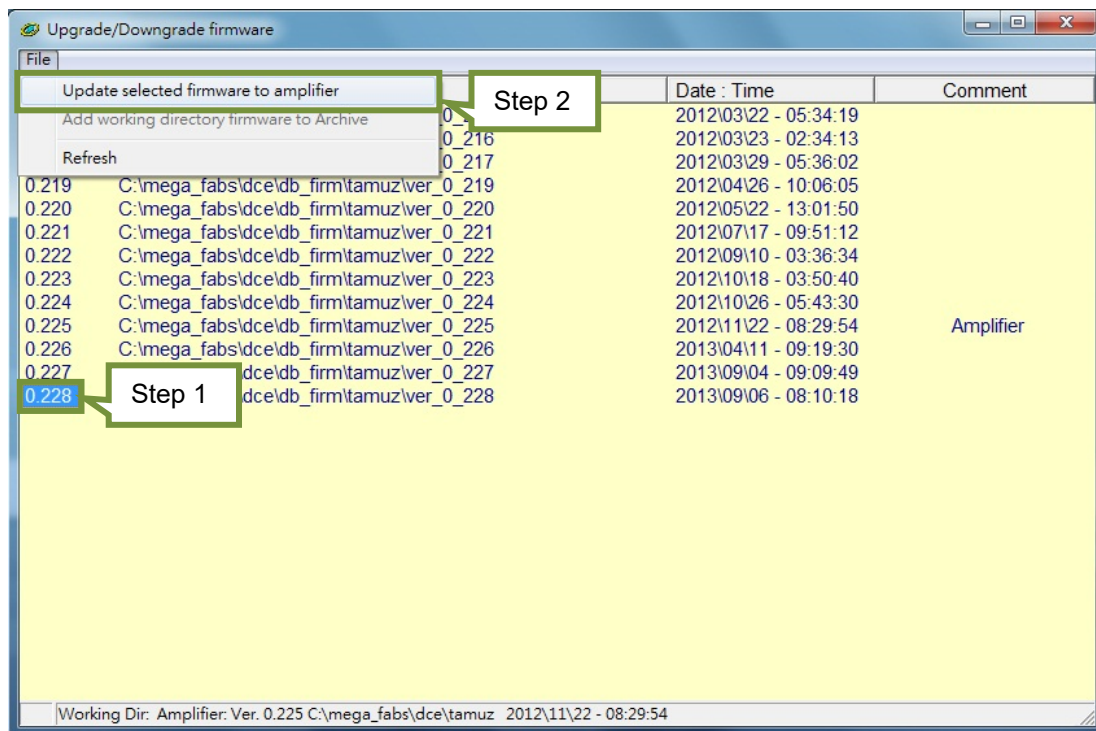


Figure14.1.2 Upgrade/Downgrade firmware window

In **Upgrade/Downgrade firmware** window, follow the steps below to update firmware.

- Step 1: Left click on the firmware version to be updated. The selected firmware version will be shown in white text on a blue background.
- Step 2: Click on **File** and select **Update selected firmware to amplifier**. A message dialog shown as figure 14.1.3 appears.

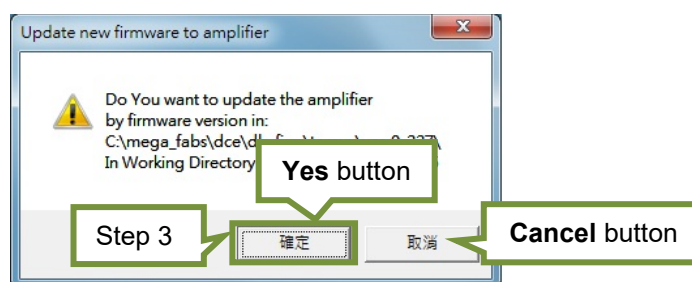


Figure14.1.3

- Step 3: Click on **Yes** button and **Auto load programs** window appears. The firmware is loaded to the servo drive automatically.

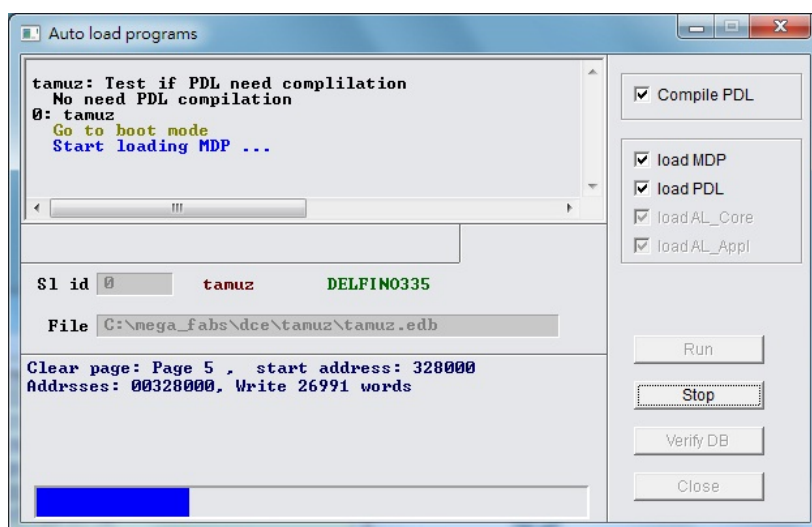


Figure14.1.4

- Step 4: After the firmware is updated, a window shown as figure 14.1.5 appears. Click on **Yes** button.

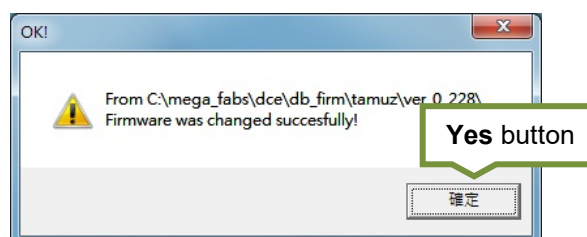


Figure14.1.5

Note:

If power failure or communication interruption occurs during firmware update, Lightning stays in “Boot mode” and cannot be changed even when power is supplied again or communication cable is reconnected, as figure 14.1.6. If this occurs, please contact local distributor.

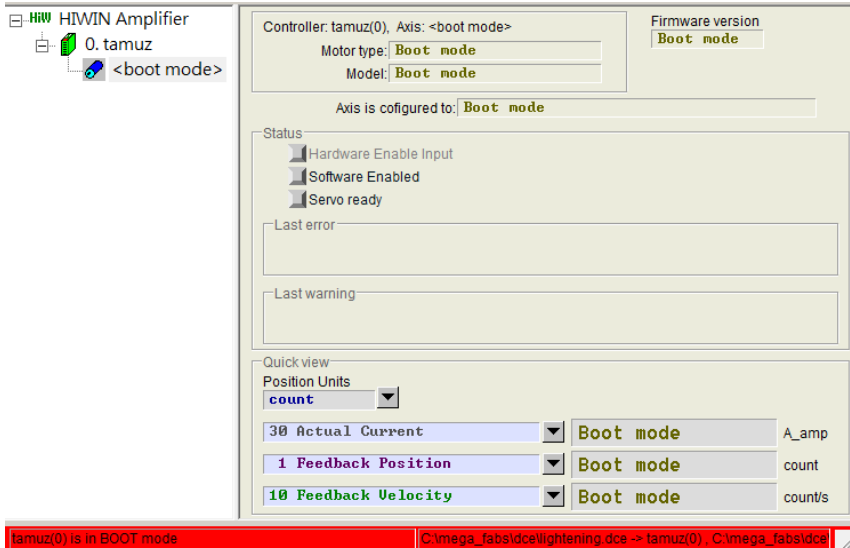


Figure14.1.6

14.2 Loading PDL program

Follow the steps provided below to load PDL program to the servo drive. To clear the PDL program in the servo drive, please delete the program codes in user.pdl and follow the steps below to load an empty user.pdl.

Step 1: To open **PDL** window, click on the icon (🖨️) indicated in figure 14.2.1.

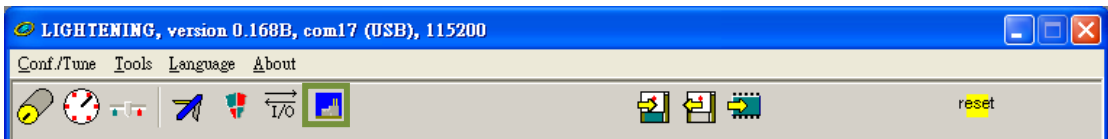


Figure14.2.1

Step 2: Click on **Edit** button to open the interface for editing PDL program.

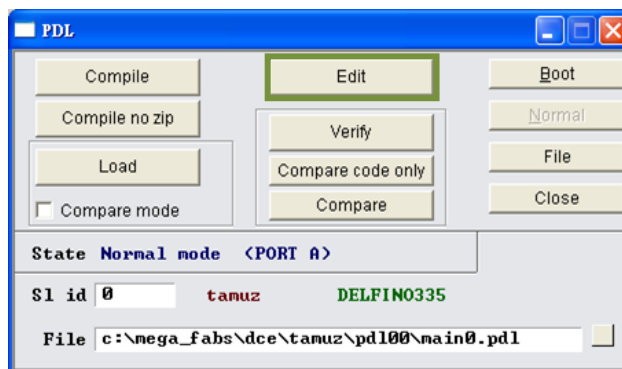


Figure14.2.2

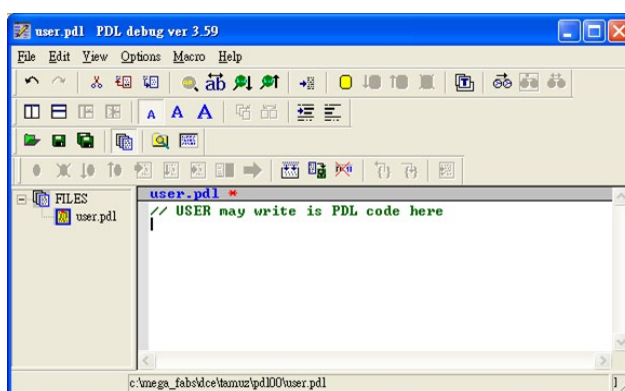



Figure14.2.3

Step 3: After PDL program is loaded or editing program codes is completed, click on  (Compile) to show **PDL compiler** window.

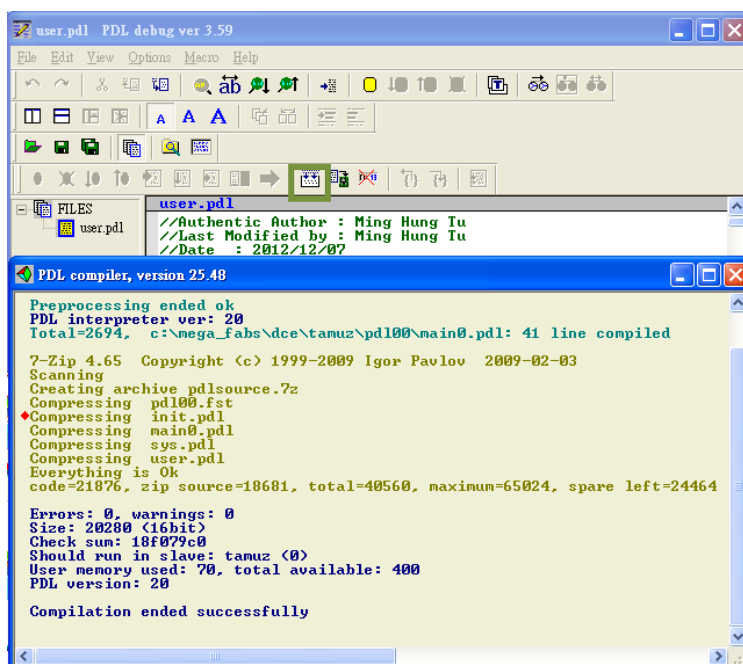



Figure14.2.4

Step 4: Click on  (Send to slave) after compilation finishes. Click on **Yes** button when the dialog shown in figure 14.2.5 appears. Then a window with progress bar appears and closes as PDL program is loaded, as figure 14.2.6.

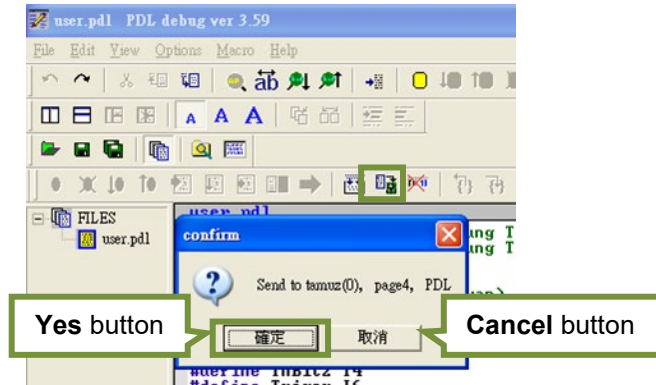


Figure14.2.5

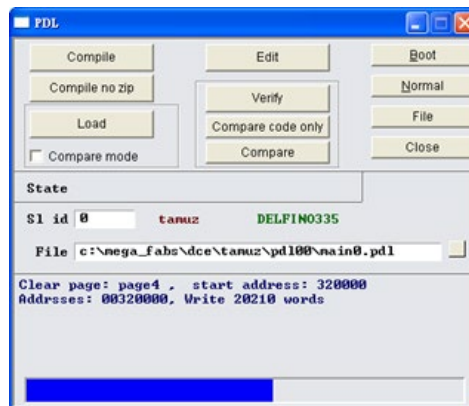


Figure14.2.6

15. Troubleshooting for interference

15.	Troubleshooting for interference	15-1
15.1	Common mode filter	15-2

15.1 Common mode filter

User can use common mode filter to decrease common mode interference. The model number of HIWIN common mode filter for D1 series servo drive is MF-40-S. For its specifications, please refer to the table below.

Table16.1.1

Item		Specification
Input	Maximum Voltage	373 Vdc
	Maximum Current	20 A_amp
Output	Maximum Voltage	373 Vdc
	Maximum Current	20 A_amp
Instantaneous Current*/Duration of Instantaneous Current		40 A_amp / 1 second
Ambient Temperature †		0 to 40°C

Note:

- (1) *The maximum input/output instantaneous current can last one second after power on.
- (2) †When continuous current is higher than 12 A_amp, use external fan for cooling. The fan must have at least 110 CFM.



Figure16.1.1

The dimensions of MF-40-S are shown in the figure below.

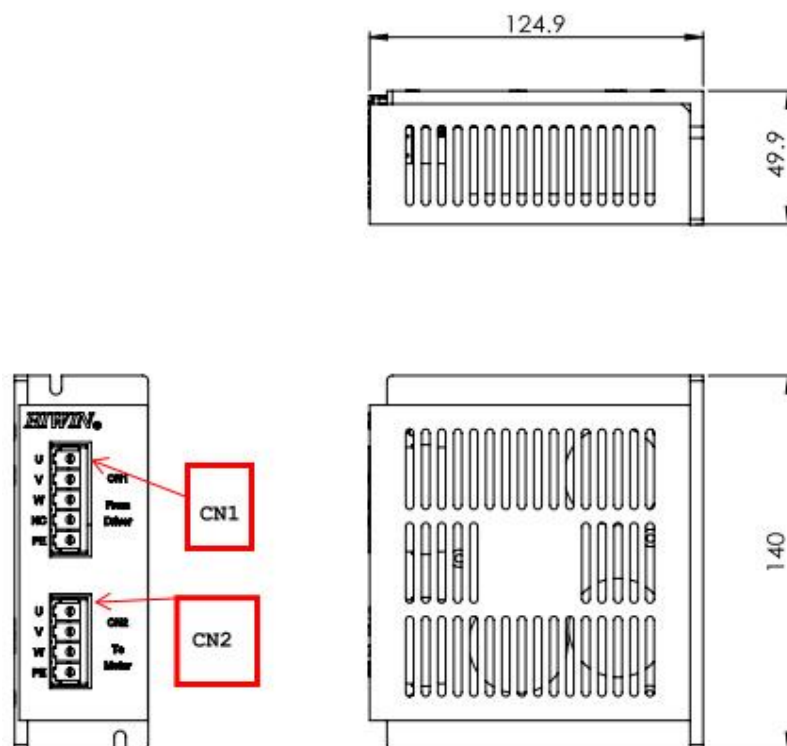


Figure 16.1.2

The wiring of common mode filter, servo drive and motor is shown in the figure below.

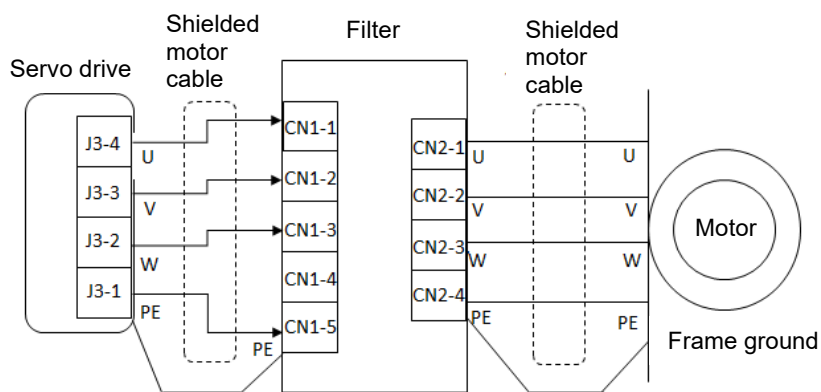


Figure 16.1.3

■ Wiring

- (1) Insert the wires from the servo drive into the CN1 of the common mode filter.
- (2) Connect motor power cable to the CN2 of common mode filter.

A. Filter (CN1) to servo drive

Table16.1.2 The specifications of CN1 connector (input)

Description	5 positions and 7.62 mm pitch
Cable Size	24-8 AWG
Suggested Cable	12 AWG, 600 V
Suggested Tool	Flathead screwdriver

Table16.1.3 The definition of CN1 connector

Pin	Name	Function
1	U	U phase current from the servo drive
2	V	V phase current from the servo drive
3	W	W phase current from the servo drive
4	PE	Frame ground and cable shield

B. Filter (CN2) to motor

Table16.1.4 The specification of CN2 connector (output)

Description	4 positions and 7.62 mm pitch
Cable Size	24-8 AWG
Suggested Cable	12 AWG, 600 V
Suggested Tool	Flathead screwdriver

Table16.1.5 The definition of CN2 connector

Pin	Name	Function
1	U	U phase current to the motor
2	V	V phase current to the motor
3	W	W phase current to the motor
4	NC	No connection
5	PE	Frame ground and cable shield



Figure16.1.4 CN2 connector

**DANGER**

- There is a risk of electric shock.
- The circuit of connecting servo drive main power and motor to the CN1 and CN2 of MF-40-S is high-voltage.
- If the precautions are not observed, it is likely to cause machine damage, injury or death.
- Be careful while performing adjustment or installation.