HIWIN®

D1-N Series Servo Drive

User Manual

www.hiwinmikro.tw

Revision History

Release Date	Version	Applicable Product	Revision Contents
June 21st, 2019	1.9	● D1N firmware version 0.819 or later version ● D1NCOE firmware version 0.523 or later version ● Lightening software version 0.194 or later version	This user manual is translated from the Chinese user manual D1-N 驅動器使用者操作手冊 (version 1.9), so the version number starts from 1.9.

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1. About this user manual

1.1 General precautions

Before using our 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 users.
- Before installing or using the product, ensure there is no damage on its appearance. If any damage is found after inspection, please contact HIWIN or local distributors.
- Carefully read through the specification noted on product label or technical document. Install the product according to its specification and installation instructions stated in this user manual.
- Ensure the product is used with the power supply specified on product label or in product requirement. HIWIN is not responsible for any damage, accident or injury caused by incorrect power supply.
- Ensure the product is used with 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 yourselves 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.

1.1.1 Risk identification

Warning When installing or replacing motor power cable, wiring must be correctly performed. Incorrect wiring may lead to abnormal operation of motor, serious injury or machine damage. Connect motor power cable according to the noted symbols on the cable.	**Warning** Each motor has its maximum rated load. If the motor is overloaded, it may lead to abnormal operation of motor, machine damage or injury.
Warning If users are using a self-made extension cable for motor encoder, please carefully read through our manuals or contact customer service department. Incorrect connection may lead to abnormal operation of motor or injury.	**Warning** If encoder extension cable is accidently disconnected when power on, reconnect it to the servo drive after power off. If not, it may lead to abnormal operation of motor, machine damage or injury.
Warning When using open-type optical feedback system (such as optical scale), if there is stain or scratch on the scale, it may lead to abnormal operation of motor, motor damage, machine damage or injury.	**Warning** If encoder connector is subject to any impact during operation, check if the servo drive is damaged. It is suggested to power on the servo drive again. Otherwise it may lead to abnormal operation of motor, machine damage or injury.
Warning When using open-type magnetic feedback system (such as magnetic scale), prevent strong magnetic objects from getting close to the scale. Otherwise, it may lead to abnormal operation of motor, motor damage, machine damage or injury.	**Warning** Do not disconnect encoder extension cable and reconnect it to the servo drive when power on, or it may lead to abnormal operation of motor, machine damage or injury.
Warning When using linear motor with Hall sensor, ensure the selected Hall sensor is applicable to your linear motor. If not, it may lead to motor burn-out, abnormal operation of motor or injury.	**Warning** If users are using a self-made signal extension cable of Hall sensor, please carefully read through our manuals or contact customer service department. Incorrect connection may lead to abnormal operation of motor or injury.

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 the 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 contact.
- 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	◆ Do not touch the terminals and internal part of the product when power on, or it may cause electric shock. ◆ Do not touch the terminals and internal part of the product within 10 minutes after power off, or the residual voltage may cause electric shock. ◆ Do not modify wiring when power on, or it may cause electric shock. ◆ Do not damage, apply excessive force to, place any heavy object on cables or put cables between two objects, or it may cause electric shock or fire.
Attention	◆ Do not use the product in location which is subject to humidity, corrosive materials, flammable gas or flammable materials.

■ Storage

Prohibited	◆ Do not store the product in location which is subject to water, water drop, direct sunlight, harmful gas or liquid.

■ Transportation

Attention	◆ Carefully move the product to avoid damage. ◆ Do not apply excessive force to the product. ◆ Do not stack the products to avoid collapse.

■ Installation site

Required	◆ Do not install the product in location with high ambient temperature and high humidity or location which is subject to dust, iron powder or cutting powder. ◆ Install the product in location with ambient temperature stated in the 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.

■ Installation

Attention	◆ 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 the product weight. Improper installation may cause damage. ◆ Install the product on noncombustible object, such as metal to avoid fire.

■ Wiring

Attention	◆ 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	◆ 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	◆ Set external wiring for emergency stop to stop the motor at any time.

■ Maintenance

Prohibited	◆ Do not disassemble or modify the product. ◆ Do not repair the product by yourselves, please contact HIWIN for repair.

2. Specifications

2.1 Safety certificates and model explanations

2.1.1 Safety certificates

D1-N servo drive complies with the following safety standards.

Table 2.1.1.1

Certification		Standards
CE Certification	EMC	EN 61800-3: 2004/A1: 2012 (Category C3)
		Emission Standards
		CISPR 11: 2015/AMD1: 2016 (Conduction & Radiation)
		EN 61000-3-2: 2014 (Harmonics)
		EN 61000-3-3: 2013 (Flicker)
		Immunity Standards
		IEC 61000-4-2: 2008 (ESD)
		IEC 61000-4-3: 2006/A1: 2007/A2: 2010 (RS)
		IEC 61000-4-4: 2012 (EFT)
		IEC 61000-4-5: 2014 (Surge)
		IEC 61000-4-6: 2013 (CS)
		IEC 61000-4-11: 2004 (Dips)
		IEC 61000-4-13: 2009
		IEC 61000-2-1: 1990
		IEC 61000-2-4: 2003
		IEC 60146-1-1: 2009
	LVD	EN 61800-5-1: 2007
Safe Torque Off (STO) Certification		IEC 61508: 2010; SIL 3
		ISO 13849-1: 2006; PL e (Cat.3)
		IEC 62061: 2005; SILcl 3
UL Certification		UL 61800-5-1: Edition 1
CSA Certification		CSA C22.2 No. 274-17: Secondary edition

2.1.2 Nameplate information

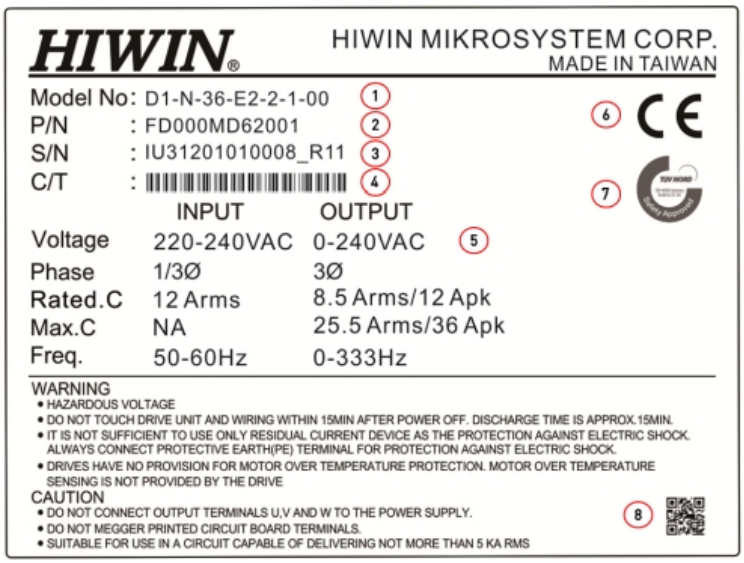


Figure 2.1.2.1

Table 2.1.2.1

Number	Description
①	Model number
②	HIWIN part number
③	Serial number
④	Barcode
⑤	Voltage, phase, rated current, maximum current and frequency
⑥	CE compliant
⑦	Compliance functional safety STO
⑧	QR code

2.1.3 Model explanation

Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Example	D	1	-	N	-	3	6	-	S	2	-	2	-	1	-	0	0

Product Name
D1-N……..……=D1-N

Peak Current
09 A……..……..….= 09
18 A……..……..…= 18
36 A……..……..……= 36
90 A……..…= 90

Communication Interface
Standard (without communication interface)……..…= S
EtherCAT (CoE) ……...…...= E
EtherCAT (mega-ulink)……..…..…...= F
Modbus……..……..= M

Encoder Type
Standard (digital/analog)……...…..……...…...= 2
Resolver……..= 4
Multi encoder……..= 9

Voltage Range
1Φ/3Φ 230 Vac (for 09/18/36A D1-N servo drive)……..…..= 2
3Φ 230/400 Vac (for 90A D1-N servo drive)..……= 6

Heat Sink Type
Without heat sink……..……..……..…..= 0
High profile ..……..……...……...= 1

Mark
HIWIN mark.……..……..…= 00
mega-fabs mark……..……= 01

Note:

(1) D1-N-□□-□9 supports dual loop control.

- Supported linear encoder: Digital AqB encoder
- Supported rotary encoder: BiSS encoder or T-code

(2) When D1-N-90 servo drive is used with 400 Vac, the rated current is 20 A_{amp} and the instantaneous current is 60 A_{amp}.

(3) D1-N-□□-□9 supports the following encoder types: EnDat2.1/2.2, BiSS, digital, analog, T-code, Hiperface, Hiperface DSL, Nikon and SSI.

2.2 Servo drive specification

2.2.1 Basic specification

D1-N			D1-N-09	D1-N-18	D1-N-36	D1-N-90
Input Power	Main Power Voltage	Voltage	230 Vac (-20%/+15%)			230 Vac (-20%/+15%) 400 Vac (±10%)
		Frequency	50/60 Hz ± 5%			
		Phase	1 Ø or 3 Ø			3 Ø
	Main Power Current		3 A_{rms}	6 A_{rms}	12 A_{rms}	30 A_{rms}
	Control Voltage		+24 Vdc ± 10%			
	Control Current		Minimum 1 A			
Output Power	Continuous Current		3 A_{amp} [2.1 A_{rms}]	6 A_{amp} [4.2 A_{rms}]	12 A_{amp} [8.5 A_{rms}] (Note: with external heat sink)	• 230 Vac 30 A_{amp} [21 A_{rms}] • 400 Vac 20 A_{amp} [14 A_{rms}] (Note: The case of D1-N-90 is different from the one of D1-N-36.)
	Instantaneous Current		9 A_{amp} [6.4 A_{rms}]	18 A_{amp} [12.7 A_{rms}]	36 A_{amp} [25.5 A_{rms}]	• 230 Vac 90 A_{amp} [63.6 A_{rms}] • 400 Vac 60 A_{amp} [42.3 A_{rms}]
	Peak Time of Instantaneous Current		Maximum 1 second			
	Maximum Supported Power for Motor		0.2 KW	0.5 KW	1 KW	5.5 KW
State Indication	Servo Drive State		LCD matrix (2x8) Dual color LED • Red: Error • Green: Servo ready			
Main Circuit Control			IGBT SVPWM control			
Control Motor Type			• AC servo motor • Linear motor • Torque motor			
Control Mode	Position Mode	Pulse Command Format	• Pulse/Direction • CW/CCW • AqB			
		Maximum Input Pulse Frequency: Differential signal	4 M line/sec, 5 V 16 M count/sec (Cable length < 2 m) (CW+/CW-, CCW+/CCW-input)			
		Maximum Input Pulse Frequency: Single-ended signal	12 V ~ 24 V, 500 KHz (CWL, CCWL input)			
		Command Source	Pulses from controller			
		Electronic Gear	Electronic gear ratio: pulses/counts Pulse: 1 ~ 2,147,483,647; Count: 1 ~ 2,147,483,647			
	Velocity Mode	Analog Input Command: Voltage Range	±10 Vdc			
		Analog Input Command: Resolution	12 bits			
		Command Source	Voltage from controller			

	Force/ torque Mode	Analog Input Command	Voltage Range	±10 Vdc
			Resolution	12 bits
		Command Source		Voltage from controller
Encoder Input		Type		Analog or digital differential input, serial input and resolver
		Operating Voltage		+5 Vdc (500 mA)
		Digital	Input Signal	Differential signal (A, /A, B, /B, Z and /Z)
			Bandwidth	5 MHz line frequency, x4 frequency: 20 M counts/s
		Analog	Input Amplitude	Differential signal (Sin/cos 1 Vpp) Z and /Z signals are digital.
			Bandwidth	1 MHz maximum line (Cycle) frequency
			Resolution	Maximum 65,528 counts/cycle
		Resolver		Differential signal (Sin/cos), reference 3 KHz, 6 Vpp, 100 mA
Encoder Counting Range				-2,147,483,648 ~ 2,147,483,647 (32 bits)
Buffered Encoder Output		Digital Encoder		• 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) • Open collector output (CZ): Outputs with Z phase signal. Signal width can be adjusted via software. • The delay time between the time the servo drive receives encoder signal from the encoder and the time the servo drive outputs signal from X6 connector is in nanosecond (ns).
		Analog Encoder		• Maximum 18 M counts/s, digital AqB output, differential signal output • The 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 X6 connector is in nanosecond (ns).
Emulated Encoder Output				• Maximum 18 M counts/s, digital AqB output, differential signal output • The ratio of encoder input to emulated encoder output can be adjusted. The width of emulated index signal output can be adjusted. • Open collector output (CZ): Outputs with Z phase signal. Signal width can be adjusted via software. • 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 revolution • The maximum delay time between the time the servo drive receives encoder signal from the encoder and the time the servo drive outputs signal from X6 connector is 66.67 us.
Digital Hall Sensor				Digital single-ended signal with 120 degrees phase difference

Communication	Standard USB 2.0	Set servo drive parameters and monitor servo drive status via computer.			
Digital Input	Input	I1 ~ I10 input functions can be user-defined. (Optical coupler, general-purpose input) Input pin: 5 V/1 mA, 24 V/5 mA			
	Safety input	Two sets of safety inputs. The voltage for STO safety function is 24 V. Signal interrupts > 6 ms			
Digital Output	Output	O1 ~ O3 output functions can be user-defined. (Optical coupler, general-purpose output) Output pin: 24 V/0.1 A			
	Brake Output	+24 Vdc, 1 Adc max			
	PT Output	• PT+ and PT- signals are 3.3 V differential outputs. • When the set position is reached, PT output is ON. • Response time of digital encoder is below 0.1 us. • Only supports digital AqB encoder • PT pulse width: 25 ns ~ 100 us • PT position accuracy: ±1 count (Up to 5,000,000 counts/sec)			
	Monitoring	Monitoring STO status.			
PDL Editor	Maximum Storage for Codes	32 Kbytes			
	Storage for Variables	800 bytes			
	Supported Variable Type	Float: 32 bits Integer: 16 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	Variable: 17 characters Label: 24 characters Proc: 24 characters			
Regenerative Resistor	Resistance	Internal regenerative resistor 50 Ω/150 W (Note: When regenerative energy is above 150 W, please install regenerative resistor.)			External regenerative resistor is required.
	Voltage Threshold for Activation	+HV > 390 Vdc (Input power: 230 Vac)			• +HV > 390 Vdc (Input power: 230 Vac) • +HV > 735 Vdc (Input power: 400 Vac)
	Voltage Threshold for Deactivation	+HV < 380 Vdc (Input power: 230 Vac)			• +HV < 380 Vdc (Input power: 230 Vac) • +HV < 695 Vdc (Input power: 400 Vac)
	Tolerance	± 5%			
	DC Link Capacity	940 uF	940 uF	1,880 uF	940 uF
Protection Function	Overvoltage	+HV > 404 Vdc			+HV > 800 Vdc
	Undervoltage	+HV < 184 Vdc (Input power: 230 Vac)			• +HV < 184 Vdc (Input power: 230 Vac) • +HV < 320 Vdc

					(Input power: 400 Vac)
	Over Temperature	IGBT > 80 °C ± 3 °C			
	Short Circuit	• Short circuit between UVW wires • Short circuit between UVW cable and ground (PE) • Internal PWM bridge short circuit			
	Software Over Temperature Protection	Starts to estimate temperature rise as continuous current is exceeded.			
	Encoder Feedback Error	• The input voltage is 85% lower than normal voltage 5 V. • Phase error (A/B phase) • The signal of analog encoder is too weak. • Serial encoder error			
Safety Function	STO (Safe Torque Off)	• Two safety inputs are used to suspend motor current. • STO status can be monitored via digital output. • To disable safety function, X6-pin 20 and X6-pin 40 should be short-circuited. • To enable safety function, the servo drive must be turned off first. Connect safety inputs. X6-pin 20 and X6-pin 40 should not be short-circuited. After that, turn on the servo drive again.			
Error Compensation	Applicable Motor	• Linear motor • AC servo motor • Torque motor			
	Compensation Method	Creates error map to compensate encoder error by means of linear interpolation.			
	Storage Point	Maximum 5,000 points			
	Storage Location	Flash ROM			
	Unit	um, count, mm and rev			
	Enabling Method	• Enabled after internal homing completes. • Enabled by external input signal.			
Communication Module	EtherCAT	Connect to two RJ-45 connectors of X13. Supports EtherCAT function (CoE or mega-ulink)			
	Modbus (RS485)	Connect to two RJ-11 connectors of X13. • Supports serial communication with other servo drives. • Supports Modbus RTU and ASCII protocols (Half duplex)			
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	1 G (10 ~ 500 Hz)			
	IP Rating	IP20			
Weight (Accessory kit included) (kg)		2.05 (Approx.)	2.2 (Approx.)	3 (Approx.)	6 (Approx.)
Dimensions (Length x Width x Height)		249 mm x 75 mm x 182 mm	249 mm x 75 mm x 182 mm	249 mm x 101 mm x 182 mm	272 mm x 119 mm x 254 mm
Case		Complies with CE U.L. Spec 94 V-0 Flammability Rating			

2.2.2 Dimensions

The dimensions and mounting holes of D1-N servo drives are shown in figure 2.2.2.1 to 2.2.2.3. The unit is mm. The diameter of the mounting hole is 4 mm.

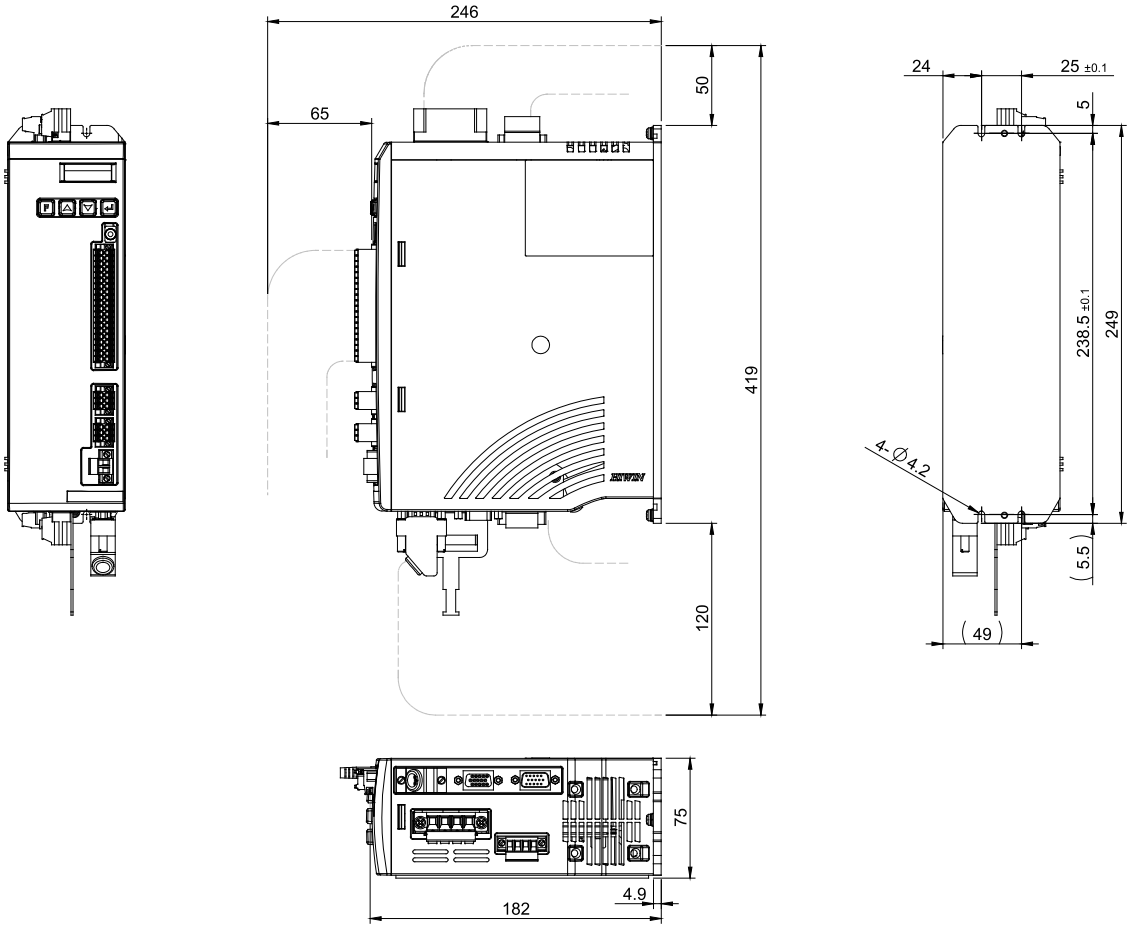


Figure 2.2.2.1 D1-N-09 and D1-N-18 servo drives

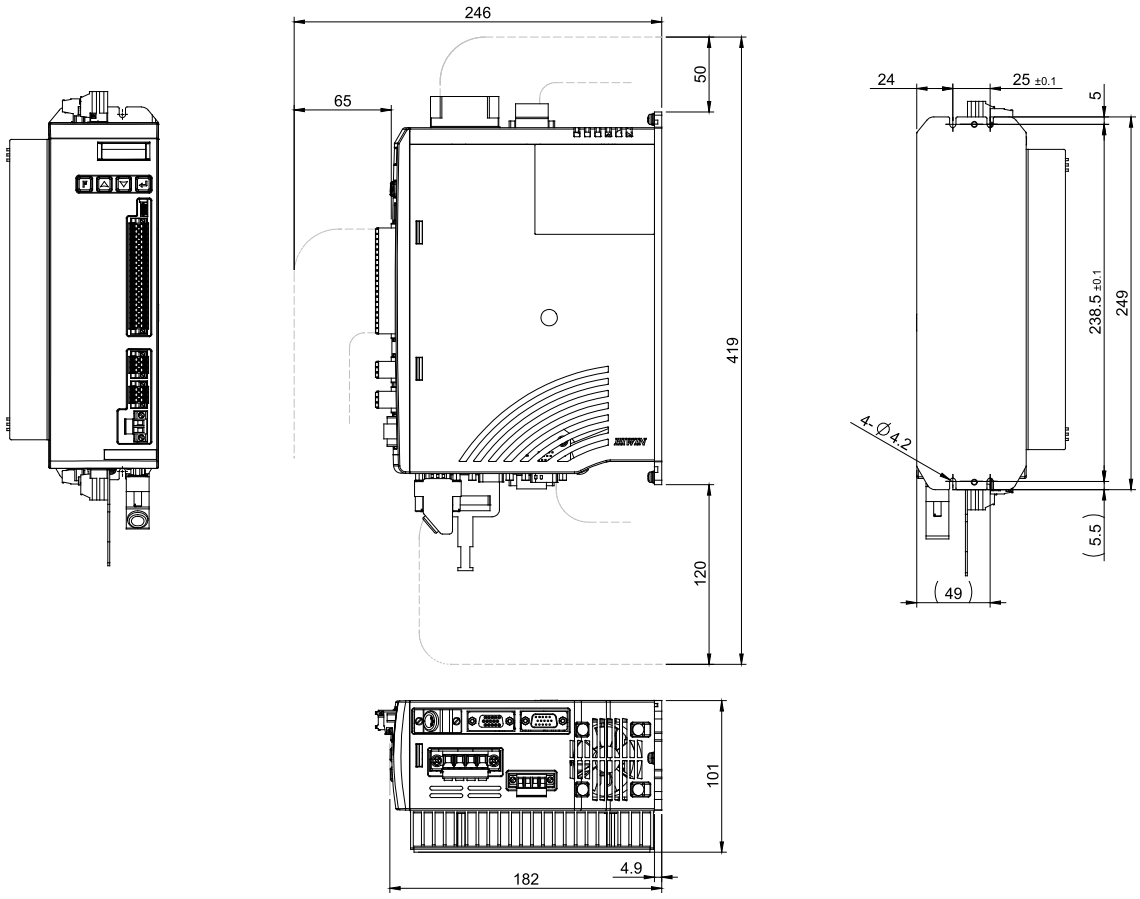


Figure 2.2.2.2 D1-N-36 servo drive

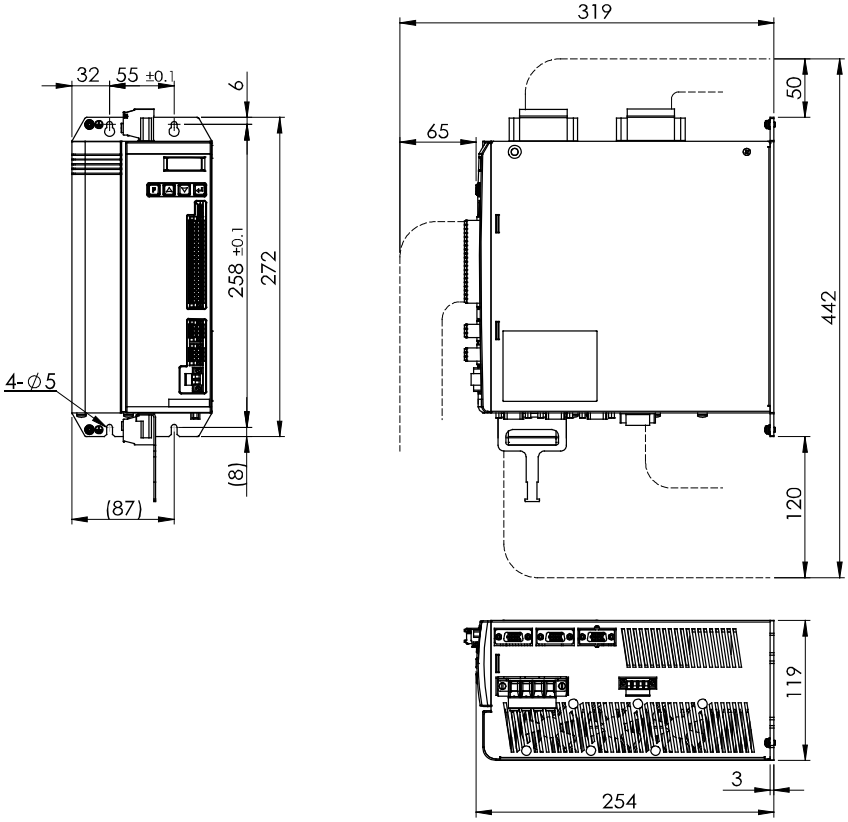


Figure 2.2.2.3 D1-N-90 servo drive

2.3 Installation

When the servo drive is installed in an electric box, ensure the servo drive is mounted with conductive screws. The insulating materials, such as paint, on the contact surface of the electric box must be removed for grounding the servo drive through the electric box. For further information about grounding, please refer to chapter 15. The suction hole and vent hole of the servo drive must not be obstructed. Install the servo drive according to the specified orientation. Otherwise the servo drive may malfunction. To ensure well cooling and circulation effect, there must be enough clearance space between the servo drive and the adjacent objects or baffles. While installing multiple servo drives, if the servo drives are without heat sinks, the clearance space between two servo drives must be at least 10 mm. If the servo drives are with heat sinks, the clearance space between two servo drives must be at least 40 mm. Install a fan in the electric box to facilitate heat dissipation.

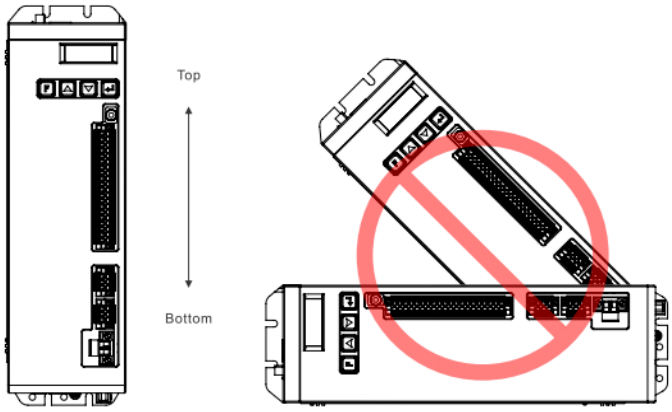


Figure 2.3.1

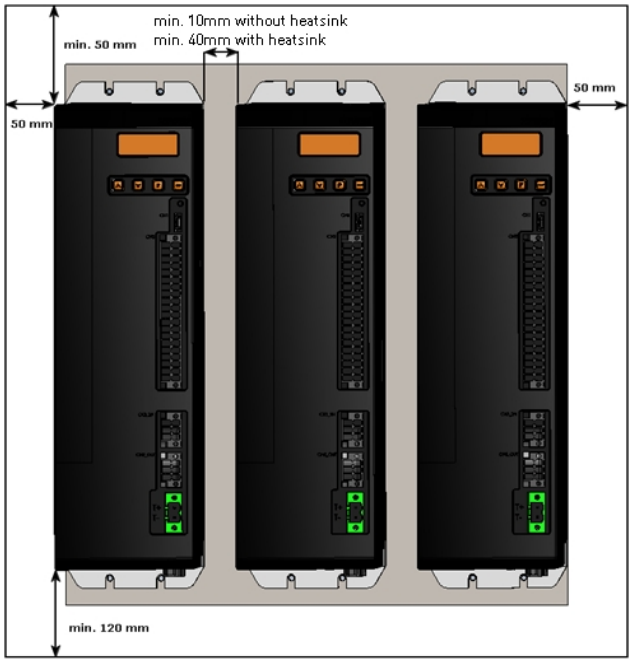


Figure 2.3.2

2.4 System requirements

Table 2.4.1

CPU	1.0 GHz or higher
RAM	512 MB or more
Hard Disk Space	50 MB or more
Communication Port	USB communication port
Operating System	Win 2000, Win XP or Win 7
Display	1024*768 pixel or higher

3. Operation principles

3.1 Operation mode

D1-N 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 the motor to run a corresponding distance. Path planning is done by the controller. At what speed the motor runs is decided by the sending frequency of pulses. The motor runs at faster speed as pulses are sent at faster speed; the motor runs at constant speed as pulses are sent at fixed speed. As figure 3.1.1.1, three pulse formats are supported: Pulse/Direction (Pulse/Dir), Pulse up/Pulse down (CW/CCW) and A/B phase (AqB). By different wirings, pulse signals can be classified into TTL differential signals and single-ended signals. Users can set electronic gear ratio in position mode. Normally one pulse is equivalent to one encoder count. For instance, when the electronic gear ratio is set to 2:3, it means two pulses is equivalent to three encoder counts.

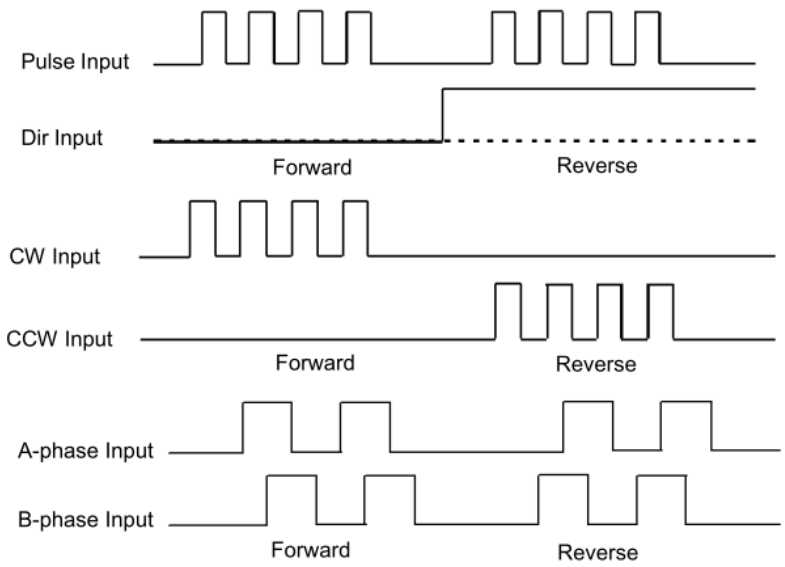


Figure 3.1.1.1

3.1.2 Velocity mode

In velocity mode, the servo drive receives analog commands (or V commands) from controller. The input voltage range is from -10 V to +10 V. The input voltage is transformed into corresponding velocity command to drive the motor. The higher the voltage is, the faster the motor runs. (Note: The maximum speed still depends on the specification of the motor.) The lower the voltage is, the slower the motor runs. If the voltage value is negative, the motor runs in reverse direction. The corresponding velocity command of input voltage can be set in the servo drive.

3.1.3 Force/torque mode

In force/torque mode, the servo drive receives analog commands (or V commands) from controller. The input voltage is transformed into corresponding current command. The force or torque of the motor is controlled by the output current from the servo drive. The higher the voltage is, the larger the current is. (Note: The maximum current still depends on the specification of the motor.) The lower the voltage is, the smaller the current is. If the voltage value is negative, the output current is negative. When the output current is negative, the motor runs in reverse direction. The corresponding current command of input voltage 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 users would like the servo drive to be tested alone or operate without controller. In stand-alone mode, servo loop is 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 loop. 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 the optical scale or magnetic scale is transformed into digital signal or analog signal. Normally optical scale or magnetic scale may support either digital signal or analog signal output.

(1) Digital type

Digital encoder (or incremental encoder) normally outputs TTL RS422 differential signals. TTL RS422 differential signal includes two digital pulses with 90 degrees phase difference. Its resolution definition is shown in figure 3.2.1. The resolution of linear optical scale is usually 1 um.

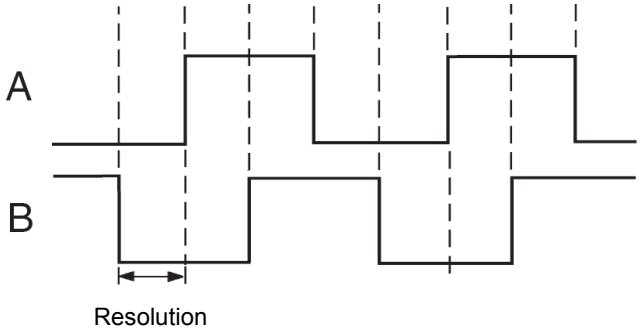


Figure 3.2.1

(2) Analog type

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

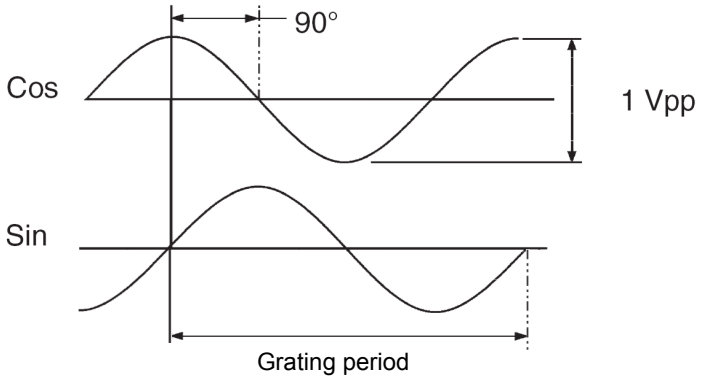


Figure 3.2.2

3.3 Encoder signal output

The input signals from encoder are used by the servo drive to perform servo control. When the servo drive is used with controller, the servo drive transmits position or angle signal received from the encoder to the controller. D1-N 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-N servo drive. When invert function is selected, the signals received from encoder will be reversed 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 the 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.

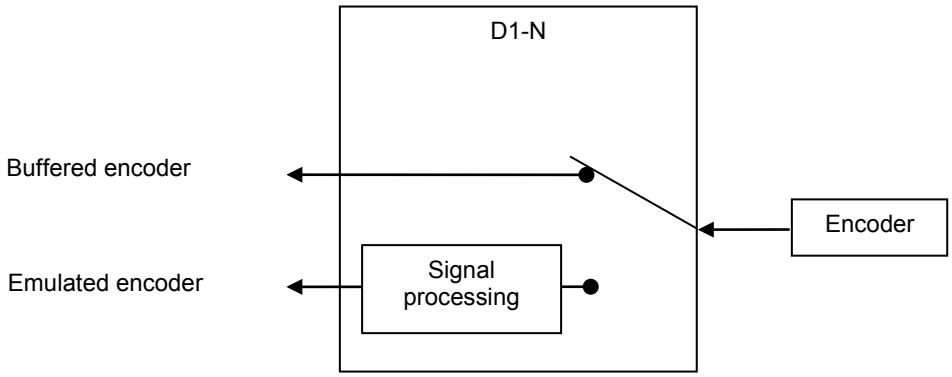


Figure 3.3.1

3.4 Path planning

Path planning is usually done by controller. The controller calculates suitable motion commands according to 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).

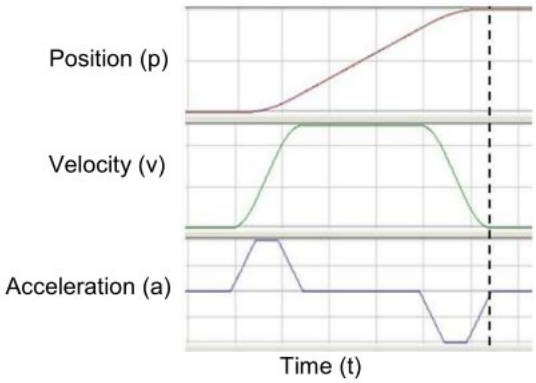


Figure 3.4.1

(1) Position

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

Table 3.4.1

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

(2) Velocity

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

Table 3.4.2

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.

Table 3.4.3

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 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.

(5) Emergency stop

D1-N 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

■ Servo loops

D1-N servo drive includes three servo loops, current loop, velocity loop and position loop, to control motor. The servo loops of D1-N servo drive 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-N servo drive can be set and adjusted by one common gain (CG).

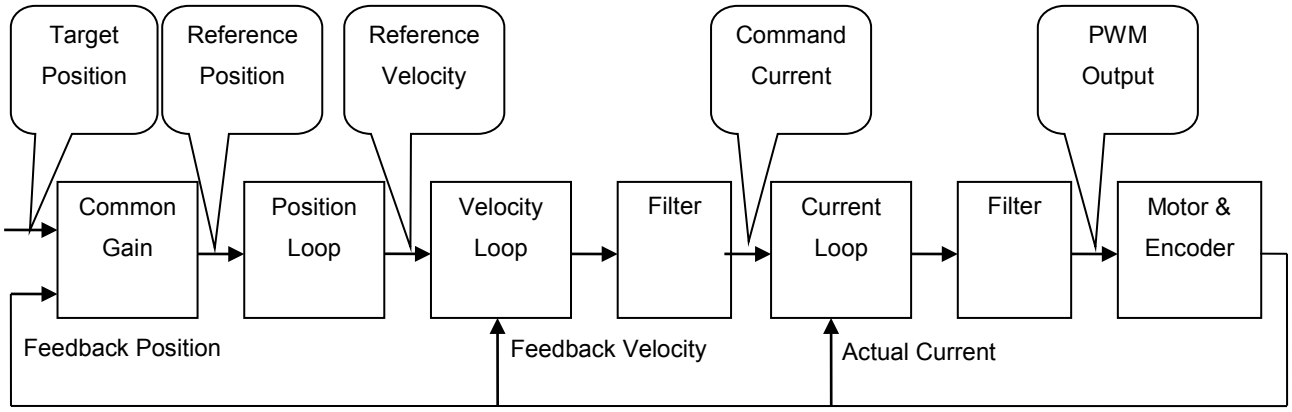


Figure 3.5.1

■ Servo gains

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

Figure 3.5.2

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, $\angle G(j\omega_p) = 180°$. For the transfer function $G(s)$ in a loop system, its gain margin =

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

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 $GM = \infty\ dB$. When the Nyquist plot does not intersect with the negative real axis at any non-zero finite frequency, $GM = \infty\ dB$. 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 $GM > 0\ dB$. 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 $GM = 0\ dB$. When $G(j\omega)$ is on (-1, j0), $GM = 0\ dB$. It means 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 $GM < 0\ dB$. When $G(j\omega)$ passes (-1, j0), $GM < 0\ dB$. Loop gain must be decreased to have stable system.

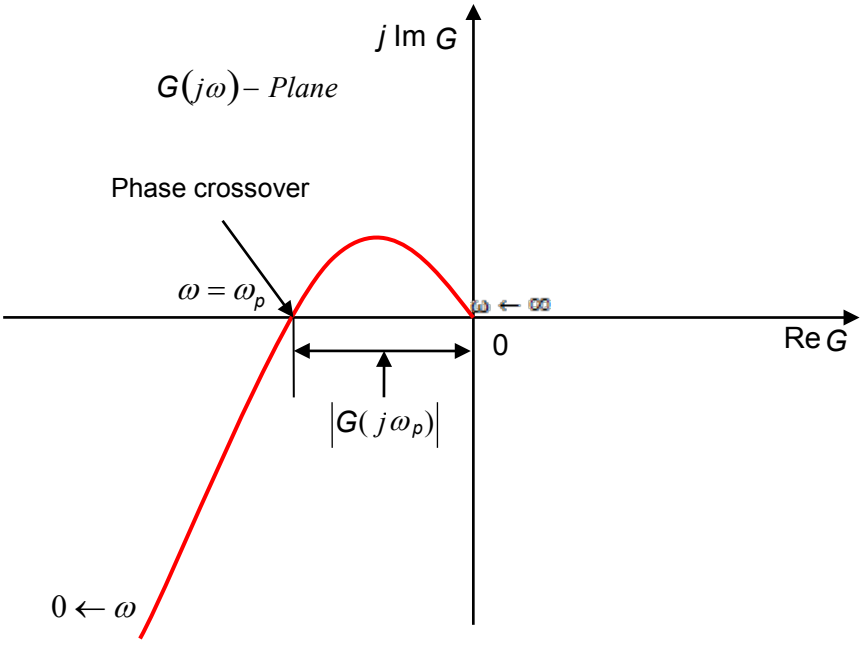


Figure 3.6.1.1 Gain margin

(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.

Phase margin = PM = $\angle G(j\omega_g) - 180°$

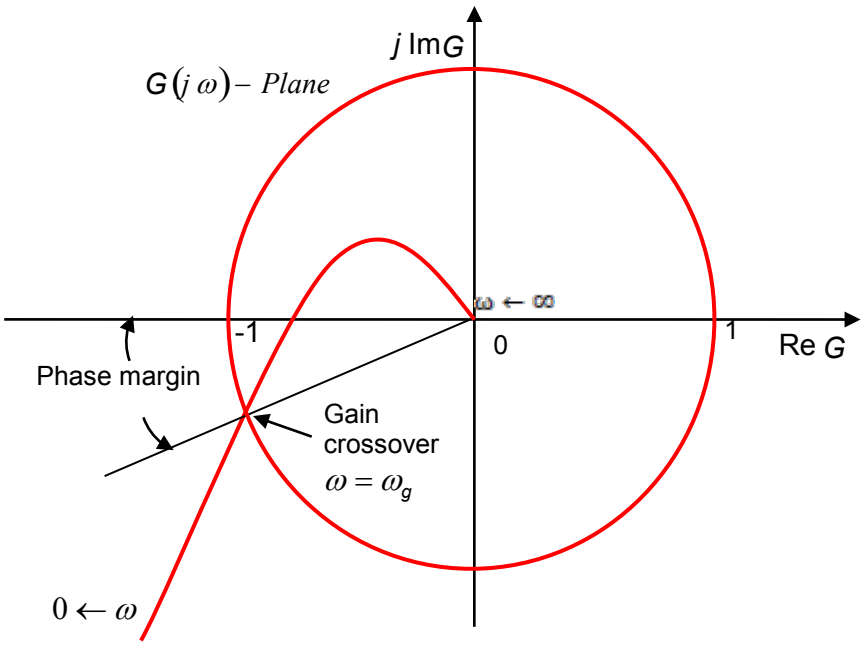


Figure 3.6.1.2 Phase margin

3.6.2 Bode plot

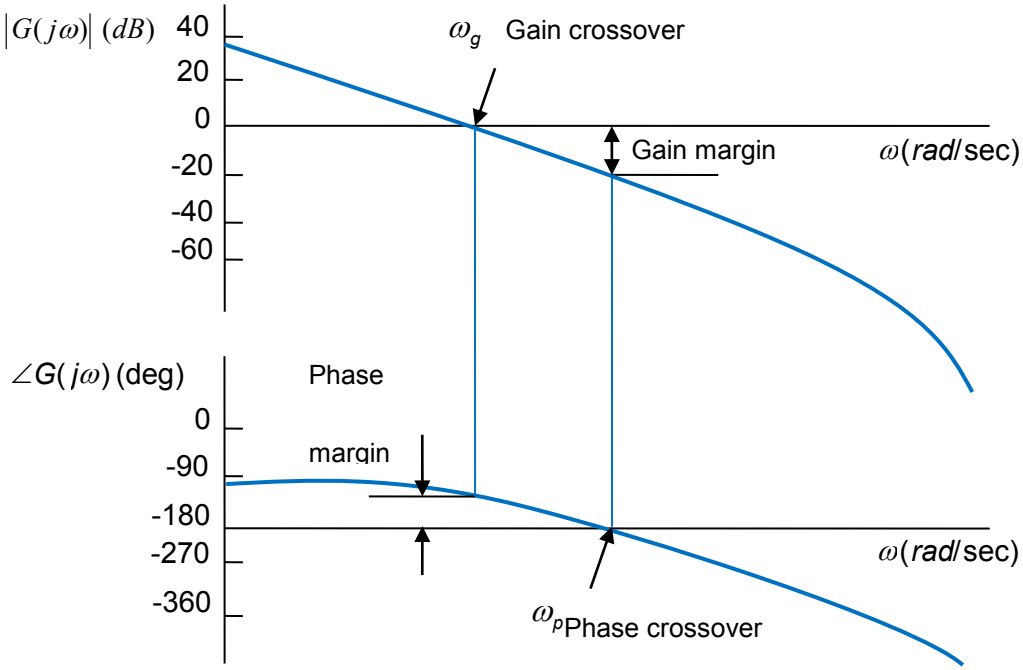


Figure 3.6.2.1 Gain margin and phase margin in Bode plot

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

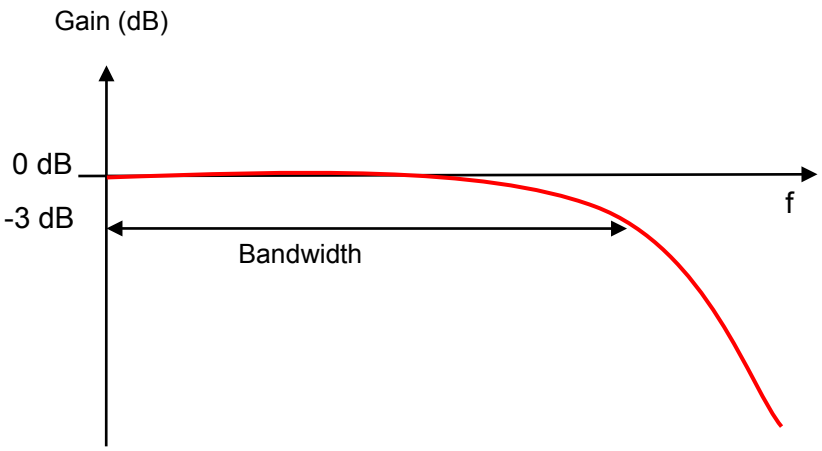


Figure 3.6.2.2 Bandwidth of Bode plot

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.

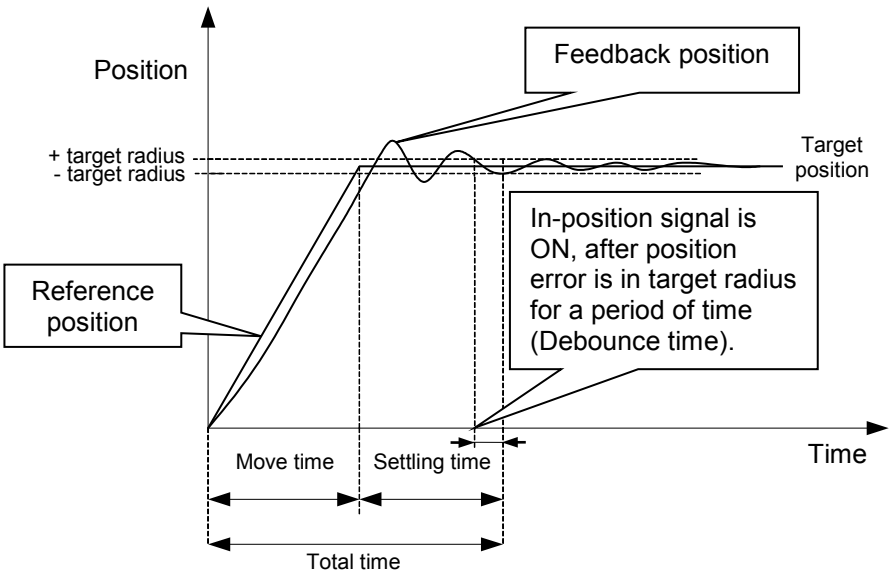


Figure 3.7.1

3.8 Error compensation

Normally the positioning accuracy of a servo drive is decided by encoder. When an encoder cannot meet users' requirement for accuracy, users may use equipment with higher accuracy level (such as laser interferometer) to measure system error. Then, as figure 3.7.1, D1-N servo drive is able to store system error in its error map and calculate error compensation value by means of linear interpolation between fixed distances to enhance positioning accuracy.

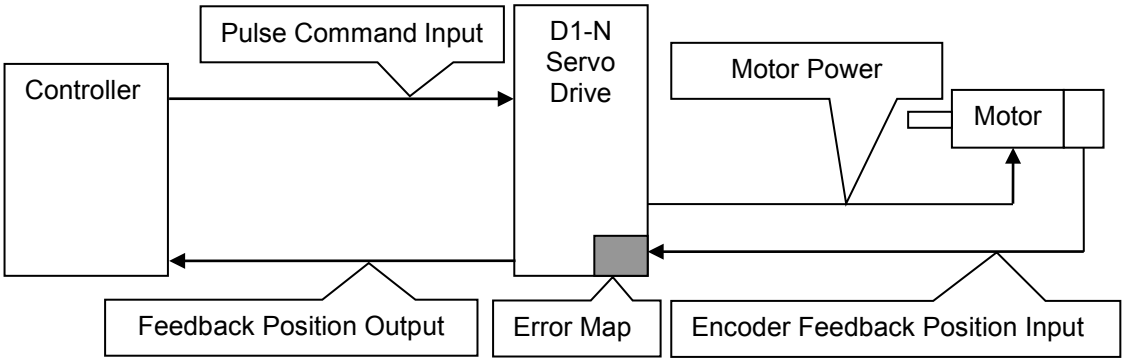


Figure 3.8.1

The effective range of error compensation is determined by index signal. Error compensation is effective only in the forward direction of index signal. If home offset is applied, the effective range of error compensation is still the same.

(1) When home offset is set to 0

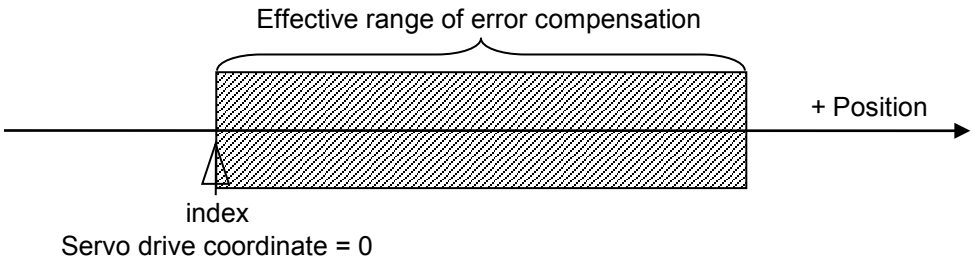


Figure 3.8.2

(2) When home offset is set to 100

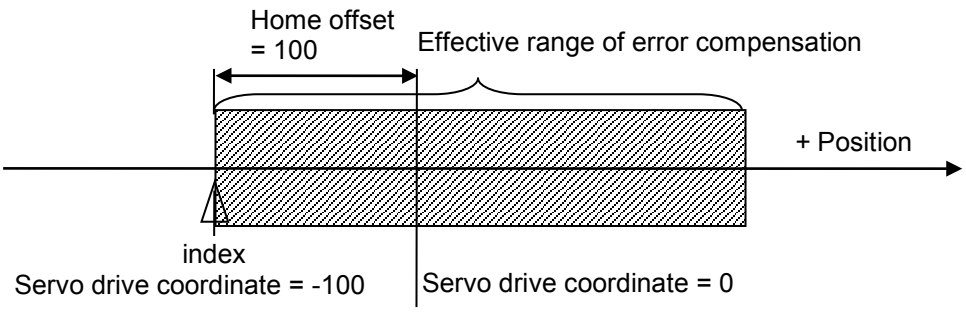


Figure 3.8.3

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 and guideway friction, etc. 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:

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

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.

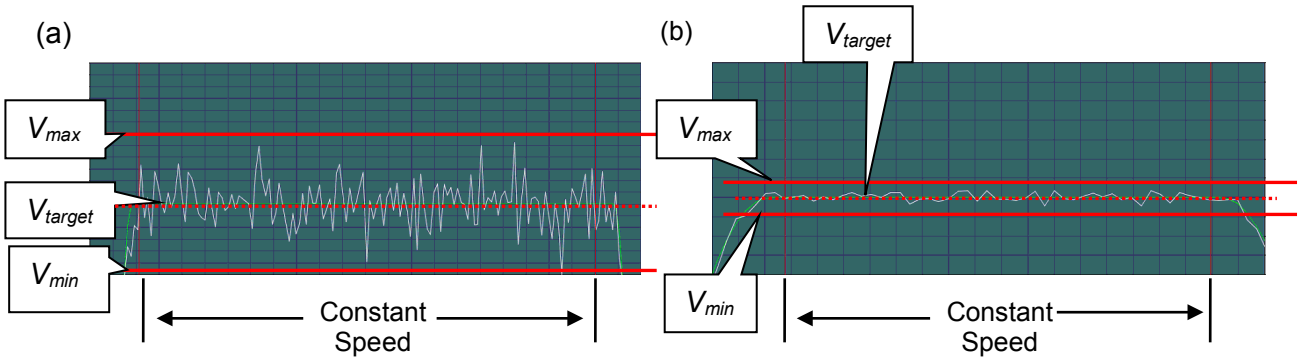


Figure 3.9.1

3.10 Enabling

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

(1) Step motion mode (SM mode)

Step motion mode (SM mode) is an open loop 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 works 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. Another commonly-used method for phase initialization is by Hall sensor. Normally phase initialization and enabling can be completed via an output signal from controller (such as I1 input of D1-N servo drive).

3.11 Basic physical quantities

Table 3.11.1

Number	Name	Description
1	Feedback position	Feedback position
2	Reference position	Position command
3	Target position	Target position
4	Position error	Position error
5	Single turn feedback position	Feedback position of single-turn absolute encoder (Only for servo drive which supports single-turn absolute encoder)
6	Dual loop feedback position	Feedback position of dual loop control (Only for servo drive which supports dual loop control)
10	Feedback velocity	Feedback velocity
11	Reference velocity	Velocity command
12	Velocity error	Velocity error
20	Reference acceleration	Acceleration command
30	Actual current	Actual current
31	Command current	Current command
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
46	Digital hall bits	Signal of digital Hall sensor
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
66	I6	Input 6
71	I7	Input 7
72	I8	Input 8
67	I9	Input 9
68	I10	Input 10
81	O1	Output 1
82	O2	Output 2
83	O3	Output 3
84	O4/BRK	Output 4 (For brake signal)

4. Wiring

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

The names, functions and specifications of terminals on D1-N servo drive are described in the following figures.

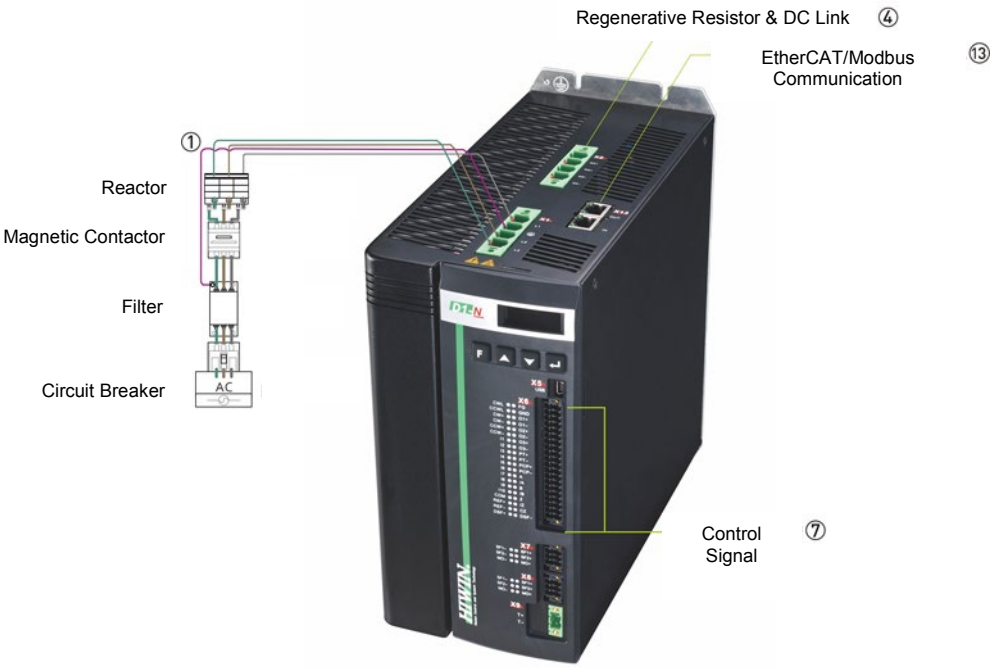


Figure 4.1.1.1

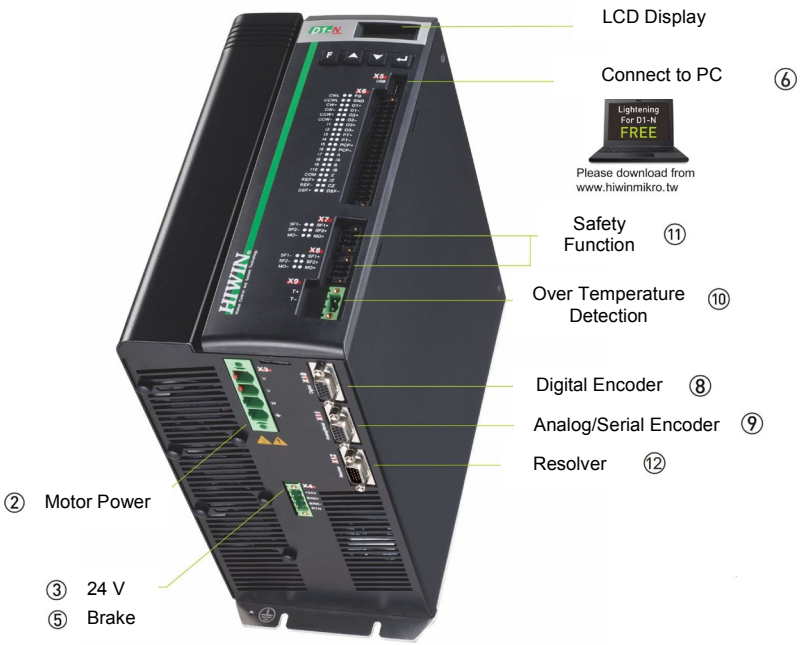


Figure 4.1.1.2

Table 4.1.1.1

Item	Name	Description
①	AC main power (X1)	• 09/18/36A model (L1, L2, L3): Single-phase/Three-phase 230 Vac, 50/60 Hz • 90A model (L1, L2, L3): Three-phase 230/380 Vac, 50/60 Hz
②	Motor power (X3)	Connect to motor. Three-phase power for motor (⏚, U, V, W)
③	24 V control power (X4)	Power for servo drive control and IO (+24 V, RTN)
④	Regenerative resistor and DC link (X2)	Connect to regenerative resistor. (Optional) (Install according to actual application.) (RG+/RG-)
⑤	Brake (X4)	Connect to brake. (Optional) (Install according to actual application.) (BRK+/BRK-)
⑥	USB communication (X5)	Connect to PC for parameter setting. Disconnect after setting. Use mini USB cable to connect to PC for monitoring, test run and parameter setting, etc.
⑦	Control signal (X6)	Connect to controller.
⑧	Signal of digital encoder/Hall sensor (X10)	Connect to digital encoder and Hall sensor.
⑨	Signal of analog/serial encoder (X11)	Connect to analog encoder, EnDat encoder or BiSS encoder.
⑩	Motor over temperature detection (X9)	Connect to device for motor temperature detection.
⑪	Safety function (X7, X8)	Connect to signals of safety function.
⑫	Signal of resolver (X12)	Connect to resolver.
⑬	EtherCAT/Modbus communication (X13)	Connect to controller via EtherCAT/Modbus.

⚠ CAUTION

- Wiring and examination must be performed by professional technician.
- Turn off the power before wiring or examination to avoid electric shock.
- Do not touch power terminals within five minutes after power off. There could be residual voltage in power terminals.
- Ensure wiring is correctly performed, or it may cause motor malfunction, injury or machine malfunction.
- Do not connect U, V, W terminals to power supply.
- Ensure motor power cable is firmly connected, or it may cause fire.
- Ensure the servo drive and motor are properly grounded.
- Wiring must be performed after the servo drive and motor are properly installed, or it may cause electric shock.
- Do not damage, pull or squeeze cables, or it may cause electric shock.
- The servo drive could have interference on adjacent electronic equipment. Use noise filter to reduce electromagnetic interference.
- Do not modify the servo drive.
- Do not put main circuit cable, output/input signal cable and encoder cable in the same tube or tie them together. They should be at least 30 cm apart.
- While wiring for terminals of main circuit, please pay attention to the following.
  - Insert one wire per terminal only.
  - After wires are inserted, ensure no short circuit occurs between wires.
  - Use specified voltage, or it may cause fire or servo drive malfunction.
- Use power supply specified in product specification, or it may cause damage to the servo drive.
- Use circuit breaker to prevent short circuit of external wiring from damaging the servo drive.
- In the following locations, ensure the servo drive is properly isolated or shielded, or it may cause operation failure.
  - Location which is subject to electrostatic interference
  - Location which is subject to strong electric field or magnetic field
  - Location which is subject to emitted radiation

4.1.2 Connector specifications

■ D1-N-09/18/36

Table 4.1.2.1

Connector	Specification	Manufacturer	Wire Gauge Range	Note
Connector for AC main power cable	European standard 4-pin 7.62 mm pluggable connector (Female)	PHOENIX Part number: 1777859	22-12 AWG Suggested: 12 AWG, 600 V	
Connector for motor power cable	European standard 4-pin 7.62 mm pluggable connector (Female)	PHOENIX Part number: 1778191	22-12 AWG Suggested: 12 AWG, 600 V	
Connector for regenerative resistor	European standard 4-pin 5.08 mm pluggable connector (Male)	PHOENIX Part number: 1825336	22-14 AWG Suggested: 14 AWG, 600 V	
Connector for control power	European standard 4-pin 5 mm pluggable connector (Female)	PHOENIX Part number: 1786857	22-14 AWG Suggested: 18 AWG	
Connector for control signals	European standard 40-pin 3.5 mm pluggable connector (Female)	PHOENIX Part number: 1790470	24-30 AWG	
Connector for feedback signal	D-Sub 15-pin standard solder connector (Male)		24-30 AWG	
	D-Sub 15-pin standard solder connector (Female)			
Connector for motor over temperature signal	European standard 2-pin 5 mm pluggable connector (Female)	PHOENIX Part number: 1786831	20-28 AWG	
Connector for safety function	European standard 6-pin 3.5 mm pluggable connector (Female)	PHOENIX Part number: 1790302	24-30 AWG	
Connector for mini USB communication	USB 2.0 type A to mini-B 5-pin (1.8 M) (Shielding)	HIWIN Part number: 051700800366		Optional

Note:

Use wiring tools to avoid electric shock when wiring.

■ D1-N-90

Table 4.1.2.2

Connector	Specification	Manufacturer	Wire Gauge Range	Note
Connector for AC main power cable	European standard 4-pin 10.16 mm pluggable connector (Female)	PHOENIX Part number: 1967472	20-11 AWG Suggested: 11 AWG, 600 V	
Connector for motor power cable	European standard 4-pin 10.16 mm pluggable connector (Female)	PHOENIX Part number: 1970359	20-11 AWG Suggested: 11 AWG, 600 V	
Connector for regenerative resistor	European standard 4-pin 10.16 mm pluggable connector (Male)	PHOENIX Part number: 1967472	20-11 AWG Suggested: 11 AWG, 600 V	
Connector for control power	European standard 4-pin 5 mm pluggable connector (Female)	PHOENIX Part number: 1786857	22-14 AWG Suggested: 18 AWG	
Connector for control signals	European standard 40-pin 3.5 mm pluggable connector (Female)	PHOENIX Part number: 1790470	24-30 AWG	
Connector for feedback signal	D-Sub 15-pin standard solder connector (Male)		24-30 AWG	
	D-Sub 15-pin standard solder connector (Female)			
Connector for motor over temperature signal	European standard 2-pin 5 mm pluggable connector (Female)	PHOENIX Part number: 1786831	20-28 AWG	
Connector for safety function	European standard 6-pin 3.5 mm pluggable connector (Female)	PHOENIX Part number: 1790302	24-30 AWG	
Connector for mini USB communication	USB 2.0 type A to mini-B 5-pin (1.8 M) (Shielding)	HIWIN Part number: 051700800366		Optional

Note:

Use wiring tools to avoid electric shock when wiring.

4.2 Main power (X1)

Ensure the servo drive is properly grounded before connecting to its main circuit. If the power for the servo drive is turned off during operation, the motor will not be disabled immediately, since there is residual power in capacitors. It is suggested to use STO safety function for emergency stop.

(1) Connector

A. D1-N-09/18/36

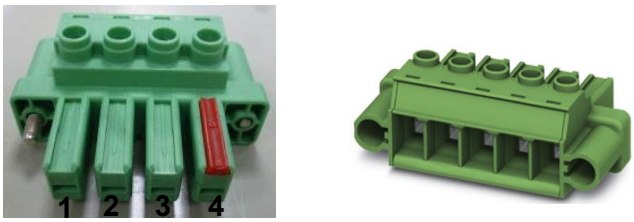


Figure 4.2.1 Connector: PC 5/4-STF1-7, 62 (1777859)

Table 4.2.1

Pin	Signal
1	L3
2	PE
3	L2 (N)
4	L1

B. D1-N-90

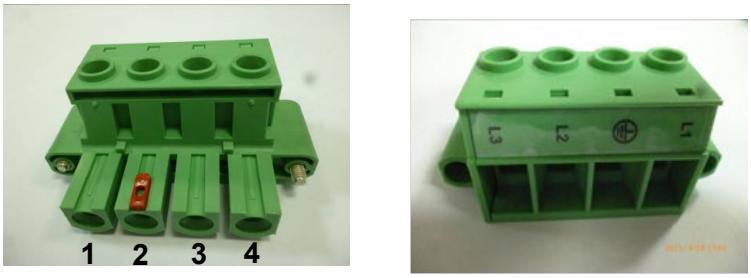


Figure 4.2.2 Connector: PC 16/4-STF-10.16 (1967472)

Table 4.2.2

Pin	Signal
1	L1
2	PE
3	L2 (N)
4	L3

(2) Wiring example

A. Wiring for single-phase filter for D1-N-09/18/36 servo drive

For selecting single-phase filter for D1-N-09/18/36 servo drive, B84113H filter (Part number: B84113H0000G120) from TDK (EPCOS) is suggested.

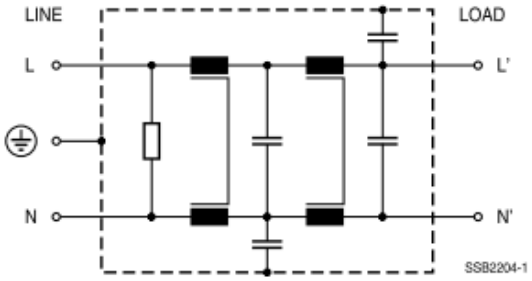


Figure 4.2.3 Wiring diagram for single-phase filter (Part number: B84113H0000G120) (Reference: Datasheet of B84113H filter)

Table 4.2.3

Filter (Part number: B84113H0000G120)	
Rated Voltage	250 Vac, 50/60 Hz
Rated Current	20 A at 40 °C
Leakage Current	1.73 mA (250 Vac, 50 Hz)
Approval	IEC 60939, UL 1283, CSA C22.2 No.8

B. Wiring for three-phase filter for D1-N-09/18/36 servo drive

For selecting three-phase filter for D1-N-09/18/36 servo drive, B84143A filter (Part number: B84143A0020R106) from TDK (EPCOS) is suggested.

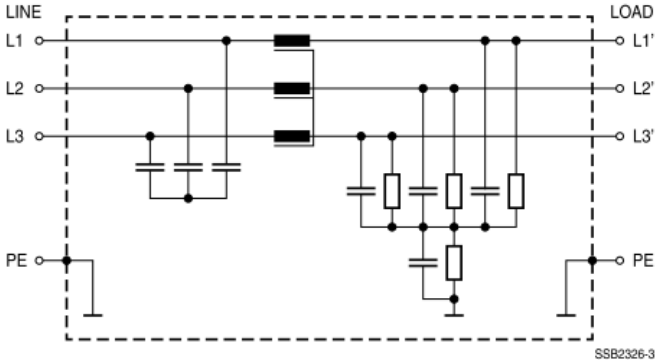


Figure 4.2.4 Wiring diagram for three-phase filter (Part number: B84143A0020R106) (Reference: Datasheet of B84143A filter)

Table 4.2.4

Filter (Part number: B84143A0020R106)	
Rated Voltage	520/300 Vac, 50/60 Hz
Rated Current	20 A at 50 °C
Leakage Current	3.1 mA (520/300 Vac, 50 Hz)
Approval	IEC 60939, UL 1283, CSA C22.2 No.8

C. Wiring for three-phase filter for D1-N-90 servo drive

For selecting three-phase filter for D1-N-90 servo drive, B84143A filter (Part number: B84143A0035R166) from TDK (EPCOS) is suggested.

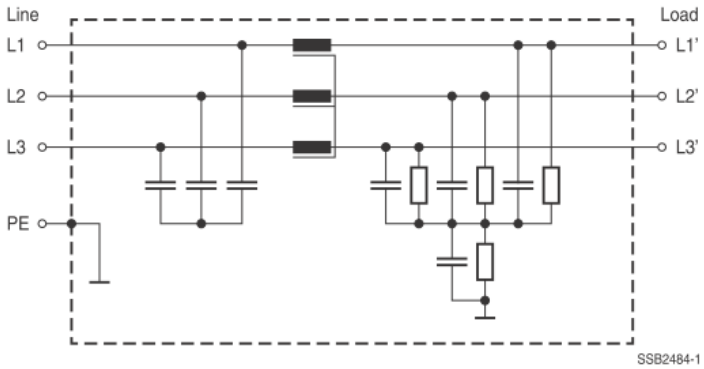


Figure 4.2.5 Wiring diagram for three-phase filter (Part number: B84143A0035R166) (Reference: Datasheet of B84143A filter)

Table 4.2.5

Filter (Part number: B84143A0035R166)	
Rated Voltage	520/300 Vac, 50/60 Hz
Rated Current	35 A @ 50 °C
Leakage Current	5.0 mA (520/300 Vac, 50 Hz)
Approval	IEC 60939, UL 1283, CSA C22.2 No.8

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

While using two or more servo drives, and power on at the same time: $I_B = C1 \times I_{n1} + C2 \times I_{n2} + \cdot\cdot\cdot\cdot + CN \times I_{nN}$

Note:

I_B: Rated current of no-fuse breaker

I_n: Rated current of servo drive

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

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

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

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

Example:

If three D1-N-18 and one D1-N-36 servo drives are used:

We assume C and C_{MAX} are 2.

Do not power on at the same time: I_B = (3×6+12-12)×1 + 12×2 = 42 A_{rms}

Power on at the same time: I_B = 2×6+2×6+2×6 + 2×12 = 60 A_{rms}

Table 4.2.6 Rated current of D1-N servo drive

Model	Rated Current
D1-N-09	3 A_{rms}
D1-N-18	6 A_{rms}
D1-N-36	12 A_{rms}
D1-N-90	30 A_{rms}

4.3 Regenerative resistor and DC link (X2)

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. D1-N-09, 18 and 36 servo drives have one internal regenerative resistor (50 Ω/150 W), but D1-N-90 servo drive does not have internal regenerative resistor. For fast movement (Regenerative energy is larger than 150 W.), external regenerative resistor must be installed since the internal regenerative resistor cannot absorb all the returned energy.

(1) Connector

A. D1-N-09/18/36

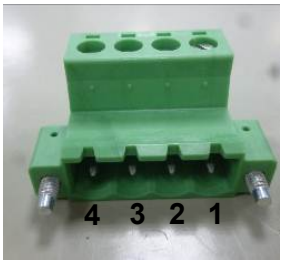


Figure 4.3.1 Connector: IC 2, 5/4-STF-5, 08 (1825336)

Table 4.3.1

Pin	Signal
1	DC+
2	RGP
3	RGS
4	DC-

B. D1-N-90

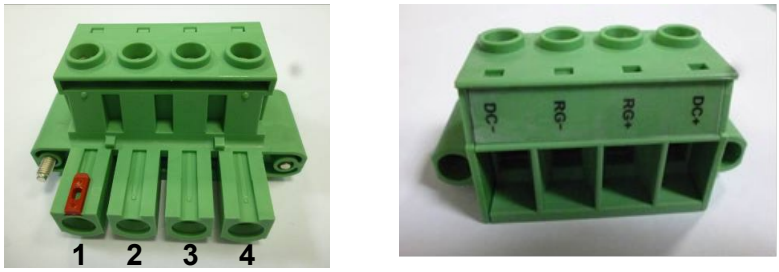


Figure 4.3.2 Connector: PC 16/4-STF-10.16 (1967472)

Table 4.3.2

Pin	Signal
1	DC+
2	RG+
3	RG-
4	DC-

(2) Wiring example

A. D1-N-09/18/36 servo drive

a. Only the internal regenerative resistor (50 Ω/150 W) is used.

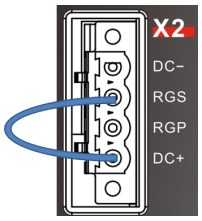


Figure 4.3.3

b. Both the internal regenerative resistor and external regenerative resistor are used. (Parallel connection)

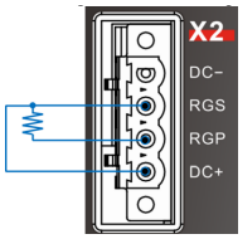


Figure 4.3.4

c. Both the internal regenerative resistor and external regenerative resistor are used. (Serial connection)

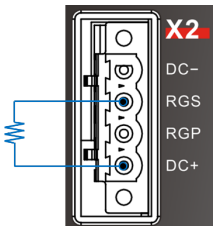


Figure 4.3.5

d. Only the external regenerative resistor is used.

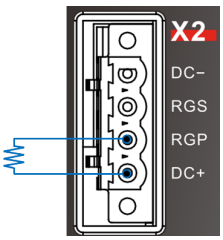


Figure 4.3.6

B. D1-N-90 servo drive

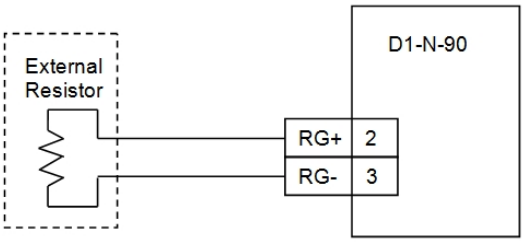


Figure 4.3.7

4.4 Motor power (X3)

The servo drive and motor must be properly grounded.

(1) Connector

A. D1-N-09/18/36 servo drive

Figure 4.4.1 Connector: PC 5/4-STF-SH1-7, 62 (1778191)

Table 4.4.1

Pin	Signal
1	U
2	V
3	W
4	PE

B. D1-N-90 servo drive

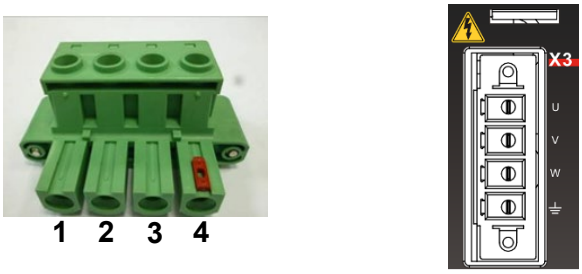


Figure 4.4.2 Connector: PC16/4-STF-SH-10.16 (1970359)

The pin definition is the same as table 4.4.1.

(2) Wiring example

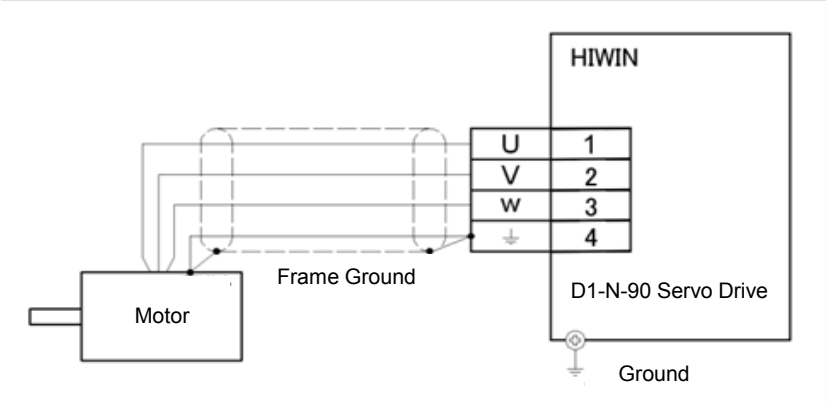


Figure 4.4.3

4.5 Control power and brake (X4)

For connecting 24 Vdc control power and brake, please refer to figure 4.1.1.2. When no brake is used, +24 V should be connected to pin +24 V (Pin 1) and 0 V should be connected to pin RTN (Pin 4). When brake is used, pins BRK+ and BRK- should be connected to relay. After brake signal is output, dynamic brake or electromagnetic brake will be activated. Pins BRK+ and BRK- are open-drain output pins. (Max. voltage: 40 V; Max. current: 1 A) The default output for brake signal is O4. For setting output function, please refer to section 5.4.2.

Note:
If brake is connected and “boot mode” or “COM error” occurs after motor is enabled, it means the +24 V input current could be insufficient for control circuit to be normally operated. Ensure input current is sufficient.

(1) Connector

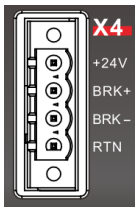


Figure 4.5.1 Connector: MSTB 2, 5/X-STF

Table 4.5.1

Pin	Signal
1	+24V
2	BRK+
3	BRK-
4	RTN

(2) Wiring example

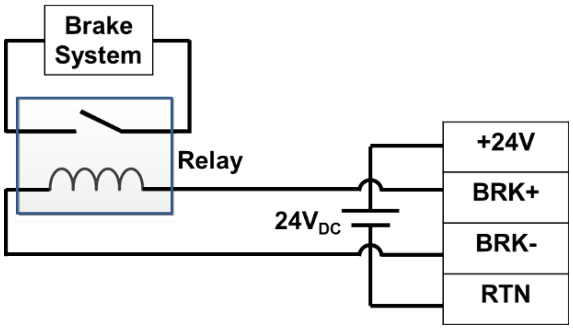


Figure 4.5.2

4.6 USB communication (X5)

Connect to PC by mini USB cable (HIWIN USB 2.0 type A to mini-B 5-pin (1.8 M) cable is suggested.) for monitoring, test run, parameter writing, etc. For servo drive operation, please refer to chapter 5.

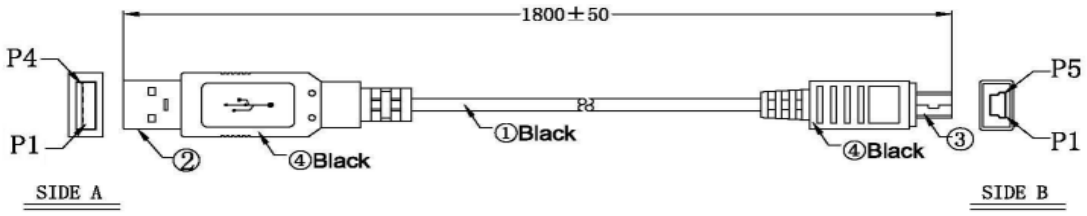


Figure 4.6.1

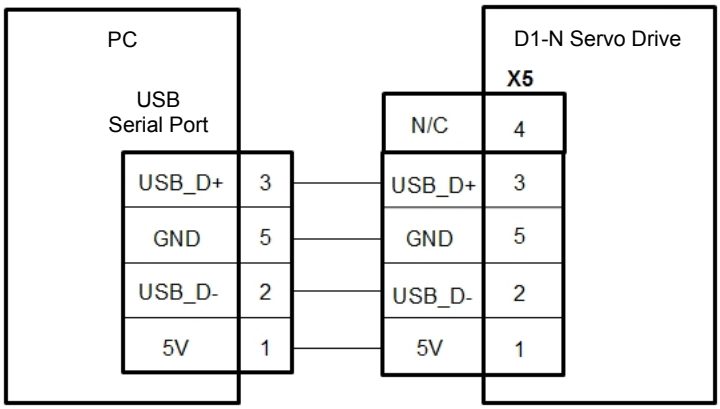


Figure 4.6.2

4.7 Control signals (X6)

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

Table 4.7.1 Pin definition of connector for control signals

Pin	Signal	Function	Note
1	CWL	DC 12 V ~ DC 24 V must be provided.	-
2	CCWL		
3	CW+	Differential signal input (4 MHz) Channel 1: Pulse, CW, A phase	-
4	CW-		
5	CCW+	Differential signal input (4 MHz) Channel 2: Dir, CCW, B phase	-
6	CCW-		
7	I1	Axis enable	Programmable
8	I2	General input signals	
9	I3		
10	I4		
11	I5		
12	I6		
13	I7		
14	I8		
15	I9		
16	I10		
17	COM	Common point for general input signals (I1 ~ I10)	For NPN type: 12 V ~ 24 V must be provided. For PNP type: Connect to ground (GND).
18	REF+	Analog command input (Positive)	Default velocity/torque analog command (+/-10 V)
19	REF-	Analog command input (Negative)	
20	DSF+	Disable safety function (Positive)	-
21	FG	Frame ground	-
22	GND	Ground reference for input and output signals	-
23	O1+	General output signals	Programmable
24	O1-		
25	O2+		
26	O2-		
27	O3+		
28	O3-		
29	PT+	Output for position trigger	-
30	PT-		
31	N/A	-	-
32	N/A		
33	A	Feedback pulse output (Buffered encoder or emulated encoder)	-
34	/A		
35	B		
36	/B		
37	Z		
38	/Z		
39	CZ	Z phase open-collector output	-
40	DSF-	Disable safety function (Negative)	-

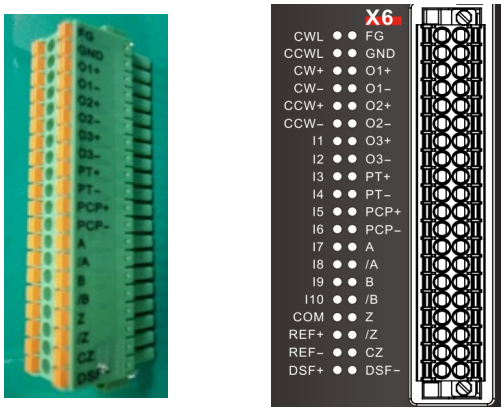


Figure 4.7.1 Connector: R-DFMC 1.5/20-STF-3.5 (1790470)

4.7.1 Digital command

Optical coupler: HCPL-060L, 5 mA < I_{IN} < 15 mA, 1.4 V < V_F < 1.75 V

A. Differential input

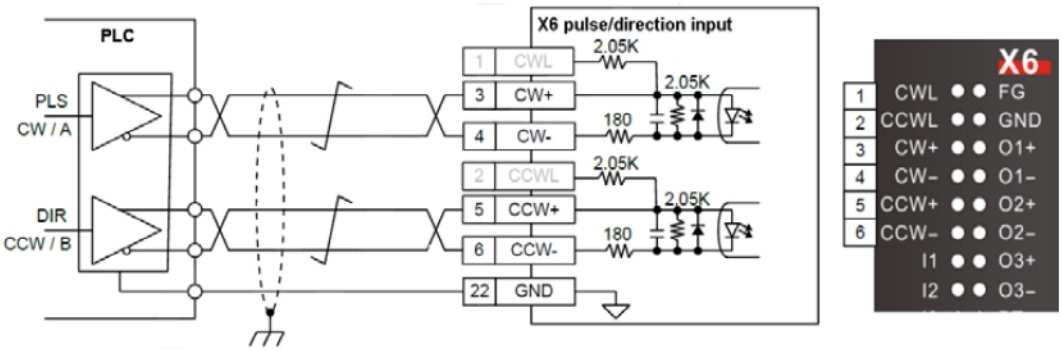
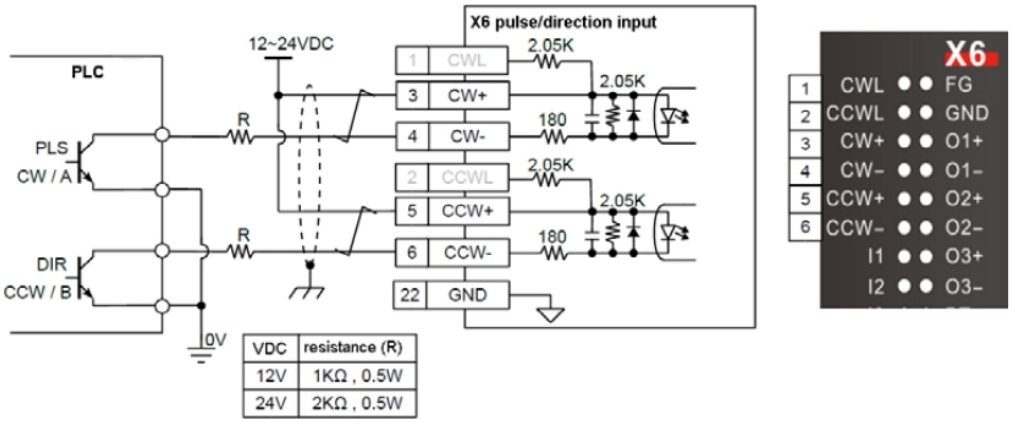


Figure 4.7.1.1

B. Single-ended input (With external resistor)



VDC	resistance (R)
12V	1KΩ , 0.5W
24V	2KΩ , 0.5W

Figure 4.7.1.2

C. Single-ended input (Without external resistor)

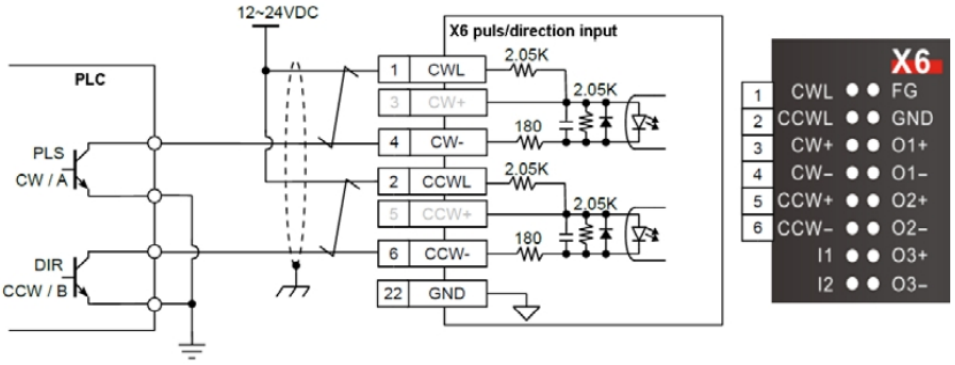


Figure 4.7.1.3

4.7.2 Programmable I/O

A. PNP type: COM is connected to ground (GND).

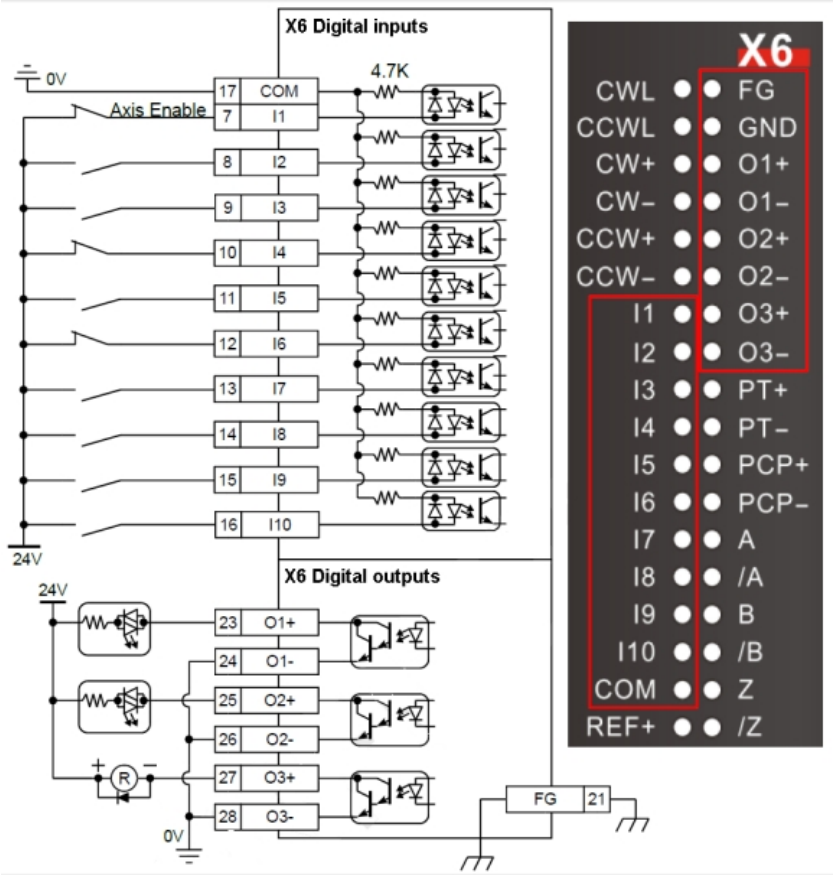


Figure 4.7.2.1

B. NPN type: COM is connected to 24 V.

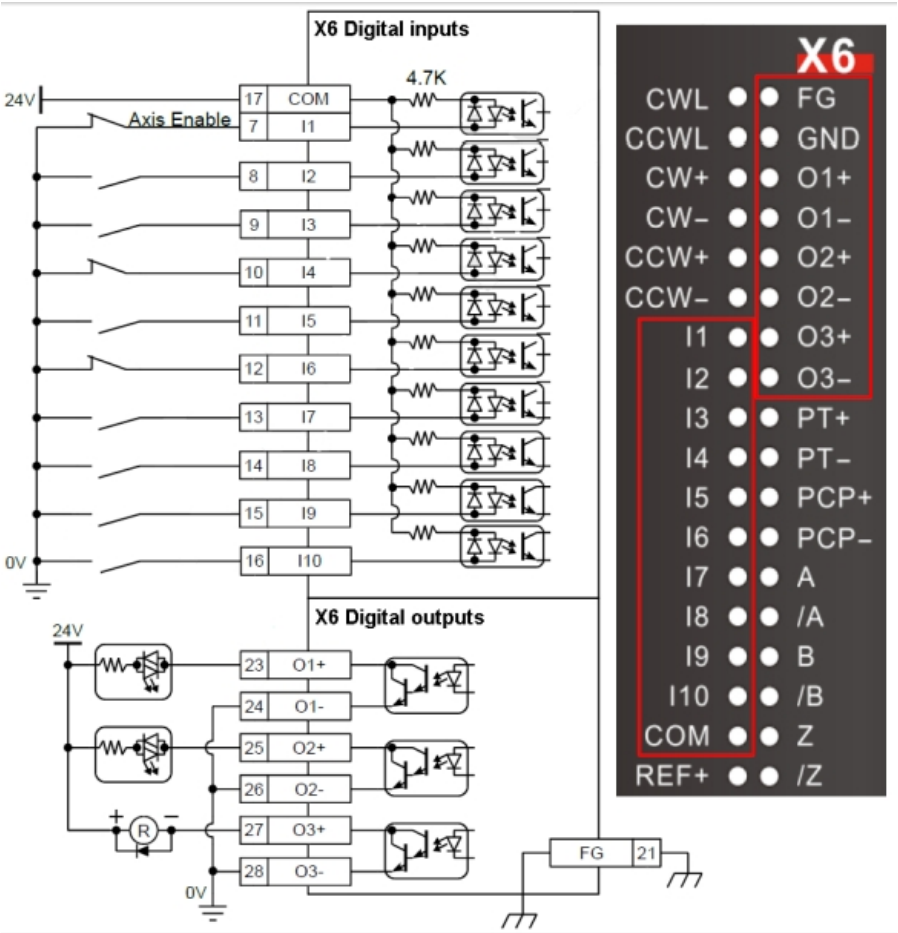


Figure 4.7.2.2

4.7.3 Encoder output

The encoder output is 5 V differential output.

A. Optical coupler

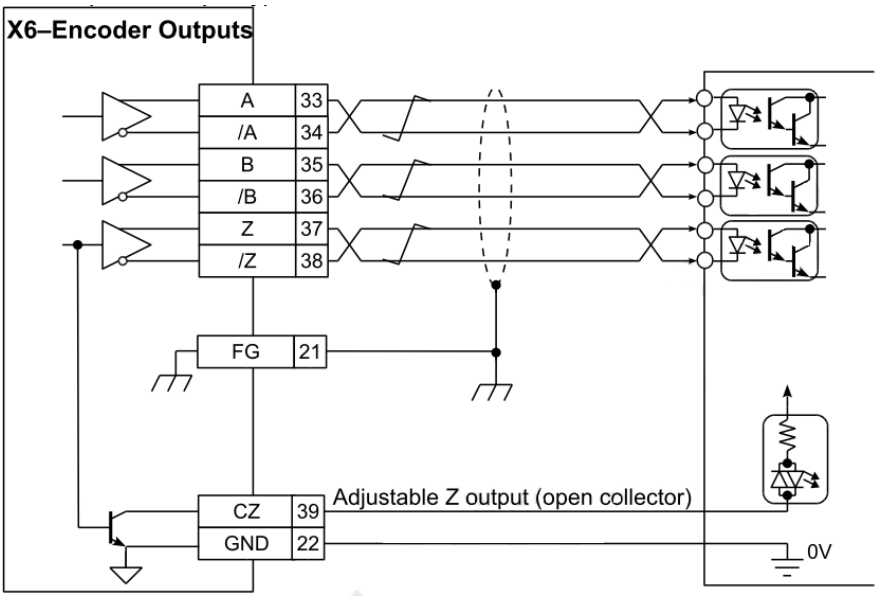


Figure 4.7.3.1

B. Differential type

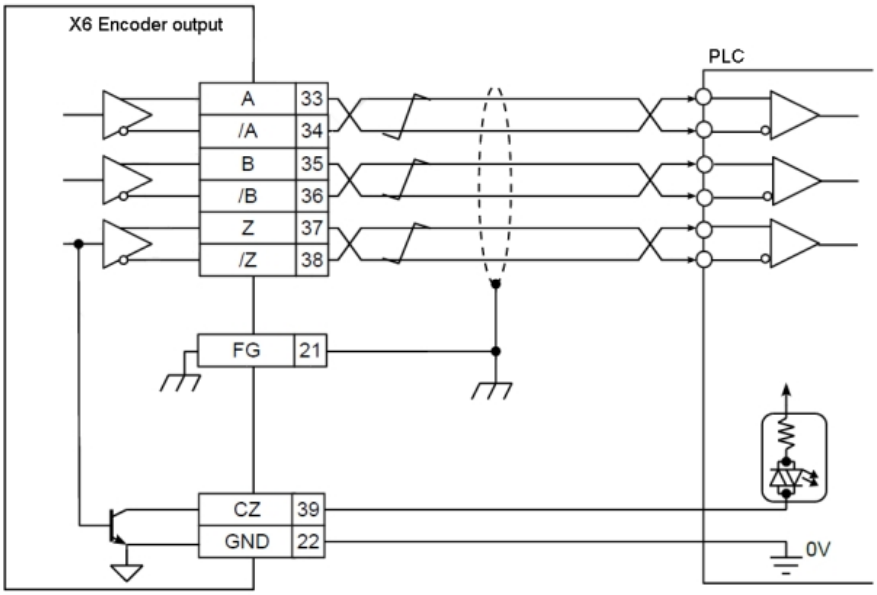


Figure 4.7.3.2

4.7.4 PT signal output

PT signal output is 3.3 V (20 mA) differential output.

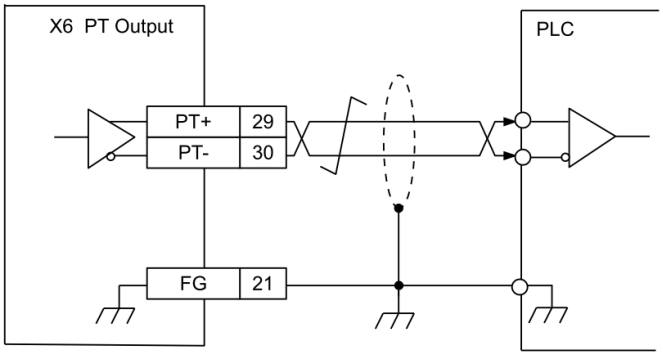


Figure 4.7.4.1

4.7.5 Analog command

Analog command is -10 Vdc ~ +10 Vdc differential signal. The resolution is 12 bits.

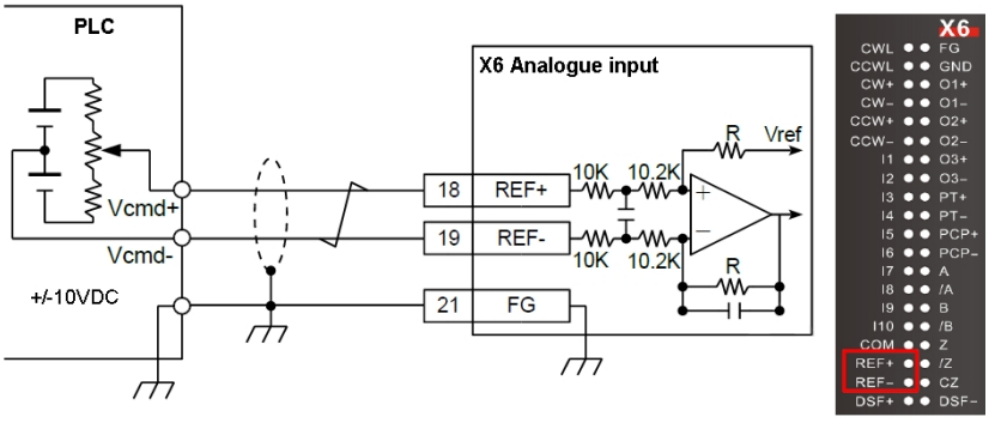


Figure 4.7.5.1

4.8 Safety function (X7, X8)

D1-N servo drive supports STO (Safe-Torque-Off) safety function which complies with IEC61800-5-2. Connectors for STO safety function are X7 and X8. When STO safety function is activated by SF1 and SF2 signals, the servo drive stops outputting current to motor. At this time, error messages may occur. The motor will not generate torque or force and will coast to a stop.

If STO safety function has been activated, it must be reset if the motor needs to be enabled again. Follow the steps below to reset STO safety function.

Step 1: SF1 and SF2 signals must be set to “High”.

Step 2: DSF+ and DSF- on connector X6 must be connected for at least one second to reset STO safety function.

(1) Connector

Figure 4.8.1 Connector: R-DFMC1.5/3-STF-3.5 (1790302)

Table 4.8.1

Pin	Signal	Function
1	SF1-	Safety input 1 These inputs disable motor.
4	SF1+	
2	SF2+	Safety input 2 These inputs disable motor.
5	SF2-	
3	MO-	STO status feedback
6	MO+	

Table 4.8.2

Item	Range
Low status	-3 ~ +3 Vdc
High status	+10 ~ +30 Vdc
Max. input current for safety input pins	5 mA
Debounce time	>= 1 ms
Time requirement of activating safety inputs SF1 and SF2	1 s

(2) Wiring example

A. STO safety function check

Below is the wiring diagram when checking STO safety function.

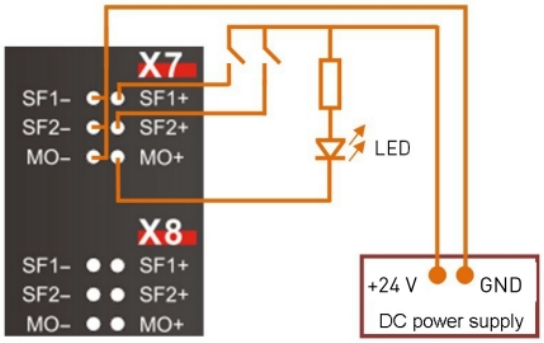


Figure 4.8.2

⚠ CAUTION

- Testing the wiring of STO safety function

  Step 1: Apply 24 Vdc to SF1 and SF2. Enable motor via I1 on connector X6.

  ➔The motor is enabled.

  Step 2: Deactivate SF1.

  ➔Error message “E18 STO activated” appears. The motor is disabled.

  Step 3: Activate SF1 again. Connect DSF+ and DSF- on connector X6 for at least one second.

  ➔The motor is enabled.

  Step 4: Deactivate SF2.

  ➔Error message “E18 STO activated” appears. The motor is disabled.

  Step 5: Activate SF2 again. Connect DSF+ and DSF- on connector X6 for at least one second.

  ➔The motor is enabled.

  Step 6: Deactivate SF1 and SF2 at the same time.

  ➔Error message “E06 motor may be disconnected” appears. The motor is disabled.

  Step 7: Activate SF1 and SF2. Connect DSF+ and DSF- on connector X6 for at least one second.

  ➔The motor is enabled.

- It is suggested to use the power supply below to test safety inputs SF1 and SF2 with 24 Vdc.

Power Supply	Input Specification	Output Specification	Protection
MEAN WELL RS-35-24	88 to 264 Vac 47 to 63 Hz Eff. = 88%	24 Vdc 1.5 Amax	Overload Overvoltage 32.4 Vmax

- If the desired function (such as motor disabling) cannot be performed after safety inputs are disabled, or STO safety function does not successfully restart after connecting DSF+ and DSF-, please contact HIWIN.

B. Wiring for emergency stop (Motor is not controlled after emergency stop is activated.)

Additional safety module is not required for the wiring in figure 4.8.3. When emergency switch is activated, STO safety function is enabled. Then, the servo drive stops outputting current to the motor and the motor will coast to a stop.

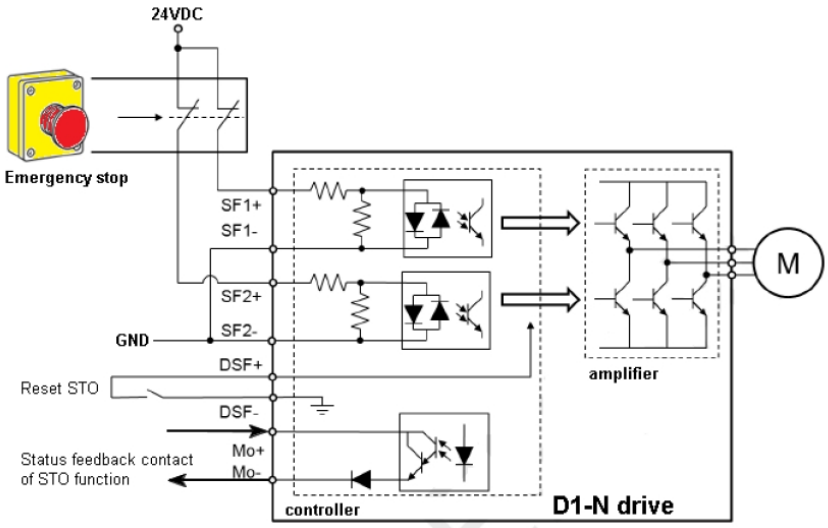


Figure 4.8.3

C. Wiring for emergency stop (Motor is controlled after emergency stop is activated.)

A safety module with safety time delay function is required when wiring for emergency stop. The safety module used in figure 4.8.4 is UE410-MU3T5 from SICK. The enabling signal of D1-N servo drive becomes OFF via Q1 of the safety module. Dec. kill and smooth factor are used in decelerating the motor. After the safety time delay elapses, Q3 and Q4 of the safety module send out signals to activate STO safety function. D1-N servo drive stops outputting current to the motor.

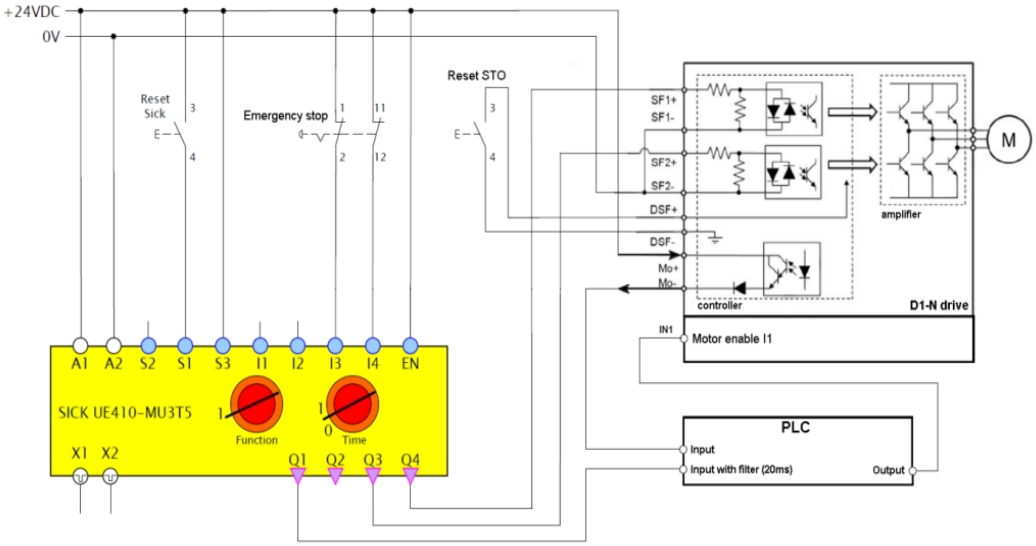


Figure 4.8.4

The formulas of time delay and the required maximum deceleration are as below:

(1) Time Delay (T) = (Smooth Factor X 8)/Sampling Rate

(2) Maximum Deceleration (Max. dec.) = Speed/T

Example:

Sampling rate is 16 KHz. Motor speed is 400 mm/s. Smooth factor is 100.

Time Delay (T) = (100X8)/16,000 = 0.05 s

Maximum Deceleration (Max. dec.) = 400/0.05 = 8,000 mm/s^2

D. Wiring for multiple servo drives

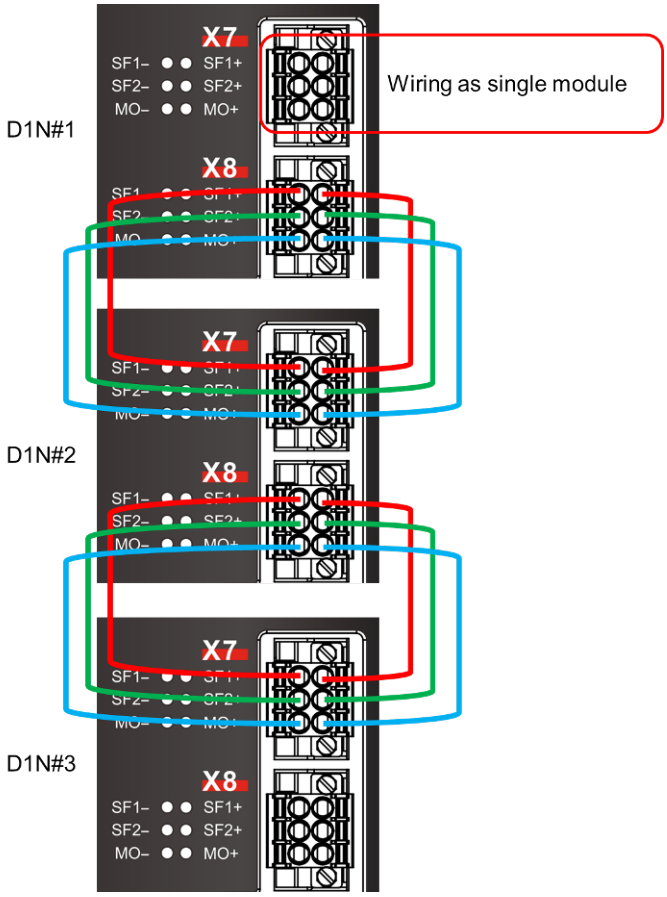


Figure 4.8.5

(3) Timing of activating STO safety function

STO safety function is activated by SF1 and SF2 inputs. The relationship between the logic states of SF1 and SF2 inputs and STO safety function are described in table 4.8.3.

Table 4.8.3

Function	Pin	Logic States			
Safety Input	SF1	High	High	Low	Low
	SF2	High	Low	High	Low
Status of STO Safety Function	-	Off	On	On	On
Feedback Contact of STO Safety Function	MO	Closed	Open		

The time between activation of SF1 and SF2 inputs and activation of STO safety function is called response time. The response time is 6 ms to 10 ms. To prevent STO safety function from being activated unexpectedly, signal interrupts less than 6 ms will be ignored. STO safety function will only be activated when safety input signals are OFF for at least 6 ms.

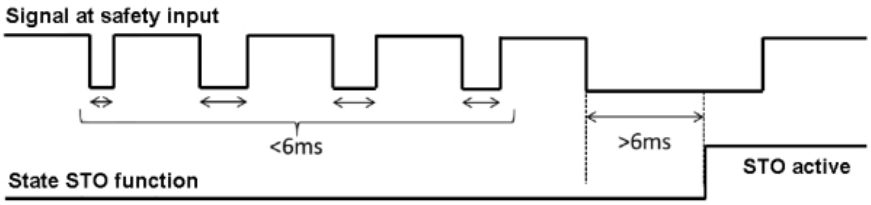


Figure 4.8.6

A. Timing diagram of activating STO safety function

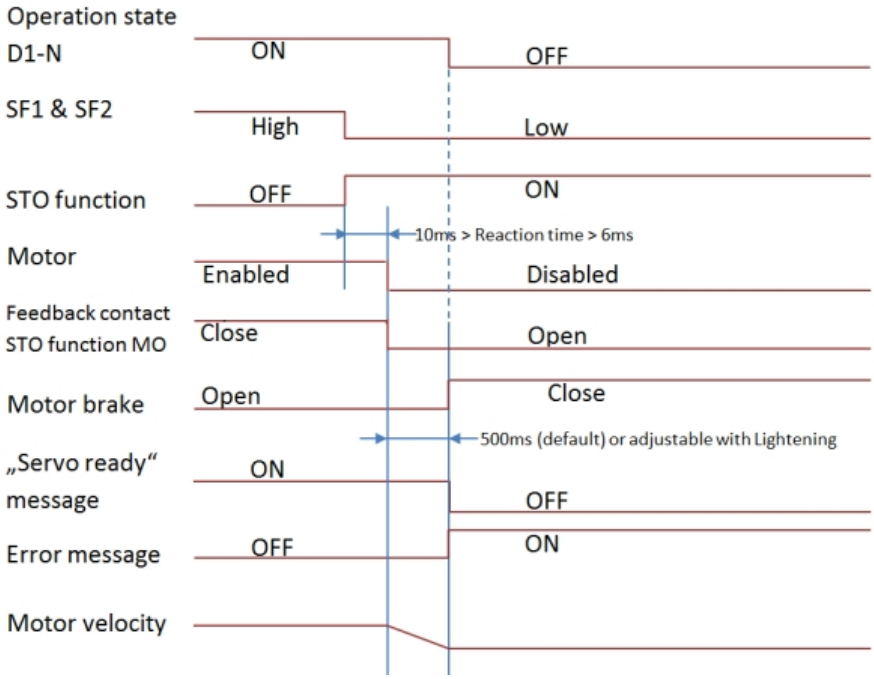


Figure 4.8.7

B. Timing diagram of deactivating STO safety function

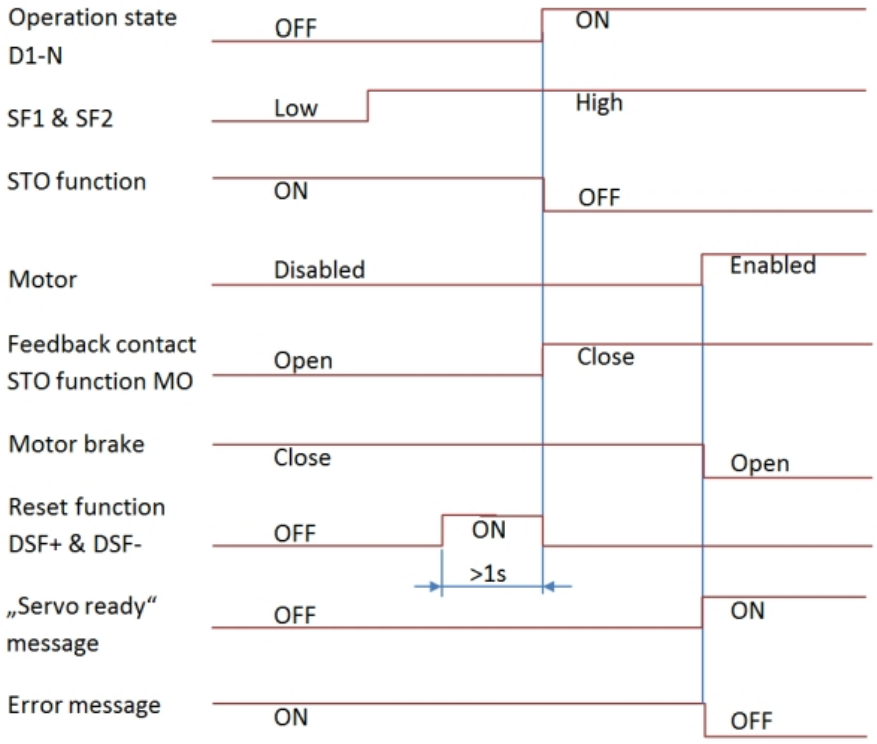


Figure 4.8.8

(4) Maintenance plan

According to IEC 61508 (High demand mode), the minimum maintenance interval of STO safety function is one year. Table 4.8.4 is provided for your maintenance plan and safety calculation.

Table 4.8.4

Item	Unit	Value
Lifetime of STO Safety Function (IEC 61508)	Years	20
Safe Failure Fraction, SFF (IEC 61508)	%	99.7
Hardware Fault Tolerance, HFT (IEC 61508) Type A Subsystem		1
Safety Integrity Level, SIL IEC 61508: 2010 IEC 62061: 2010		SIL3 SILcl3
Performance Level, PL (ISO 1384: 2008)		e (Category 3)
Mean Time to Dangerous Failure, MTTFD (ISO 13849-1)	Years	1606 (After further calculation, the maximum value is limited to 100 years)
Diagnostic Coverage, DC (ISO 13849-1)	%	99
Probability of Dangerous Failure per Hour, PFH_d (IEC 62061)	1/h	$1.6 \times 10^{(-9)}$

4.9 Motor temperature detection (X9)

D1-N servo drive is able to monitor motor temperature via PTC resistor or NTC resistor.

Figure 4.9.1 Connector: R-MSTB2.5/2-STF (1786831)

Table 4.9.1

Pin	Signal
1	T+
2	T-

4.10 Encoder (X10, X11, X12)

D1-N servo drive provides D-Sub high density connectors (15 pins) for encoder feedback.

Figure 4.10.1

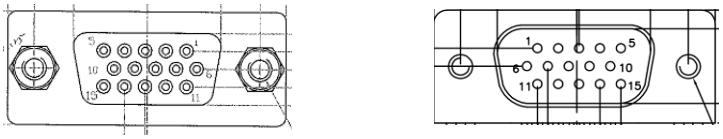


Figure 4.10.2

Table 4.10.1

Connector Type	X10	X11	X12
	Female	Female	Male
Description	Digital/Hall Sensor	Analog/Serial	Resolver
Pin	Signal	Signal	Signal
1	A+	SIN+	SIN1+
2	B+	COS+	COS1+
3	Z+	Index+	SIN2+
4	FLT	+9 Vdc	AGND
5	+5 Vdc	+5 Vdc	+5 Vdc
6	A-	SIN-	SIN1-
7	B-	COS-	COS1-
8	Z-	Index-	SIN2-
9	Hall A	n.c.	COS2+
10	Hall B	n.c.	COS2-
11	Hall C	DX+ (Data)	REF+
12	n.c.	DX- (Data)	REF-
13	DSL+(Note 4)	CLK+ (Clock)	Index+
14	DSL-(Note 4)	CLK- (Clock)	Index-
15	GND	GND	GND

Table 4.10.2

Encoder Type(Note 4)	EnDat2.1	EnDat2.2/Nikon /BiSS/SSI	Hiperface DSL	Hiperface	T-code
Signal	+5 Vdc GND DX+ DX- SIN+ SIN- COS+ COS-	+5 Vdc GND DX+ DX- CLK+ CLK-	DSL+ DSL-	+9 Vdc GND DX+ DX- SIN+ SIN- COS+ COS-	+5 Vdc GND DX+ DX-
Connector	X11	X11	X10	X11	X11

Note:

(1) If analog/serial encoder and digital Hall sensor are used, connectors X10 and X11 must both be connected.

(2) To avoid EMC malfunction, encoder cable must be shielded. The shield of the encoder cable must contact the shell of the connector.

(3) FLT signal on connector X10 can only be used with encoder which supports encoder fault signal.

(4) Available on D1-N-□□-□9.

4.11 EtherCAT/Modbus communication (X13)

(1) EtherCAT communication

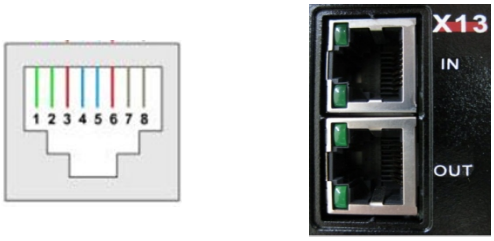


Figure 4.11.1

Table 4.11.1

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) Modbus communication

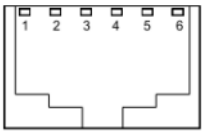


Figure 4.11.2

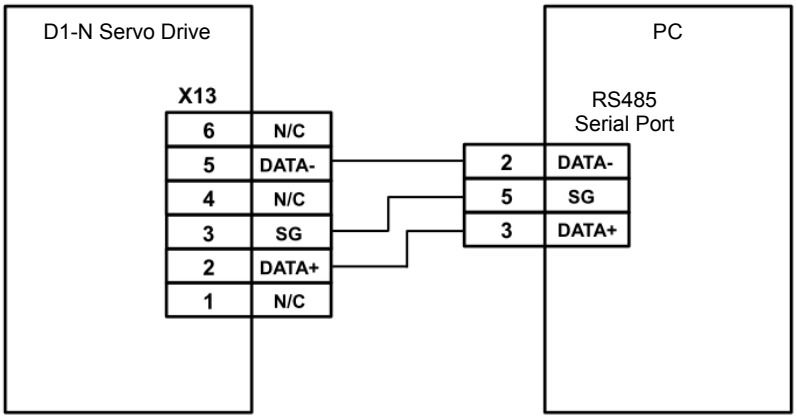


Figure 4.11.3

4.12 Accessories of D1-N servo drive

(1) Motor power cable

A. Linear motor

Table 4.12.1

Product Name	Model	Description
Motor Power Cable	LMACS□□U	Applicable linear motor: LMS, LMSA, LMC-EFE and LMC-EFF Supports over temperature signal. D-type connector 220 Vac
	LMACS□□V	Applicable linear motor: LMSA Supports over temperature signal. D-type connector 380 Vac
	LMACT□□G	Applicable linear motor: LMSA Supports over temperature signal. Round metal connector 220 Vac
	LMACT□□F	Applicable linear motor: LMSA Supports over temperature signal. Round metal connector 380 Vac
	LMACS□□M	Applicable linear motor: LMCA, LMCB, LMCC, LMCD, LMCE, LMC-EFC, LMTA, LMTB, LMTC and LMTD Supports over temperature signal.
	LMACS□□N	Applicable linear motor: LMCF Supports over temperature signal.
	LMACS□□S	Applicable linear motor: LMF Supports over temperature signal. Round metal connector Wire diameter: 4.0 mm^2
	LMACS□□Z	Applicable linear motor: LMFA0□□, LMFA1□□, LMFA2□□, LMFA31, LMFA31L, LMFA32, LMFA32L, LMFA41, LMFA41L, LMFA42, LMFA42L, LMFA52, LMFA52L and LMFA62 Supports over temperature signal. Round metal connector Wire diameter: 1.5 mm^2
	LMACT□□A	Applicable linear motor: LMFA33, LMFA33L, LMFA34, LMFA43, LMFA43L, LMFA44, LMFA53, LMFA53L, LMFA54, LMFA62L, LMFA63 and LMFA64 Supports over temperature signal. Round metal connector Wire diameter: 2.5 mm^2
	LMACT□□B	Applicable linear motor: LMFA34L, LMFA44L, LMFA54L and LMFA63L Supports over temperature signal. Round metal connector Wire diameter: 4.0 mm^2
	LMACT□□C	Applicable linear motor: LMFA64L Supports over temperature signal. Round metal connector Wire diameter: 6.0 mm^2
	LMACT□□D	Applicable linear motor: LMTE Supports over temperature signal.

□□ stands for cable length. (Unit: m) The conversion table is as below.

Table 4.12.2

□□	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

B. Torque motor

Table 4.12.3

Product Name	Model	Description
Motor Power Cable	LMACS□□R	Applicable for torque motor: TMS, TMN and TMX Over temperature signal is not supported.

□□ stands for cable length. (Unit: m) The conversion table is as below.

Table 4.12.4

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

C. AC servo motor

Table 4.12.5

Product Name	Model	Description
Motor Power Cable	HVPS04AA□□MB	Applicable for 50 W ~ 750 W AC servo motor Brake signal is not supported. Highly-bendable
	HVPM04BA□□MB	Applicable for 1 KW ~ 2 KW AC servo motor Brake signal is not supported. Straight connector Highly-bendable
	HVPM04CA□□MB	Applicable for 1 KW ~ 2 KW AC servo motor Brake signal is not supported. L-type connector Highly-bendable
	HVPS06AA□□MB	Applicable for 50 W ~ 750 W AC servo motor Supports brake signal. Highly-bendable
	HVPM06BA□□MB	Applicable for 1 KW ~ 2 KW AC servo motor Supports brake signal. Straight connector Highly-bendable
	HVPM06CA□□MB	Applicable for 1 KW ~ 2 KW AC servo motor Supports brake signal. L-type connector Highly-bendable

□□ stands for cable length. (Unit: m) The conversion table is as below.

Table 4.12.6

□□	03	05	07	10
Cable Length	3	5	7	10

(2) Feedback signal cable

A. Linear motor

Table 4.12.7

Product Name	Model	Description
Feedback Signal Cable	LMACF□□C	D-type connector for motor For digital reader Signal of Hall sensor is not supported.
	LMACF□□D	D-type connector for motor For digital reader Supports signal of Hall sensor.
	LMACF□□A	D-type connector for motor For analog reader Signal of Hall sensor is not supported.
	LMACF□□H	D-type connector for motor For analog reader Supports signal of Hall sensor.
	LMACF□□I	Round metal connector for motor For digital reader Signal of Hall sensor is not supported.
	LMACF□□B	Round metal connector for motor For digital reader Supports signal of Hall sensor.
	LMACE□□AZ	Round metal connector for motor For analog reader Signal of Hall sensor is not supported.
	LMACF□□M	Round metal connector for motor For analog reader Supports signal of Hall sensor.

Note:

The cables listed in table 4.12.7 are all standard. The connector for encoder is D-type.

□□ stands for cable length. (Unit: m) The conversion table is as below.

Table 4.12.8

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

B. Torque motor

Table 4.12.9

Product Name	Model	Description
Feedback Signal Cable	LMACF□□L	For JENA encoder Applicable torque motor: TMS and TMN□□E Supports over temperature signal.
	LMACF□□G	For JENA encoder Applicable torque motor: TMN□□EH Supports over temperature signal and signal of Hall sensor.
	LMACF□□E	For single resolver Applicable torque motor: TMN Supports over temperature signal.
	LMACF□□J	For dual resolver Applicable torque motor: TMY and TMN□□A Supports over temperature signal.
	LMACF□□F	For EnDat 2.2 encoder

□□ stands for cable length. (Unit: m) The conversion table is as below.

Table 4.12.10

□□	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

C. AC servo motor

Table 4.12.11

Product Name	Model	Description
Feedback Signal Cable	HVE13IAD□□MB	For 13-bit encoder Applicable for 50 W ~ 750 W AC servo motor Highly-bendable
	HVE13IBD□□MB	For 13-bit encoder Applicable for 1 KW ~ 2 KW AC servo motor Straight connector Highly-bendable
	HVE13ICD□□MB	For 13-bit encoder Applicable for 1 KW ~ 2 KW AC servo motor L-type connector Highly-bendable
	HVE17IAD□□MB	For 17-bit encoder Applicable for 50 W ~ 750 W AC servo motor Highly-bendable
	HVE17IBD□□MB	For 17-bit encoder Applicable for 1 KW ~ 2 KW AC servo motor Straight connector Highly-bendable
	HVE17ICD□□MB	For 17-bit encoder Applicable for 1 KW ~ 2 KW AC servo motor L-type connector Highly-bendable

□□ stands for cable length. (Unit: m) The conversion table is as below.

Table 4.12.12

□□	03	05	07	10
Cable Length	3	5	7	10

(3) Control signal cable

Table 4.12.13

Product Name	Model	Description
Control Signal Cable	LMACK□□F	Signal cable for connecting to controller With bare wires at both ends which can be soldered by users

□□ stands for cable length. (Unit: m) The conversion table is as below.

Table 4.12.14

□□	02	04
Cable Length	2	4

(4) Communication cable

Table 4.12.15

Product Name	Part Number	Description
USB Communication Cable	051700800366	USB 2.0 type A to mini-B 5-pin Cable length: 1.8 m Mini-B connector for servo drive

(5) Connector kit and EMC kit

A. Connector kit

Table 4.12.16

Product Name	Model	Description	Part Number	Qty.
D1-N CK accessory kit (For D1-N-09/ 18/36)	D1-N CK4 (Part number: 051800200097)	Hose clamp R-10 mm (Min.) - 16 mm (Max.)	060502600003	1
		Connector for AC main power cable 4 pin, pitch 7.62 mm	051500400303	1
		Connector for motor power cable 4 pin, pitch 7.62 mm	051500400304	1
		Connector for regenerative resistor 4 pin, pitch 5.08 mm	051500400332	1
		Connector for control power 4 pin, pitch 5.00 mm	051500400301	1
		Connector for control signals: 40 pin, pitch 3.50 mm	051500400316	1
		Connector for motor over temperature signal 2 pin, pitch 5.00 mm	051500400306	1
		Connector for safety function 6 pin, pitch 3.50 mm	051500400315	2
		Connector for feedback signal D-Sub 15 pin standard solder connector (Male)	051500100045	2
		Connector for feedback signal D-Sub 15 pin standard solder connector (Female)	051500100147	1
		D-Sub connector housing	051500600153	2

Product Name	Model	Description	Part Number	Qty.
D1-N CK accessory kit (For D1-N-90)	D1-N CK5 (Part number: 051800200101)	Hose clamp R-25 mm (Min.) - 40 mm (Max.)	060502600002	1
		Hose clamp R-10 mm (Min.) - 16 mm (Max.)	060502600003	1
		Connector for AC main power cable 4 pin, pitch 10.16 mm	051500400342	1
		Connector for motor power cable 4 pin, pitch 10.16 mm	051500400385	1
		Connector for regenerative resistor 4 pin, pitch 10.16 mm	051500400342	1
		Connector for control power 4 pin, pitch 5.00 mm	051500400301	1
		Connector for control signals 40 pin, pitch 3.50 mm	051500400316	1
		Connector for motor over temperature signal 2 pin, pitch 5.00 mm	051500400306	1
		Connector for safety function 6 pin, pitch 3.50 mm	051500400315	2
		Connector for feedback signal D-Sub 15 pin standard solder connector (Male)	051500100045	2
		Connector for feedback signal D-Sub 15 pin standard solder connector (Female)	051500100147	1
		D-Sub connector housing	051500600153	2

B. EMC kit

Table 4.12.17

Product Name	Model	Included Parts	Part No.	Qty.
D1-N EMC accessory kit (Three-phase) (For D1-N-09/18/36)	D1-N EMC1 (Part No.: 051800200104)	Three-phase filter B84143A0020R106 (Rated current: 20 A, Leakage current: 3.1 mA)	051800200133	1
		Reactor B86305L0016R000 (16 A, 2 mH)	051800200103	1
D1-N EMC accessory kit (Single-phase) (For D1-N-09/18/36)	D1-N EMC2 (Part No.: 051800200107)	Single-phase filter B84113H0000G120 (Rated current: 20 A, Leakage current: 1.73 mA	051800200132	1
		Reactor TS10C-16A (2 mH)	051800200106	1
D1-N EMC accessory kit (Three-phase) (For D1-N-90)	D1-N-90 EMC1 (Part No.: 051800200094)	Three-phase filter B84143A0035R166 (Rated current: 35 A, Leakage current: 5.0 mA)	051800200093	1
		EMI core KCF-130-B	050300400026	2
D1-N EMC accessory kit (Single-phase) (For D1-N-09/18/36)	D1-N EMC3 (Part No.: 051800200135)	Single-phase filter B84113H0000G120 (Rated current: 20 A, Leakage current: 1.73 mA)	051800200132	1
		EMI core KCF-130-B	050300400026	2
D1-N EMC accessory kit (Three-phase) (For D1-N-09/18/36)	D1-N EMC4 (Part No.: 051800200136)	Three-phase filter B84143A0020R106 (Rated current: 20 A, Leakage current: 3.1 mA)	051800200133	1
		EMI core KCF-130-B	050300400026	2

Note:

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

(6) Regenerative resistor

Table 4.12.18

Product Name	Part Number	Description
Regenerative Resistor	050100700001	68 Ω Rated power: 100 W Instantaneous power: 500 W
	050100700009	120 Ω Rated power: 300 W Instantaneous power: 1,500 W
	050100700008	50 Ω Rated power: 150 W Instantaneous power: 750 W
	050100700019	50 Ω Rated power: 600 W Instantaneous power: 3,000 W

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5. Servo drive configuration

5.1 Installation and communication

Lightening is the human machine interface of D1-N servo drives. Connect PC and D1-N servo drive by mini USB cable for servo drive initialization, setting, operation, test run and parameter writing via 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).

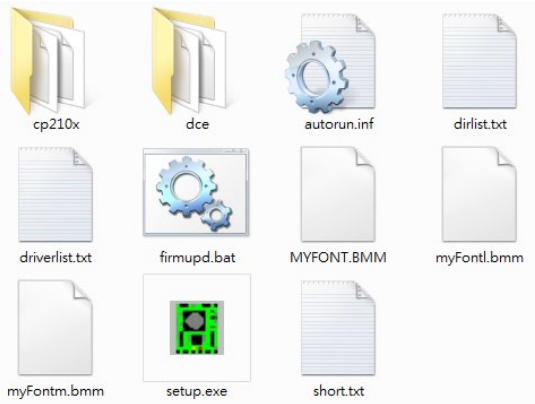


Figure 5.1.1.1

If users are 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 installation finishes, a message dialog will appear as figure 5.1.1.3. Click on 確定 (OK) button to complete installation.

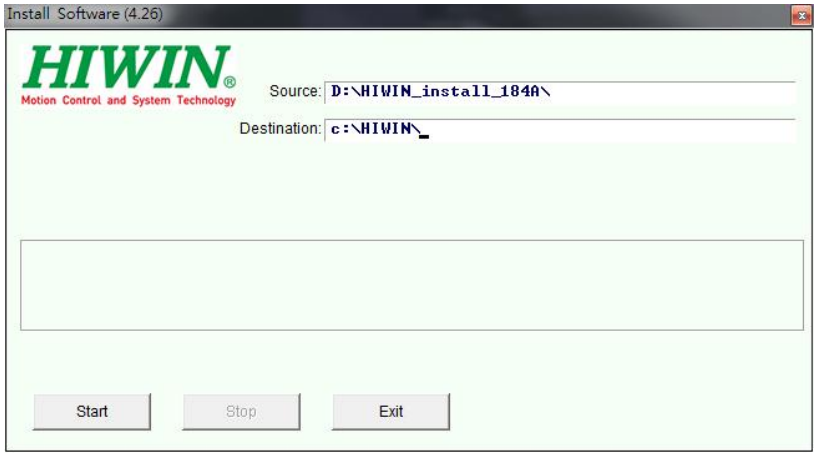


Figure 5.1.1.2

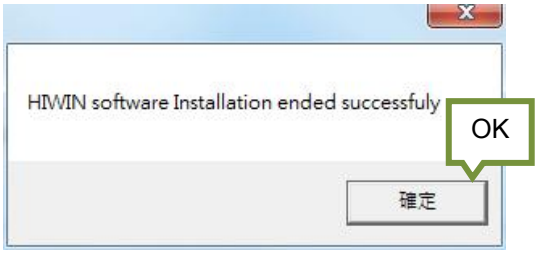


Figure 5.1.1.3

A shortcut of Lightening will be created on the desktop which is shown as figure 5.1.1.4. 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:

- USB communication
- mega-ulink communication
- CoE communication

Section 5.1.2 will introduce how to set up USB communication and mega-ulink communication. For CoE communication, please refer to *HIWIN CoE Drive User Guide*. While using USB communication and CoE communication, it is suggested to use supported network controllers of Beckhoff. (Refer to: https://infosys.beckhoff.com/english.php?content=../content/1033/tcsystemmanager/reference/ethercat/html/ethercat_supnetworkcontroller.htm&id=)

Note:

If the hardware versions of D1-N mega-ulink and CoE models are A7, please use firmware versions D1N MDP 0.809 and D1NCOE MDP 0.514 or later version.

(1) USB communication

Connect to the servo drive via mini USB cable and turn on the control power before opening Lightening. Normally the servo drive will be automatically connected after Lightening is opened. To modify communication setting, please click on **Tools** and select **Communication setup…**.

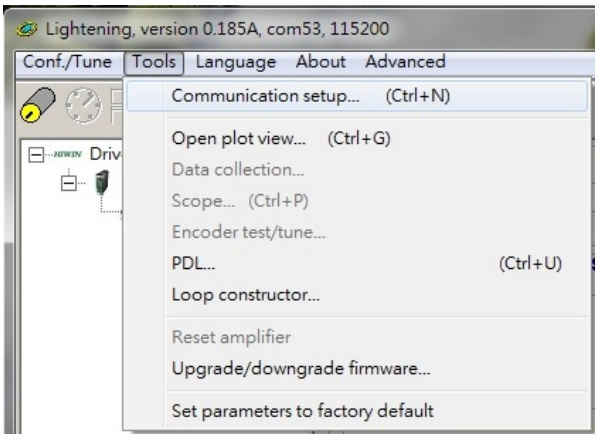


Figure 5.1.2.1

lightening Communication Setup window appears as figure 5.1.2.2. **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 the PC will be listed. Select the communication port in use. Normally Lightening can successfully communicate with the servo drive without changing the values in other fields.

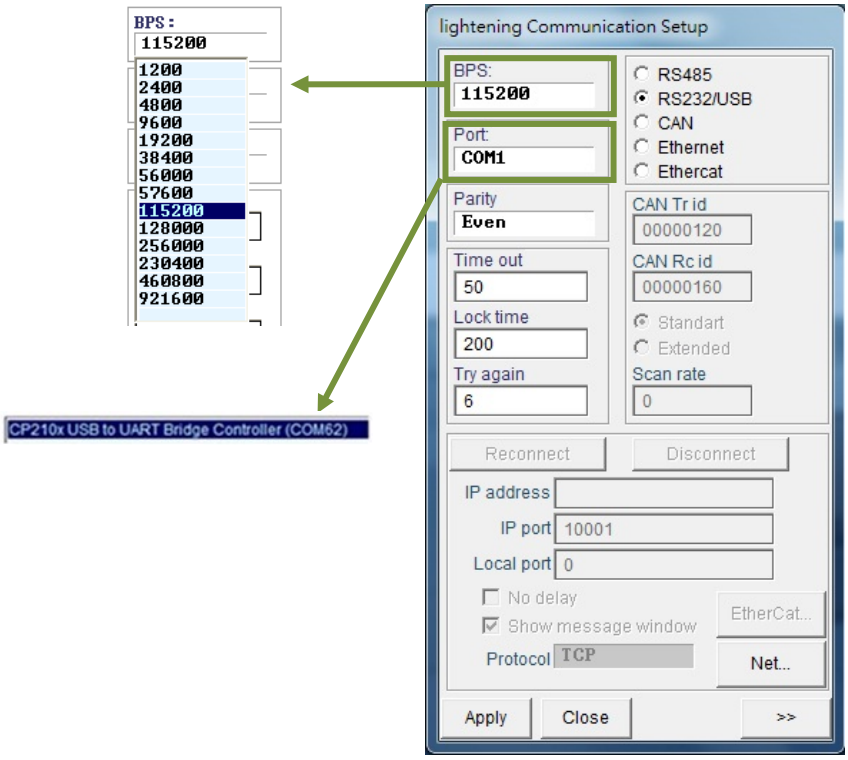


Figure 5.1.2.2

(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.

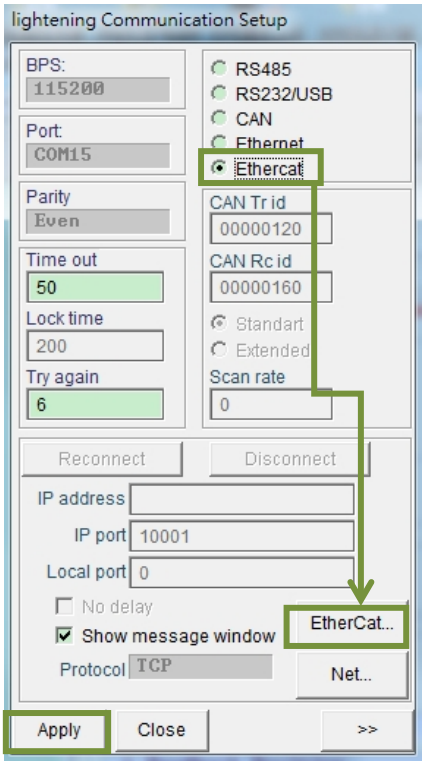


Figure 5.1.2.3

EtherCat set up window appears as figure 5.1.2.3. All the network cards of the 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.

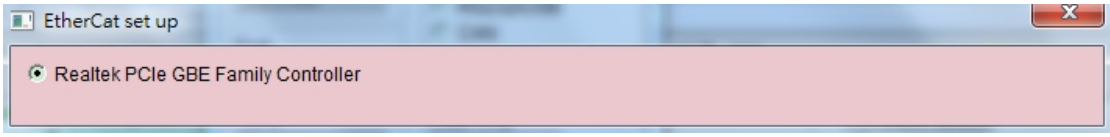


Figure 5.1.2.4

After setting completes, a window appears as figure 5.1.2.4. 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 5.1.2.5.

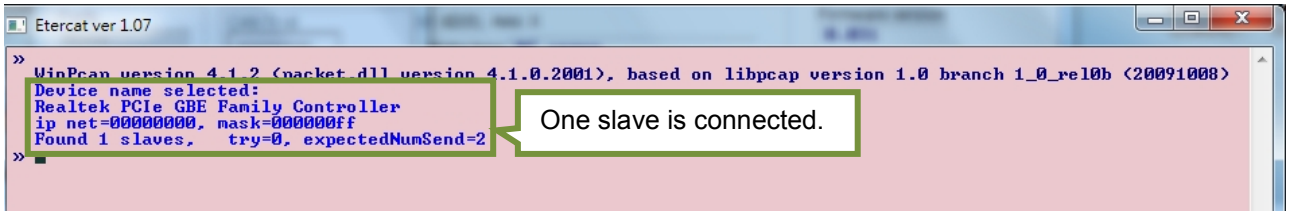


Figure 5.1.2.5

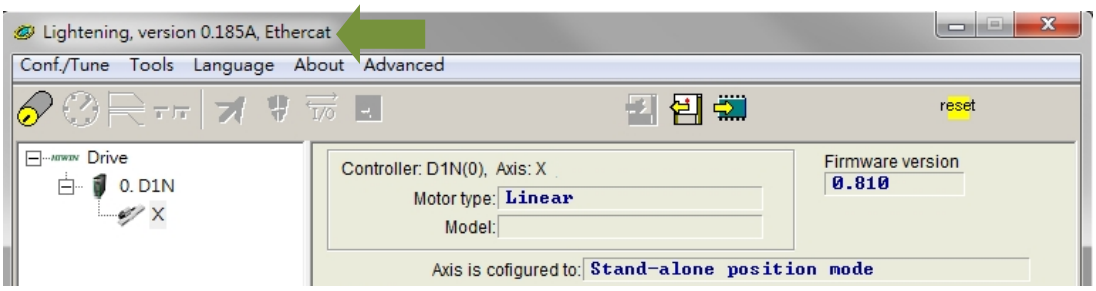


Figure 5.1.2.6

5.1.3 Main window

After connection is established, the main window of Lightening 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.

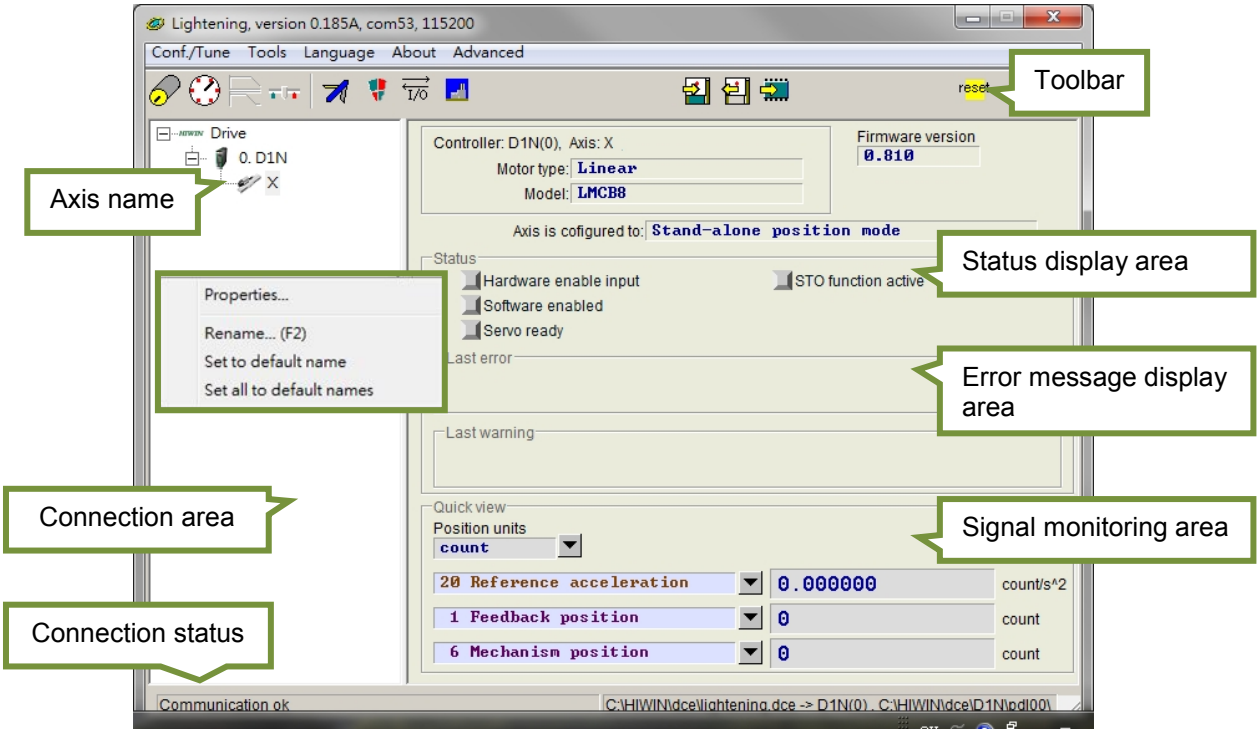


Figure 5.1.3.1

(1) Toolbar

: Open operation window for PDL program.

: Save the parameters in the servo drive RAM as file (PRM file).

: Load parameters from file (PRM file) to the servo drive RAM. If dual loop function is set, phase initialization must be performed again after parameters are loaded.

: Save 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 11.

Software Enabled : The indicator is green for software enabling. Only when hardware and software enablings 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 be activated or not.

STO function active: The indicator is green when STO safety function is activated. Ensure dangerous situation has been cleared before supplying 24 V for STO safety function. Connect DSF+ and DSF- on X6 connector for one second to reset STO safety function.

(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.

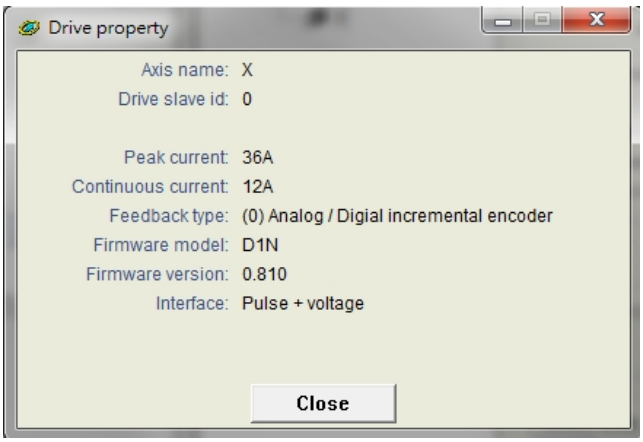


Figure 5.1.3.2

5.2 Configuration center

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

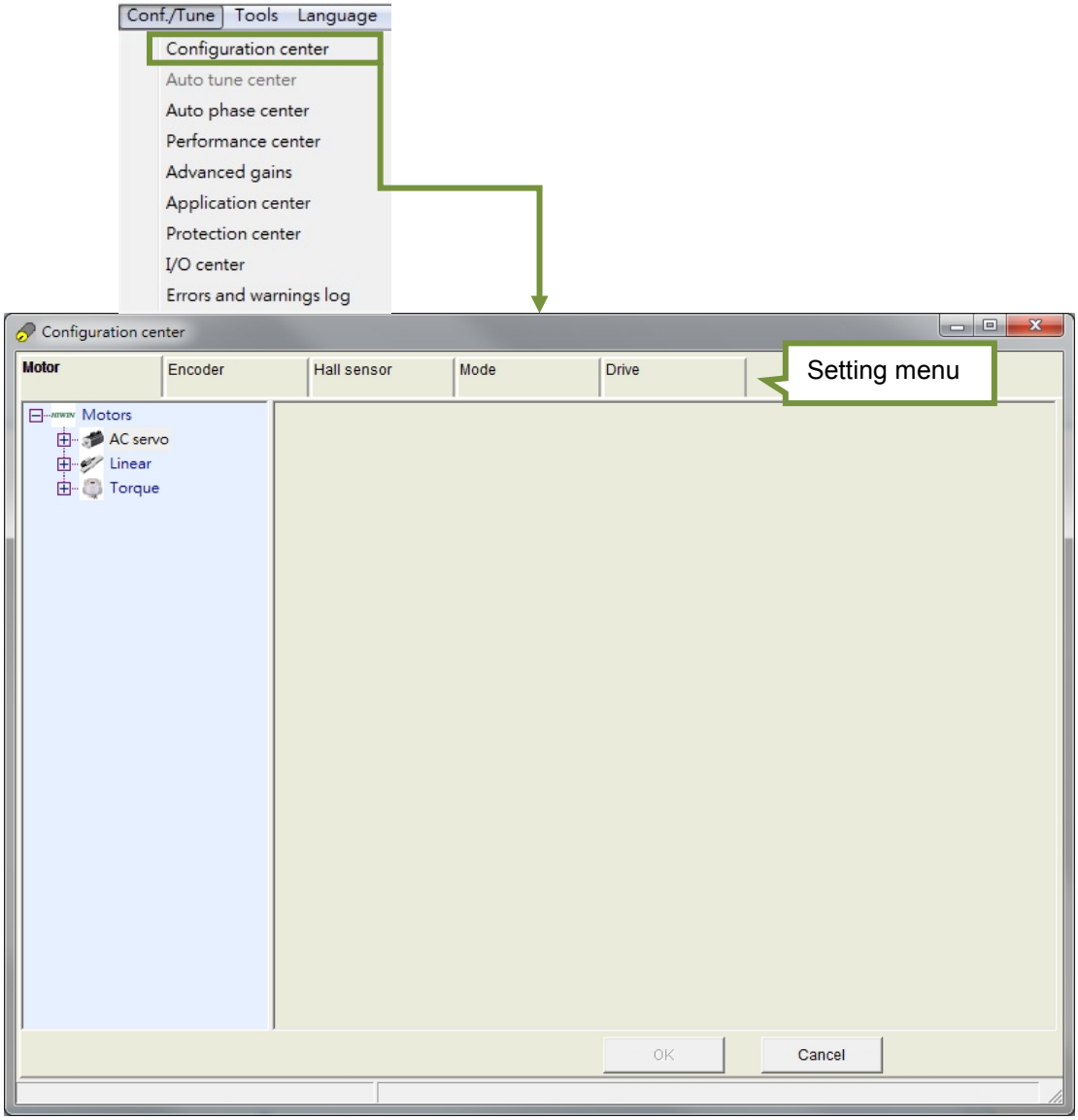


Figure 5.2.1

The following settings must be completed to drive the motor by D1-N 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.

(5) Drive: Set input voltage for the servo drive.

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, **OK** button in Configuration center will be grayed out first. After motor parameters, encoder parameters and operation mode are set, **OK** button becomes clickable.

5.2.1 Setting parameters of motor

D1-N servo drive supports AC servo motor, 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 Motors. In each groups, users are able to select HIWIN motors, such as LMC, LMS, TMS, etc.

(1) AC servo motor

A. Motor parameters

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

Note: If motor with serial encoder is used, use motor parameters of the same specification. For instance, when using motor with HIWIN 17 incremental encoder (FRLS402X6), please use motor parameters of motor with 13-bit incremental encoder (FRLS402X5).

B. Operation parameters

- Screw moment of inertia

  Moment of inertia of screw (Unit: Kg*m^2)

- Load mass

  Load mass (Unit: Kg)

- Screw pitch

  Screw pitch of ball screw (Note: Linear movement per revolution) (Unit: mm)

- Gear ratio

  The ratio of gear teeth number at load end to the one at drive end

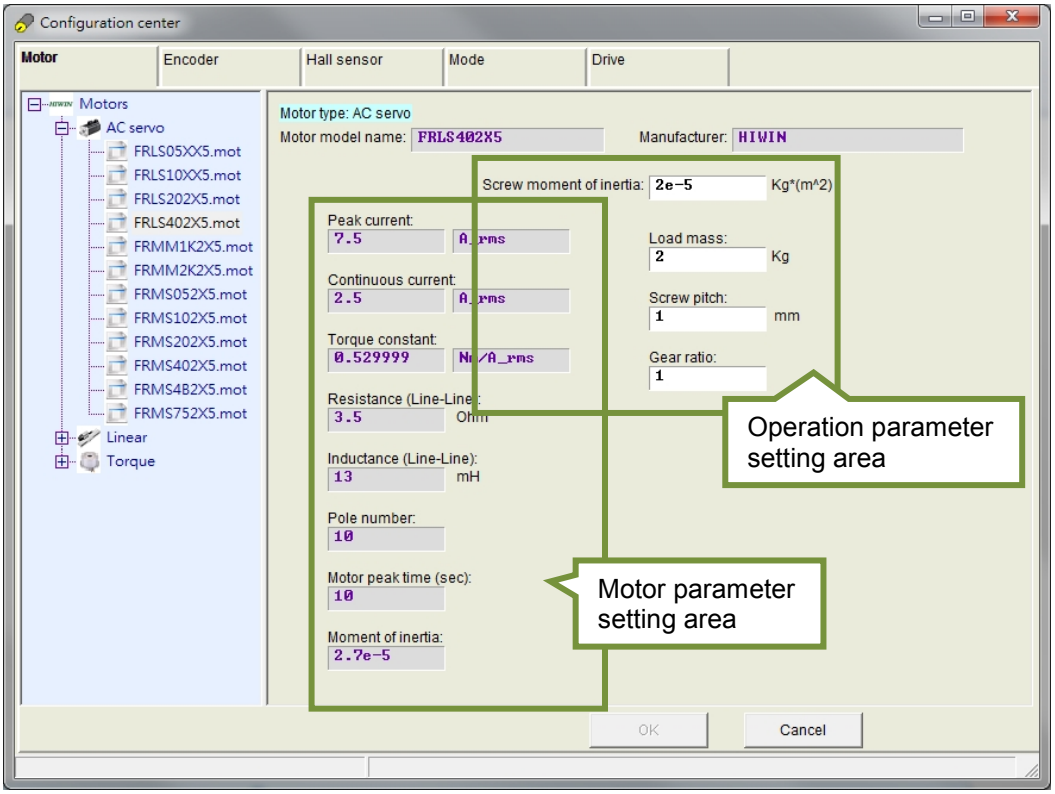


Figure 5.2.1.1

(2) 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)

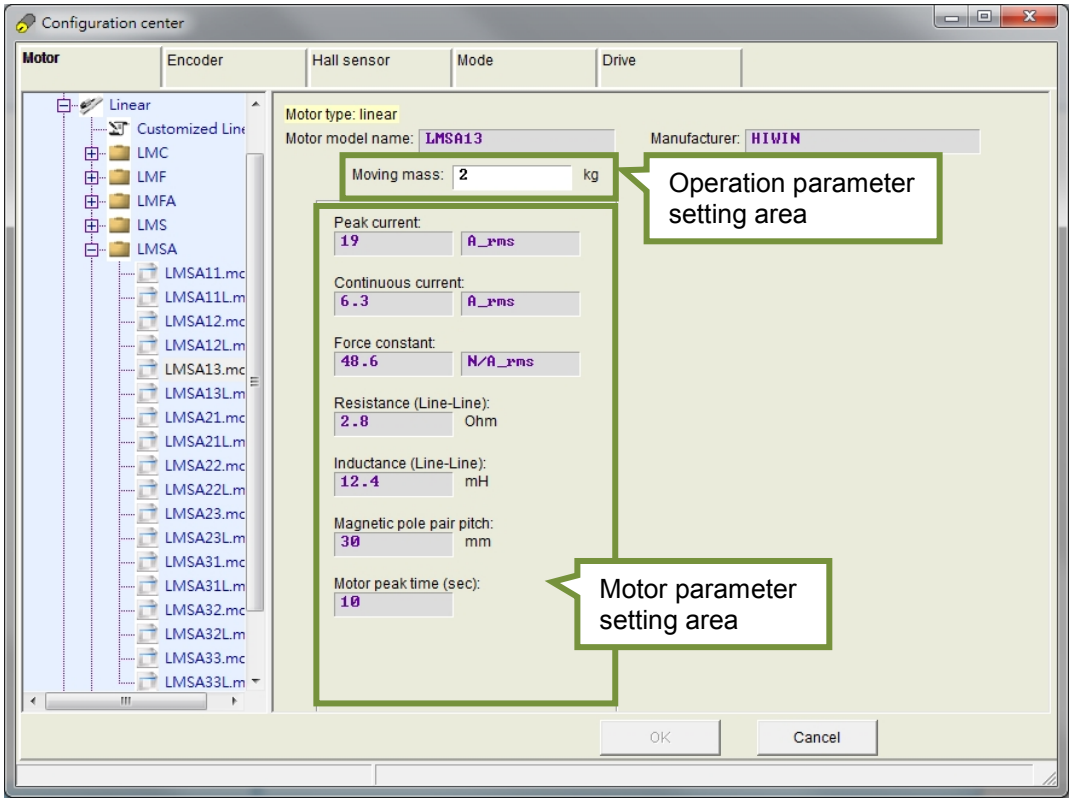


Figure 5.2.1.2

Note:

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

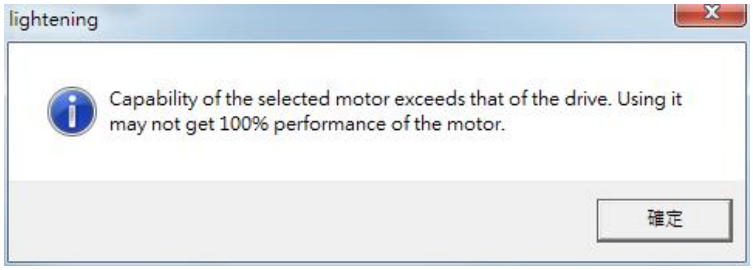


Figure 5.2.1.3

(3) 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: Kg*m^2)

- Belt feed constant

  Linear movement per motor revolution (Unit: mm/rev)

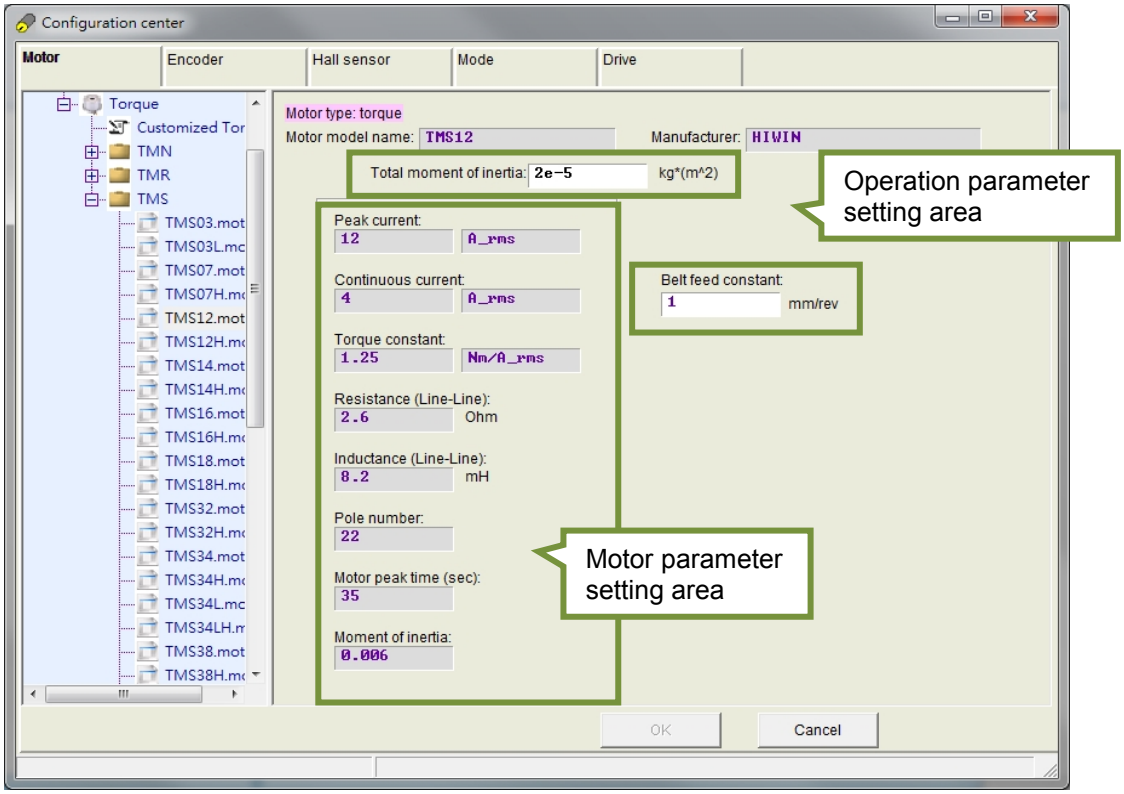


Figure 5.2.1.4

(4) Customized motor

Input motor parameters of motors other than HIWIN standard models. For linear motor, click on **Linear** in figure 5.2.1.5 and click on **Customized Linear**. Input necessary parameters according to the motor specification. After parameters are set, 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 parameters

- Moving mass

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

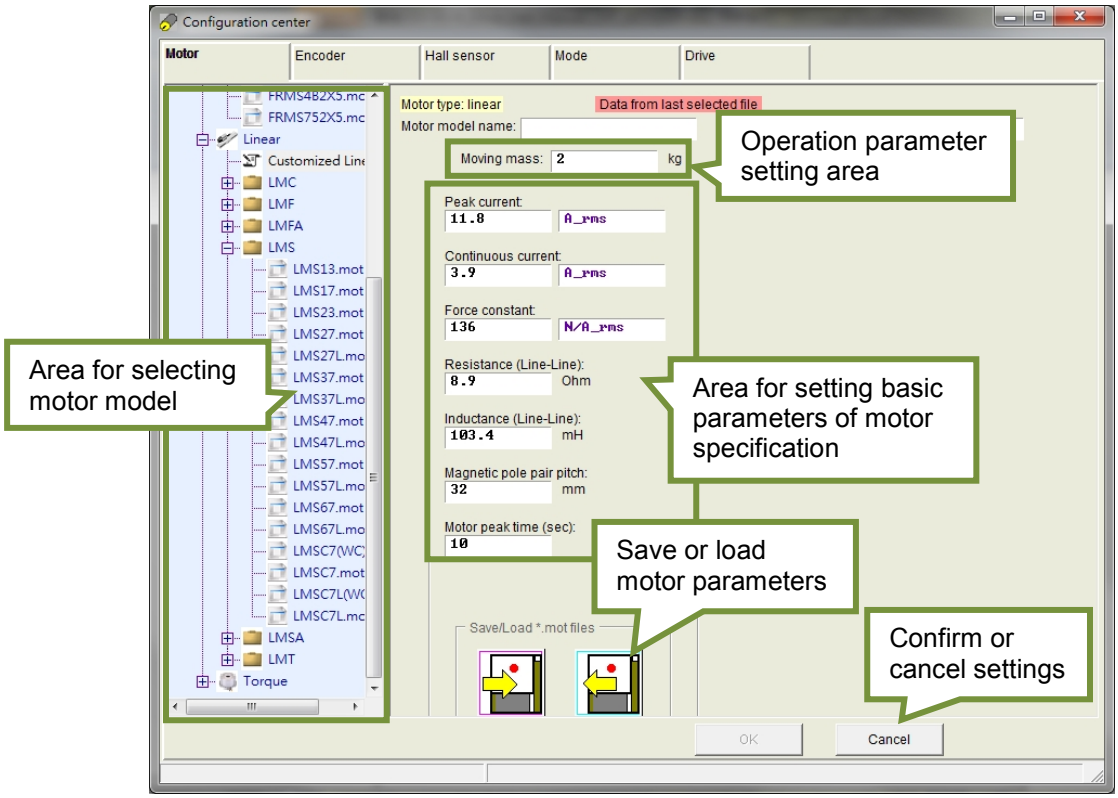


Figure 5.2.1.5

5.2.2 Setting parameters of encoder

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

D1-N 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 delay time in **Power-on time** field to avoid “Encoder error”. D1-N servo drive supports both digital and analog encoders, such as optical scale, magnetic scale, rotary encoder, etc. EnDat 2.1/2.2, BiSS-C and Nikon serial encoders are supported as well.

The supported encoders can be categorized into the following six types:

(1) Linear-digital encoder
(2) Linear-analog encoder
(3) Rotary-digital encoder
(4) Rotary-analog encoder
(5) Linear-serial encoder
(6) Rotary-serial 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-N servo drive provides buffered encoder output and emulated encoder output to output encoder signals. 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.

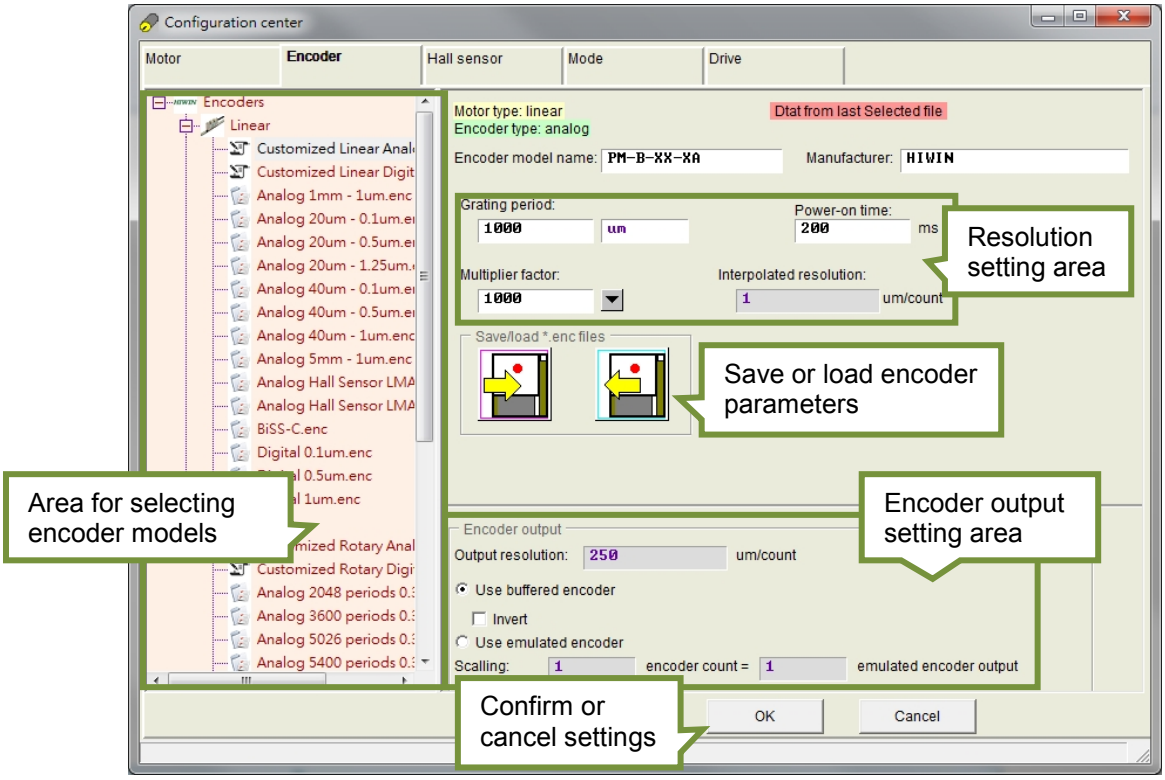


Figure 5.2.2.1 Interface for setting encoder

5.2.2.1 HIWIN standard encoder

(1) Linear-digital encoder

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

(2) Linear-analog encoder

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

(3) Rotary-digital encoder

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, users are allowed to input encoder information by themselves. For user-defined encoder setting, please refer to section 5.2.2.2.

(4) Rotary-analog encoder

For instance, 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, users are allowed to input encoder information by themselves or select other selection. For user-defined encoder setting, please refer to section 5.2.2.2.

Table 5.2.2.1.1

No.	TMS Series	Grating Period/Rev
1	TMS03, TMS03L, TMS07, TMS07H	2,048
2	TMS12, TMS14, TMS16, TMS18, TMS32, TMS32H, TMS34, TMS34H, TMS38, TMS38H, TMS3C, TMS3CL, TMS3CH	3,600
3	TMS74, TMS74L, TMS76, TMS7C, TMS7CH	5,400

(5) Linear-serial encoder

D1-N servo drive supports EnDat linear serial encoder. When serial encoder is connected, the servo drive automatically reads the parameters of the encoder. Figure 5.2.2.1.1 shows the setting page for EnDat serial encoder.

Note: D1-N servo drive does not support BiSS linear serial encoder.

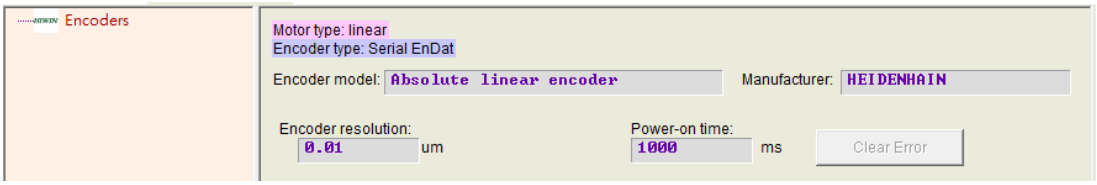


Figure 5.2.2.1.1

D1-N servo drive supports dual loop control. The supported linear and rotary encoders are listed in table 5.2.2.1.2. In the setting page shown in figure 5.2.2.1.2, digital AqB encoder is used.

Table 5.2.2.1.2

Linear Encoder	Rotary Encoder
EnDat encoder	Digital AqB or analog encoder
Digital AqB encoder	BiSS encoder

Note:

If dual loop control is selected, phase initialization must be performed again after PRM file is loaded.

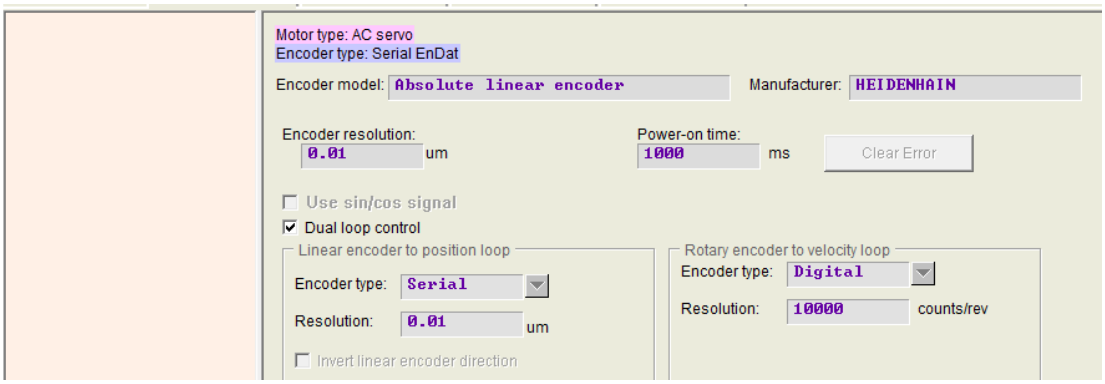


Figure 5.2.2.1.2

(6) Rotary-serial encoder

D1-N servo drive supports rotary serial encoder, such as BiSS, EnDat and Nikon. The setting pages are shown as figures 5.2.2.1.3 to 5.2.2.1.5. When serial encoder is connected, the servo drive automatically reads the parameters of the encoder. When BiSS or Nikon encoder is used, the resolution (Unit: bit) of the encoder must be input by users. The resolution per revolution (Unit: counts/rev) will be automatically calculated.

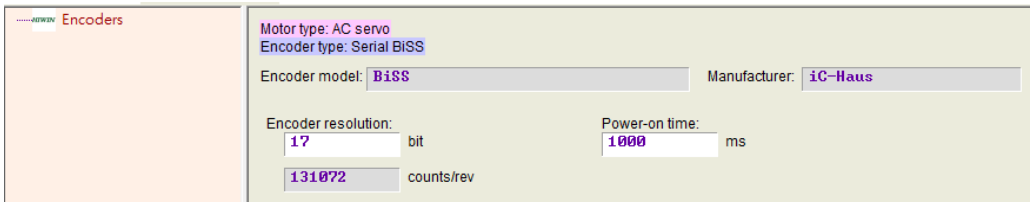


Figure 5.2.2.1.3

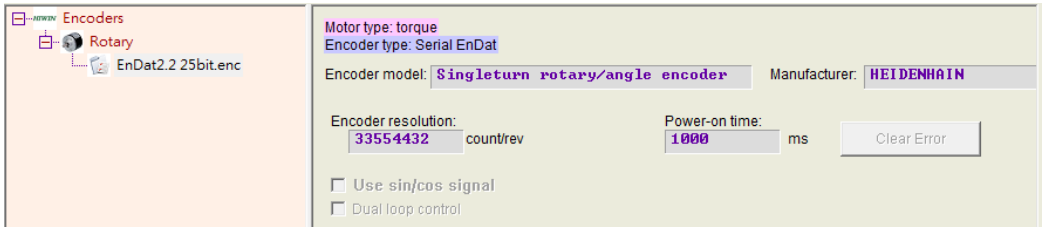


Figure 5.2.2.1.4

Figure 5.2.2.1.5

When EnDat 2.1 encoder is used, users are able to decide whether to use sin/cos signal to increase resolution. The setting page is shown as figure 5.2.2.1.6.

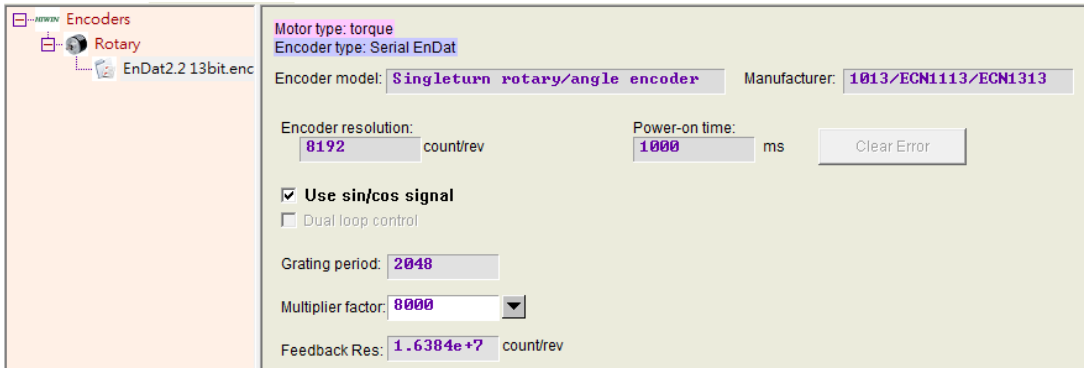


Figure 5.2.2.1.6

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.

Figure 5.2.2.2.1

(2) Linear-analog encoder

Set the grating period of the analog encoder signal and multiplier factor. The setting value of multiplier factor must be integer multiple of eight. The maximum setting value is 60,000. After multiplier factor is set, the interpolated resolution (Unit: um/count) will be automatically calculated and displayed.

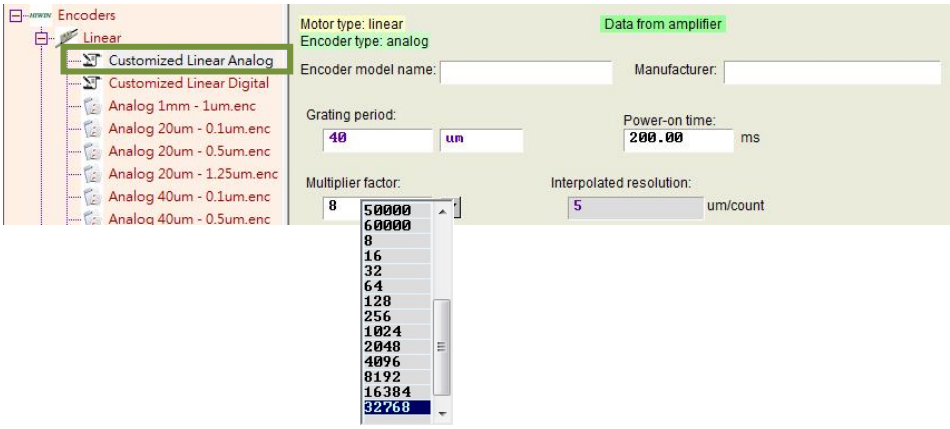


Figure 5.2.2.2.2

(3) Rotary-digital encoder

Set the resolution per revolution (Unit: counts/rev). D1-N servo drive calculates the linear resolution (Unit: um/count) of the motor according to the screw pitch and encoder resolution set by users.

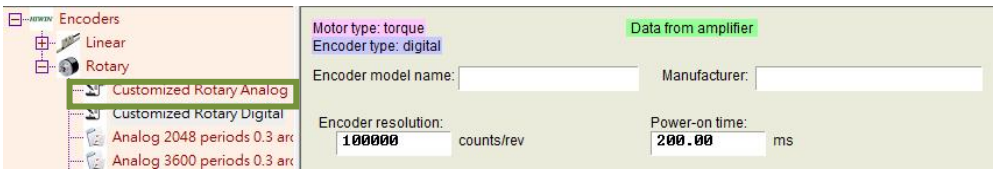


Figure 5.2.2.2.3

(4) Rotary-analog encoder

Set the resolution per revolution (Unit: grating period/rev). The setting value of multiplier factor must be integer multiple of eight. The maximum setting value is 60,000. After multiplier factor is set, the interpolated resolution (Unit: counts/rev) will be automatically calculated and displayed. D1-N servo drive also calculates the linear resolution of the motor according to the interpolated resolution and screw pitch.

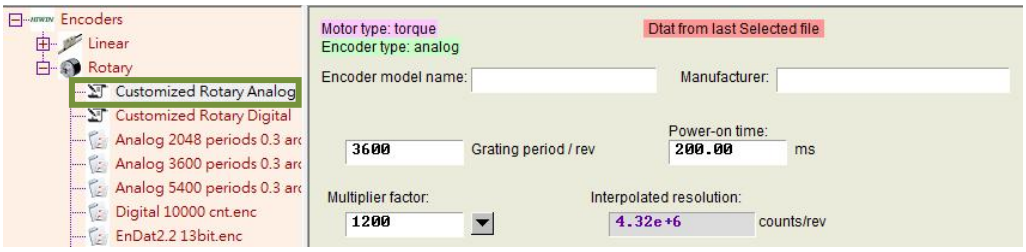


Figure 5.2.2.2.4

5.2.2.3 Setting encoder output

D1-N servo drive outputs AqB signals via connector X6. If needed, connect to controller via connector X6. In the encoder output setting area (figure 5.2.2.3.1), users are able to select **Use buffered encoder** or **Use emulated encoder**. The value in **Output Resolution** field will be updated as different selection is set.

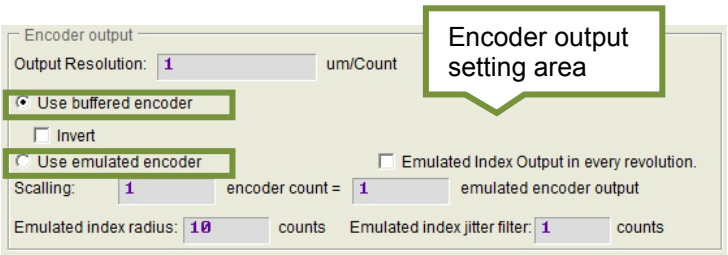


Figure 5.2.2.3.1

Note:

If AC servo motor with 17-bit encoder is used, use emulated encoder to output Z-phase signal to the controller.

(1) Buffered encoder output

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

(2) Emulated encoder output

When emulated encoder output is selected, the signals received from the encoder will be scaled before the signals are output to the controller. If the scaling is set to 1:1, the signals will be directly output to the controller according to the adopted encoder and resolution setting. In some cases, such as when the controller cannot receive encoder signals sent at high frequency, the scaling can be set to 5:1 to let five 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 5.2.2.3.2, 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 when saving parameters to Flash.

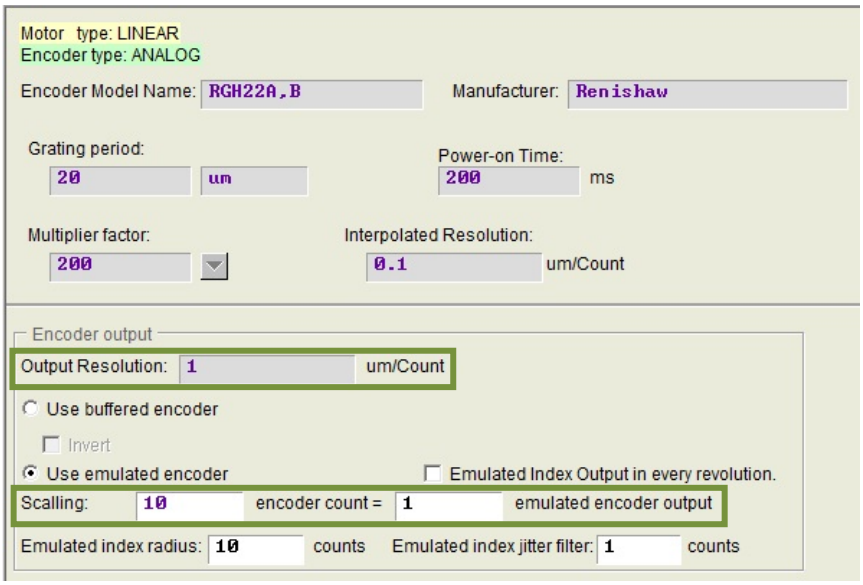


Figure 5.2.2.3.2

(3) Output emulated Z-phase signal to controller

When the bandwidth of the controller is unable to receive Z-phase signal, **Emulated index radius** and **Emulated index jitter filter** can be set to enlarge the output range of Z-phase signal to prevent the controller from missing Z-phase signal. The setting page is as figure 5.2.2.3.3.

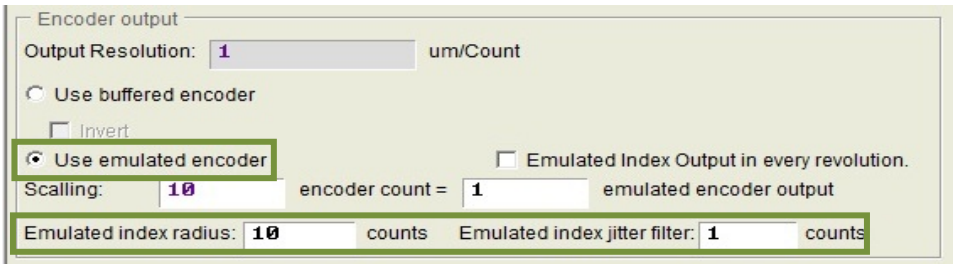


Figure 5.2.2.3.3

Select **Use emulated encoder** and set **Emulated index radius** and **Emulated index jitter filter**.

a. Emulated index radius: Output range of emulated Z-phase signal, as figure 5.2.2.3.4.

b. Emulated index jitter filter: Suppress the bounce phenomenon of emulated Z-phase signal.

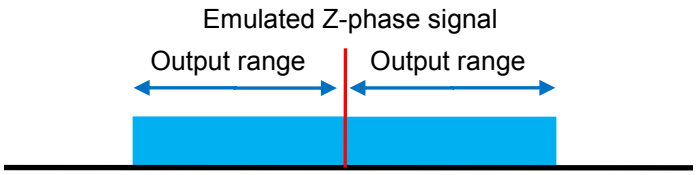


Figure 5.2.2.3.4

When home offset is used in homing, the emulated Z-phase signal will move to the home position after home offset, as figure 5.2.2.3.5.

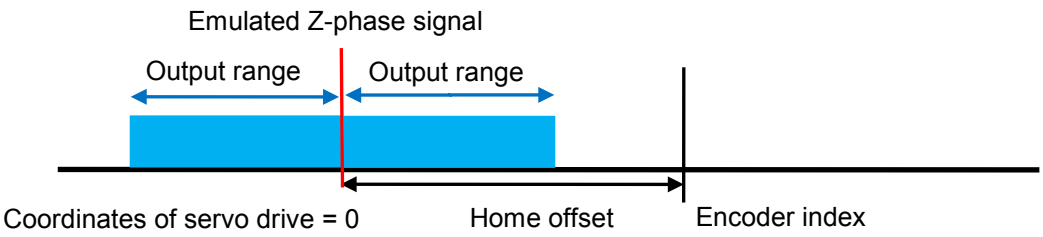


Figure 5.2.2.3.5

Output of emulated Z-phase signal

This function can only be used with AC servor motor or direct drive motor.

- When **Emulated Index Output in every revolution** is not selected
  The servo drive outputs emulated 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 emulated Z-phase signal every time when the index position is reached.

For linear motor, **Emulated Index Output in every revolution** has no function.

Note:

(1) For firmware version before D1N MDP 0.818 and D1NCOE MDP 0.522, 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 D1N MDP 0.818 and D1NCOE MDP 0.522, 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, to output multiple index signals, reference marks must be set in the digital linear encoder in use. Normally linear analog encoder does not support multiple index signal output.

5.2.3 Setting Hall sensor

Since D1-N 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-N servo drive supports both digital Hall sensor and analog Hall sensor. The setting of Hall sensor must be in accordance with the real 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 users do 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) When 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).

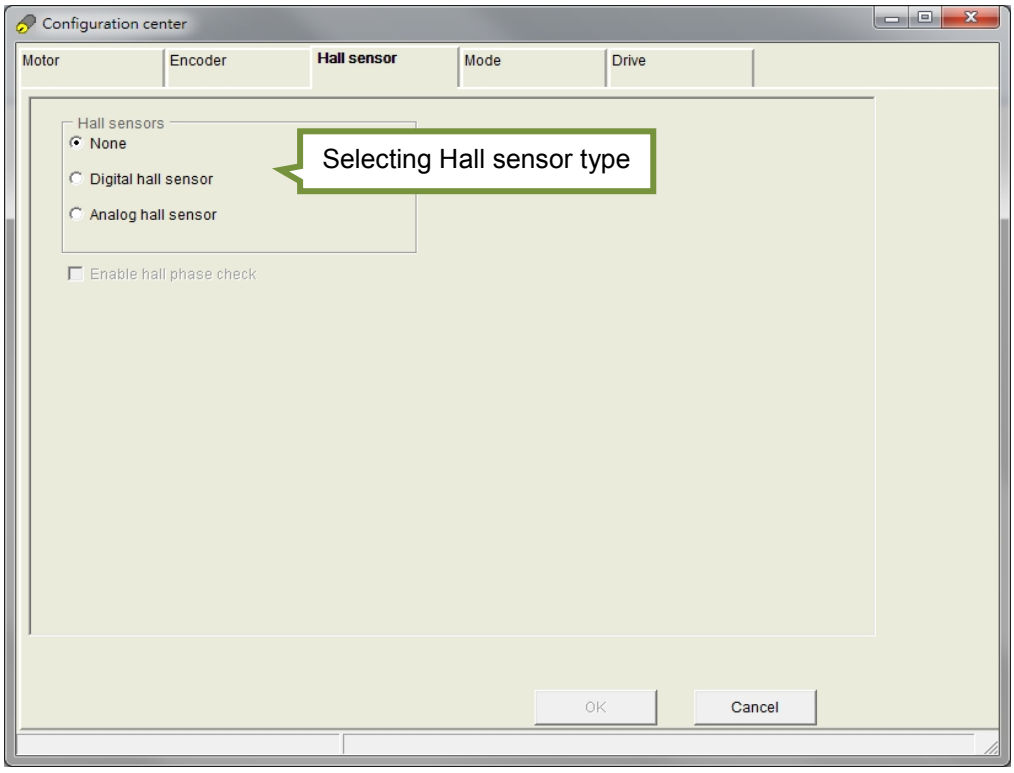


Figure 5.2.3.1

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.

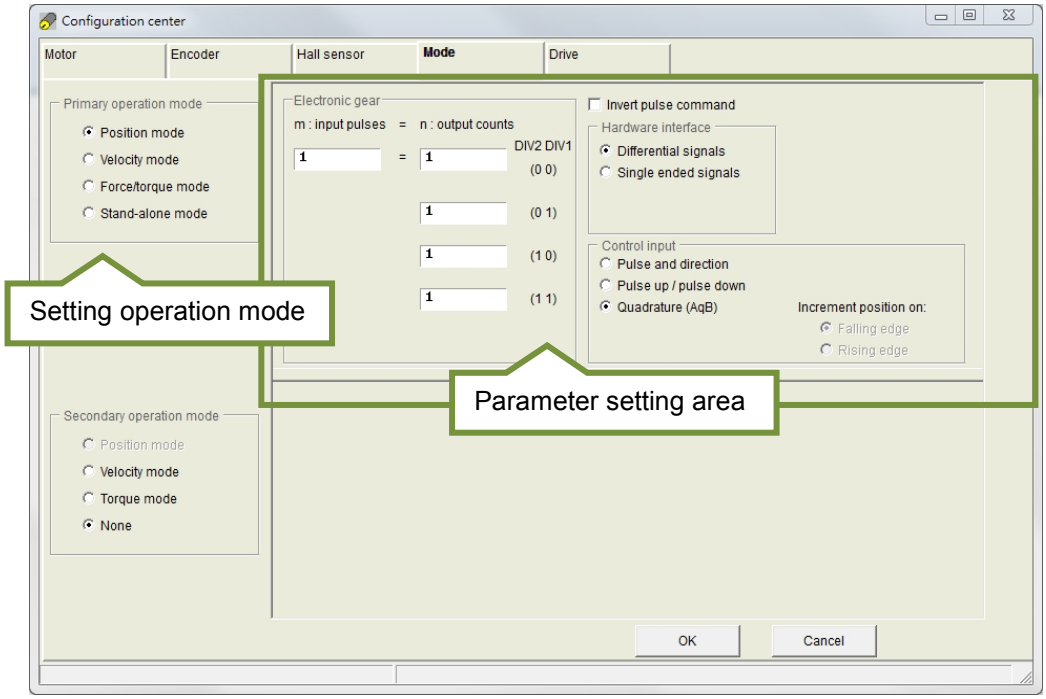


Figure 5.2.4.1

(1) Position mode

For controller which only sends pulse commands, select position mode to receive pulse commands from the controller. The closed-loop control is handled by the servo drive. D1-N servo drive supports three pulse types and two signal types. Electronic gear ratio is provided for application which requires fast movement.

Note:

(1) Pulse commands from the controller can only be accepted in servo ready state.

(2) Dual loop control is only available in position mode and stand-alone mode.

(3) When **Invert pulse command** is selected, the direction of pulse command will be reversed.

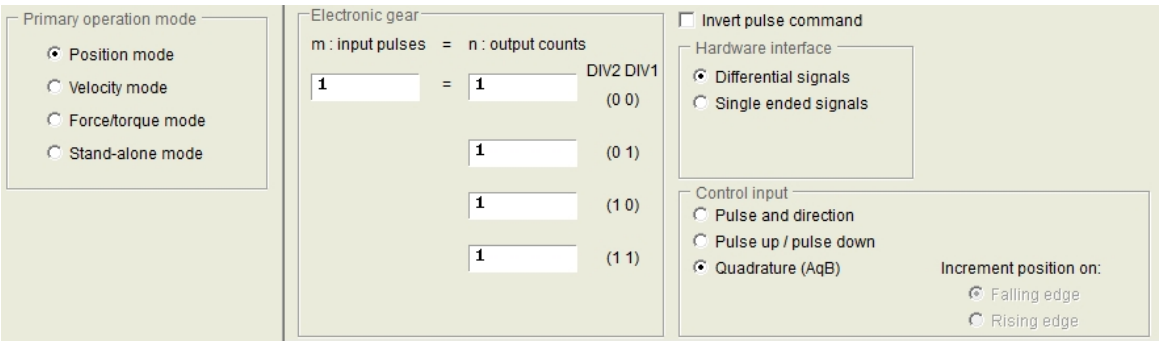


Figure 5.2.4.2

(2) Velocity mode

For controller which sends analog commands, select velocity mode to receive analog commands from the controller. The ratio (scaling) between analog 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 (rotary motor). If a negative value is set for **Scaling**, the motor moves in reverse direction.

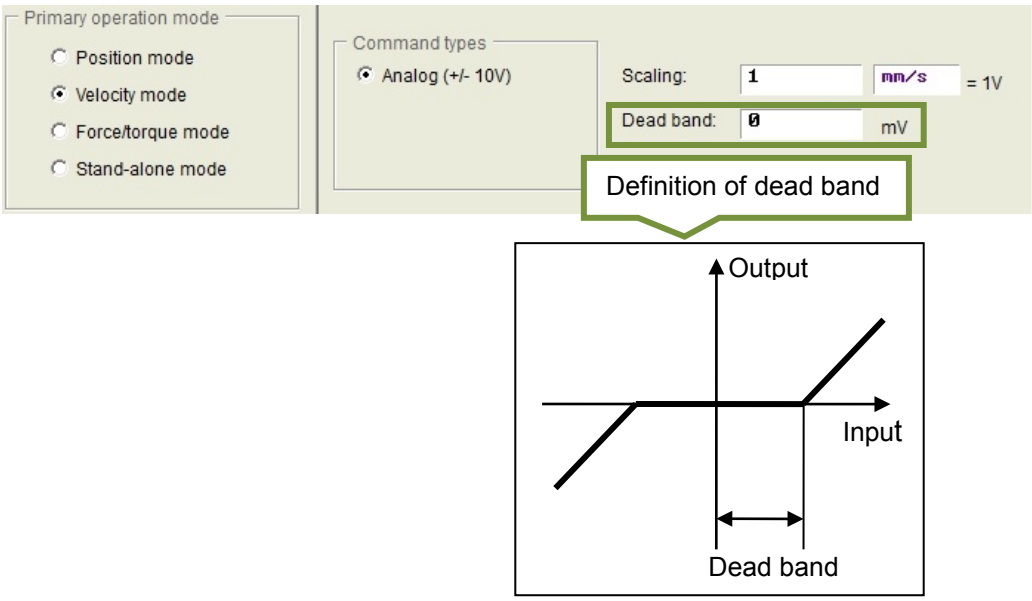


Figure 5.2.4.3

(3) Force/torque mode

Another operation mode which can be used with controller sending analog commands is force/torque mode. The ratio (scaling) between analog 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). If a negative value is set for **Scaling**, the motor moves in reverse direction.

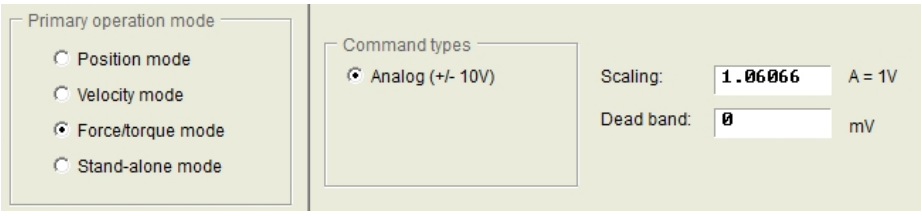


Figure 5.2.4.4

(4) Stand-alone mode

If users 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 Setting servo drive

The setting page for setting the servo drive is shown in figure 5.2.5.1. After the settings described in sections 5.2.1 to 5.2.4 are completed, the last step is to set the input power of the servo drive. Select main power value according to the actual input voltage.

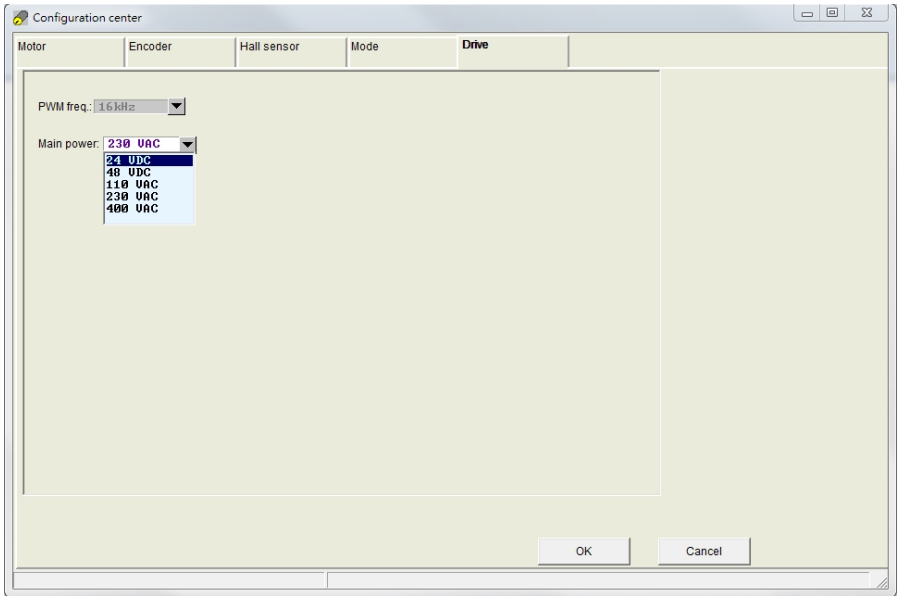


Figure 5.2.5.1

Table 5.2.5.1

Item	Specification				
Main Power	24 Vdc	48 Vdc	110 Vac	230 Vac	400 Vac
Frequency	0 Hz		50/60Hz		
Phase	NA		1 Ø/3 Ø		3 Ø
Voltage Threshold of Activating Regenerative Resistor	50 Vdc	90 Vdc	390 Vdc		735 Vdc
Voltage Threshold of Deactivating Regenerative Resistor	40 Vdc	80 Vdc	380 Vdc		695 Vdc
Threshold of Overvoltage Warning	60 Vdc	100 Vdc	404 Vdc	404 Vdc	800 Vdc
Threshold of Undervoltage Warning	19 Vdc	30 Vdc	60 Vdc	184 Vdc	320 Vdc

Note:

(1) D1-N-□□-□□-4-□-□□ supports voltage inputs 24 Vdc, 48 Vdc, 110 Vac, 230 Vac and 400 Vac.

(2) D1-N-90 supports voltage inputs 110 Vac, 230 Vac and 400 Vac.

(3) D1-N-09, D1-N-18 and D1-N-36 support voltage inputs 110 Vac and 230 Vac.

5.2.6 Modbus communication setting

The setting page for Modbus communication is shown in figure 5.2.6.1. The setting page only shows when the connected servo drive supports Modbus module.

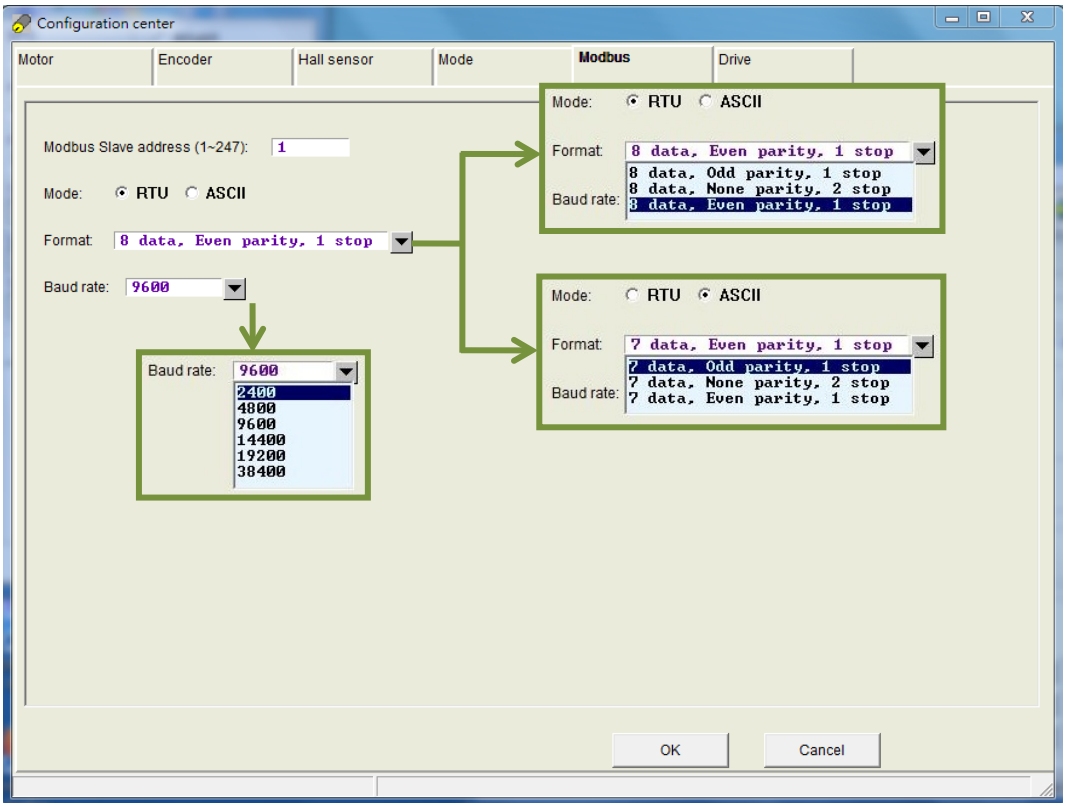


Figure 5.2.6.1

(1) Modbus slave address

Set the slave address for Modbus communication. The setting range is from 1 to 247. Different servo drives must have different slave addresses.

(2) Mode

Set the mode for Modbus communication. The default mode is RTU (Remote Terminal Unit)

(3) Format

Set data format for the selected mode. The submenu of **Format** includes data length, parity and stop bits. The data lengths in RTU mode and ASCII mode are 7 bits and 8 bits. For odd parity and even parity, one stop bit is used. For none parity, two stop bits are used.

(4) Baud rate

Set the data transmission rate of Modbus communication. The setting value can be 2,400, 4,800, 9,600, 14,400, 19,200 and 38,400 bps. The default setting is 9,600 bps.

5.2.7 Saving configuration

After the settings described in sections 5.2.1 to 5.2.5 are completed, click on **OK** button. Then the page in figure 5.2.7.1 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.

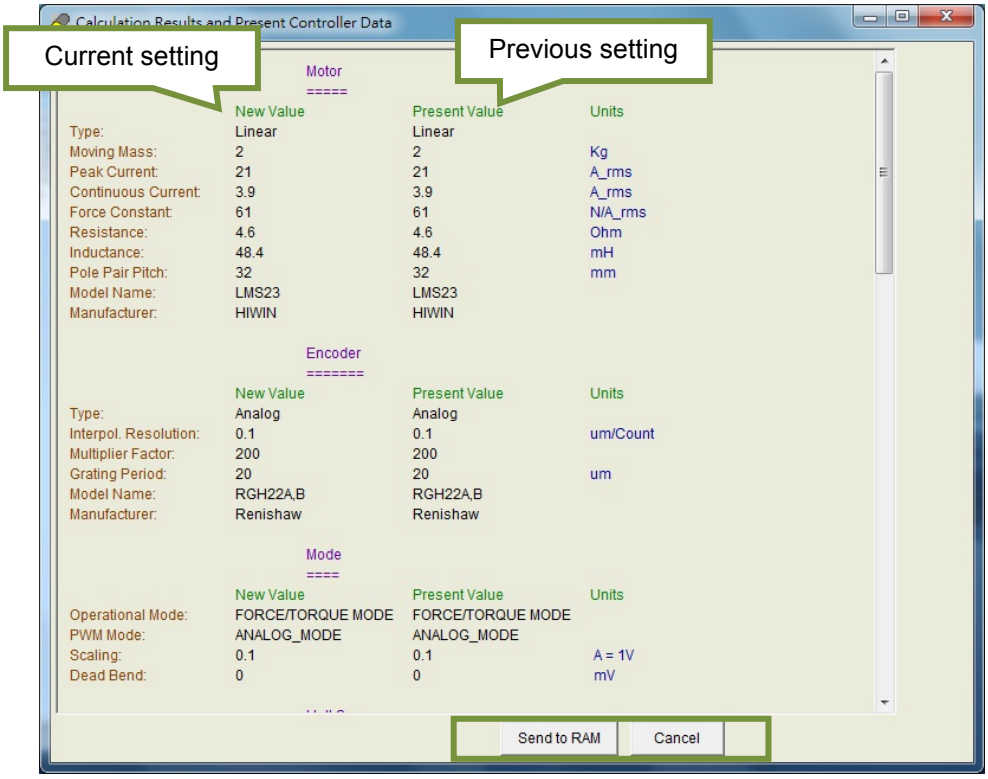


Figure 5.2.7.1

If users 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 users 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. Click on on the toolbar (Load parameters in the file to RAM) to load parameters. After the parameters are loaded, click on to save the setting to Flash.

5.3 Auto phase center

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

Note: When performing phase initialization, the motor speed must be lower than 1/6 * (pole pair pitch)/s.

(1) Phase initialization mode: Use digital Hall sensor

This mode is selected when digital Hall sensor is used. Digital Hall sensor must be set in Configuration center, please refer to section 5.2.3. Since Hall test/run is not required when HIWIN standard torque motor with Hall sensor is used, step 5 **Hall** will not appear in Auto phase center.

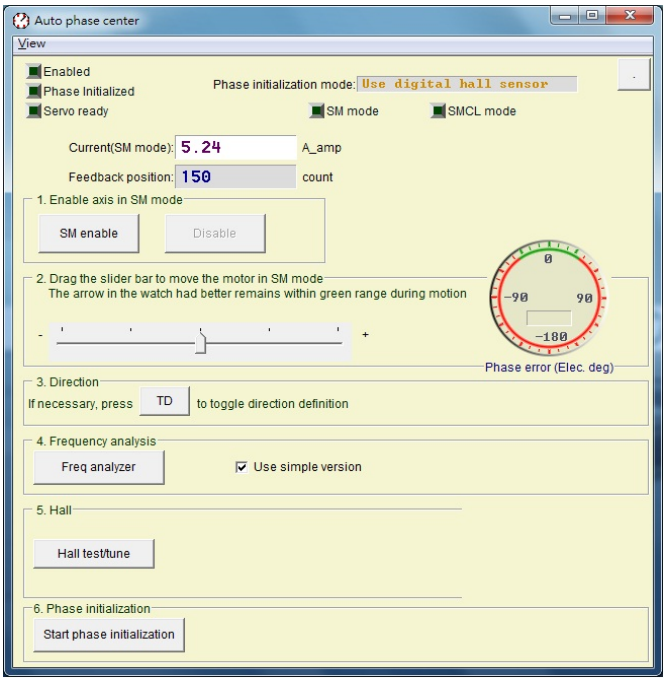


Figure 5.3.1 Phase initialization mode: Use digital Hall sensor

(2) Phase initialization mode: SW method 1

When SW method 1 is used, Hall sensor is not needed and the 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 chapter 10. If the load is changed, these parameters need to be adjusted again. When using operation mode other than stand-alone mode, external command is suggested to be sent after the controller receives servo ready signal from the servo drive. If servo ready signal cannot be received by the controller, wait at least three seconds before sending external commands (For Lightening 0.181 or later version).

Note:

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

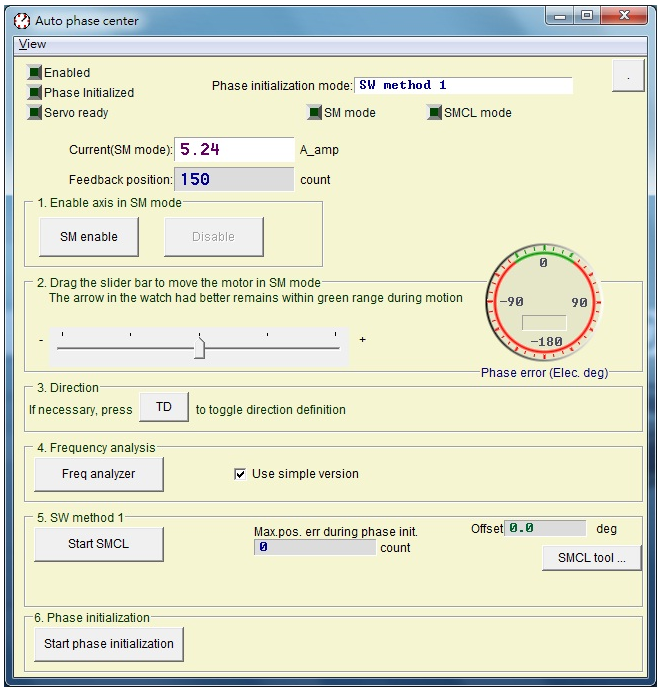


Figure 5.3.2 Phase initialization mode: SW method 1 (without Hall sensor)

(3) Phase initialization mode: STABS

Absolute encoders, such as EnDat, BiSS and Nikon are used to perform phase initialization.

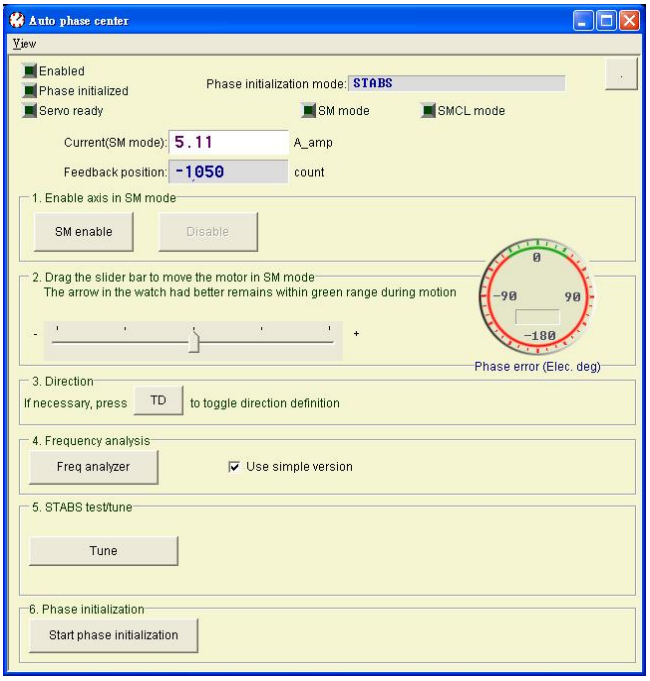


Figure 5.3.3 Phase initialization mode: STABS

(4) Phase initialization mode: LSWIR

This mode is for less-wire incremental encoder with built-in Hall sensor (The ninth code of motor model is 5, such as FRLS4020**5**06A.). Phase initialization can be completed without tuning and additional wiring. No jitter occurs during phase initialization.

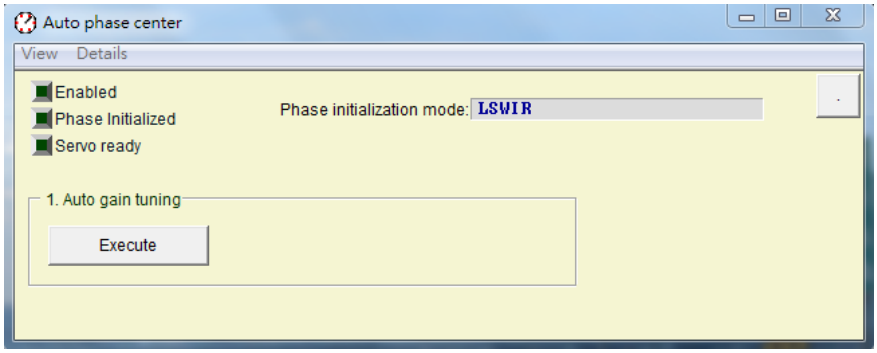


Figure 5.3.4 Phase initialization mode: LSWIR

5.3.1 Inspection before auto phase initialization

Check the following items before auto phase initialization.

(1) Check if the motor power cable is correctly connected.

(2) Check if the encoder signal is normal.

(3) Check if the servo drive receives hardware enable signal, please refer to chapter 11.

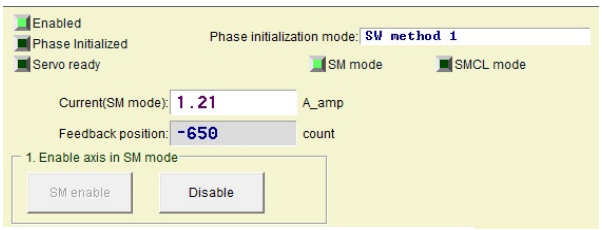
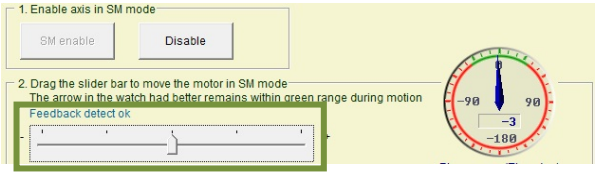
(4) Check if over temperature cable is connected.

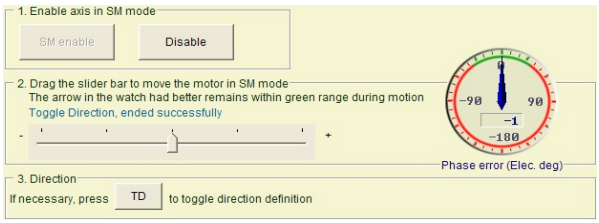
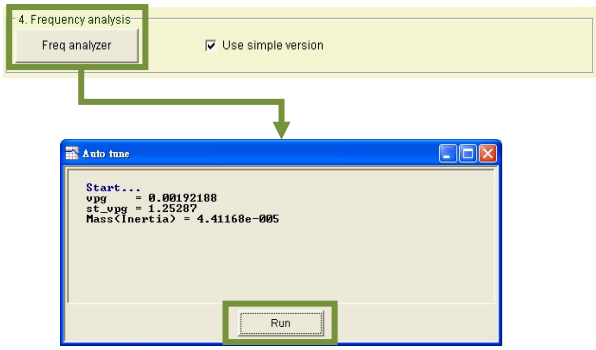
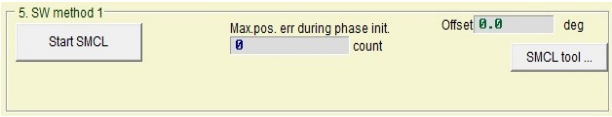
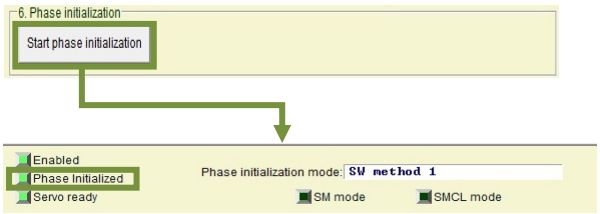
(5) Check if AC main power is turned on.

(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 and does not exceed the default setting value which is 95% of the continuous current of the motor.

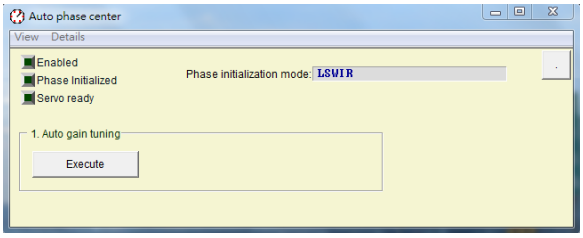
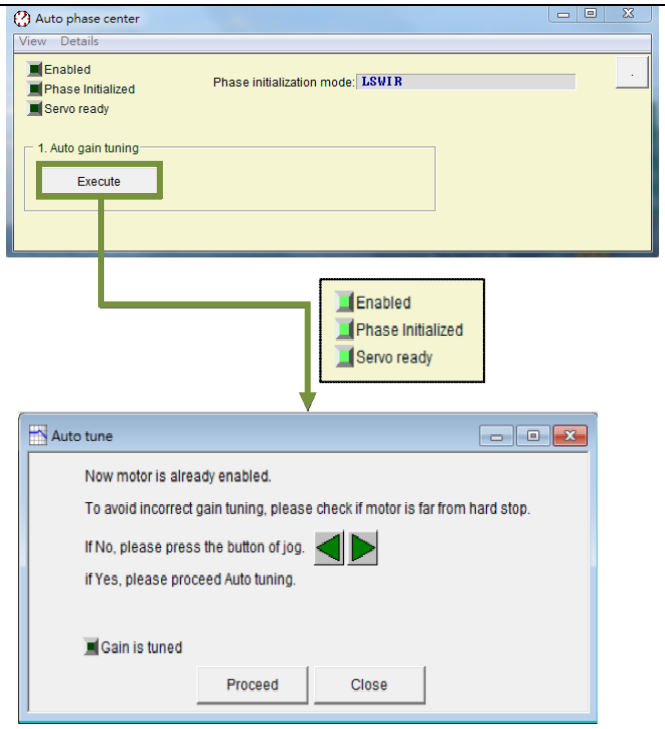
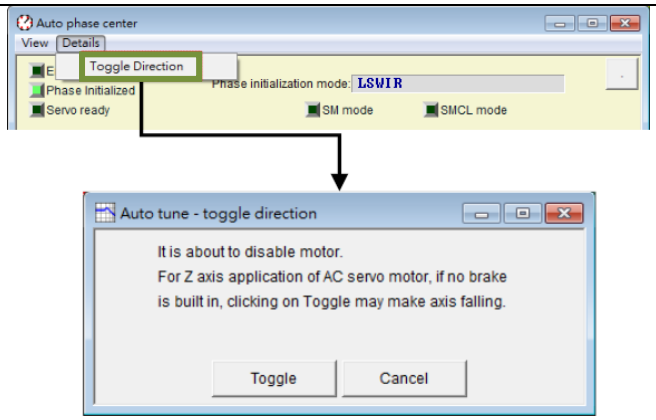
5.3.2 Operating procedures for auto phase initialization

■ The operating procedure of phase initialization mode SW method 1 is as below.

Step	Figure	Description
1		Enabling the motor in SM mode: Click on **SM enable** button and **Enabled** indicator becomes green. Note: (1) Enable the motor 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 the controller.
2		Test moving direction in SM mode: Drag the slider bar leftward and rightward to move the motor. The motor moves in forward direction when dragging the slider bar rightward. The motor moves in reverse direction when dragging the slider bar leftward. 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 users can proceed to next step. If the pointer moves randomly, release the slider bar and drag the slider bar to move the motor again. Note: (1) If the pointer still moves randomly after moving the motor by the slider bar again, please check the following items: • The motor power cable and the encoder cable are correctly connected. • The setting of 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 the controller.

Step	Figure	Description
3		Check the definition of motion direction: If the moving direction is inconsistent with what the users have defined as forward or reverse direction, click on **TD** button to reverse the definition of motion direction. After the message "Toggle Direction, ended successfully" appears, return to step 2 and proceed again.
4		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. 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. (1) The stiffness of the mechanism is too low. (2) The backlash of the mechanism is too large. (3) The load has been changed. (4) The load inertia ratio is over 20. Note: (1) If mechanical resonance occurs during execution, stop inputting Hardware enable signal or press **F12** function key (Refer to section 6.1.3). (2) Users are allowed to tune manually, please refer to section 10.3. For description of parameters vpg and st_vpg, please refer to sections 6.6.3 and 10.3.
5		Adjusting phase initialization: By using SW method 1, the motor only needs to move for a small distance to complete phase initialization. After tuning completes in step 4, confirm the tuning result by the following steps. Step 1: Click on **Start SMCL** button to find electrical angle. 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. Step 3: Repeat step 1 and 2 to observe if the offset is within +/- 15 degrees. Step 4: If offset is too large, click on **SMCL tool…** button for advanced tuning.
6		Execute 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.

■ The operating procedure of phase initialization mode LSWIR is as below.

Step	Figure	Description
1		Setting phase initialization mode: When the ninth code of the motor model is 5, phase initialization mode is automatically set to LSWIR.
2		Phase initialization and auto tuning: Click on **Execute** button and start phase initialization. After phase initialization completes, **Auto tune** window appears. Click on ◀ and ▶ in **Auto tune** window to continuously move the motor. Ensure the motor moves away from the hard stop. Then click on **Proceed** button to start auto tuning. After tuning completes, click on **Close** button to close **Auto tune** window. Then auto phase initialization completes and users can start test run. Note: (1) Observe **Phase Initialized** indicator and **Servo ready** indicator to check if phase initialization succeeds and the servo drive is able to perform closed-loop control. (2) **Gain is tuned** indicator keeps flashing when auto tuning is being executed. The indicator stops flashing as auto tuning completes. The indicator becomes red when auto tuning fails. At this time, close **Auto tune** window and repeat step 2.
3		Confirm the definition of motion direction: If the moving direction is inconsistent with what the users have defined as forward or reverse direction, close **Auto tune** window and open **Auto tune-toggle direction** window. Click on **Toggle** button to reverse the setting. After that, repeat step 2. Note: When motion direction is toggled, the motor will be disabled. If the motor is used in vertical axis and no mechanical brake is applied, the motor may drop.

■ Phase initialization when digital Hall sensor is used

Click on **Hall test/tune** button in figure 5.3.1 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 the 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.

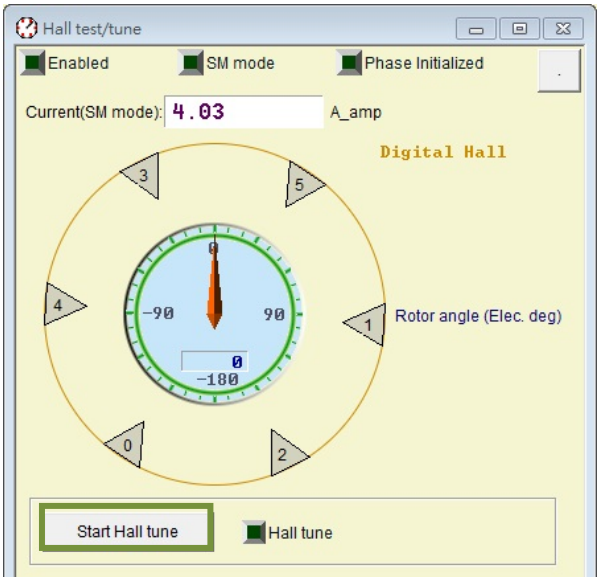


Figure 5.3.2.1

- Phase initialization mode: STABS

  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 the motor. After the motor stops, a message will appear to indicate the tuning has completed. Then, phase initialization can be started.

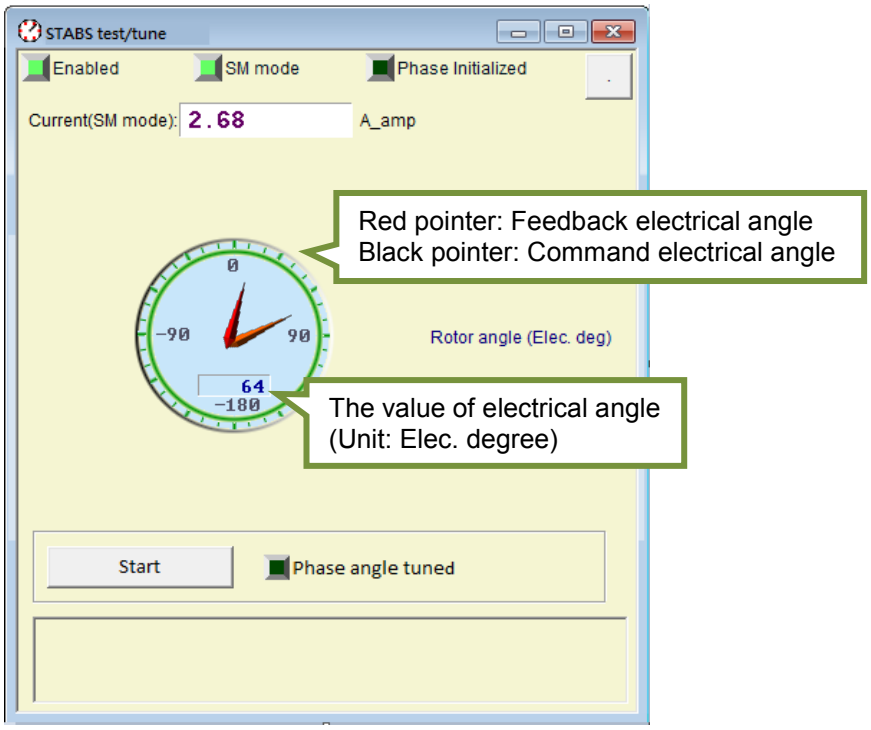


Figure 5.3.2.2

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 of Auto phase center.

- The current must be less than 95% of the continuous current of the motor. If users are not sure about the load, please start with small current first.
- If the friction increases, larger current is required to move the load.
- If the static friction is large, larger current is required.
- The motor may jog when static friction changes to dynamic friction as the motor starts to move or when dynamic friction changes to static friction as the motor stops.

(2) The moving direction of the motor

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

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

(3) Moving the motor

Pay attention to the following when the motor cannot move.

- Check if the 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 the motor power cable is correctly connected.
- Check if the resistance of the motor is appropriate.

(4) Hall sensor signal

- Confirm the cable for Hall sensor is correctly connected.
- Confirm 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

Click on  on the toolbar to open I/O center. The servo drive supports 11 digital inputs (I1 to I10 and OT). Digital inputs I1 to I10 locate on connector X6. OT locates on connector X9 for motor over temperature.

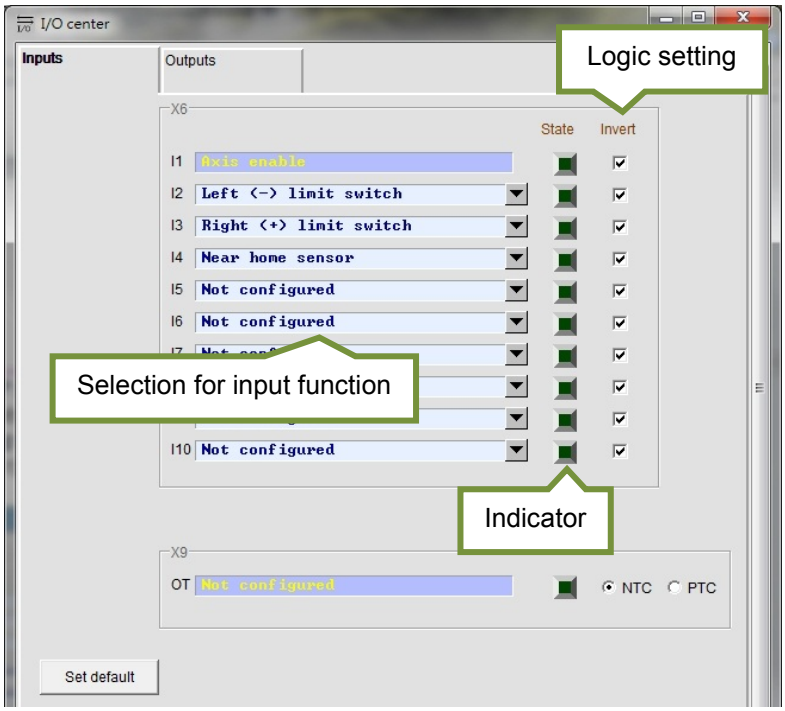


Figure 5.4.1.1

(1) Indicator

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

(2) Logic setting

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

(3) Selection for input function

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

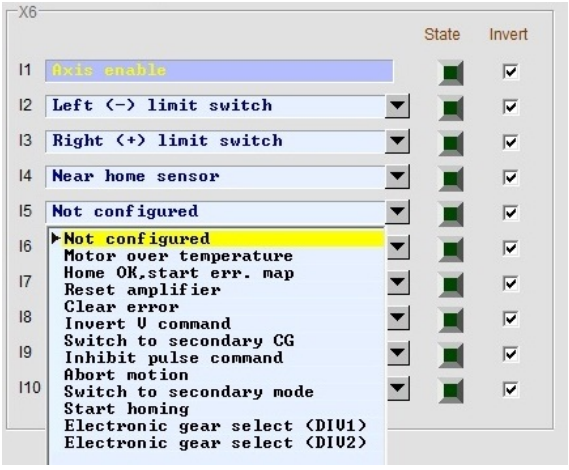


Figure 5.4.1.2

Table 5.4.1.1 Input functions

No.	Abbr.	Input Function	Description	Trigger Method
1	SVN	Axis enable	Enable or disable axis. Digital input I1 (Cannot be changed)	Level triggered
2	LL	Left limit switch	Left hardware limit Digital input I2 (Default)	Level triggered
3	RL	Right limit switch	Right hardware limit Digital input I3 (Default)	Level triggered
4	MOT	Motor over temperature	Motor over temperature detection Digital input OT (Cannot be changed)	Level triggered
5	MAP	Home ok, start err. map	Homing completion command from controller	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	INVC	Invert V command	Invert analog command in velocity mode or force/torque mode.	Level triggered
10	GNS	Switch to secondary CG	Switch to second servo gain.	Level triggered
11	INH	Inhibit pulse command	Inhibit pulse command	Level triggered
12	EMG	Abort motion	Emergency stop When this signal is received, the motor stops according to the emergency stop procedure.	Level triggered
13	MOD	Switch to secondary mode	Switch from first operation mode to second operation mode.	Level triggered
14	HOM	Start homing	Activate the built-in homing procedure in the servo drive.	Edge triggered
15	DIV1	Electronic gear select (DIV1)	Electronic gear ratio selection for position mode	Level triggered
16	DIV2	Electronic gear select (DIV2)	Electronic gear ratio selection for position mode	Level triggered

Table 5.4.1.2 Supported input functions in each operation mode

	Not CoE Model				CoE Model
Input Function \ Operation Mode	Position Mode	Velocity Mode	Force/torque Mode	Stand-alone Mode	Stand-alone Mode
Axis enable	O	O	O	O	Δ
Left limit switch	V	-	-	V	O
Right limit switch	V	-	-	V	O
Motor over temperature	O	O	O	O	O
Home ok, start err. map	V	V	V	V	V
Reset amplifier	V	V	V	V	V
Near home sensor	V	V	V	V	O
Clear error	V	V	V	V	-
Invert V command	-	V	V	-	-
Switch to secondary CG	V	V	V	V	-
Inhibit pulse command	V	-	-	-	-
Abort motion	-	-	-	V	-
Switch to secondary mode	V	V	V	V	-
Start homing	V	V	V	V	-
Electronic gear select (DIV1)	V	-	-	-	-
Electronic gear select (DIV2)	V	-	-	-	-

Note:

(1) V means the input function is supported in the operation mode and can be assigned to I2 to I10.

(2) O means the input function is supported in the operation mode, but cannot be assigned by users.

(3) Δ means for D1-N CoE model, its digital input I1 can only be set for “Axis enable” or “Not configured”.

Table 5.4.1.3 Default input functions of digital inputs

Pin	Signal	Not CoE Model				CoE Model	Invert
		Position Mode	Velocity Mode	Force/torque Mode	Stand-alone Mode	Stand-alone Mode	
7	I1	Axis enable	Axis enable	Axis enable	Axis enable		Yes
8	I2	Left (-) limit switch	Left (-) limit switch	Left (-) limit switch	Left (-) limit switch	Left (-) limit switch	Yes
9	I3	Right (+) limit switch	Right (+) limit switch	Right (+) limit switch	Right (+) limit switch	Right (+) limit switch	Yes
10	I4	Near home sensor	Near home sensor	Near home sensor	Near home sensor	Near home sensor	Yes
11	I5						Yes
12	I6						Yes
13	I7						Yes
14	I8						Yes
15	I9						Yes
16	I10						Yes

Input Function	Clear Error		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	CE	Default Input	None	Wiring Diagram	Refer to section 4.7.2.			

◆ 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	None	Wiring Diagram	Refer to section 4.7.2.			

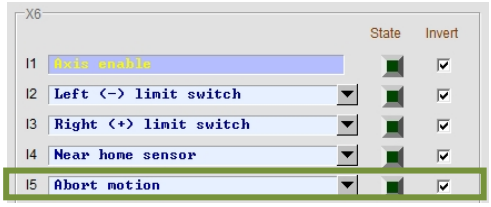
◆ Function
Homing

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

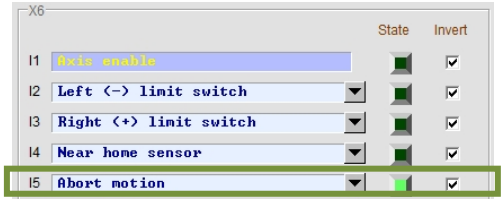
Input Function	Abort Motion		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	EMG	Default Input	None	Wiring Diagram	Refer to section 4.7.2.			

◆ 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.

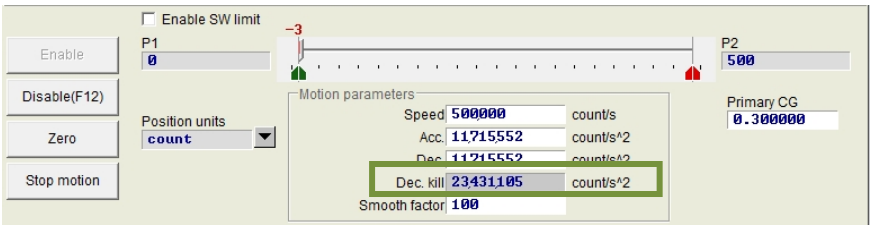
◆ Description
Set one input for aborting motion in I/O center. Use external signal to decelerate the motor at the speed set in Dec. kill to a stop. In the figure below, I5 is set for aborting motion.



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



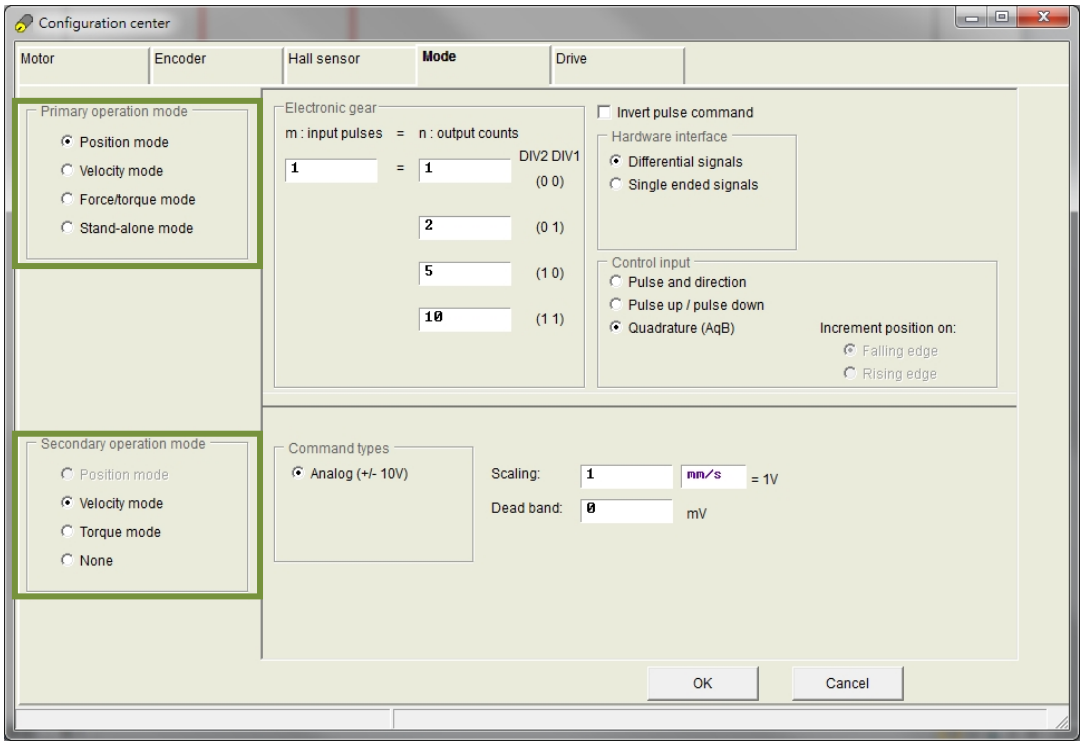
When **State** indicator becomes green, the servo drive decelerates the motor at the speed set in Dec. kill to a stop.



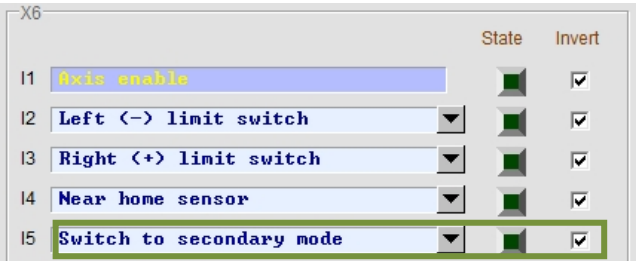
Input Function	Switch To Secondary Mode		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	MOD	Default Input	None	Wiring Diagram	Refer to section 4.7.2.			

◆ Function
Use I/O signal from the controller to switch to secondary operation mode.

◆ Description
Set primary operation mode and secondary operation mode in **Mode** tab of Configuration center.



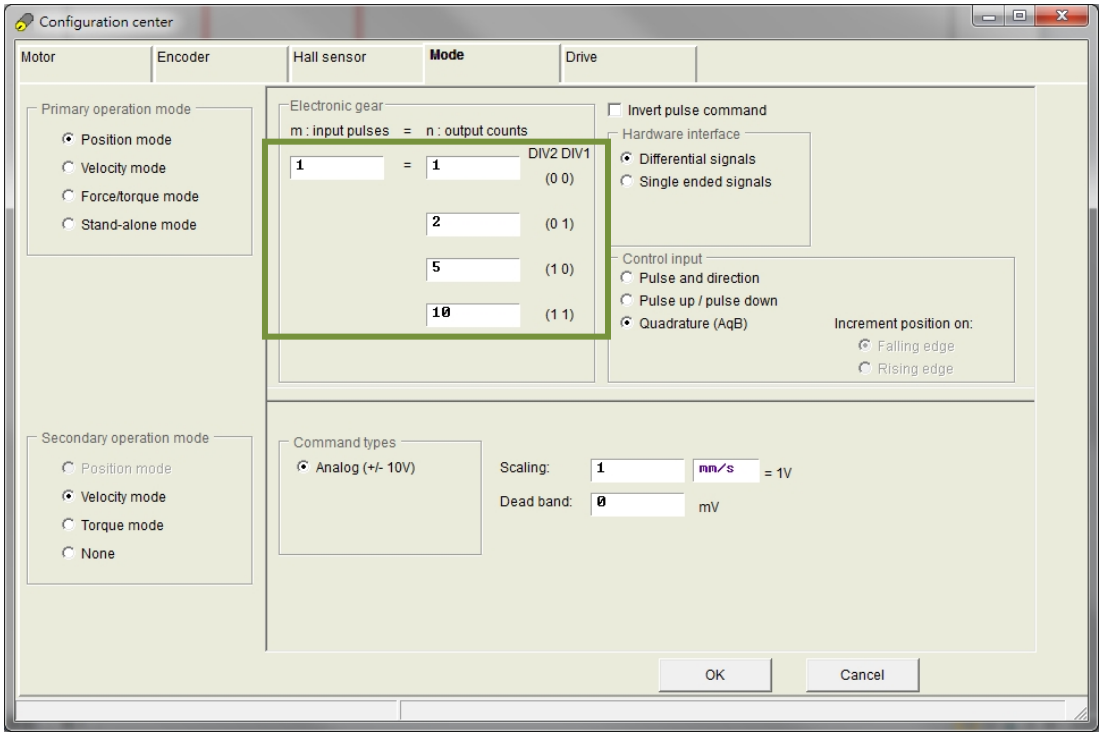
Set one input for switching to secondary mode in I/O center. In the figure below, I5 is set for switching to secondary mode. When the input signal is OFF, the mode set in **Primary operation mode** is used. When the input signal is ON, the mode set in **Secondary operation mode** is used. If **None** is selected in **Secondary operation mode**, stand-alone mode is used.



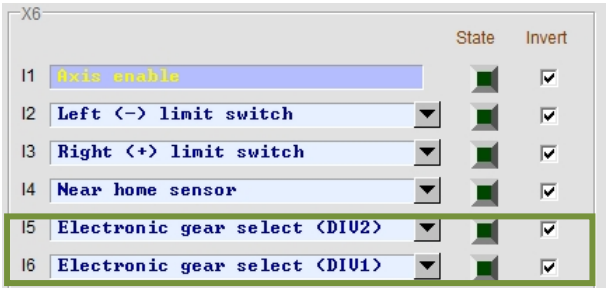
Input Function	Electronic Gear Select (DIV1, DIV2)		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	DIV1, DIV2	Default Input	None	Wiring Diagram	Refer to section 4.7.2.			

◆ Function
This input function is used to switch among four sets of electronic gear ratios.

◆ Description
Select **Position mode** in **Mode** tab of Configuration center. Four sets of electronic gear ratios can be set, please refer to below.



Set two inputs for “Electronic gear select (DIV1)” and “Electronic gear select (DIV2)”, as I5 and I6 in the figure below.



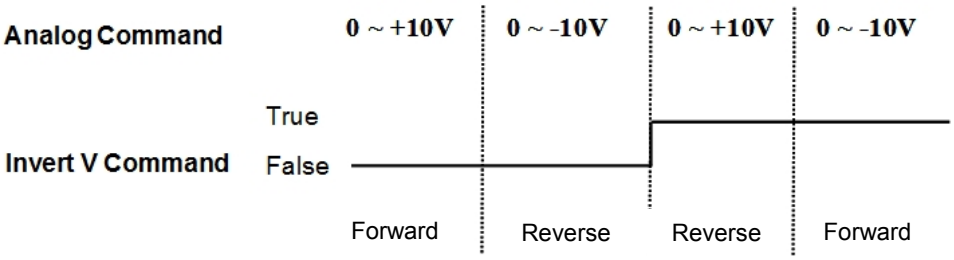
Use different combinations of the states of DIV1 and DIV2 to select desired electronic gear ratio. The corresponding electronic gear ratios are shown in the table below. For instance, to use the second electronic gear ratio, “Electronic gear select (DIV2)” must be OFF, and “Electronic gear select (DIV1)” must be ON.

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

Input Function	Invert V Command		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	INVC	Default Input	None	Wiring Diagram	Refer to section 4.7.2.			

◆ Function
Invert analog command sent from the controller.

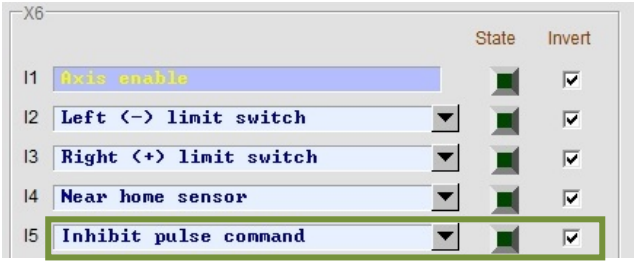
◆ Description
In velocity or force/torque mode, select **Invert V Command** for one input. When the input is OFF, the motor moves in forward direction as 0 ~ +10 V analog command is received. The motor moves in reverse direction as 0 ~ -10 V analog command is received. When the input is ON, the motor moves in reverse direction as 0 ~ +10 V analog command is received. The motor moves in forward direction as 0 ~ -10 V analog command is received.



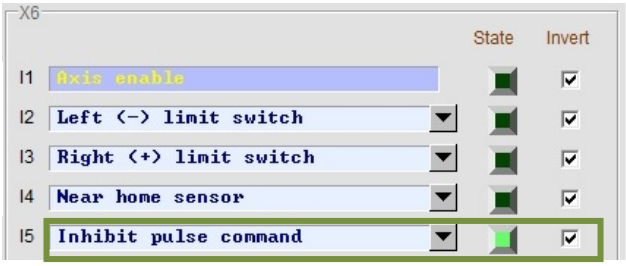
Input Function	Inhibit Pulse Command		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	INH	Default Input	None	Wiring Diagram	Refer to section 4.7.2.			

◆ Function
Users are allowed to inhibit receiving pulse command from the controller.

◆ Description
Select **Inhibit pulse command** for one input. If the input is ON, pulse command sent from the controller will be inhibited. If the input is OFF, pulse command sent from the controller can be received to drive the motor.



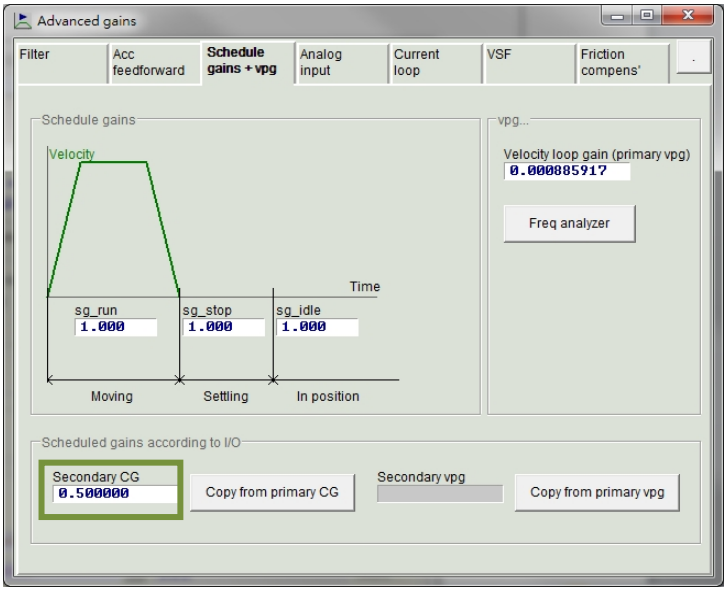
After external signal is input, the motor stops moving.



Input Function	Switch To Secondary CG		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	GNS	Default Input	None	Wiring Diagram	Refer to section 4.7.2.			

◆ Function
Users are allowed to switch between two common gains (CG).

◆ Description
Set secondary CG in **Schedule Gains + vpg** tab of **Advanced gains** window, as the figure below.



When the input is ON, secondary CG is used. When the input is OFF, primary CG is used.

5.4.2 Digital outputs

The servo drive provides four sets of programmable digital outputs. Three outputs (O1 to O3) are general-purpose outputs which locate on connector X6. One output (O4) which locates on connector X4 is for brake and can also be used as general-purpose output.

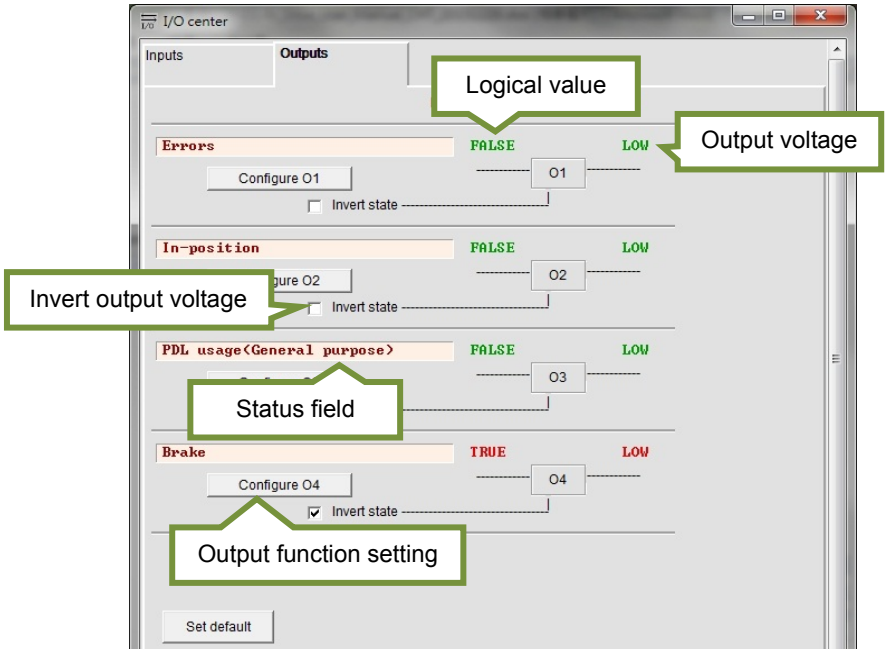


Figure 5.4.2.1

(1) Output function setting

Each output has its corresponding setting button. For instance, the setting button of O1 is **Configure O1** button. Click on **Configure O1** button 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** button to cancel the selection. Click on **Apply** button to finish the setting or click on **Cancel** button to cancel the setting. If **Set all errors** button is clicked on, all the listed errors will be selected.

(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)” which means the output can be used for PDL program.

(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 state** to invert the polarity of output voltage. Please be noted the internal logic value of the servo drive will not be affected.

(5) Output voltage

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

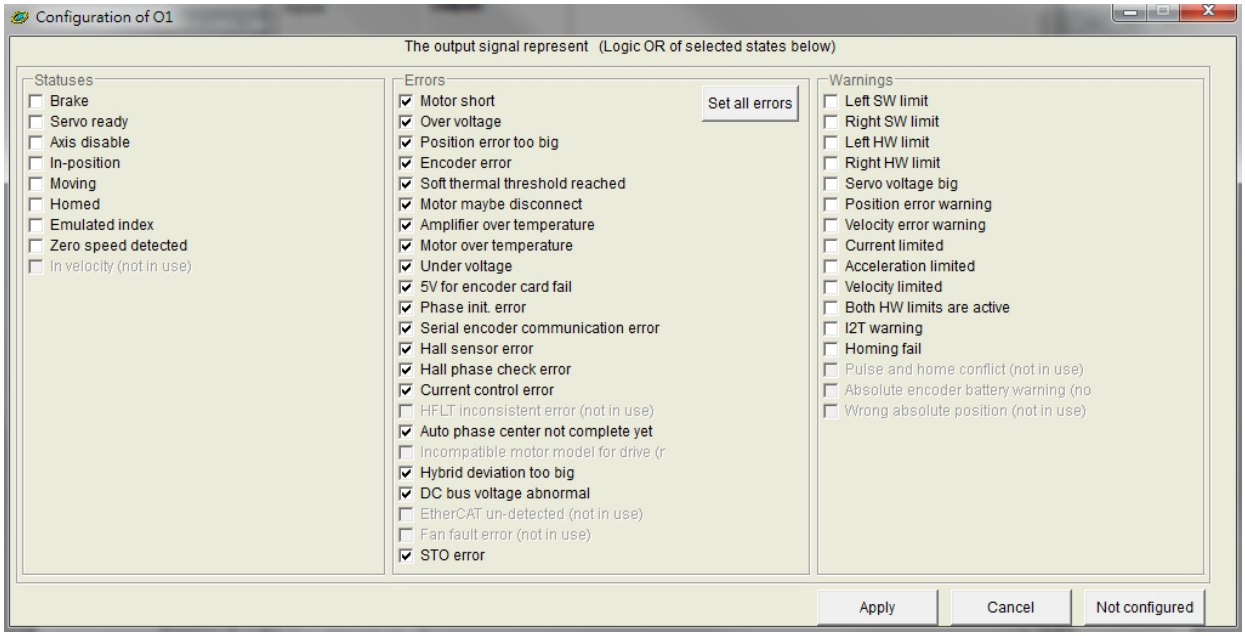


Figure 5.4.2.2

Table 5.4.2.1

Item	Abbr.	Output Function	Description
Statuses			
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 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. Users can also set according to their needs.
Warnings			
1	LS	Left SW limit	Left software limit is triggered.
2	RS	Right SW limit	Right software limit is triggered.
3	LH	Left HW limit	Left hardware limit is triggered.
4	RH	Right HW 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 and home conflict	In position mode, both pulse command and homing command are received at the same time.

Table 5.4.2.2 Default output settings of D1-N servo drive

Output	Not 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

	Not CoE Model				CoE Model
Operation Mode / Output Function	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	-	-	-	-	-

Note:

"V" means the output function is supported.

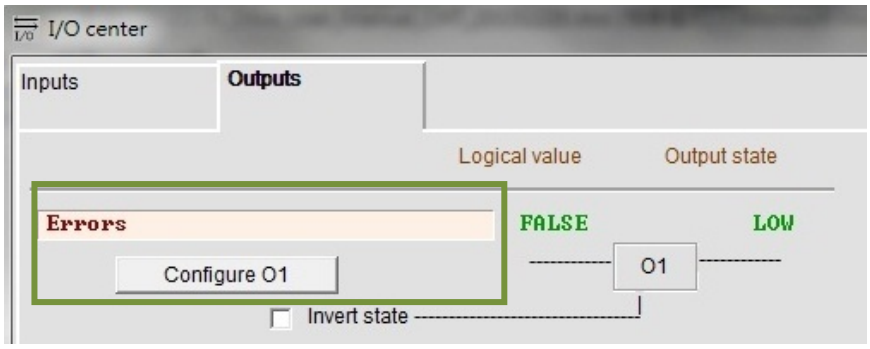
Output Function	Errors		Applicable Operation Mode		Pos	Vel	Trq	Std
Abbr.	ALM	Default Output	O1	Wiring Diagram	Refer to section 4.7.2.			

◆ Function

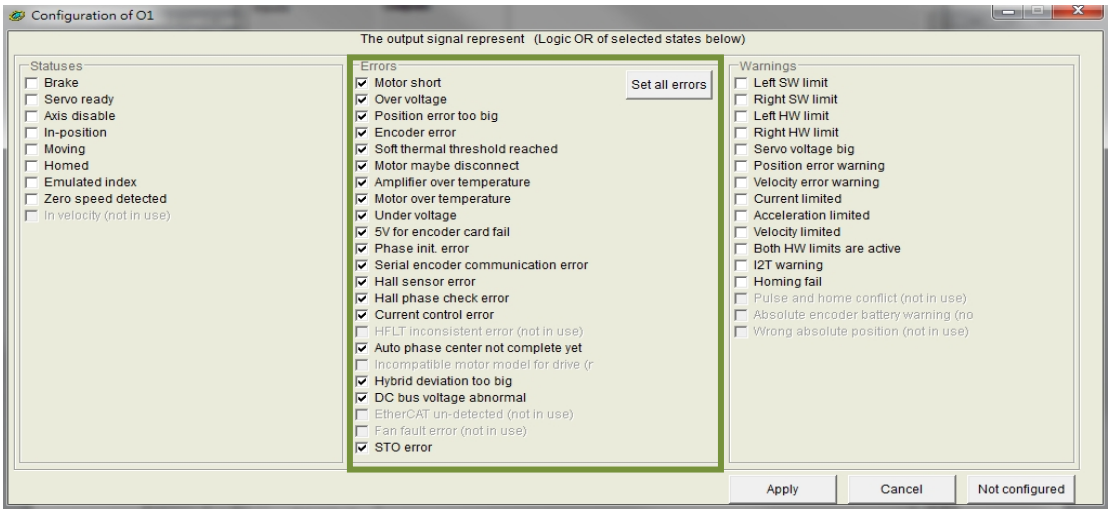
Users are allowed to output error statuses.

◆ Description

Users can select **Errors** (Default output: O1) for one output in **Outputs** tab of I/O center.



Click on **Configure O1** button to show **Configuration of O1** 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 the motor arrives at the target position is called settling time. After that, the motor goes into target radius. D1-N servo drive supports in-position settings for users to set target radius and debounce time to observe if the motor has reached the target position. In-position settings are only available in position mode and stand-alone mode. Users can set one output for in-position signal to notify the controller that the motor has arrived at the 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 the waveforms, click on **Set scope…** button. The default output of in-position signal is O2. For setting digital outputs, please refer to section 5.4.2.

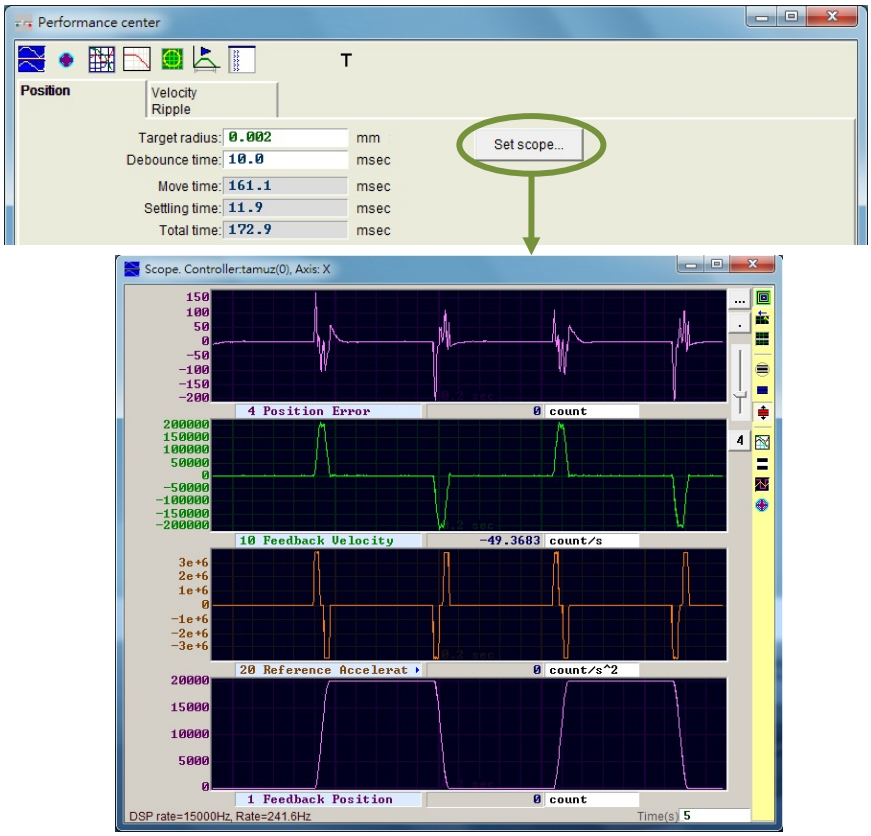


Figure 5.5.1

Table 5.5.1

Parameter	Description
Target radius	The motor will be regarded as in-position after position error is within the target radius for a specific time (Deboucne time). The default value is 100 times of encoder resolution.
Debounce time	The position error needs to be within the target radius for the set debounce time for the 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, users 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
1st	1.5 ms
2nd	1.4 ms
3rd	1.4 ms
4th	1.3 ms
5th	1 ms
6th	1 ms

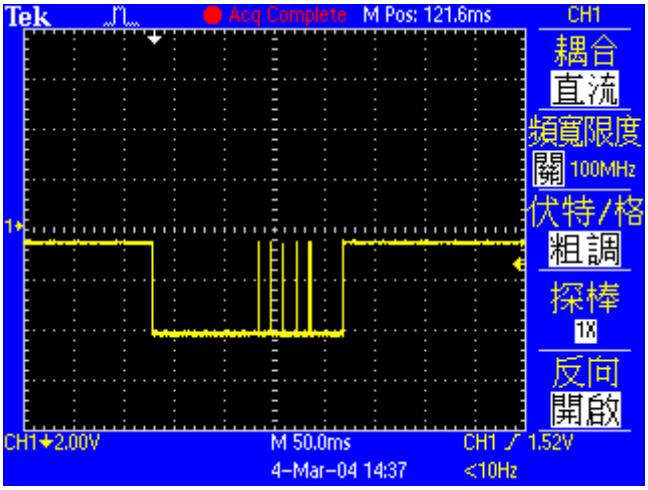


Figure 5.5.2 In-position signal when debounce time is set to 0 ms.

(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.

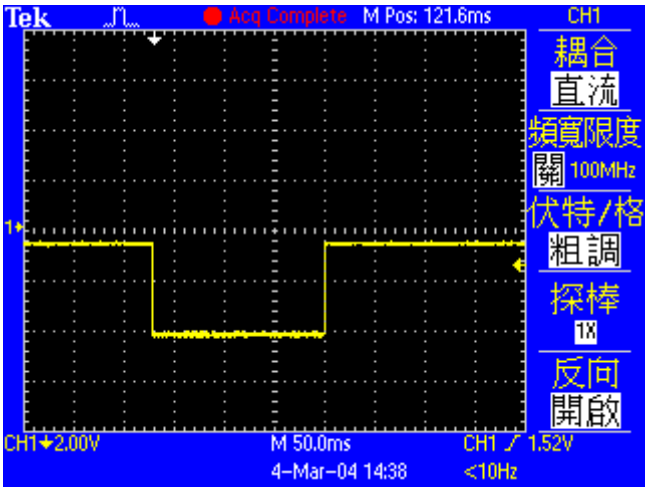


Figure 5.5.3 In-position signal when debounce time is set to 3 ms.

5.6 Homing

Click on to go to Application center. The setting page for homing is in **Homing** tab, as figure 5.6.1.

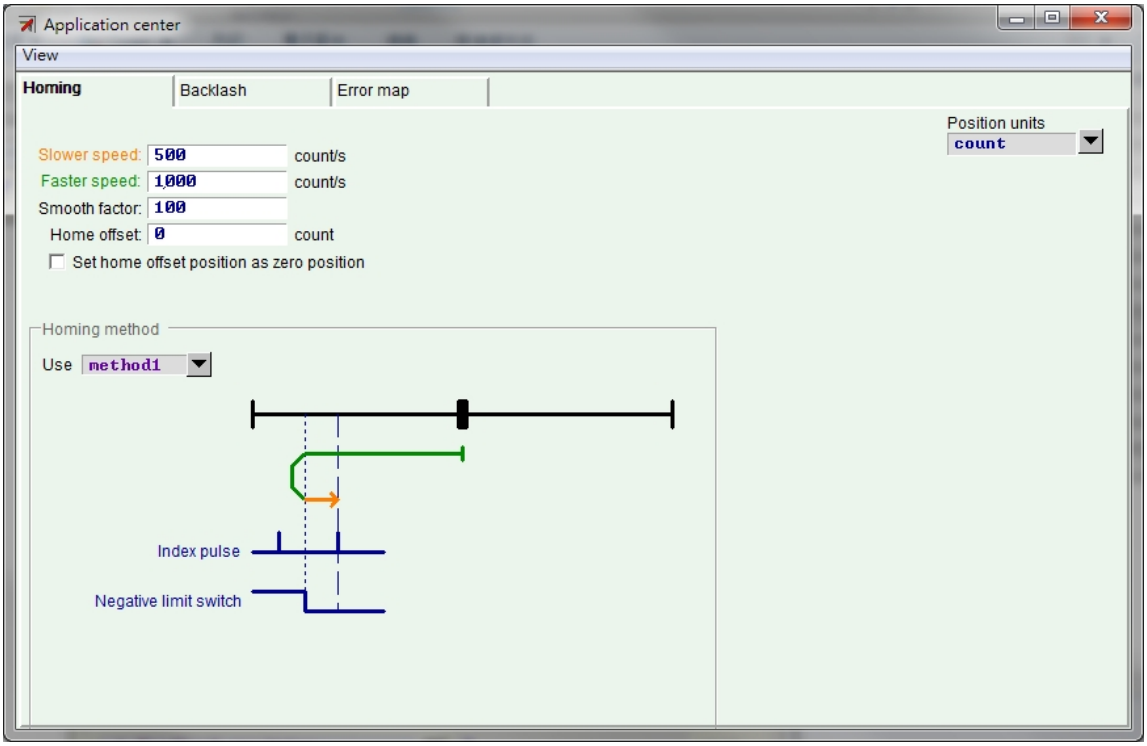


Figure 5.6.1 Homing setting

There are four basic parameters for homing.

Table 5.6.1

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)
Home Offset	Home offset

The supported homing methods of D1-N servo drive are listed in table 5.6.2. Green line means homing at faster speed; orange line means homing at slower speed. 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 (Homed). If homing fails, **Homed** indicator becomes red (Homed).

■ Home offset

(1) **Set home offset position as zero position** is not selected.

If **Set home offset position as zero position** is not selected, the position of index pulse is regarded as home position. The motor stops at this position, as figure 5.6.2. If home offset is positive, zero position will be on the left of the home position. If home offset is negative, zero position will be on the right of the home position.

(2) **Set home offset position as zero position** is selected.

If **Set home offset position as zero position** is selected, the position of index pulse with home offset will be regarded as home position and zero position. The motor moves to that position. If home offset is positive, zero position will be on the right of index pulse. If home offset is negative, zero position will be on the left of index pulse.

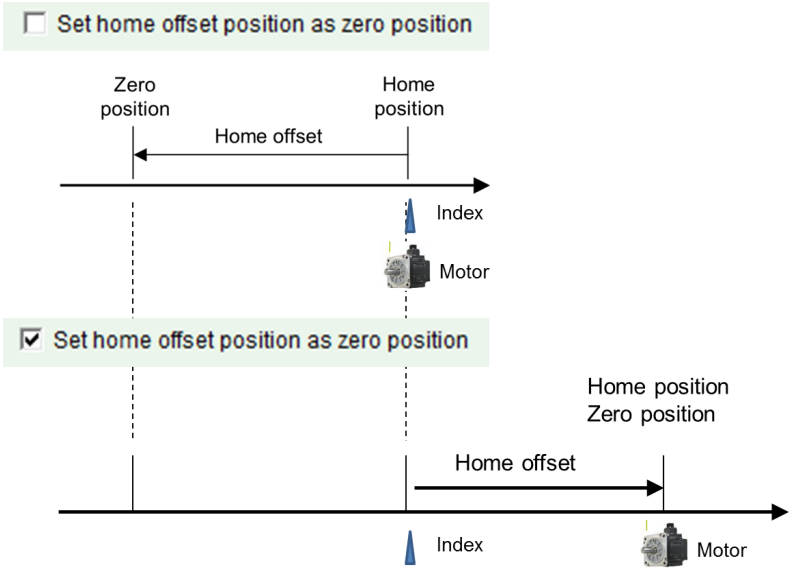
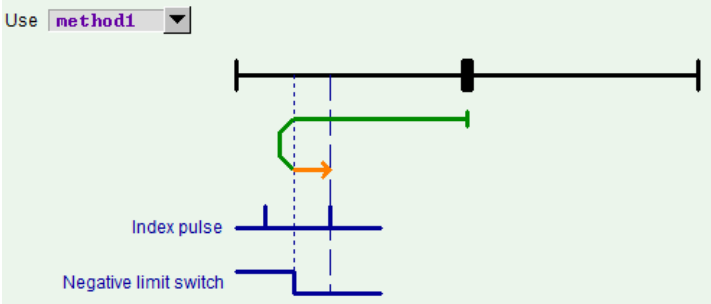
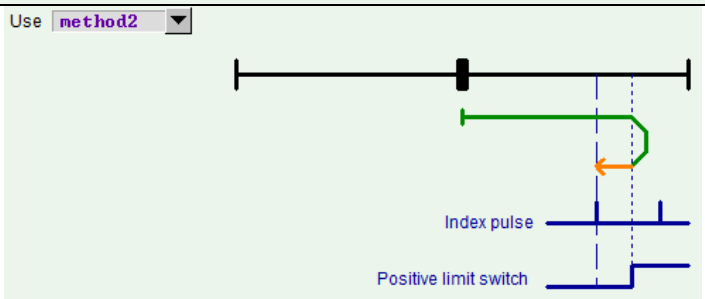
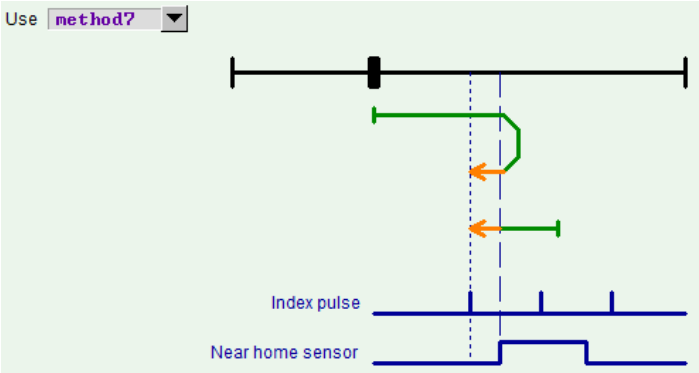
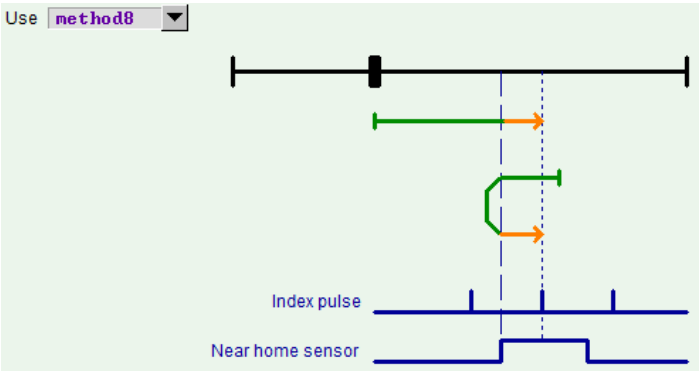
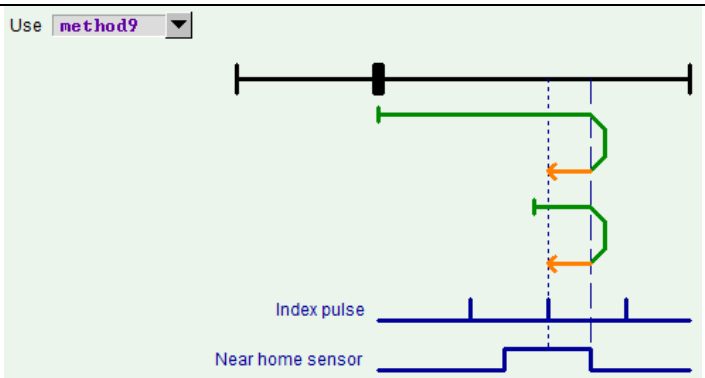
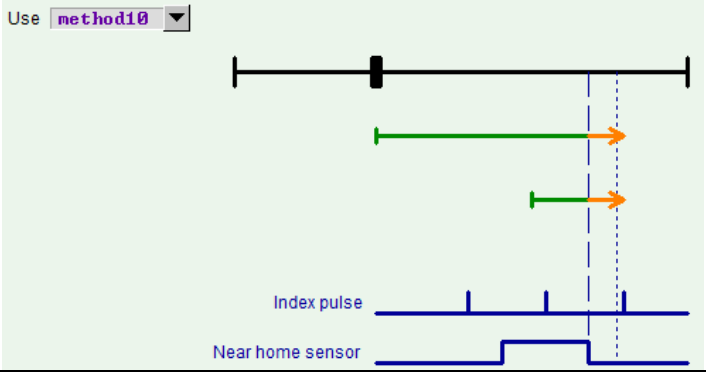
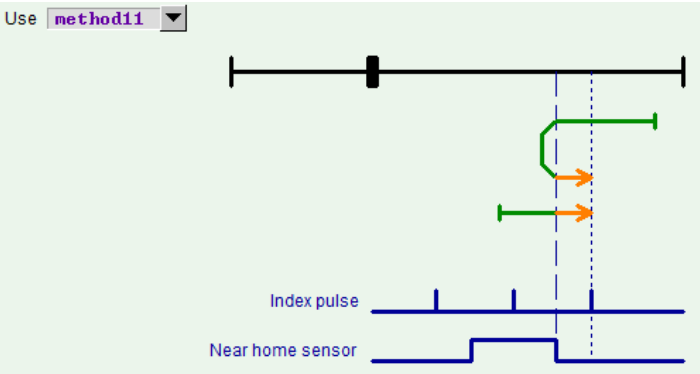
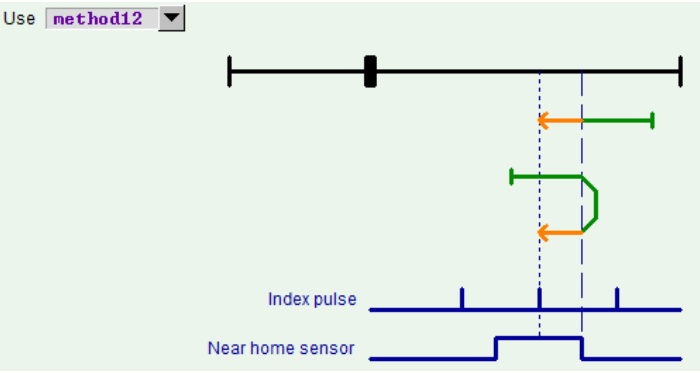
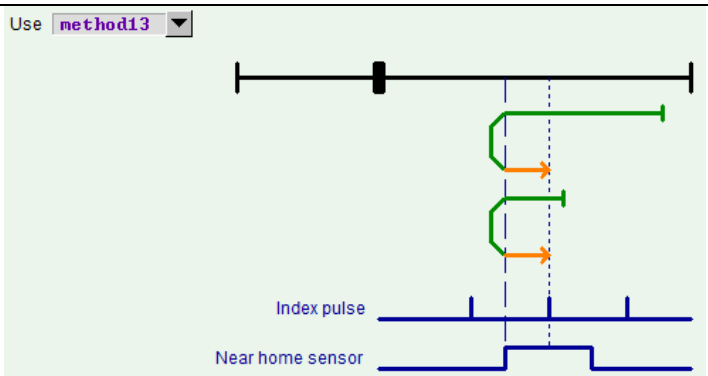
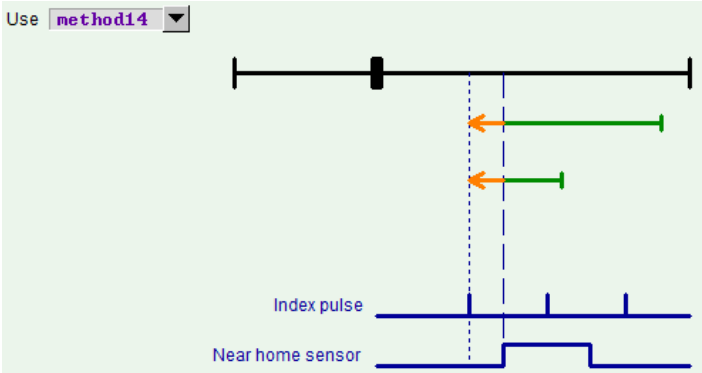
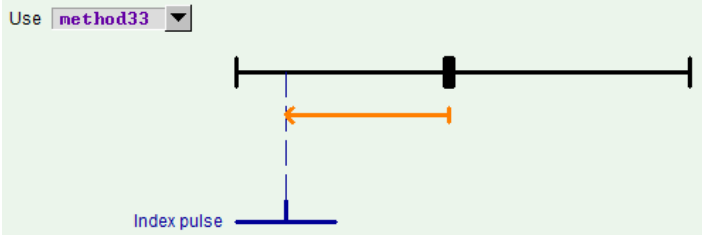
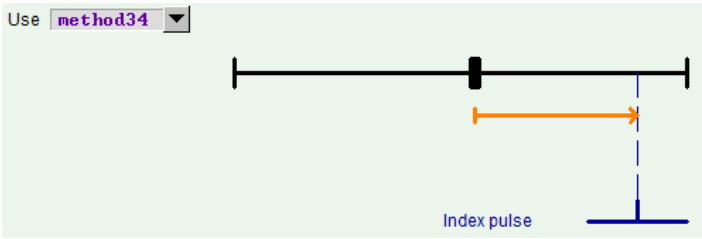
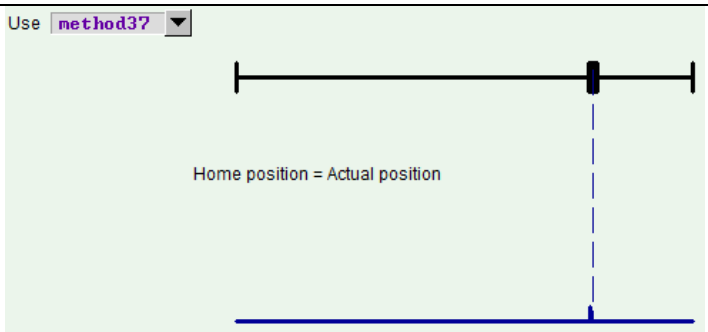


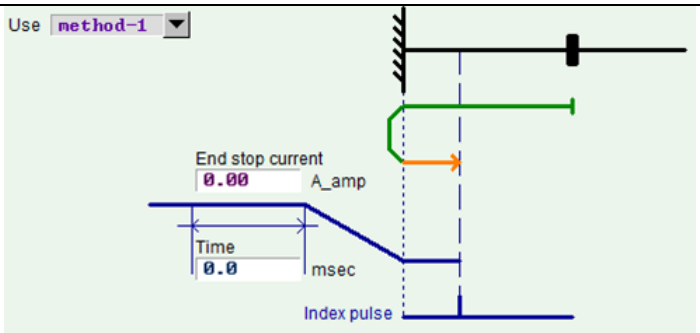
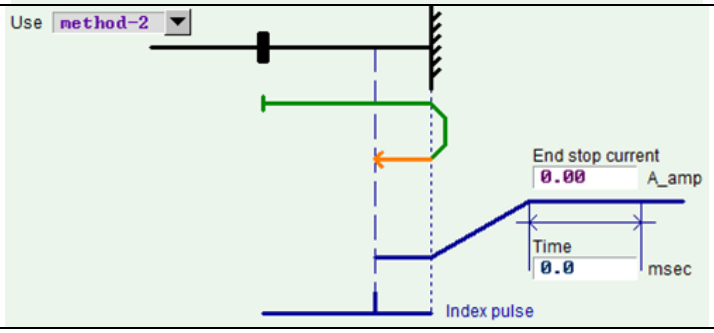
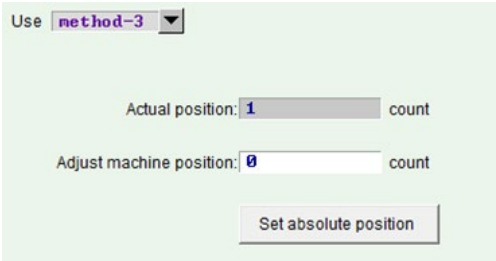
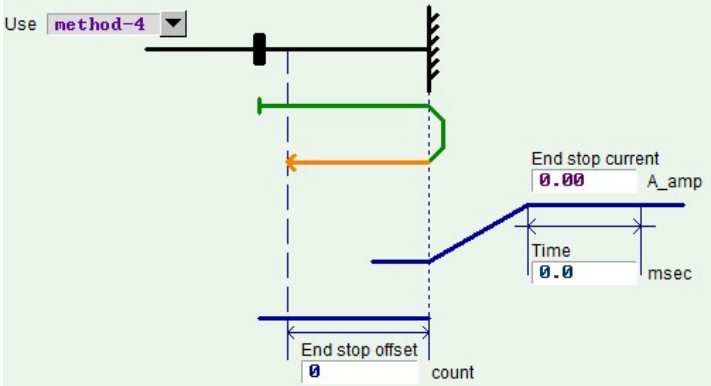
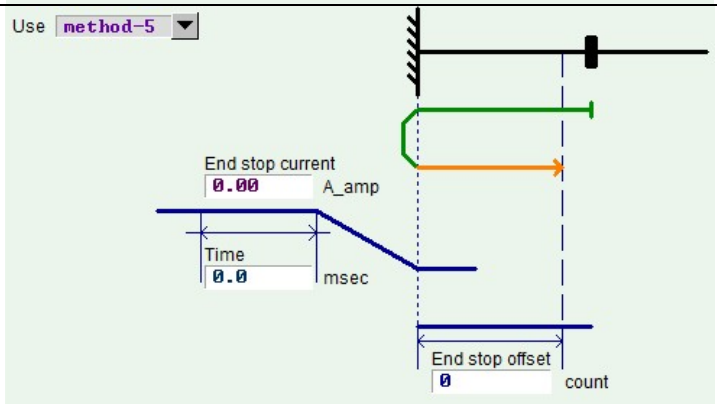
Figure 5.6.2

Table 5.6.2

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.	
7	**Homing with the rising edge of near home sensor signal and left index pulse, starting in positive direction.** **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. **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.	
8	**Homing with the rising edge of near home sensor signal and right index pulse, starting in positive direction.** **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. **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.	

9	**Homing with the falling edge of near home sensor signal and left index pulse, starting in positive direction.** 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.	
10	**Homing with the falling edge of near home sensor signal and right index pulse, starting in positive direction.** 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.	
11	**Homing with the rising edge of near home sensor signal and right index pulse, starting in negative direction.** **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. **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.	
12	**Homing with the rising edge of near home sensor signal and left index pulse, starting in negative direction.** **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. **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.	

13	**Homing with the falling edge of near home sensor signal and right index pulse, starting in negative direction.** Search for the falling edge of near home senor signal at faster speed in negative direction. After it is found, search for right index pulse at slower speed in positive direction.	
14	**Homing with the falling edge of near home sensor signal and left index pulse, starting in negative direction.** 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.	
33	**Homing with index pulse, starting in negative direction.** Search for index pulse at slower speed in negative direction.	
34	**Homing with index pulse, starting in positive direction.** Search for index pulse at slower speed in positive direction.	
37	Set current position as home position.	

-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.	
-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.	
-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:

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 when 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 5.6.3. 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 5.6.3. 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” when searching for hard stop, the setting values of Slower speed and Time must satisfy the following formula.

Slower Speed X Time < Maximum Pos Error

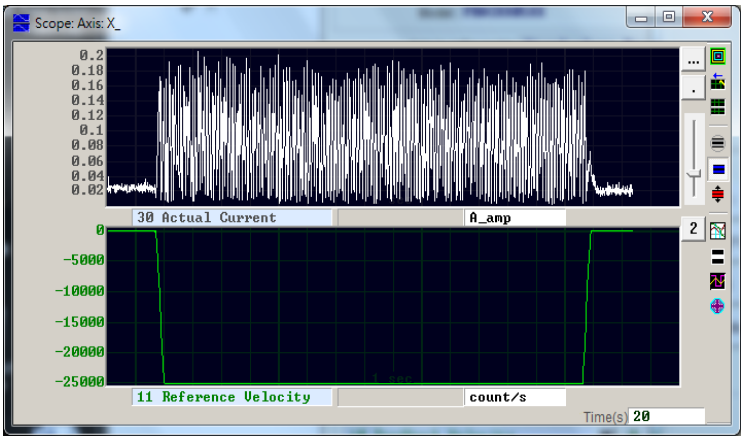


Figure 5.6.3

5.7 Position trigger function

D1-N servo drive provides position trigger (PT) function. (Note: CoE model does not support position trigger function.) When the motor moves to the set position, the servo drive outputs a synchronous pulse signal, as figure 5.7.1. PT function cannot be set via Lightening. The related parameters of PT function must be set by Message Window, PDL or MPI. PT function is mainly used for equipment which requires synchronous in-position signal for high-speed and high-accuracy processing, such as laser equipment, line scan camera and aligner.

Note:

(1) PT function is supported in D1N firmware version 0.809 or later version.

(2) PT function is still effective after the motor is disabled.

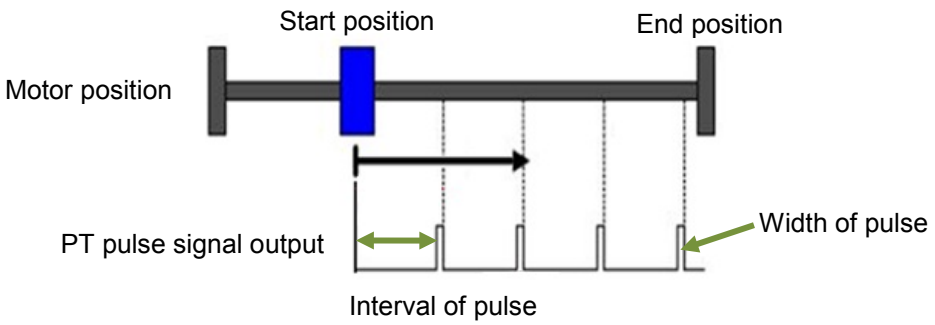


Figure 5.7.1

■ Specification

Table 5.7.1

Applicable Model	D1-N (Note: CoE model does not support position trigger function.)
Applicable Encoder	Digital AqB encoder
Position Update Frequency	16 KHz
Output Pin	PT+ and PT- (Note: The pins for PT+ and PT- are fixed. The pins for PT+ and PT- are pins 29 and 30 on X6 connector.)
Output Voltage	3.3 V
Output Pulse Width	2.5 us (Default value) The pulse width can be adjusted by PT.PulseWidth.
Max. Moving Speed	Interval of PT signal output*16,000 count/s
Delay Time for Outputting PT Signal	Normal temperature (25°C): < 100 ns High temperature (85°C): < 120 ns

■ Parameters

Table 5.7.2

PT Parameter	Definition	Default Value	Unit	Maximum Value	Minimum Value
PT.StartPosition	Start position of PT signal	0	count	2^{31} - 1	- 2^{31}
PT.EndPosition	End position of PT signal	0	count	2^{31} - 1	- 2^{31}
PT.Interval	Interval of PT signal output	0	count	2^{31} - 1	1
PT.PulseWidth	Width of PT output pulse	100	25 ns	4,000	1
PT.Polarity	Polarity of PT signal 0: Normal low 1: Normal high	1	-	1	0
PT.Status	Status of PT function 0: Disable PT function 1: Enable PT function	0	-	1	0

■ Conditions for enabling and disabling PT function

(1) Conditions for enabling PT function (The following conditions must be satisfied.)

- With digital encoder (AqB)
- Homing completes.
- Enable PT function (Set PT.Status to 1.).

(2) Conditions for disabling PT function (Either of the following conditions must be satisfied.)

- When PT.EndPosition is reached, PT function is disabled automatically.
- Disable PT function (Set PT.Status to 0.).

Note:

User can execute “call _PT_OUTPUT;” to let the servo drive output one PT signal for 1 ms for function testing.

■ Example

Homing must be completed before using PT function. The encoder resolution is 1 count = 1 um. The start position of the first PT pulse output is 25 mm. Then one PT pulse will be output every 1 mm. The polarity of pulse is normal low. The width of pulse is 2.5 us. The end position of the last PT pulse output is 100 mm. The program codes are as below.

```
_SetPT:
   PT.StartPosition =25000;
   PT.EndPosition = 100000;
   PT.Polarity = 0;
   PT.PulseWidth = 100;
   PT.Interval = 1000;
   PT.Status = 1;
ret;
```

Note:

(1) The first pulse will be output at the position set by PT.StartPosition. Set PT.StartPosition = 25,000.

(2) Pulse may not be output at the position set by PT.EndPosition. Pulse will only be output as start position + intervals = end position.

(3) The direction of PT function depends on the settings of PT.StartPosition and PT.EndPosition. If PT.EndPosition > PT.StartPosition, one PT pulse will be output every 1 mm in forward direction. If PT.StartPosition > PT. EndPosition, one PT pulse will be output every 1 mm in reverse direction.

(4) There is a limitation between the moving speed of the motor and output interval. In the example above, the update frequency of D1-N (09/18/36 model) servo drive is 16 KHz. The required output interval is 1 mm, so the moving speed of the motor must not exceed 16,000 (mm/s). The calculation is as below.

The maximum moving speed of the motor < PT.Interval x PT position update frequency
= 1 (mm) x 16 K (1/s) = 16,000 (mm/s)

The limitation between the moving speed of the motor and output interval is defined by position update frequency. The time that the motor moves to the output position must be larger than position update frequency. The smaller the output interval is, the stricter the speed limit is. The speed limits of different output intervals of D1-N (09/18/36 model) servo drive are listed in table 5.7.3.

Table 5.7.3 The speed limits of different output intervals of D1-N (09/18/36 model) servo drive

Output Interval (mm)	Maximum Speed (mm/s)
100	1,600,000
10	160,000
1	16,000
0.1	1,600
0.01	160

5.8 Save parameters to Flash and set to factory default

5.8.1 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 when 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.

5.8.2 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 5.8.2.1. **Set drive to factory default** window appears as figure 5.8.2.2 (Lightening version 0.180 to 0.185A). If users would like to clear the 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 5.8.2.3 will appear informing users 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.

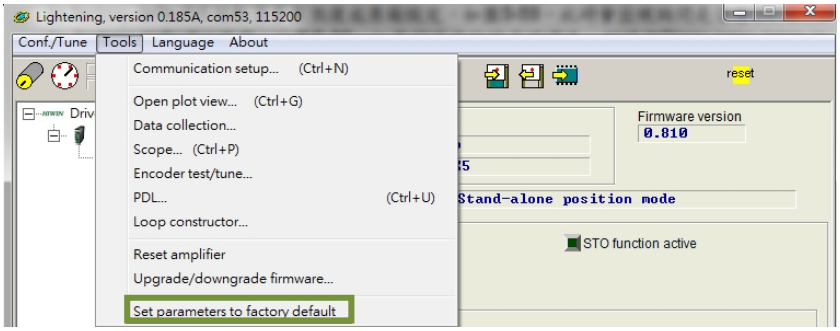


Figure 5.8.2.1

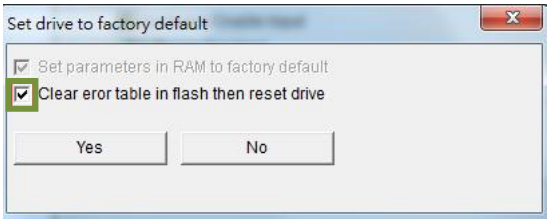


Figure 5.8.2.2

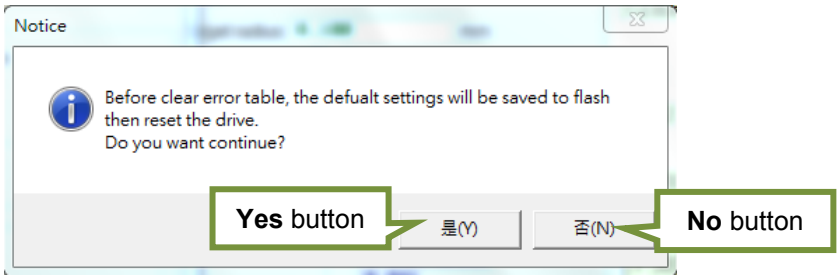


Figure 5.8.2.3

If users are using Lightening 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 5.8.2.4. Lightening 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 the users that user.pdl will be cleared, as figure 5.8.2.5. 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.

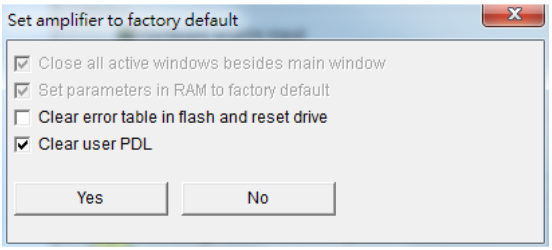


Figure 5.8.2.4

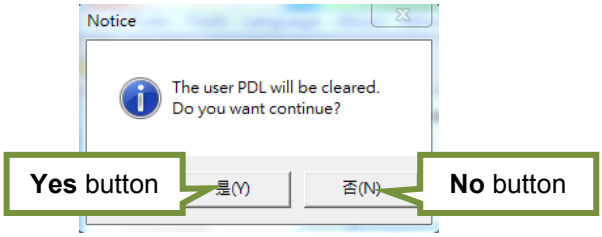


Figure 5.8.2.5

5.9 Setting operation mode via Lightening

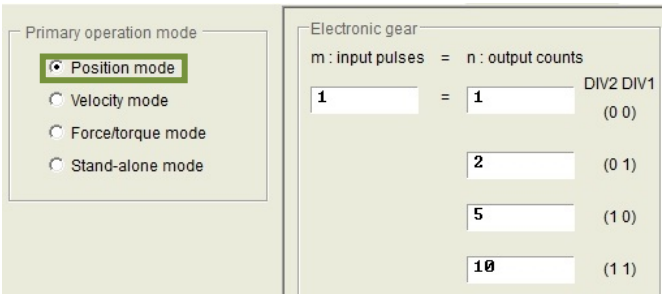
5.9.1 Position mode

In position mode, when pulse command is received from the controller, the 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.

(1) Mode selection

For mode selection, please refer to below.

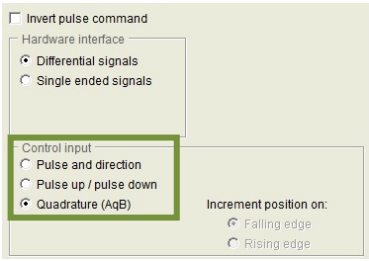
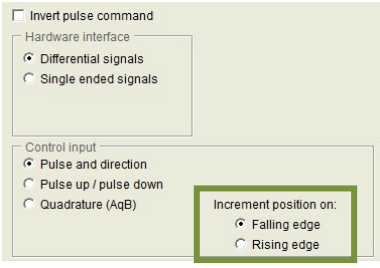
Table 5.9.1.1

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-N servo drive supports three pulse types. For more information, please refer to section 3.1.1. For pulse type selection, please refer to below.

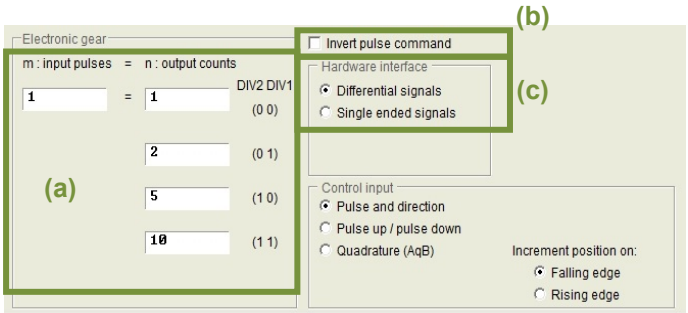
Table 5.9.1.2

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 when **Pulse and direction** or **Pulse up/pulse down** is selected.

(3) Electronic gear ratio setting

D1-N servo drive supports four sets of electronic gear ratios. For more information, please refer to section 5.4.1. For setting electronic gear ratio, please refer to below.

Table 5.9.1.3

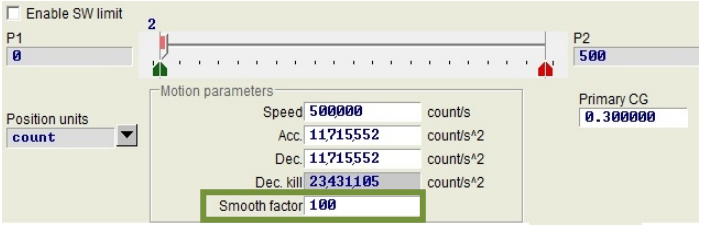
Step	Figure	Description
1		In the setting page of **Mode**, set electronic gear ratio in the setting area of **Electronic gear** which is indicated by (a) in the left figure.
2		In the setting page of **Mode**, set to invert pulse command in the setting area of **Invert pulse command** which is indicated by (b) in the left figure.
3		In the setting page of **Mode**, select **Differential signals** or **Single ended signals** according to your wiring in the setting area of **Hardware interface** which is indicated by (c) in the left figure.

After setting electronic gear ratio, go to the setting page of **Drive** to set the input power of the servo drive, please refer to section 5.2.5. Click on **OK** button to save the setting to the servo drive RAM. After setting all the parameters, save the settings to Flash by referring to section 5.8.1.

(4) Smooth factor setting

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

Table 5.9.1.4

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.

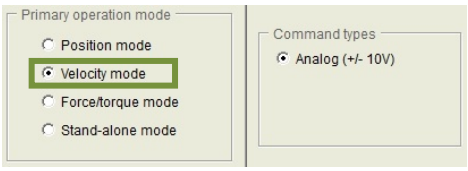
5.9.2 Velocity mode

D1-N servo drive is able to transform voltage 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.

(1) Mode selection

For mode selection, please refer to below.

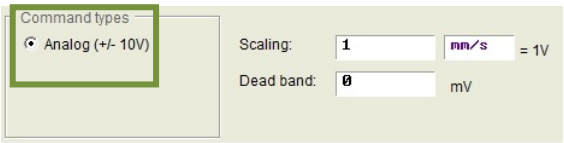
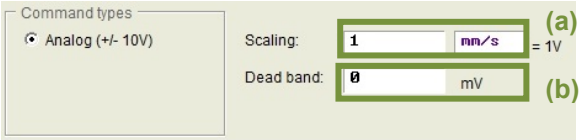
Table 5.9.2.1

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.

Table 5.9.2.2

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.
3		Set dead band in the setting page of **Mode**. For the definition of dead band, please refer to figure 5.2.4.3.

After setting, go to the setting page of **Drive** to set the input power of the servo drive, please refer to section 5.2.5. Click on **OK** button to save the setting to the servo drive RAM. After setting all the parameters, save the settings to Flash by referring to section 5.8.1.

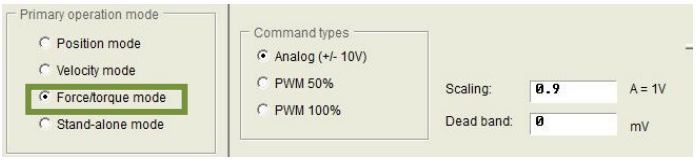
5.9.3 Force/torque mode

D1-N servo drive is able to transform voltage 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.

(1) Mode selection

For mode selection, please refer to below.

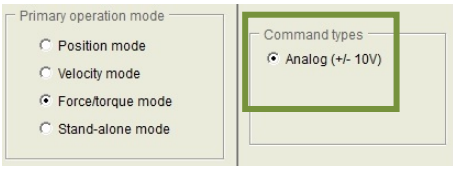
Table 5.9.3.1

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 **Force/torque mode**.

(2) Format setting of command input.

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

Table 5.9.3.2

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).
3		Set dead band in the setting page of **Mode**. For the definition of dead band, please refer to figure 5.2.4.3.

After setting, go to the setting page of **Drive** to set the input power of the servo drive, please refer to section 5.2.5. Click on **OK** button to save the setting to the servo drive RAM. After setting all the parameters, save the settings to Flash by referring to section 5.8.1.

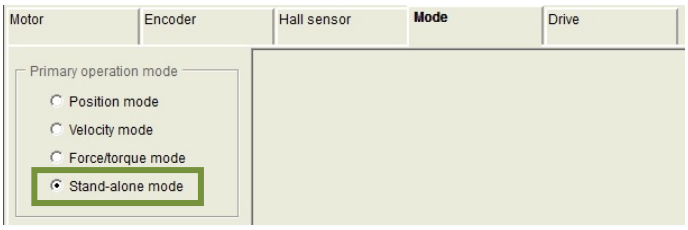
5.9.4 Stand-alone mode

In stand-alone mode, the servo drive will drive the 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.

(1) Mode selection

For mode selection, please refer to below.

Table 5.9.4.1

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**.

After setting, go to the setting page of **Drive** to set the input power of the servo drive, please refer to section 5.2.5. Click on **OK** button to save the setting to the servo drive RAM. After setting all the parameters, save the settings to Flash by referring to section 5.8.1.

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6. Tuning

6.1 Status display and Quick view

In Lightening, status display and Quick view are two essential tools which allow users to know the status of the servo drive and 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 error/warning message of the servo drive.

(1) Status

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

(2) 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.

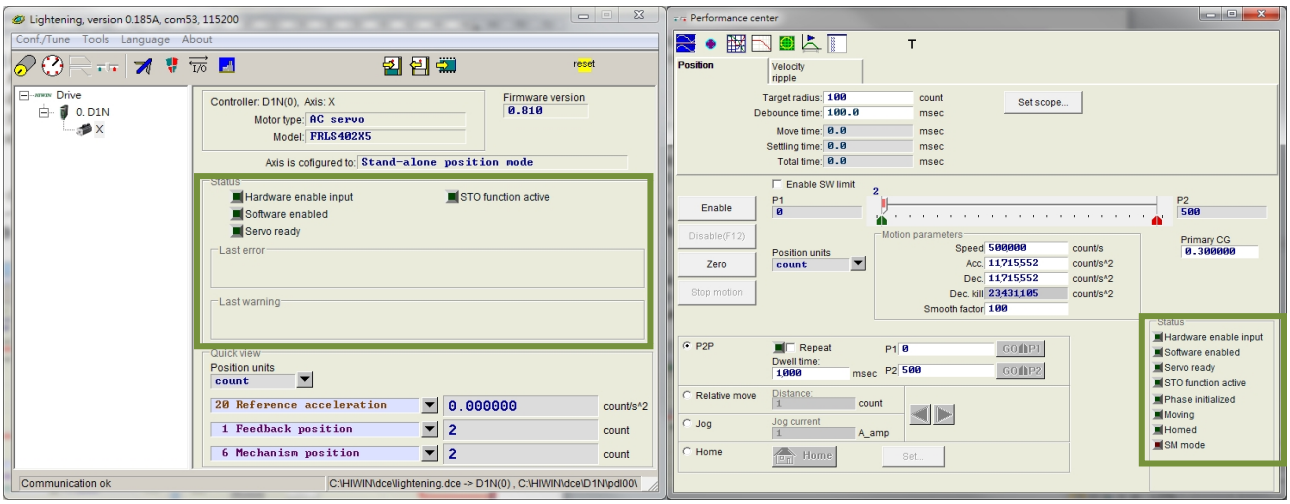


Figure 6.1.1.1

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 users to observe and analyze the system. For supported physical quantities, please refer to section 3.11.

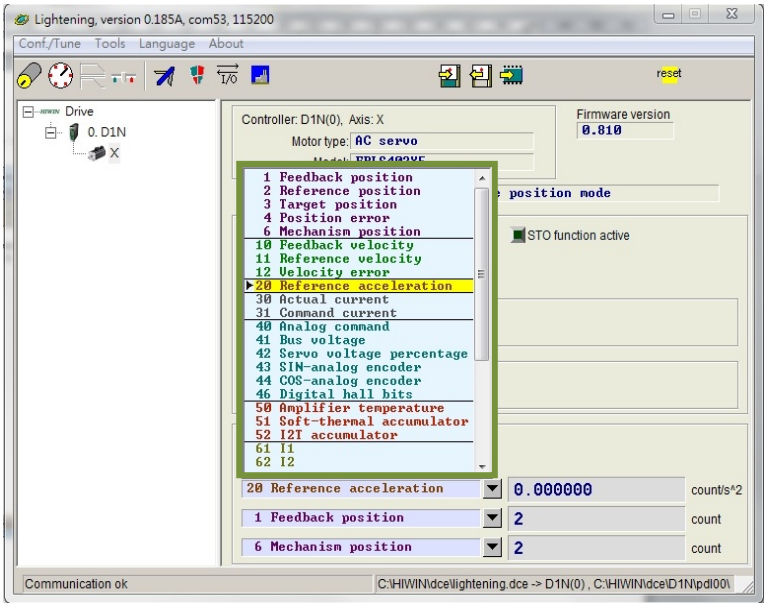


Figure 6.1.2.1 Selection of physical quantities

- Unit setting

  For physical quantities related to distance, users are allowed to display physical quantities (such as position or velocity) in their desired units.

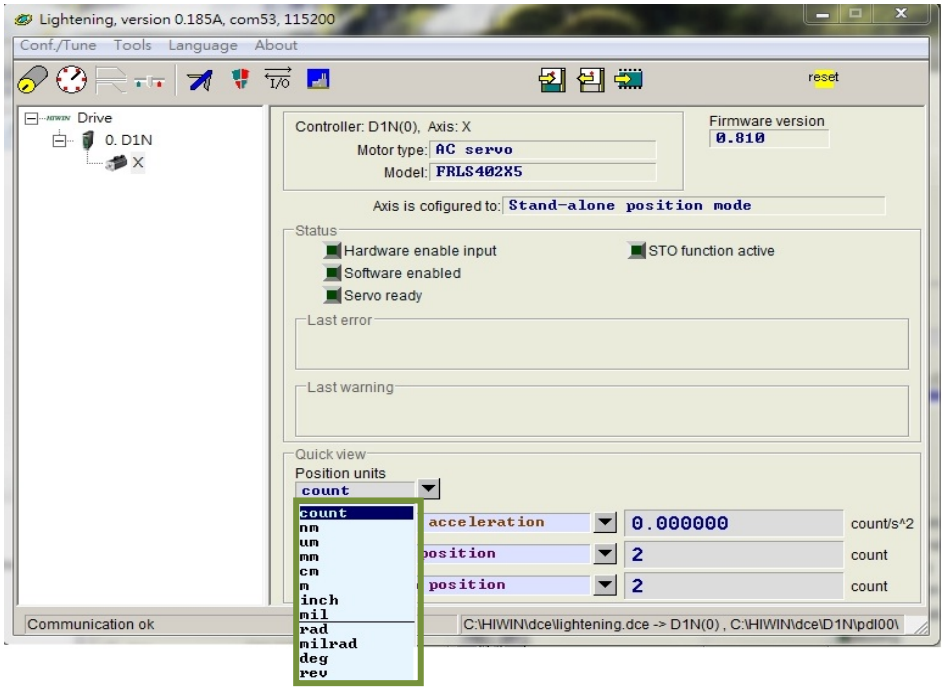


Figure 6.1.2.2 Unit setting

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, users 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.

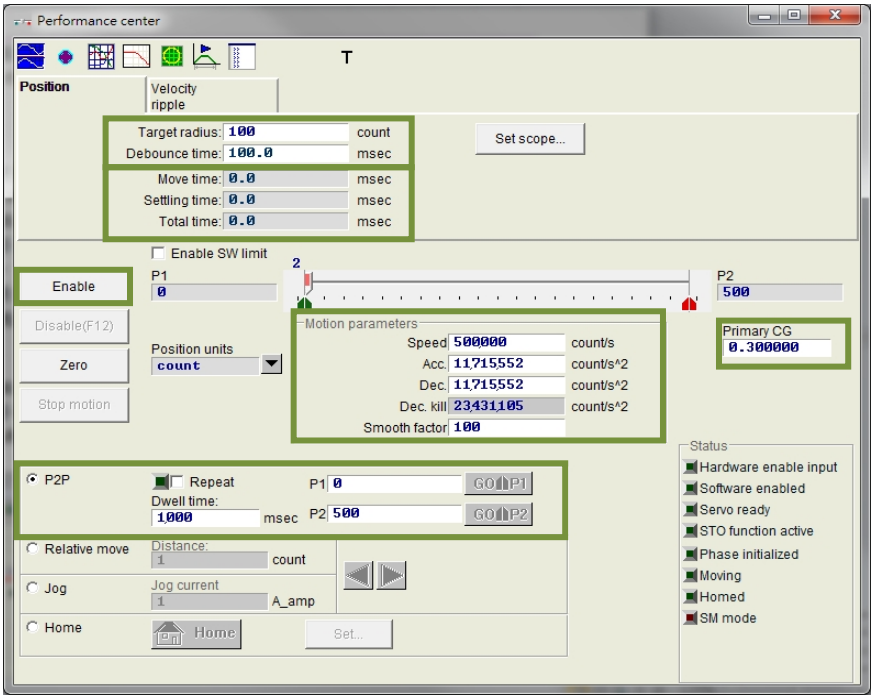
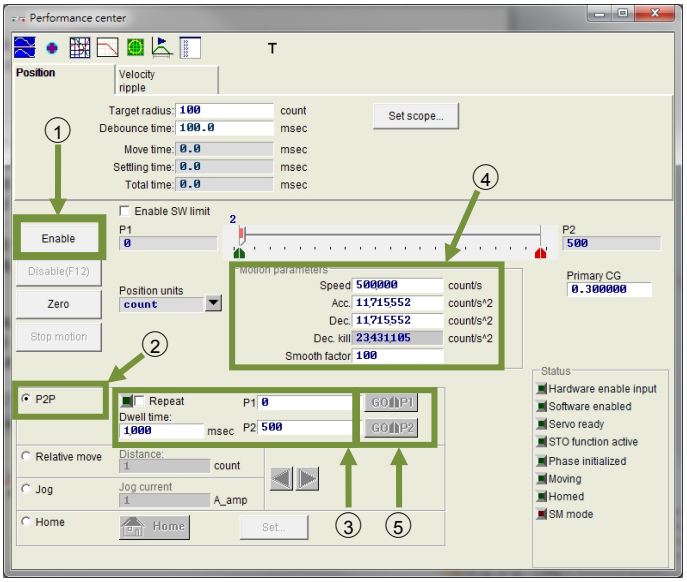


Figure 6.2.1 Performance center

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

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 desired speed, acceleration, deceleration and smooth factor (Refer to section 3.4.) in the setting area for motion parameters. If users have 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. Users 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…** button to show Scope to observe waveforms related to settling time. Velocity ripple can be measured in Performance center. Users 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.

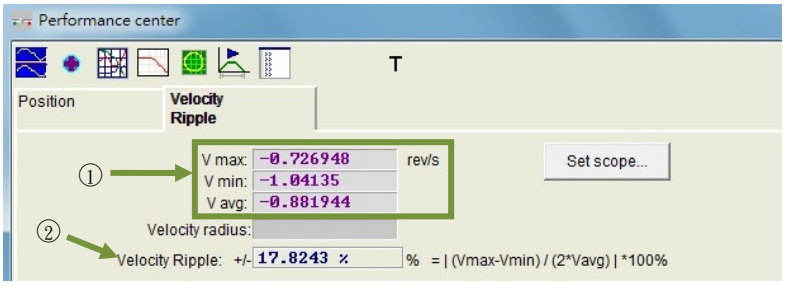


Figure 6.2.2 Performance center-**Velocity Ripple** page

①:

V max: The maximum value of velocity ripple

V min: The minimum value of velocity value

V avg: The average value of velocity value

②:

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

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

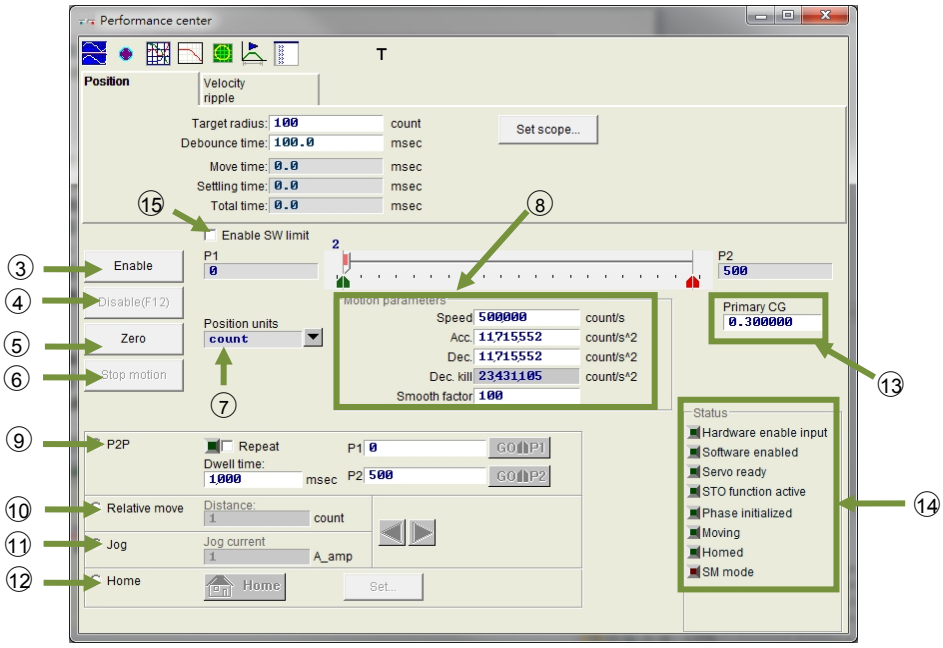


Figure 6.2.3 Performance center-**Position** page

③ Enable: Enable the motor.

④ Disable (F12): Disable the motor.

⑤ Zero: Set current position as zero position.

⑥ Stop motion: Stop the motor.

⑦ Position units: Users are allowed to set desired unit. The function is the same as the unit setting in Quick view.

⑧ Motion parameters: Parameters for test run and motion protection, including speed, acceleration, deceleration, Dec. kill and smooth factor. Users 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, it is to set current value 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. Users can use primary CG to adjust servo stiffness. If the servo stiffness is too strong, the system becomes unstable, causing vibration and electrical noise. At this time, this value must be decreased.

⑭ Status：Display status.

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

6.3 Scope

D1-N servo drive provides Scope for users to observe essential physical quantities during tuning. Users can also use Scope to find out the cause when the motor cannot be operated. Click on in Performance center or **Set scope…** button to open Scope. Click on **Set scope…** button 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 fully real time. To observe detailed information of physical quantity, please use oscilloscope or Data collection function. (Refer to section 6.4.)

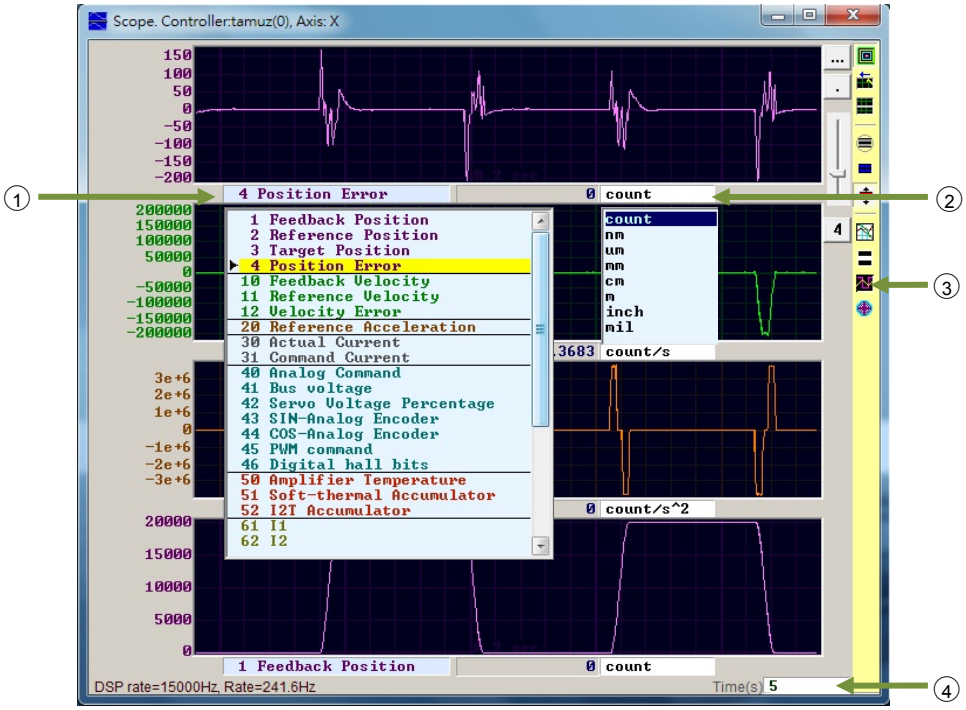


Figure 6.3.1 Scope

① Physical quantity: Select desired physical quantity to be observed. (Refer to section 3.11.)

② Unit: Select 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)

Table 6.3.1

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 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, users 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 users 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.

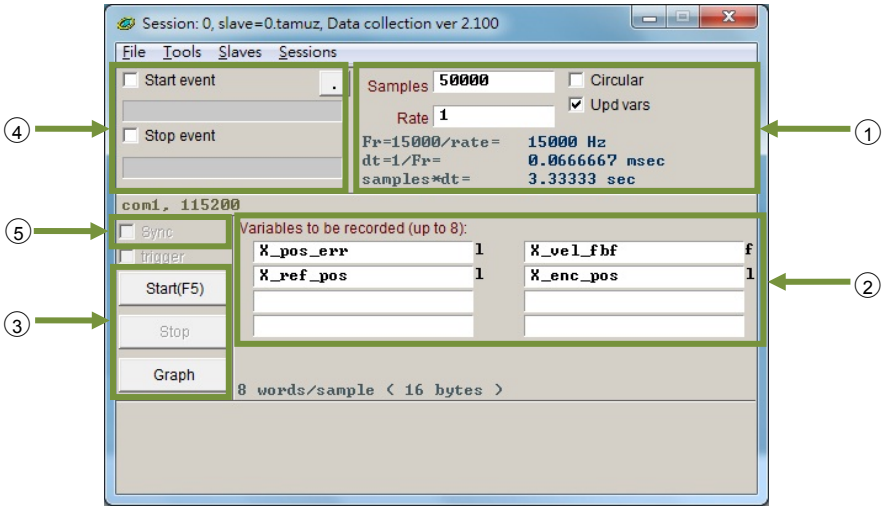


Figure 6.4.1.1 **Data collection** window

① Rate and Samples

-Samples: The number of samples

-Rate：Users 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 users set 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, users 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 the motor starts to move and stops as the 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, users can use Sync function in figure 6.4.1.1 to have more flexible and real-time Data collection then event trigger. Users need to add a program fragment with title label "_RecordSync" and set trigger condition or status. Data collection starts as trigger condition or status 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 I3 in the parentheses. The default setting of I3 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 I3 is ON, Data collection starts. If I3 is ON for more than once, only the last data will be collected.

Example:

```
#task/1;
_RecordSync:
till(I3);        // I3 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.

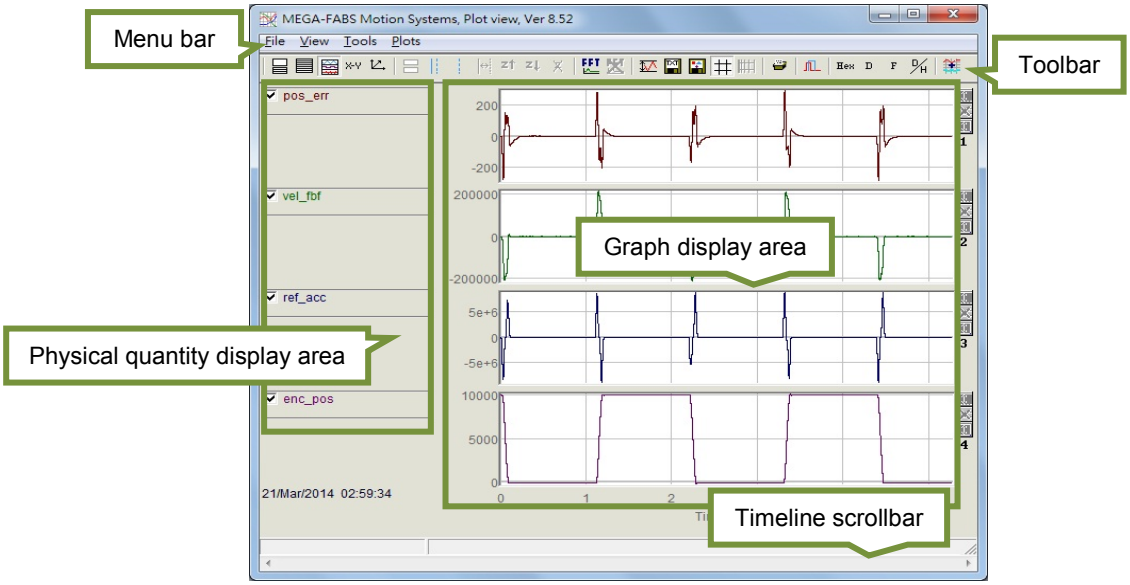


Figure 6.5.1 **Plot view** window

6.5.1 Display mode

- 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. Users 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 users would like to view two graphs at the same time, click on and select **2 graphs**. If users 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.

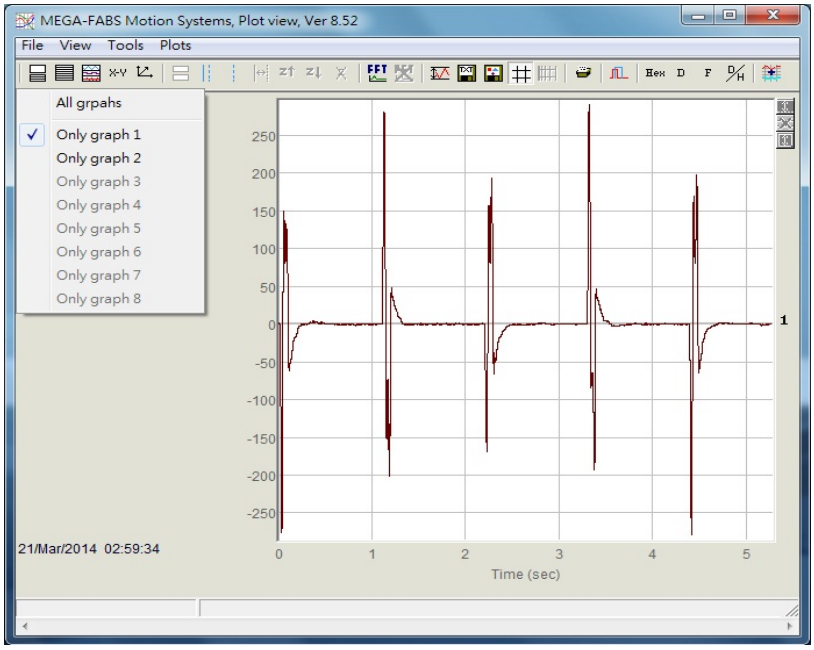


Figure 6.5.1.1

■ 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.

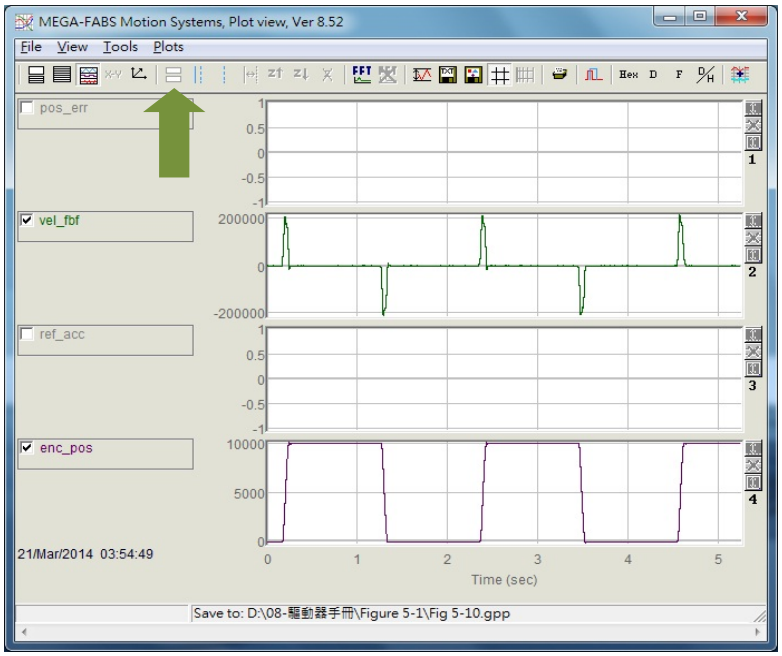


Figure 6.5.1.2

■ Zoom in and zoom out functions

Plot view window allows users to zoom in and zoom out on X axis and Y axis. If users would like to observe a certain segment of a graph, they can use reference lines to select the desired segment. 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.

■ Zoom in or zoom out on X axis

As figure 6.5.1.3, if users would like to zoom in on the segment between 2 seconds and 4 seconds, users 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.

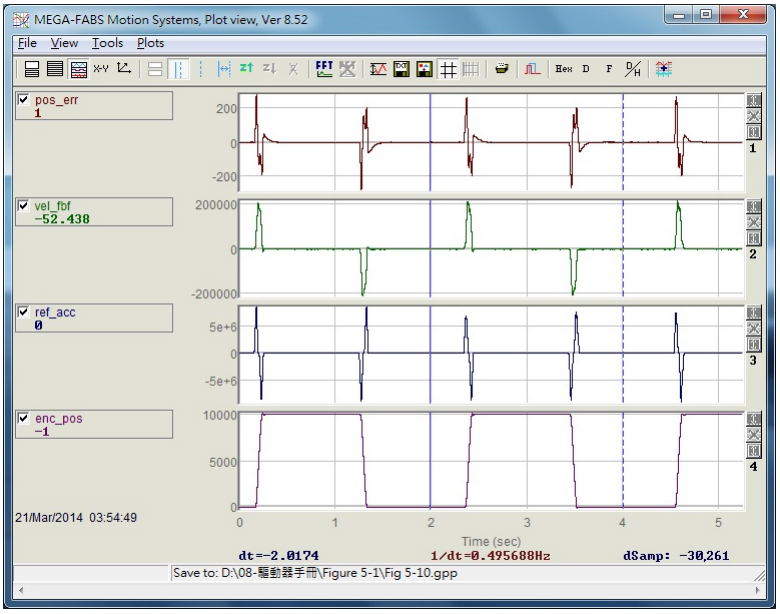


Figure 6.5.1.3

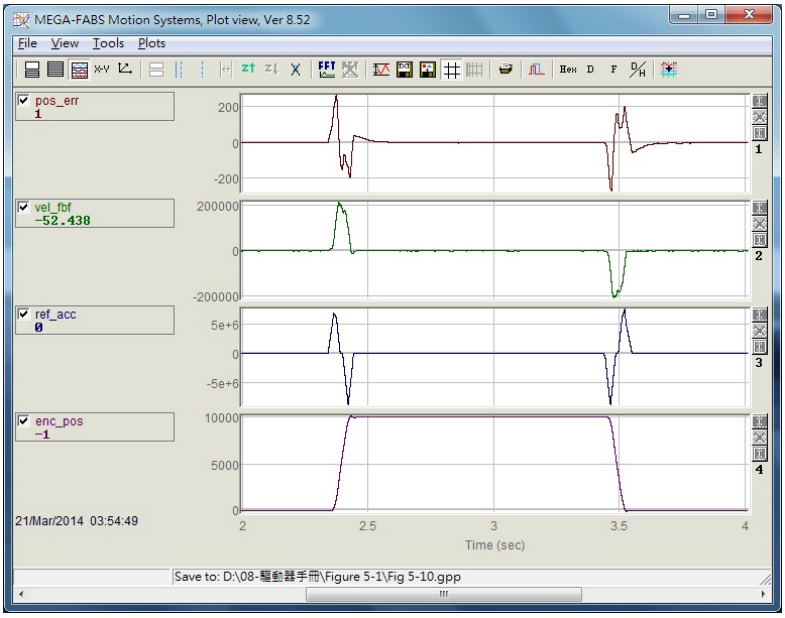


Figure 6.5.1.4

- Zoom in or zoom out on Y axis

  If users would like to zoom in on Y axis, users need 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.

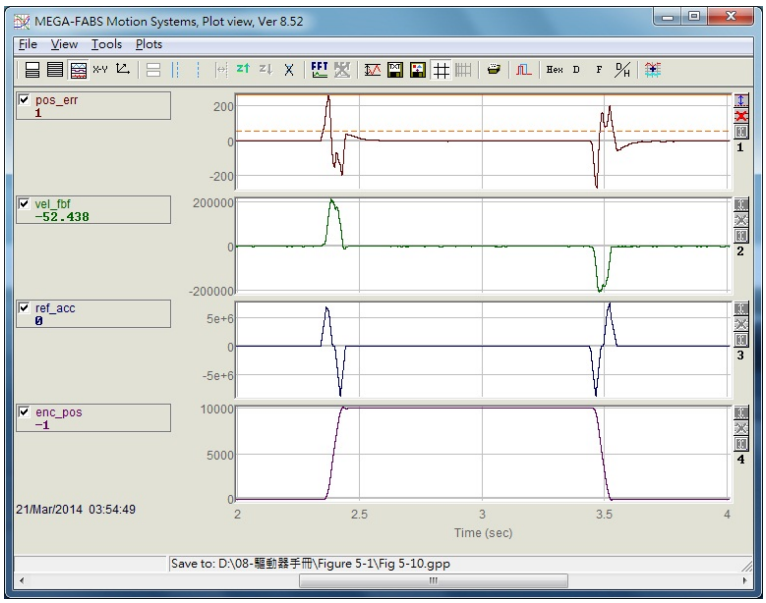


Figure 6.5.1.5

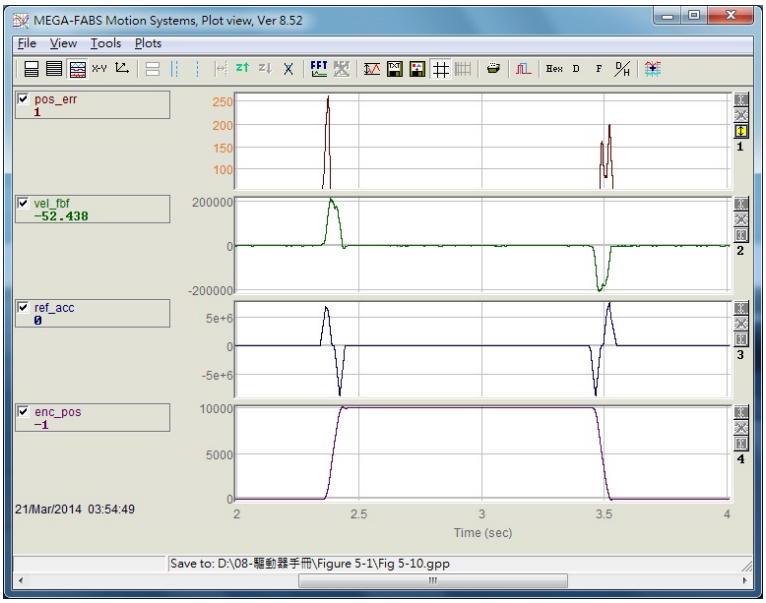


Figure 6.5.1.6

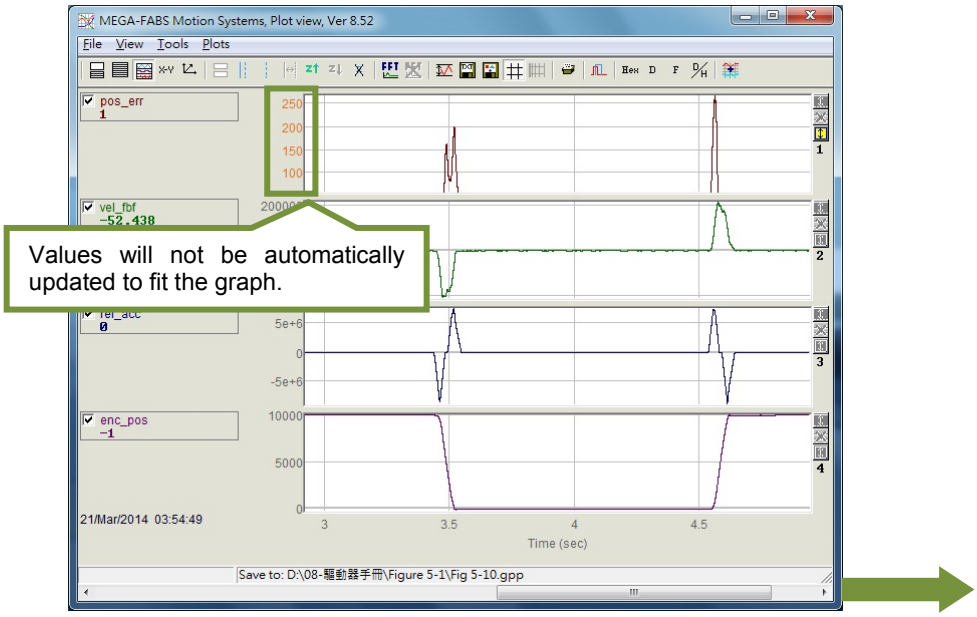


Figure 6.5.1.7

■ 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 selected segment

dSamp: The number of samples in the selected segment

- 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.

- 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.

  -Hex: Display the value in hexadecimal format.

  -D: 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**.

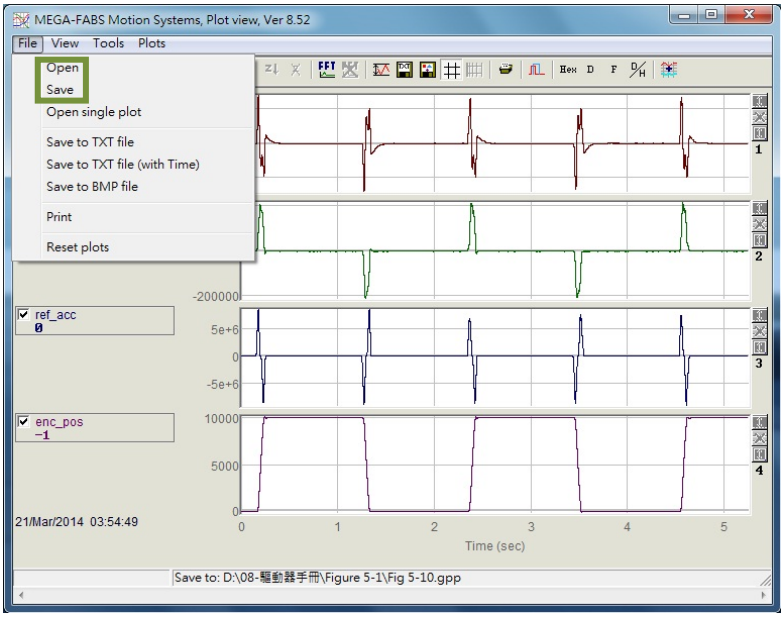


Figure 6.5.2.1 Save data as .gpp file

6.5.3 Calculation functions

Plot view window provides some calculation functions, such as integration, differentiation, addition and multiplication, etc. Users 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.

- **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 (maximum value-minimum value/average value) of the physical quantity in the selected segment.

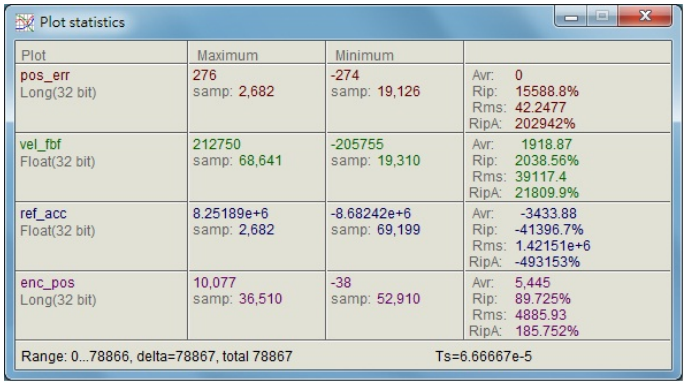


Figure 6.5.3.1 **Plot statistics** window

- Calculation function

  Click on **Tools** on 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.

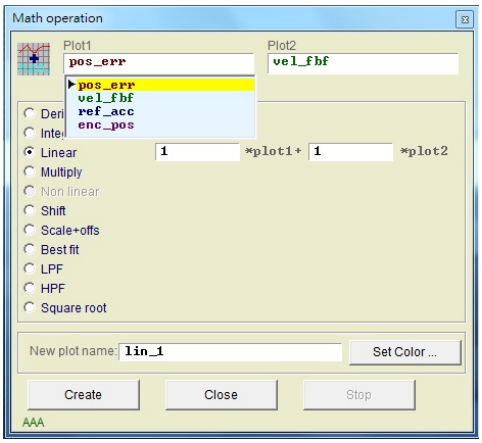


Figure 6.5.3.2

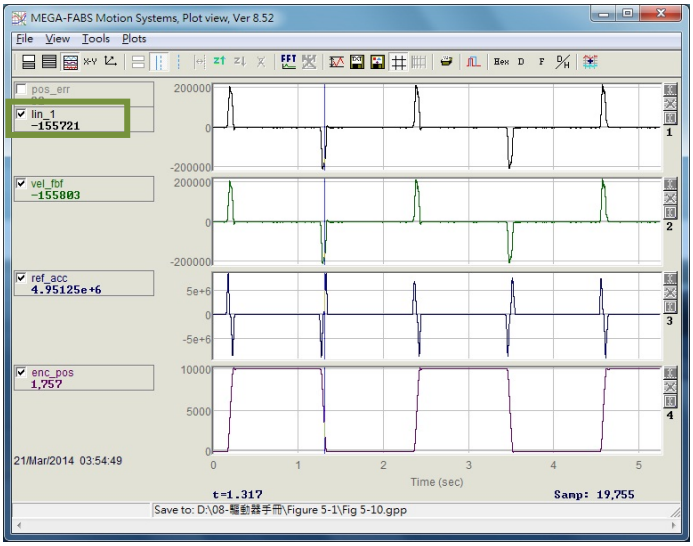


Figure 6.5.3.3

- Fast Fourier transform (FFT)

  Click on FFT 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 .

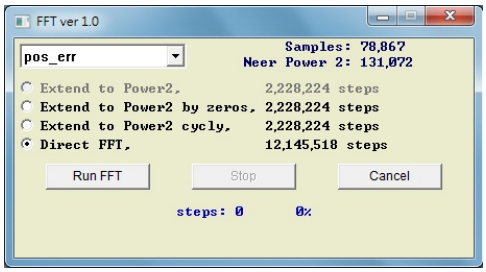


Figure 6.5.3.4

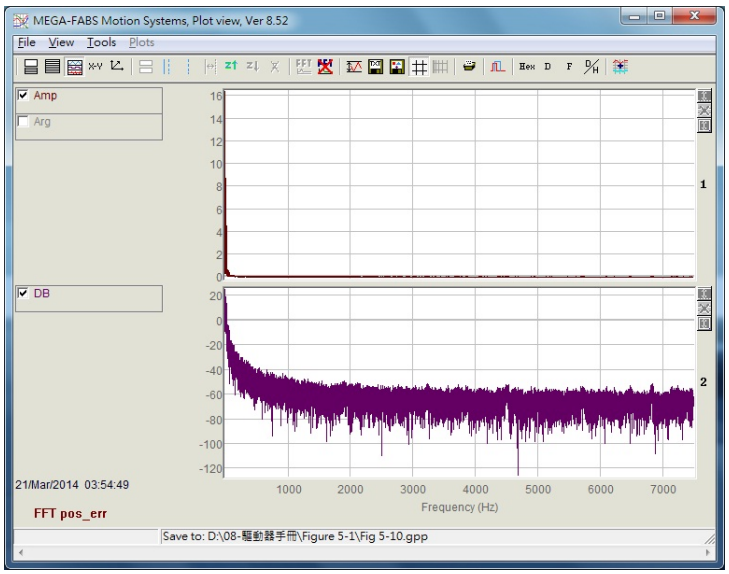


Figure 6.5.3.5

- 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 time of move and settling, small position error and smooth velocity are often preferred when performing servo control via servo drive. The performance can be improved by gain and parameter tunings. For D1-N servo drive, the simplest way to enhance the performance of the 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.

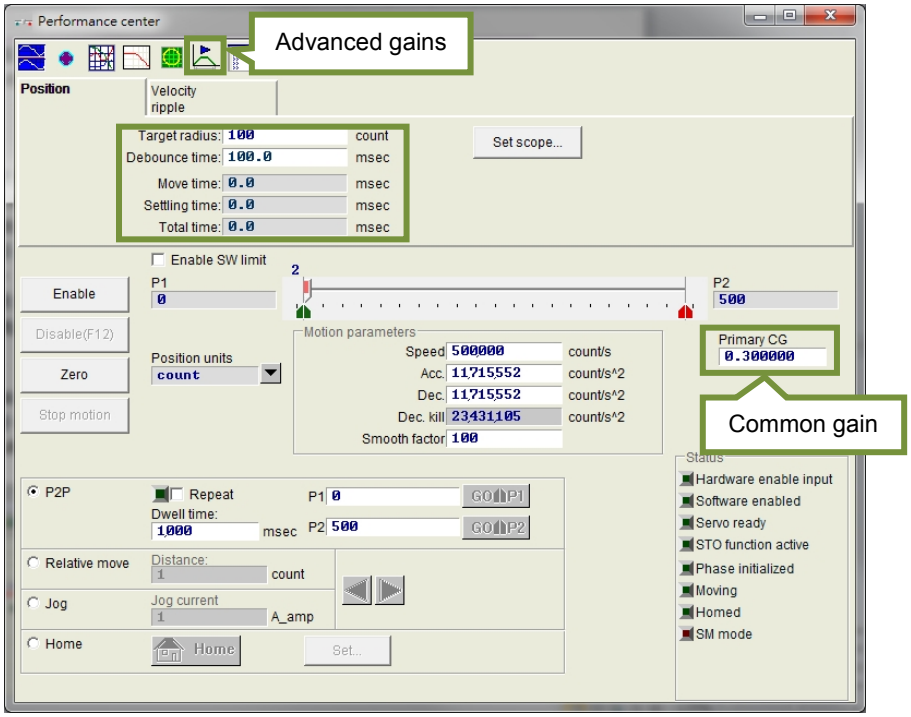


Figure 6.6.1 Performance center

If the desired performance cannot be achieved by simply adjusting common gain, D1-N 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 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 when configuring a filter. Click on **Bode…** button in figure 6.6.1.1 to open simulation interface for Bode plot.

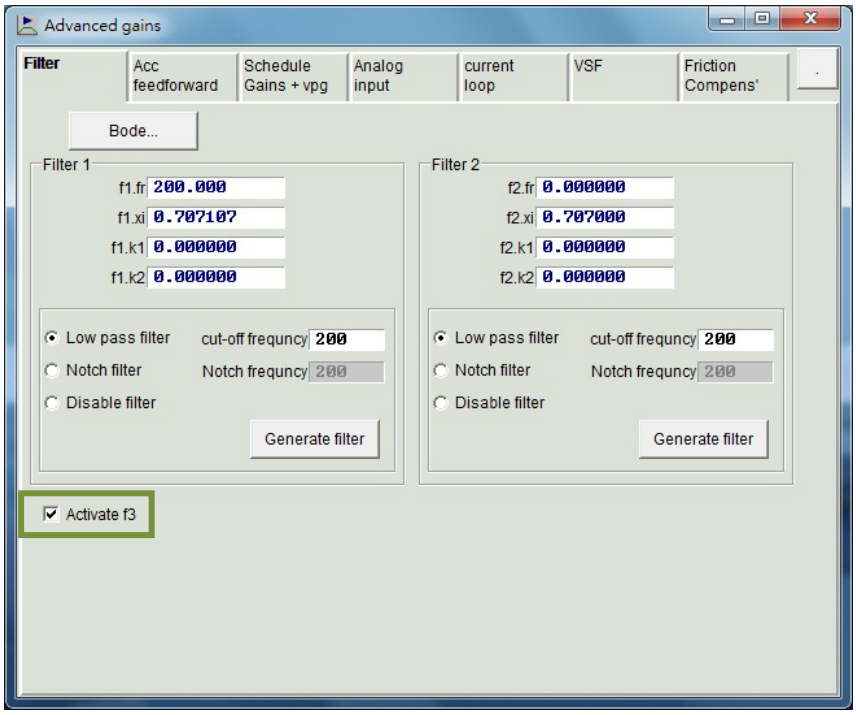


Figure 6.6.1.1 Filter

- Low-pass filter

  For how to set a low-pass filter, please refer to below.

  (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

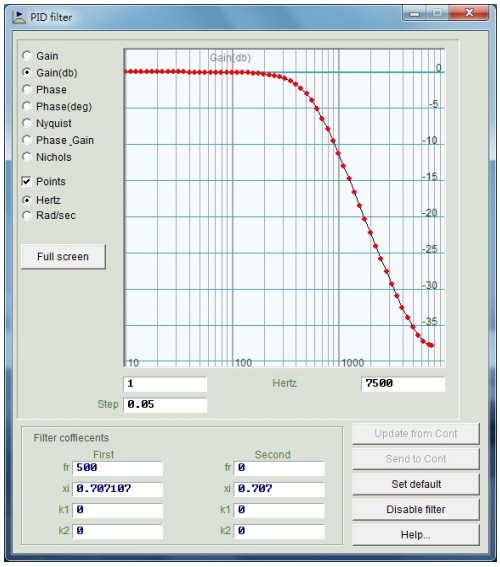


Figure 6.6.1.2 Low-pass filter

■ 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, users can consider using notch filter. The setting of notch filter is usually based on the result of frequency analysis, please refer to chapter 10. 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

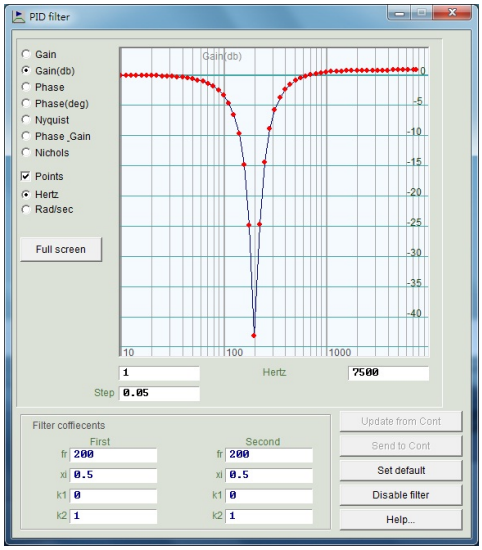


Figure 6.6.1.3 Notch filter

- 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. Users 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: Press **Set scope…** button 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.

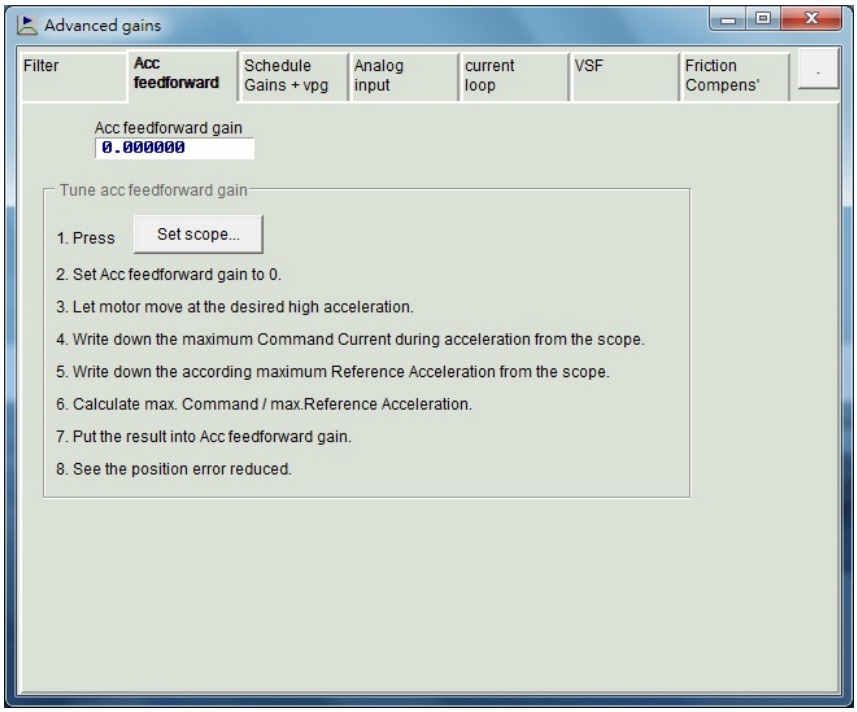


Figure 6.6.2.1 Acceleration feedforward

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.

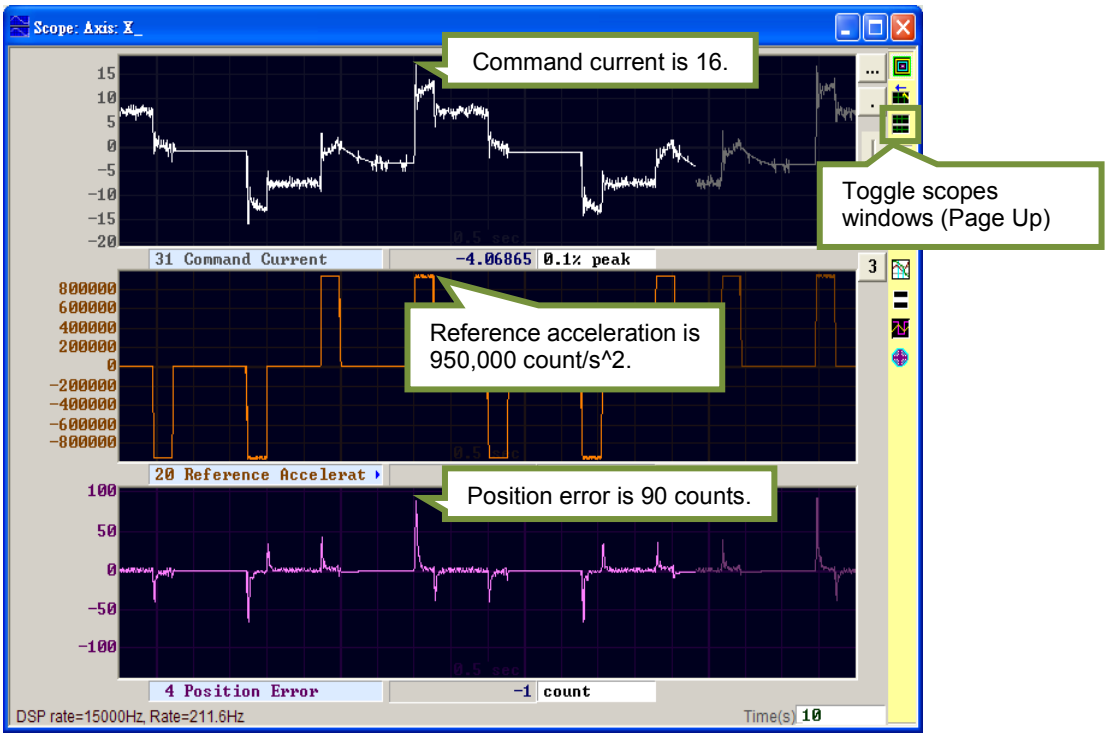


Figure 6.6.2.2 The motion trajectory of the motor

Step 5: Record the maximum reference acceleration during acceleration. In figure 6.6.2.2, the maximum reference acceleration is 950,000 count/s^2.

Step 6: Divide command current by reference acceleration.

Acc feedforward gain = command current/reference acceleration = 16/950,000 = 1.68421e-5

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

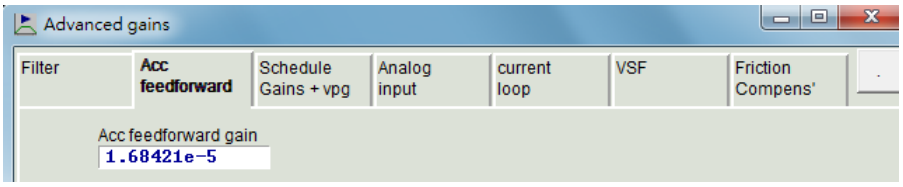


Figure 6.6.2.3 Acceleration feedforward gain

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

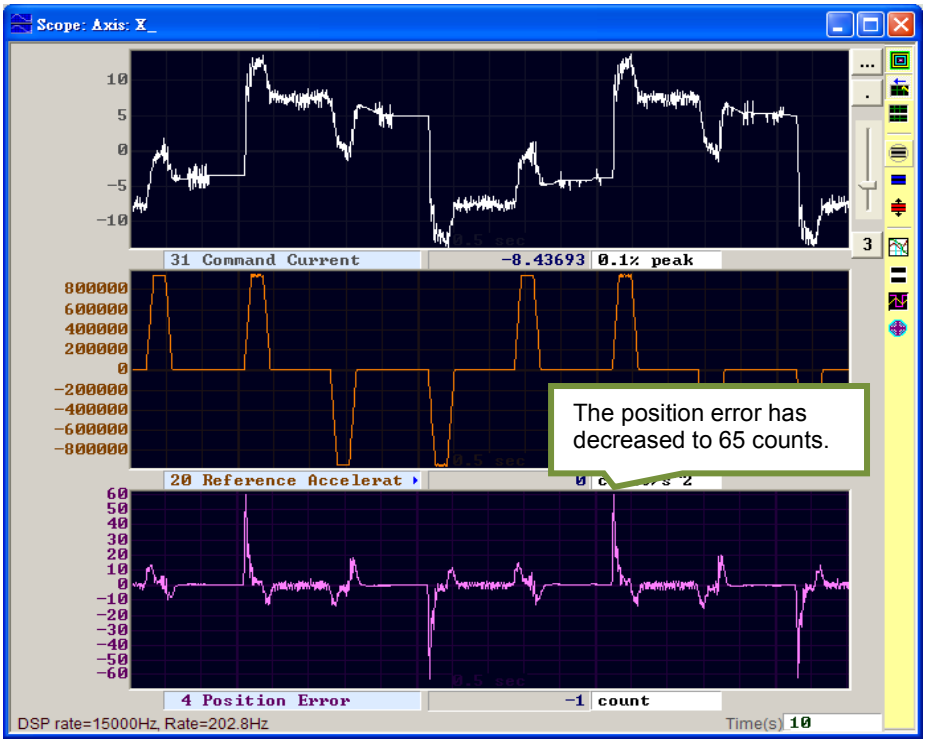


Figure 6.6.2.4 After adding acceleration feedforward gain

6.6.3 Schedule gains and velocity loop gain

■ 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: X_sg_run

(2) Settling: X_sg_stop

(3) In position: X_sg_idle

If common gain (CG) is set to 0.5 and X_sg_run is set to 1.2, the gain will be changed to 0.5*1.2 = 0.6, when motor is moving. Schedule gain can help to change gain to fit different phase.

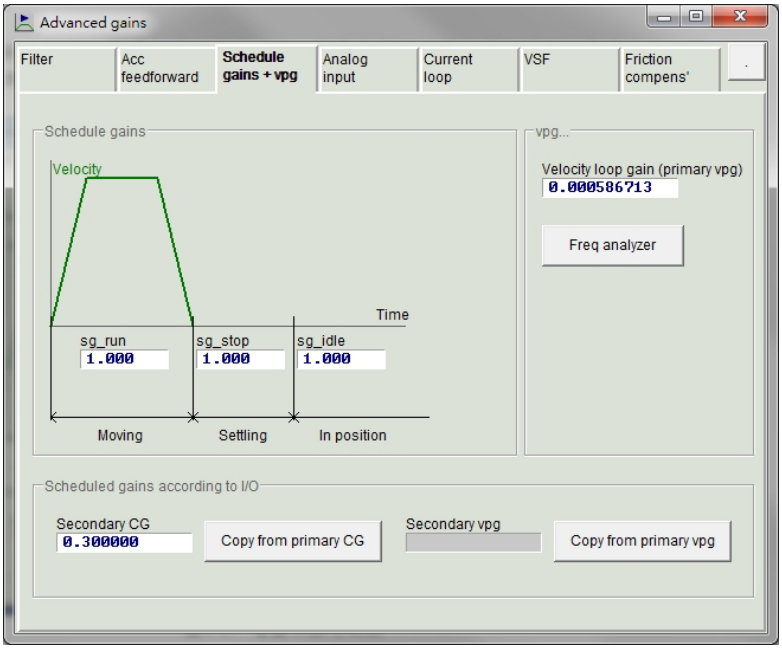


Figure 6.6.3.1

■ Velocity loop gain (vpg)

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

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

Step 2: Click on **Enable** button.

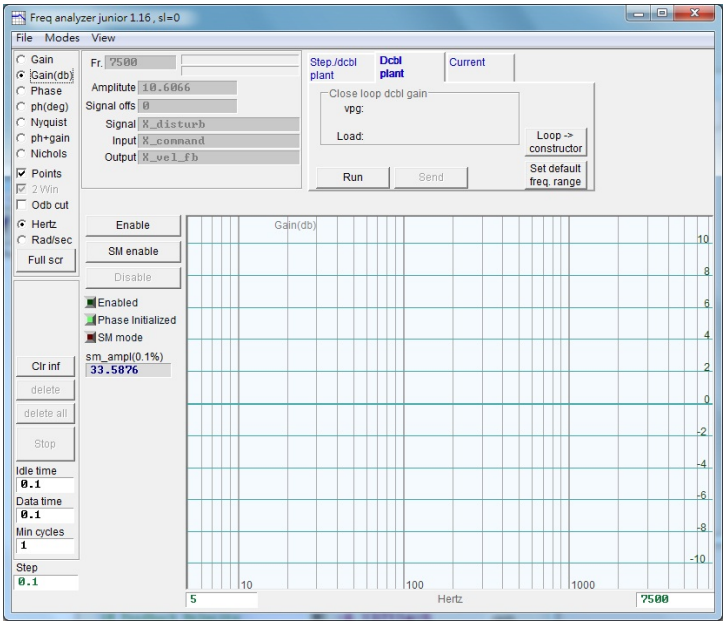


Figure 6.6.3.2

Step 3: Click on **Run** button to start frequency analysis. The 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.

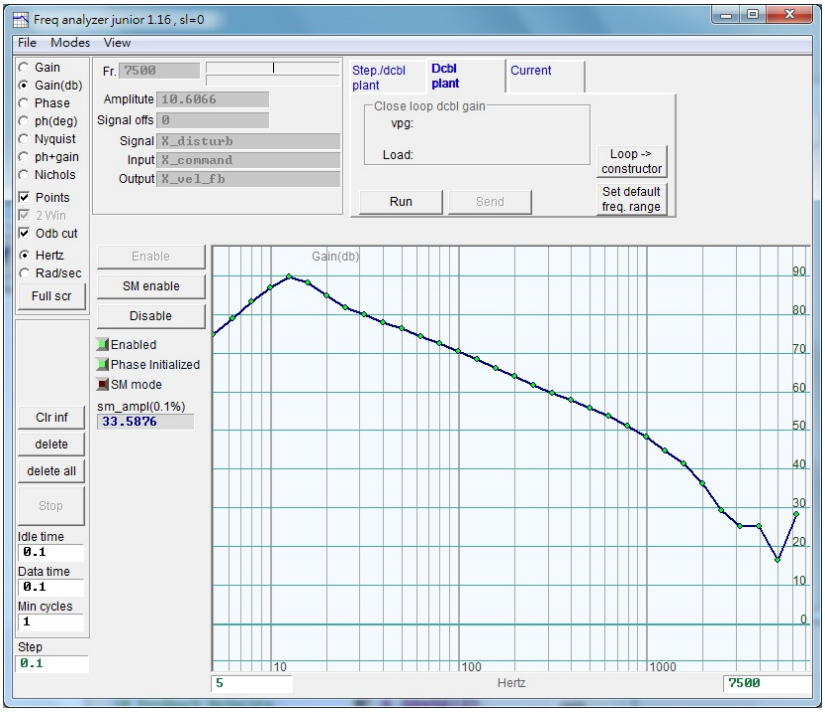


Figure 6.6.3.3

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** button 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.

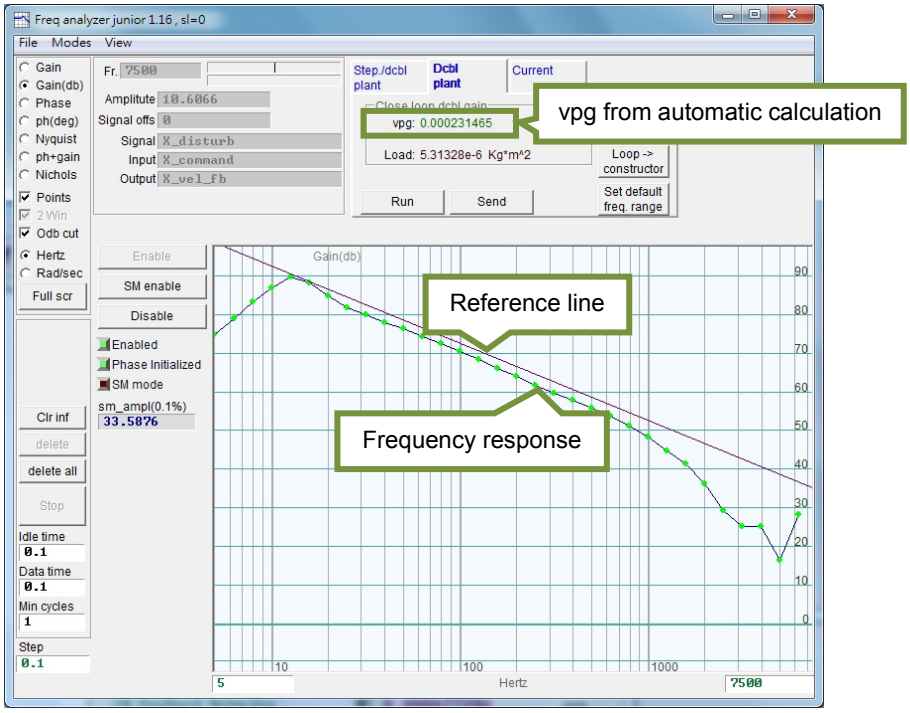


Figure 6.6.3.4

6.6.4 Offset correction for analog input

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

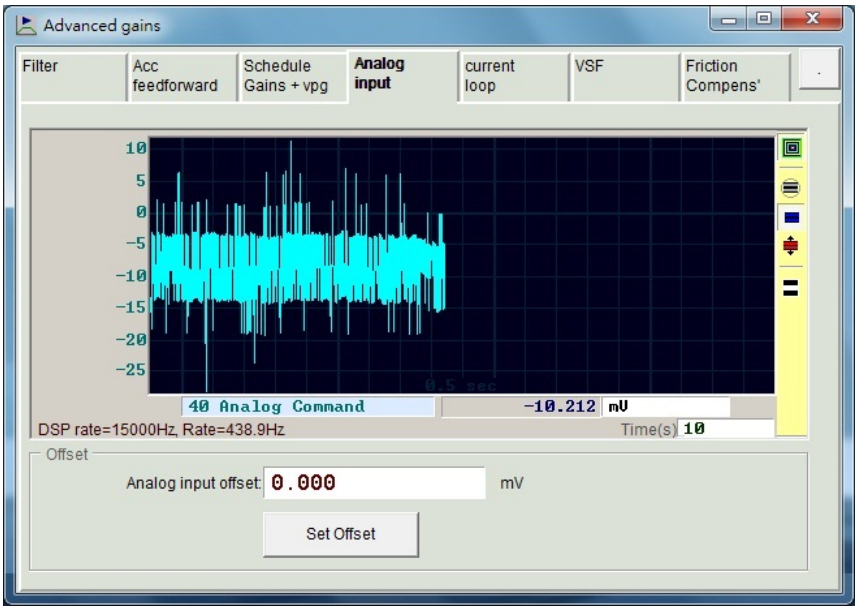


Figure 6.6.4.1 Analog voltage input

6.6.5 Current loop

The gains (Ki and Kp) of current loop are calculated according to the motor parameters and do not need to be adjusted again. However, if the motor parameters are not correctly set, users can use these gains for adjustment. The current filter is a low-pass filter which can be set according to the result of frequency response. If current loop gains are set to be too large, noise may occur. At this time, please decrease the frequency of low-pass filter. For instance, set the value to 500 HZ.

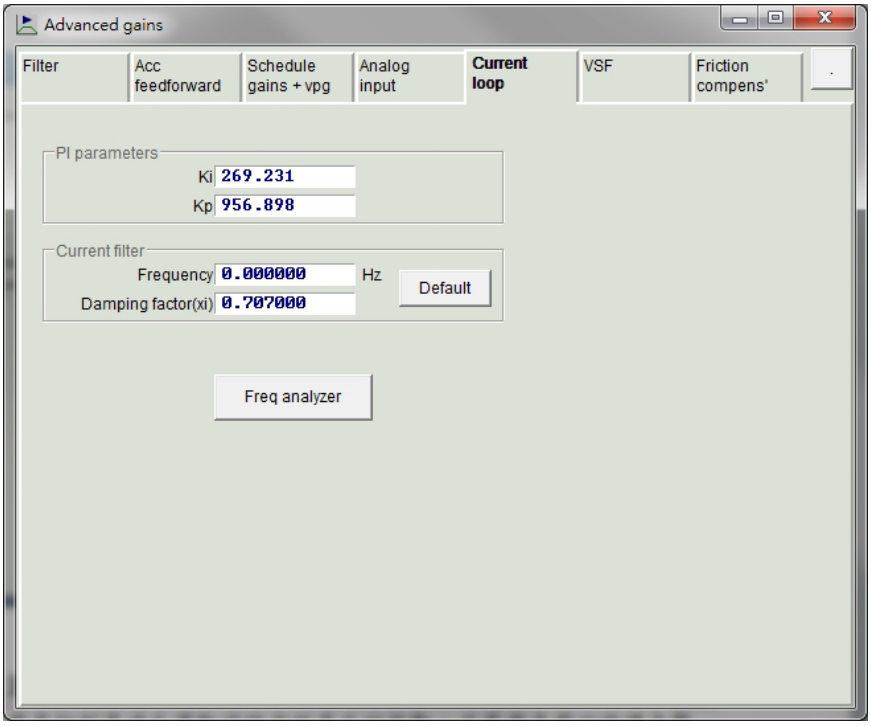


Figure 6.6.5.1 Current loop

6.6.6 Vibration suppression filter

Vibration suppression filter (VSF) is used to suppress vibration during motion. For instance, when the motor is used with robotic arm with end effector, the vibration could be greater during motion. Users 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 the 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 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.

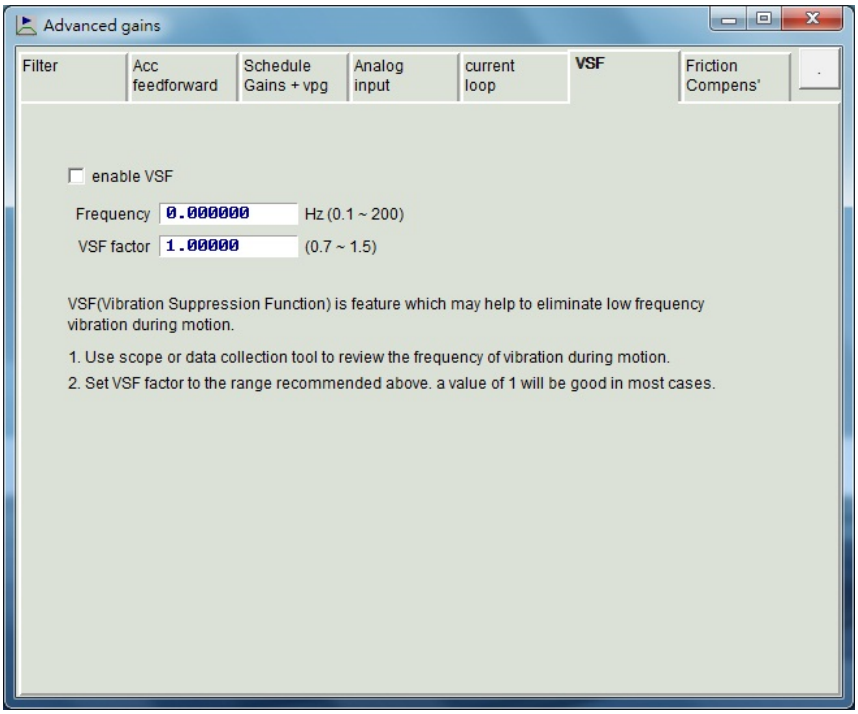


Figure 6.6.6.1 Vibration suppression filter

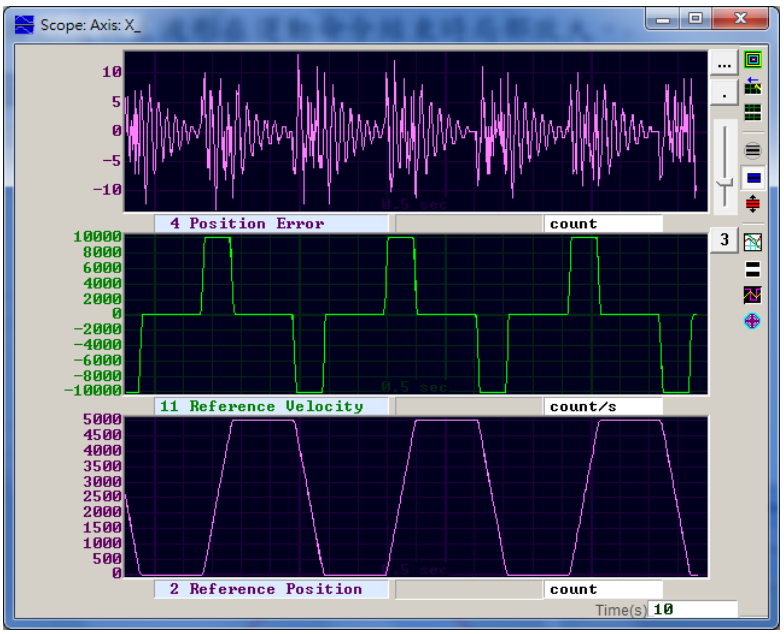


Figure 6.6.6.2

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.

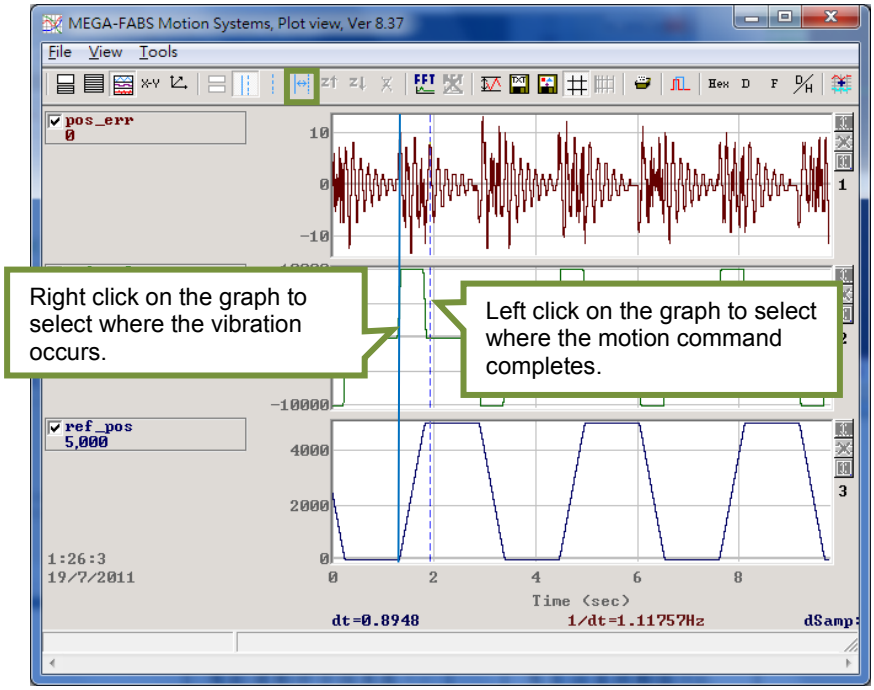


Figure 6.6.6.3

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

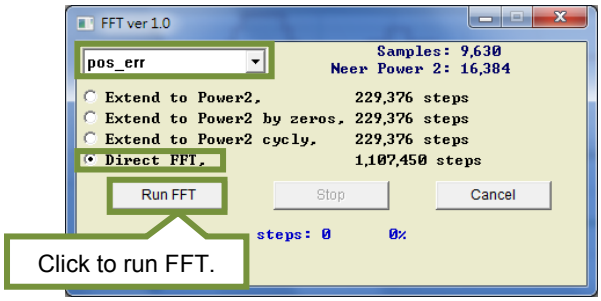


Figure 6.6.6.4

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

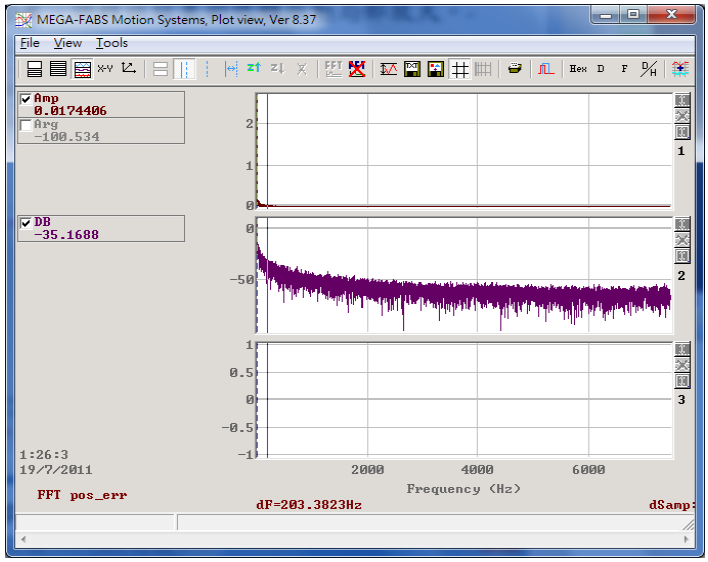


Figure 6.6.6.5

Step 7: Zoom in on the segment of low frequency and record the maximum amplitude of vibration frequency, as figure 6.6.6.6.

Step 8: Input the frequency of low-frequency vibration into the **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.

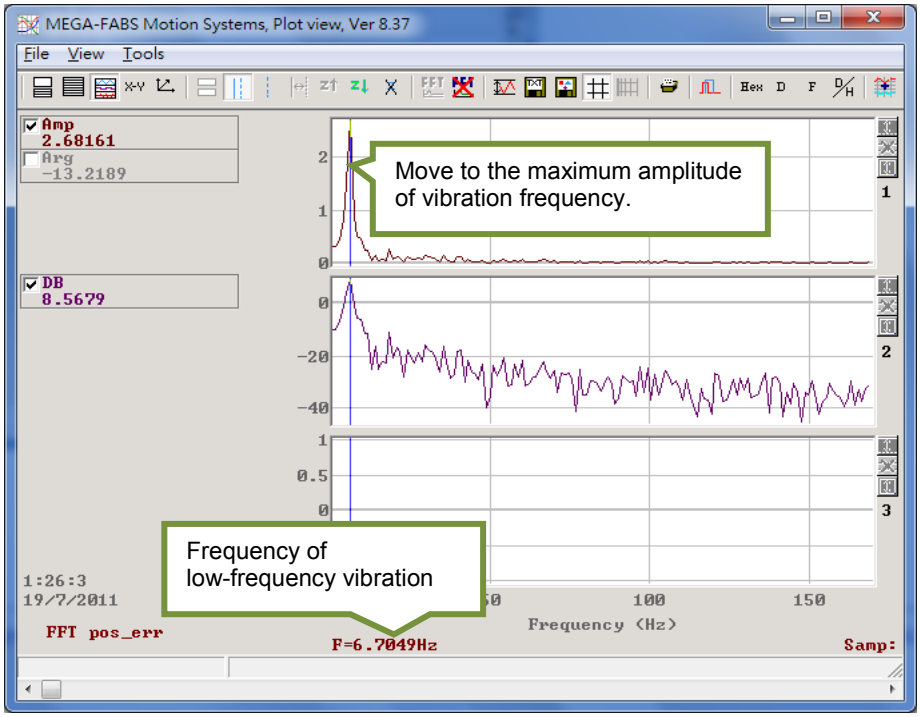


Figure 6.6.6.6

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** when the motor is moving.

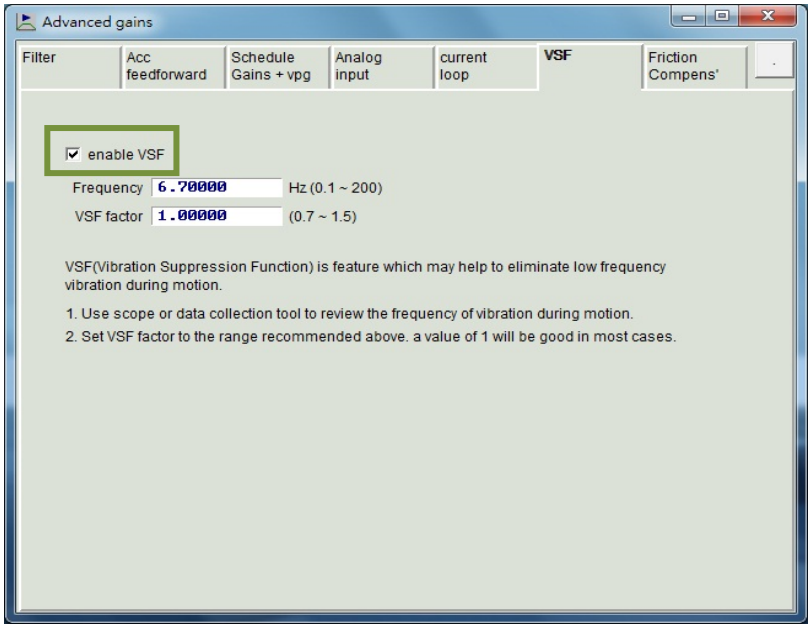
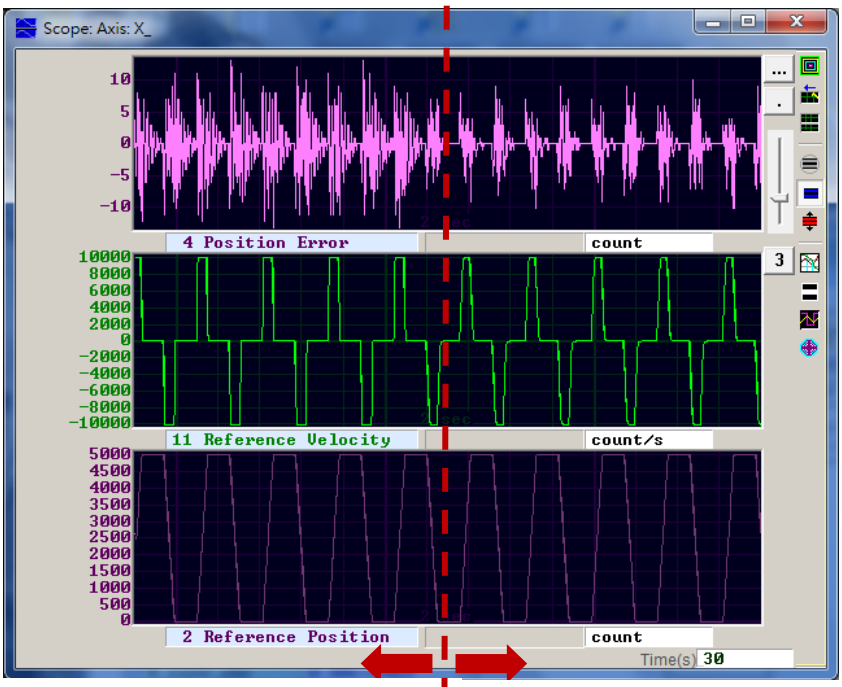


Figure 6.6.6.7

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



Vibration suppression filter (VSF) is disabled. Vibration suppression filter (VSF) is enabled.

Figure 6.6.6.8

6.6.7 Friction compensation

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

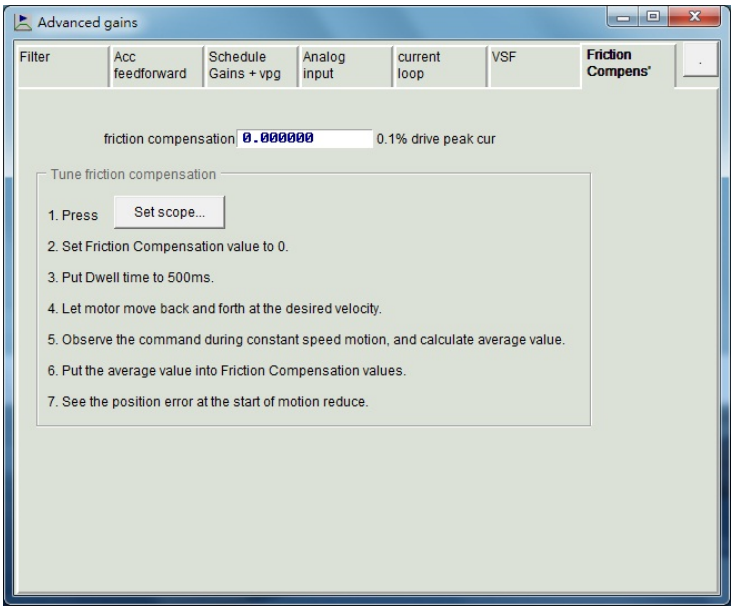


Figure 6.6.7.1

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 desired speed and perform point-to-point (P2P) motion. Observe position error in **Scope** window. It is suggested to apply friction compensation if the positon error is greater when the 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.

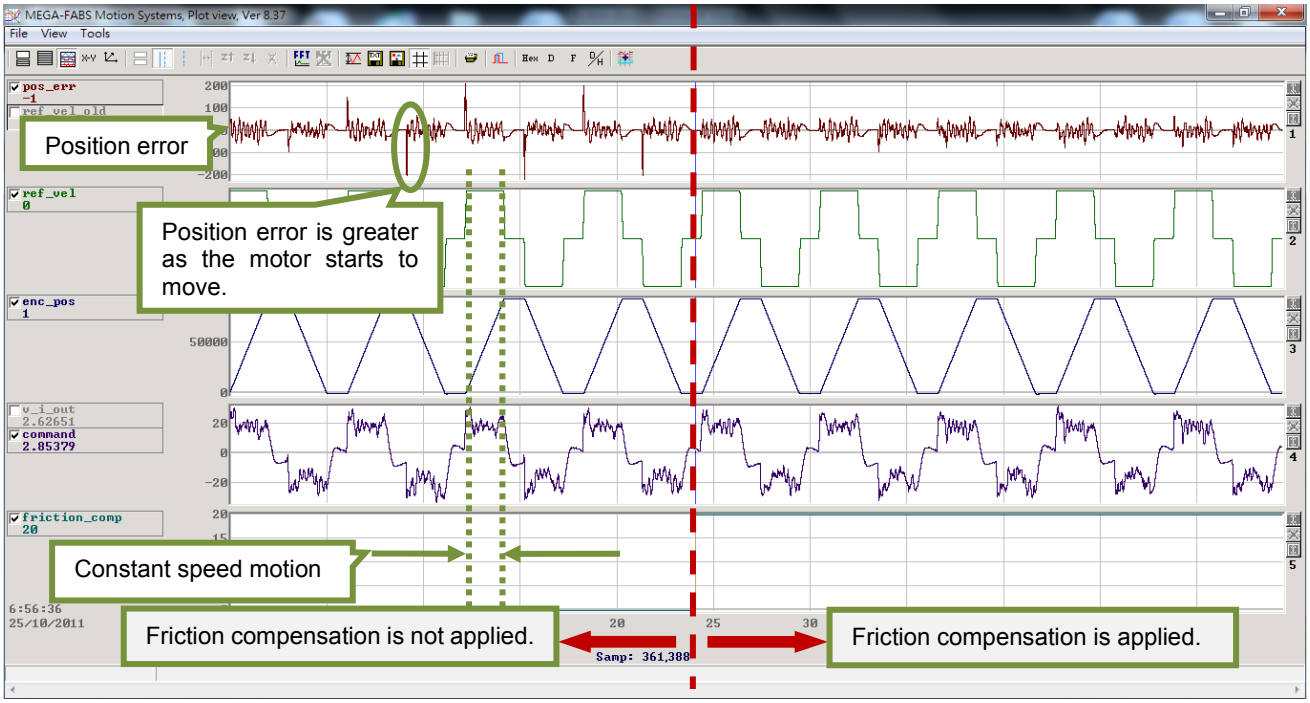


Figure 6.6.7.2 Friction compensation

6.7 Loop constructor

In Loop constructor, users are 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 users to adjust filters and gains (vpg, vig, ppg and CG). Users 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.

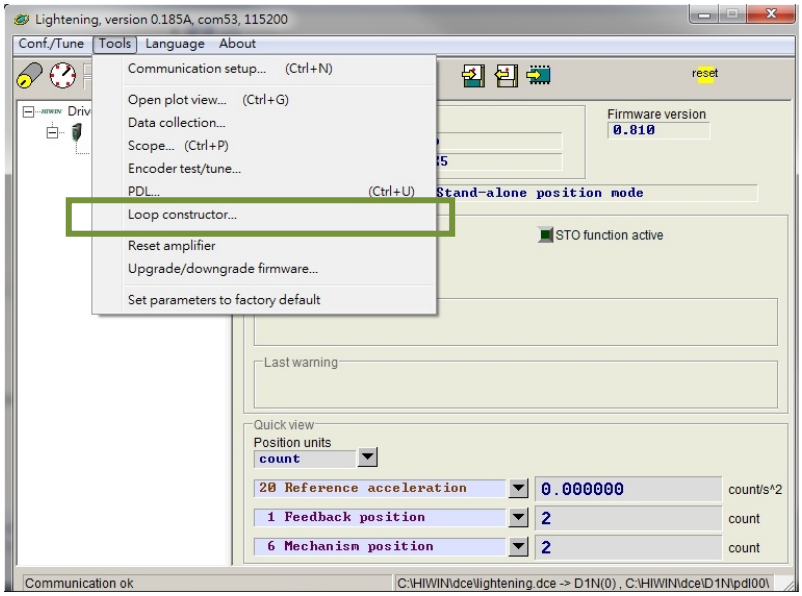


Figure 6.7.1

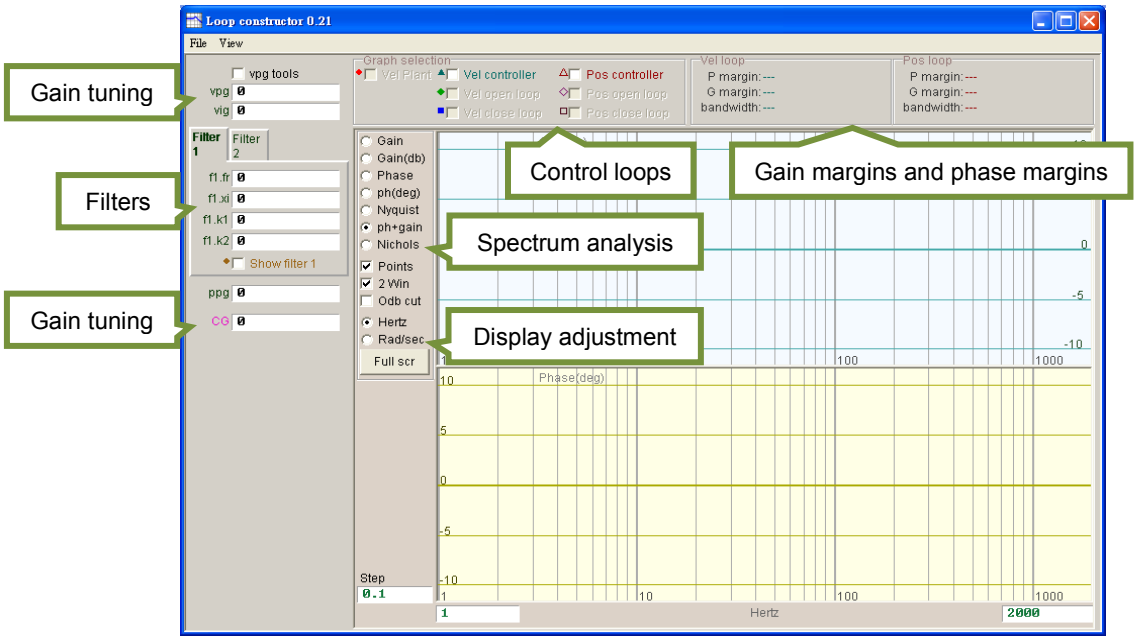


Figure 6.7.2

6.7.1 Load/save file

When 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.

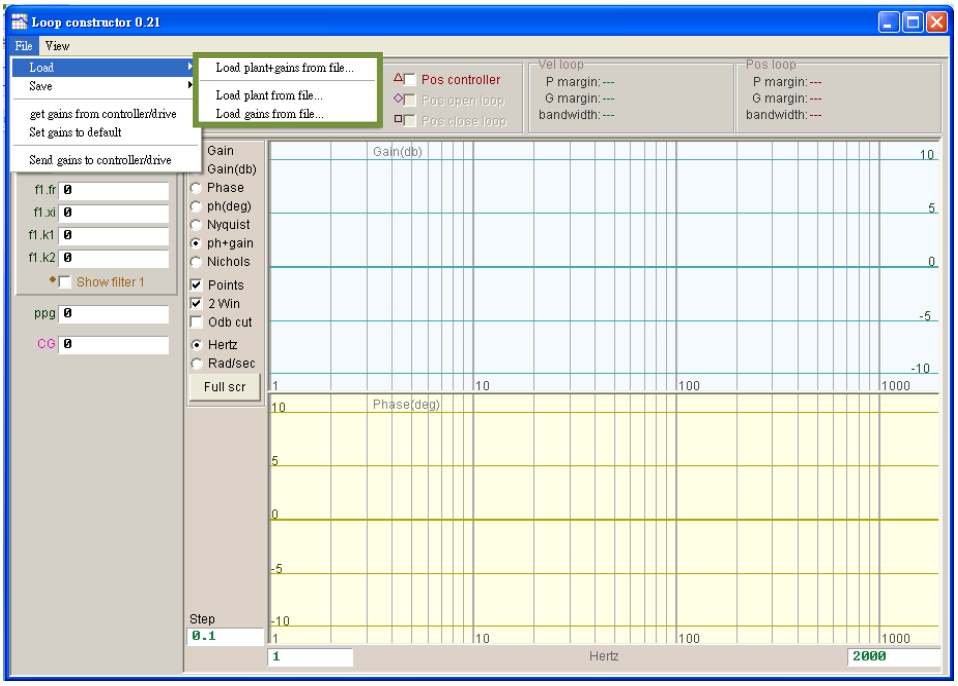


Figure 6.7.1.1

After analyzing control system in Loop constructor, users 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.

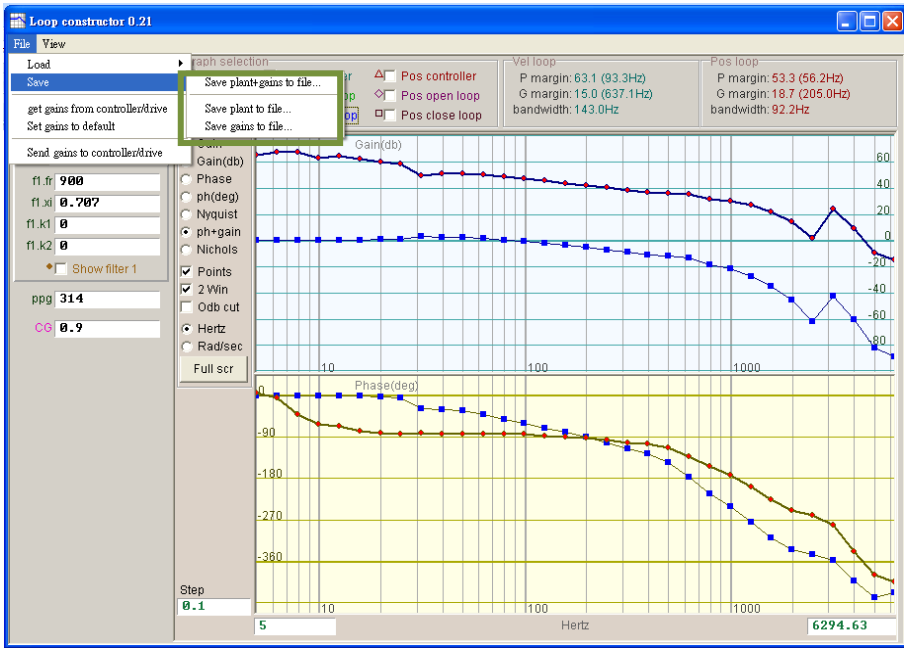


Figure 6.7.1.2

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 in 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.

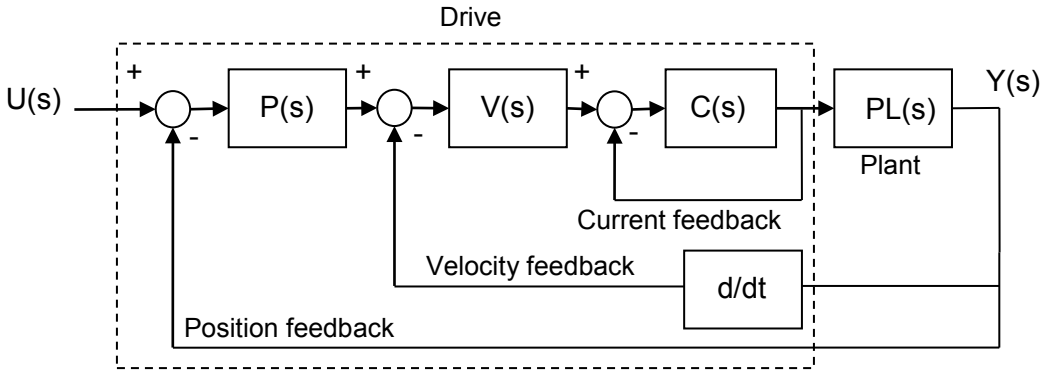


Figure 6.7.2.1.1 The control architecture of servo drive

(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)*V(s)*C(s)*PL(s). All feedback signals are ignored.

(6) Closed loop: The transfer function of closed-loop system is T(s)= P(s)*V(s)*C(s)*PL(s)/((d/dt* P(s)*V(s)*C(s)*PL)+ P(s)*V(s)*C(s)*PL).

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.

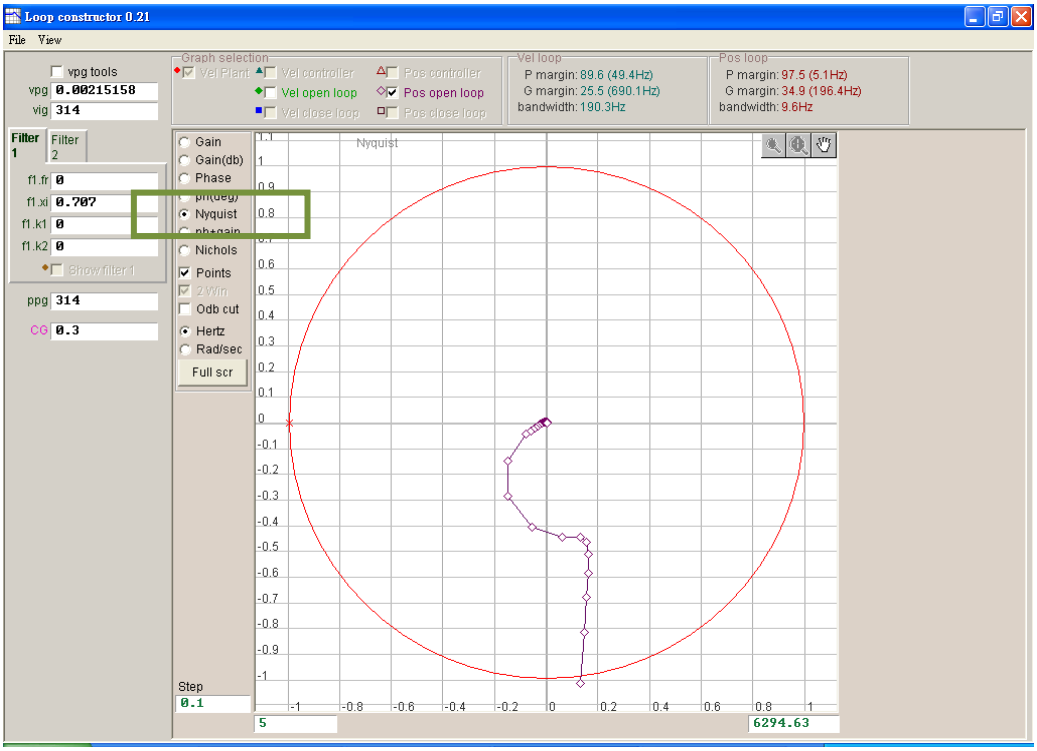


Figure 6.7.2.2.1 Nyquist plot of position open loop

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 close 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 close loop (Position close loop): Frequency response of position closed loop

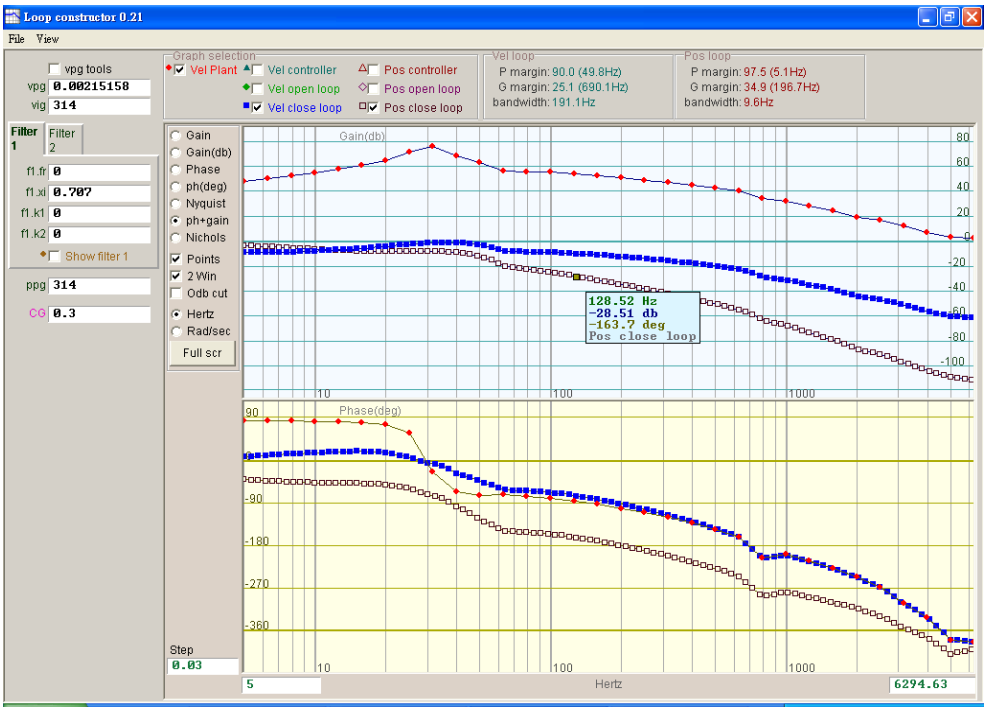


Figure 6.7.2.3.1 Bode plots of velocity closed loop and position closed loop

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

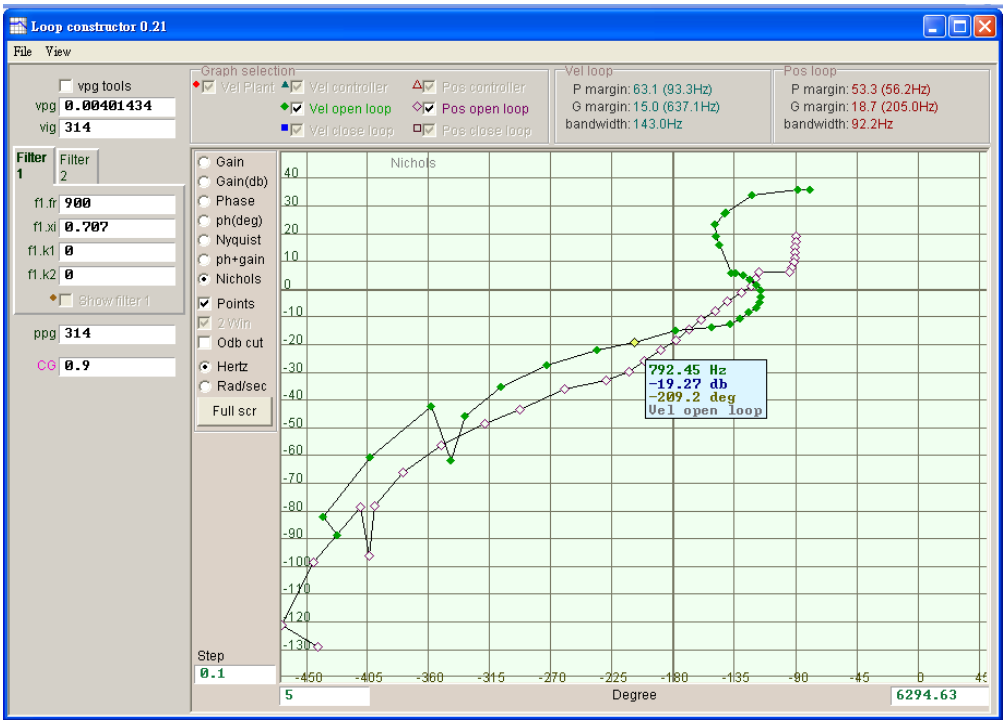


Figure 6.7.2.4.1 Nichols plots of velocity open loop and position open loop

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 the control system.

(1) fr: fr is the cutoff frequency (Unit: Hz). For normal applications, users can set cutoff frequency to 500 Hz. For other applications, users 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

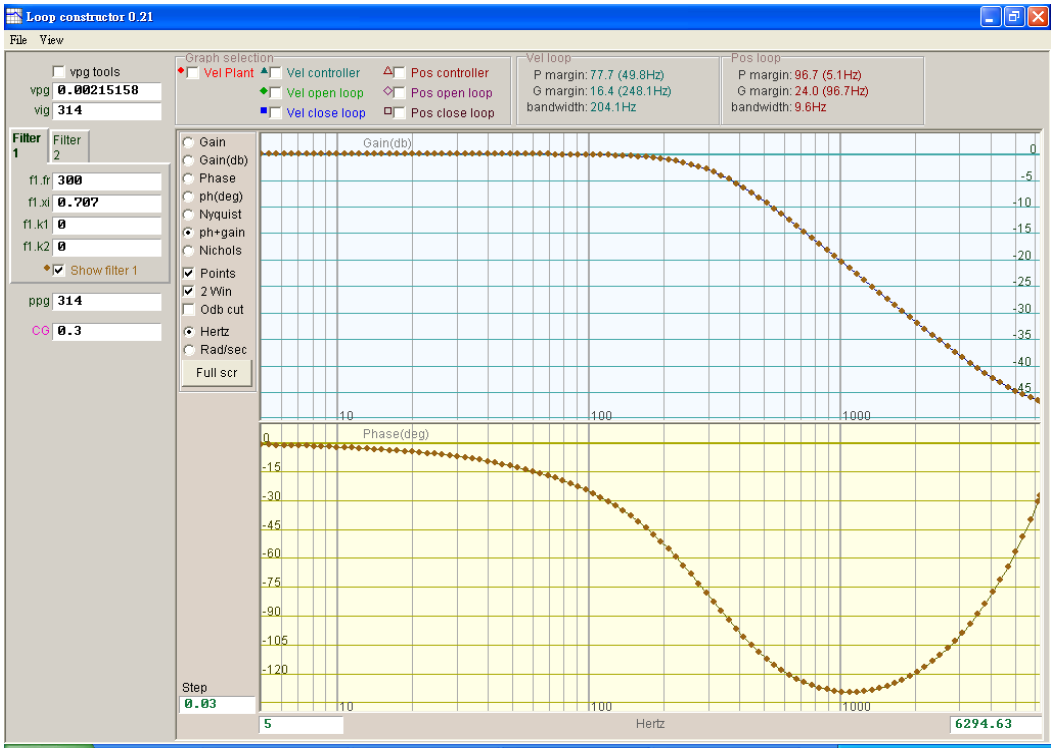


Figure 6.7.3.1.1 Low-pass filter

6.7.3.2 Notch filter

When resonance frequency occurs and cannot be fixed by modification of mechanism or improvement of design, users 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 the 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

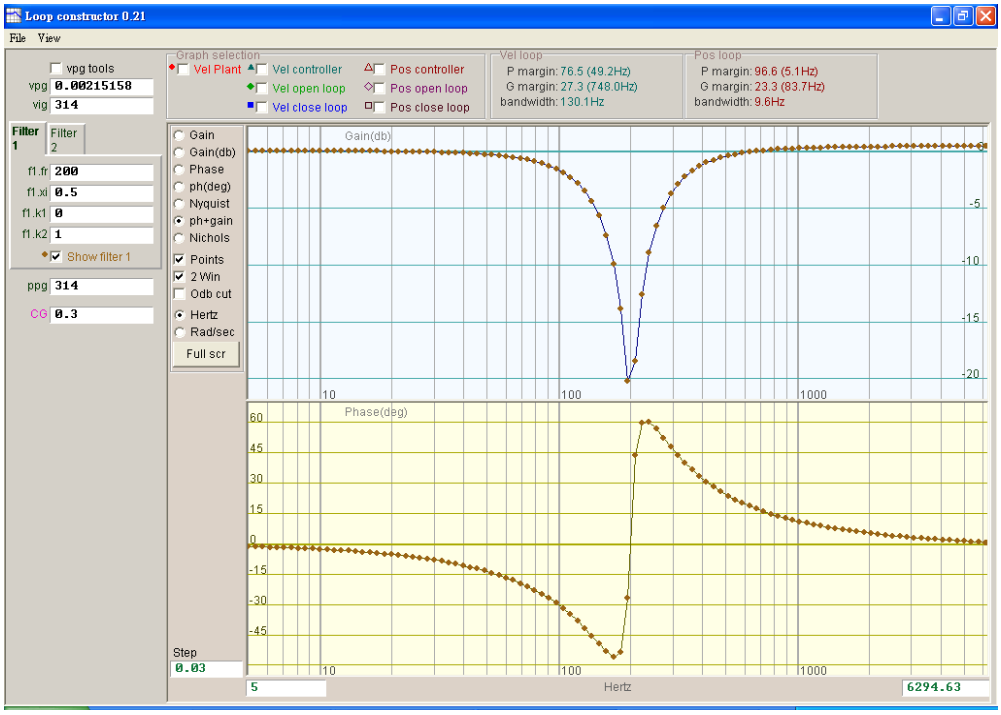


Figure 6.7.3.2.1

6.7.4 Gain tuning

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

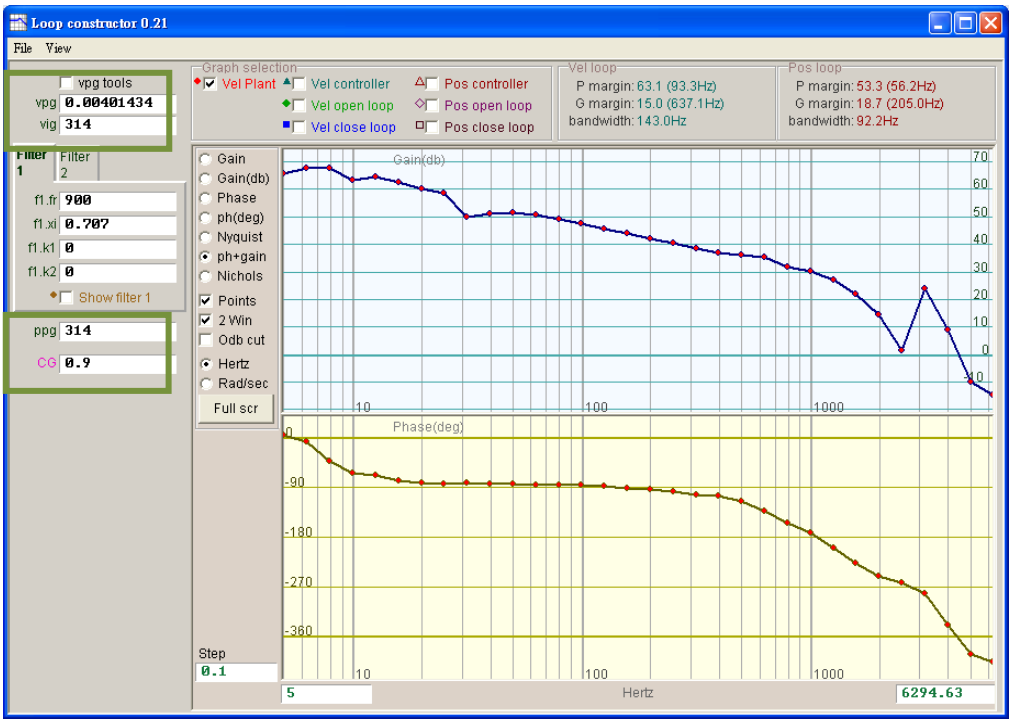


Figure 6.7.4.1 Gain tuning in Loop constructor

■ 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 users to adjust gains to simulate the stability of the 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.

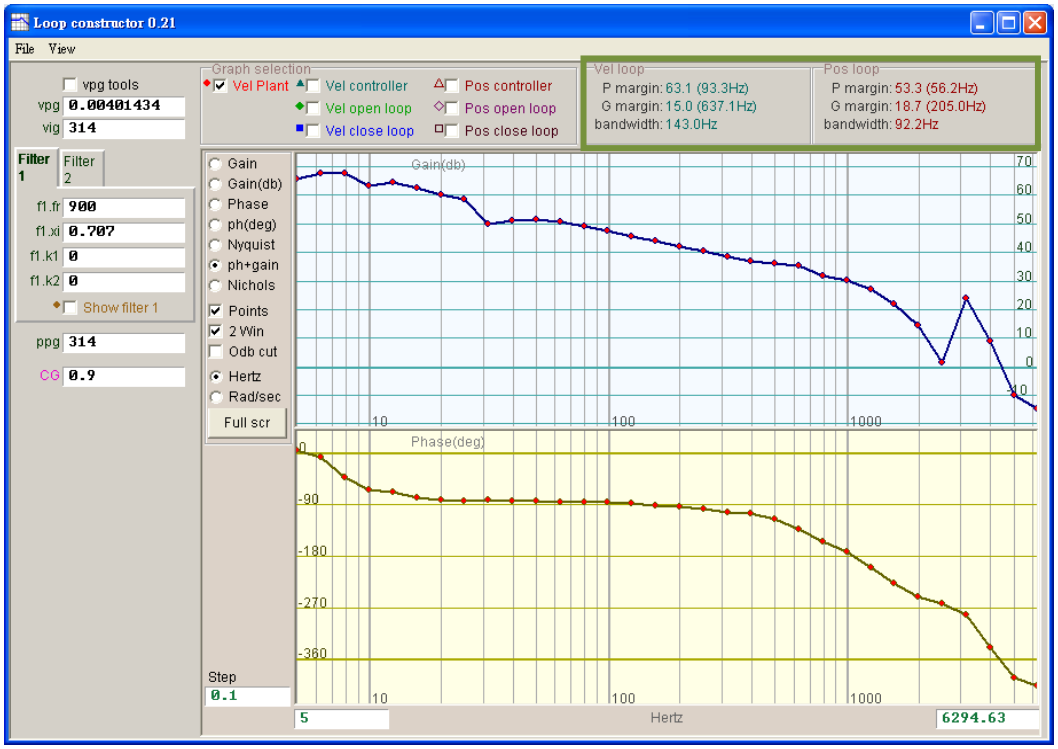


Figure 6.7.5.1 P margins and G margins in Loop constructor

6.8 Checking encoder signal

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

■ 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 the encoder signal. The windows for digital encoder and analog encoder are different.

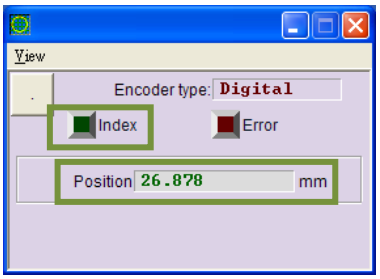


Figure 6.8.1 Digital encoder

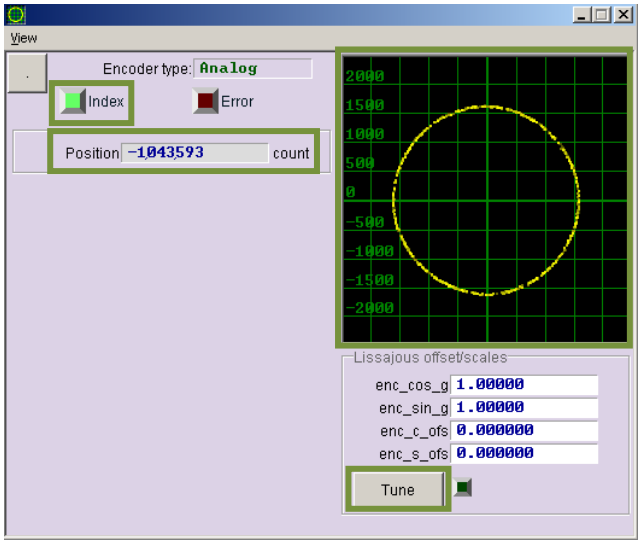


Figure 6.8.2 Analog encoder

■ Checking encoder value

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

- Checking index signal

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

- Lissajous figure

  When 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, the motor must move to let the encoder output signals, as figure 6.8.2. If the motor does not move, there will be no circle, but only a dot in the display area.

  Besides, if the 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, the motor must move slowly and let the encoder outputs signals for at least 10 grating periods.

6.9 Error map function

The positioning accuracy is determined by the linear encoder installed on the positioning platform. Normally the positioning accuracy of the positioning platform can be measured and corrected by laser interferometer. With laser interferometer, the errors can be obtained. D1-N servo drive provides a function called Error map function, which allows users 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, users need 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 forward 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.

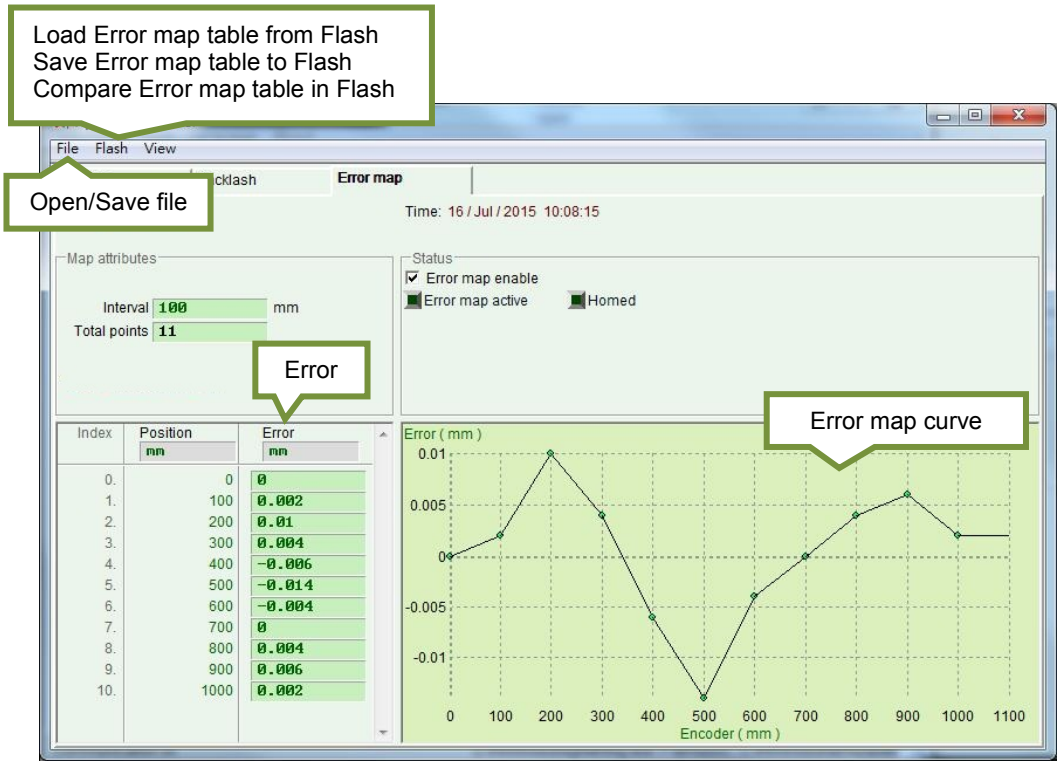


Figure 6.9.1.1 **Error map** page

Step 2: Set **Interval** and **Total points**. Input the errors into the fields of **Error**. Users are 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.

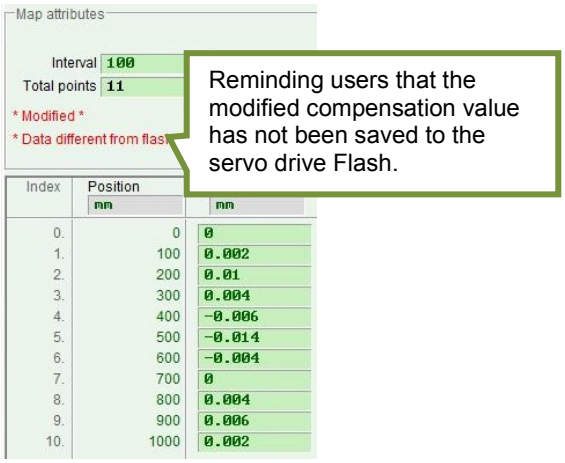


Figure 6.9.1.2 Setting Error map function

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 the 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. When 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.

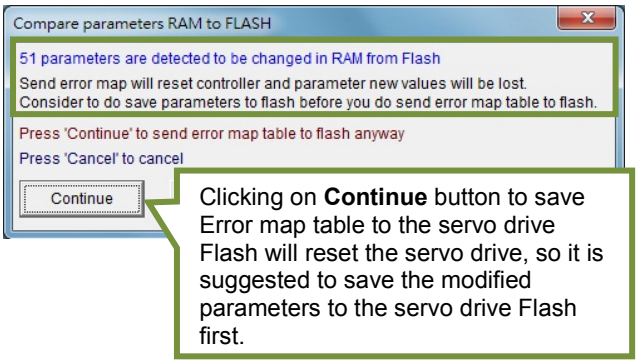


Figure 6.9.1.3

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.

Figure 6.9.1.4

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-N 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 I5, as figure 6.9.2.1. The controller sends pulse command or analog command to the servo drive to let the motor move to the home position. After that, the controller input signal via I5 to the servo drive to enable Error map function.

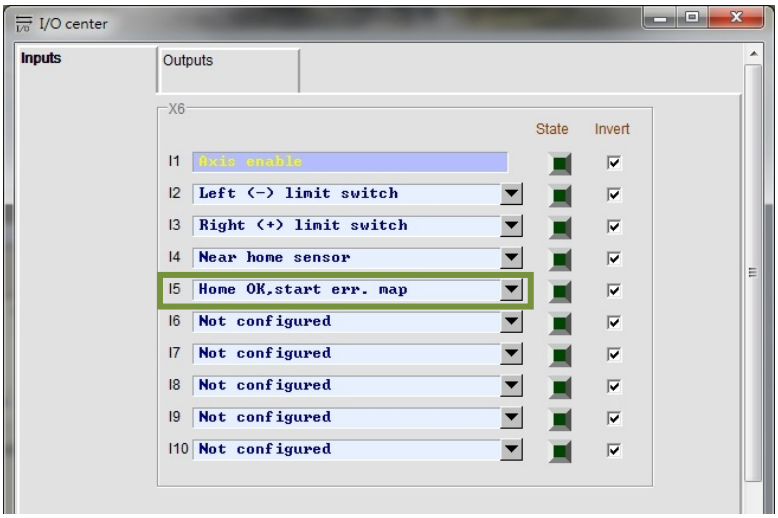


Figure 6.9.2.1

(2) Homing in stand-alone mode

Open Performance center, click on 

. (Refer to section 6.2.)

■ How to check if Error map function is enabled

If users 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 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 (Refer to section 5.8.1.) in the main window cannot save Error map table to the servo drive Flash.

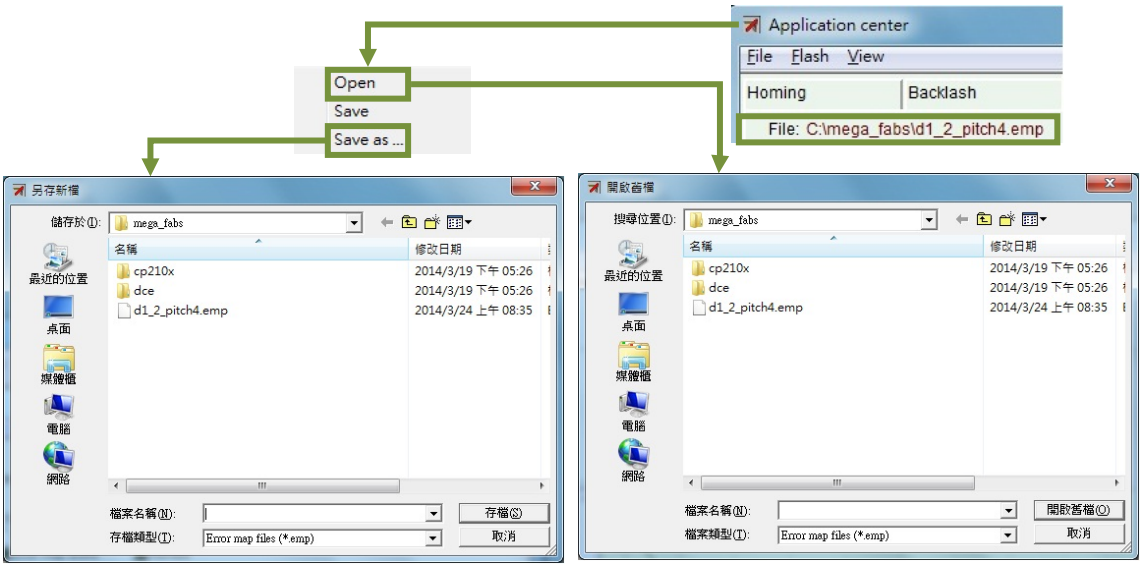


Figure 6.9.3.1

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 forward direction. Click on **Previous** button and the motor will move for one interval in reverse 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.

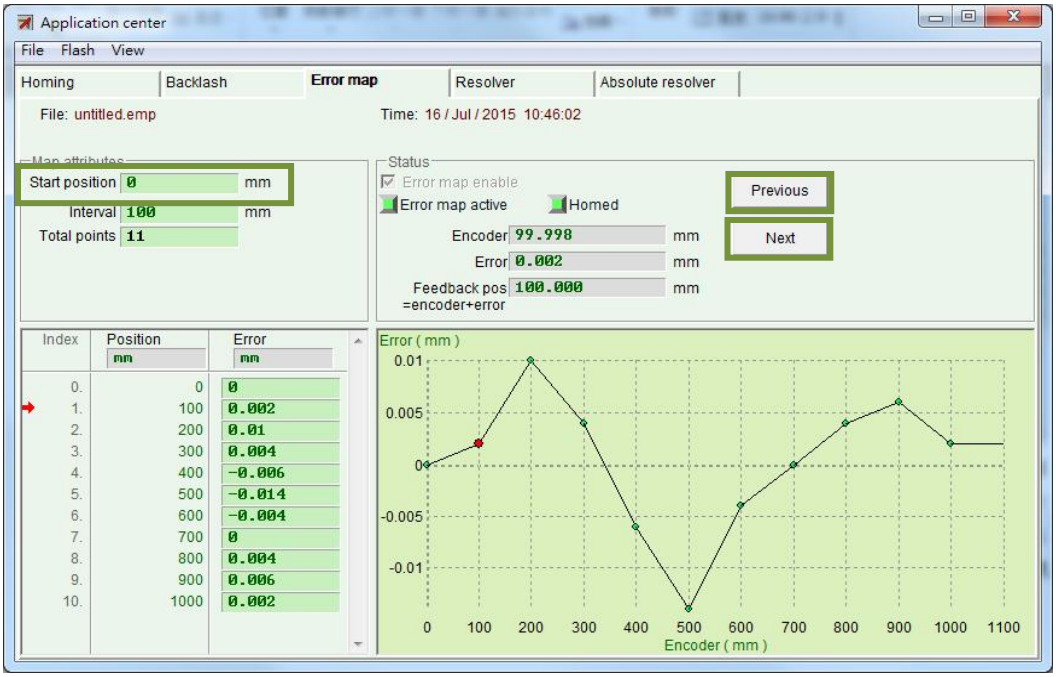


Figure 6.9.4.1

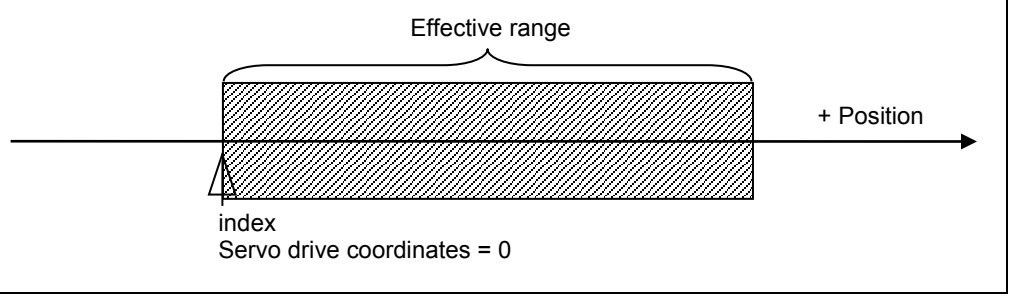
Note:

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. At index 0, the error must be 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 reverse direction, Error map function is not applied.

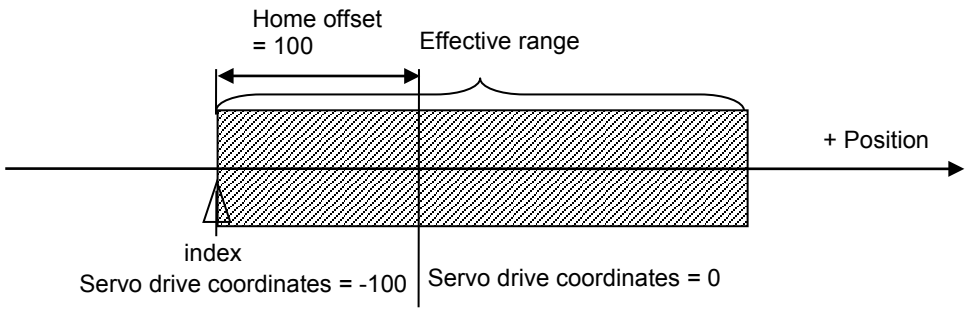
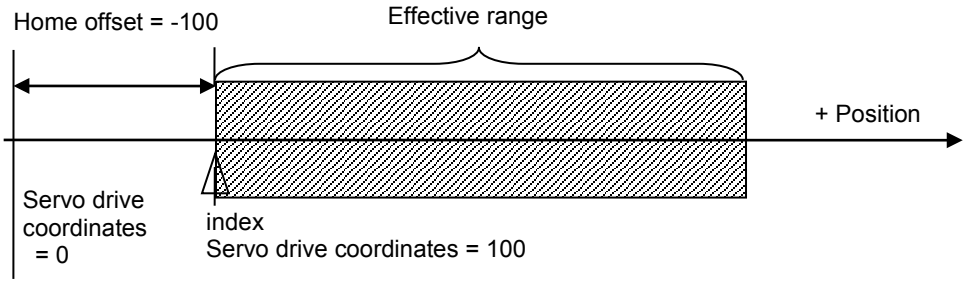
Table 6.9.4.1

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.

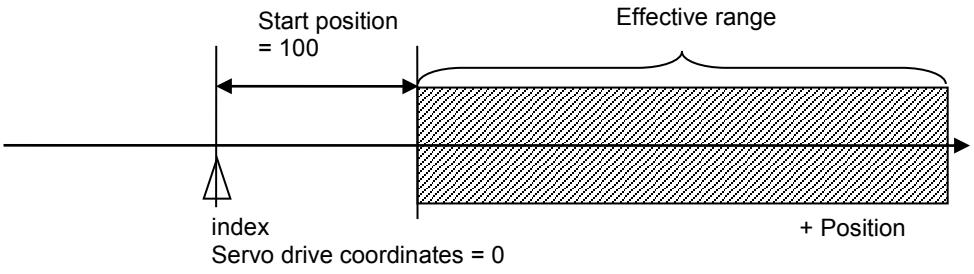
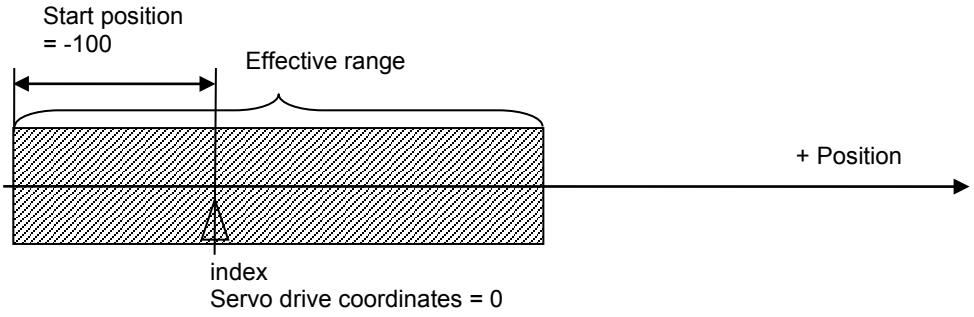
Table 6.9.4.2

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 and the effective range of Error map function varies with start position.

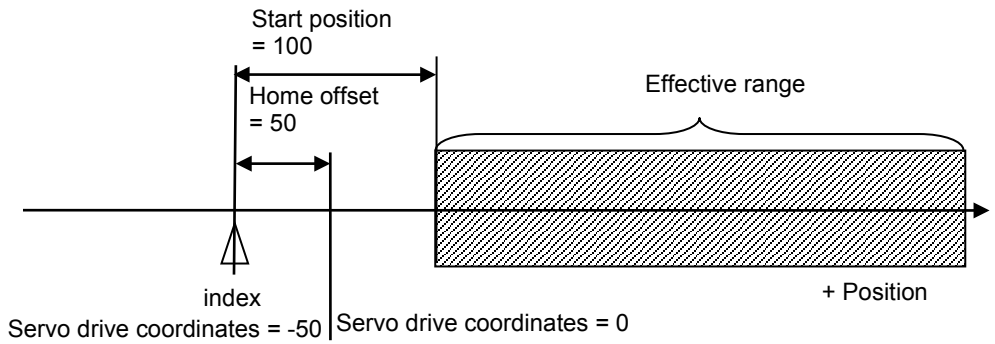
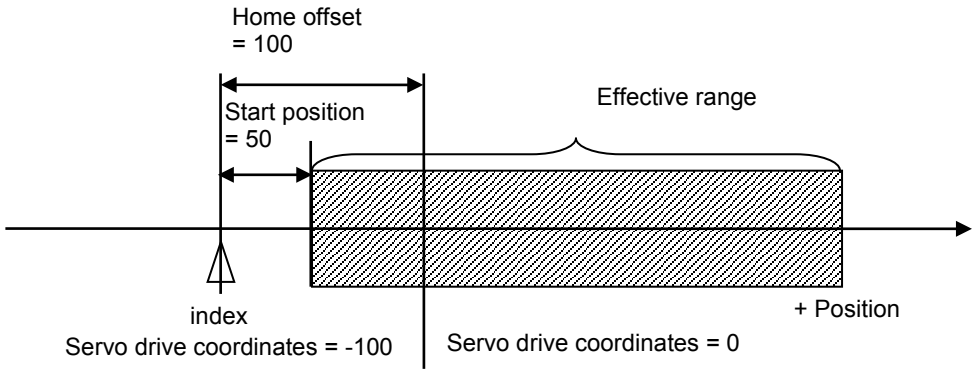
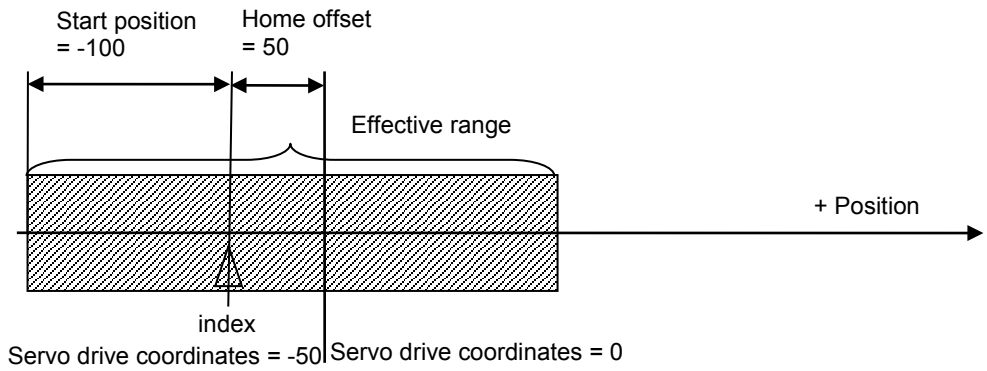
Table 6.9.4.3

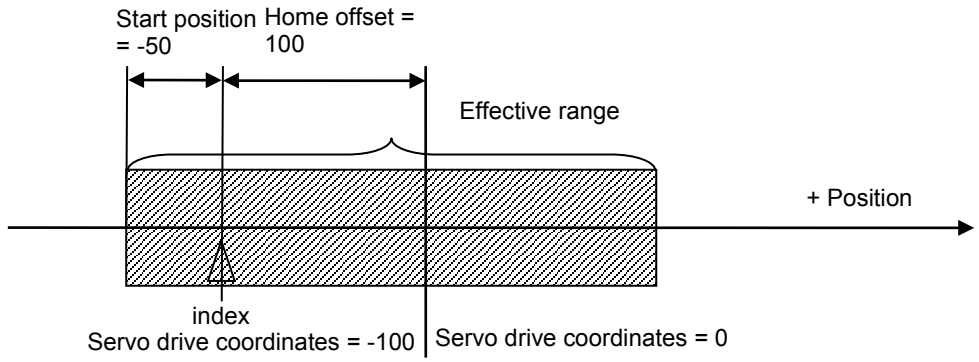
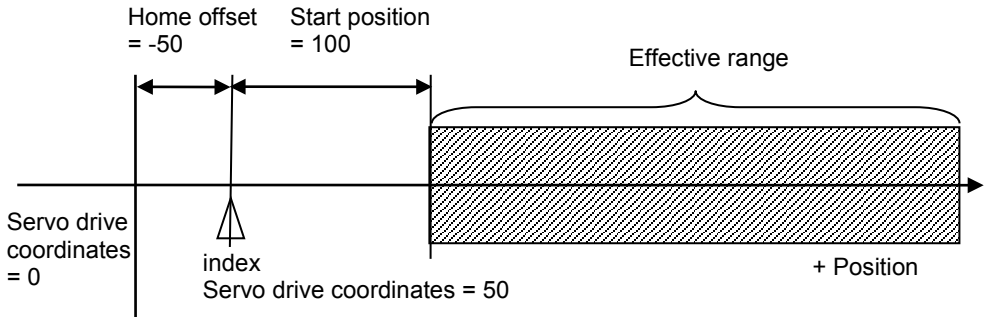
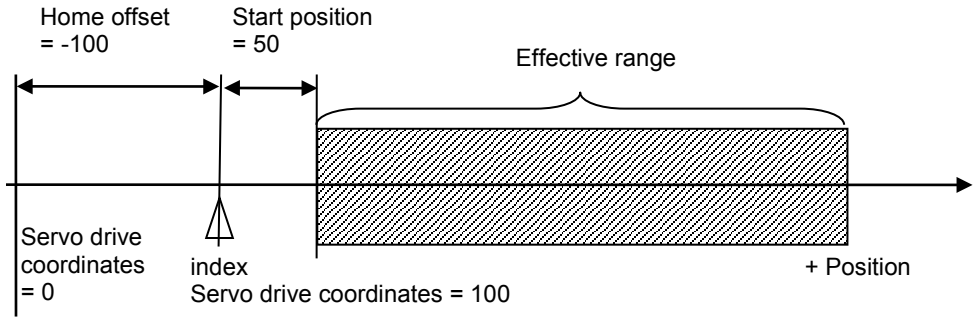
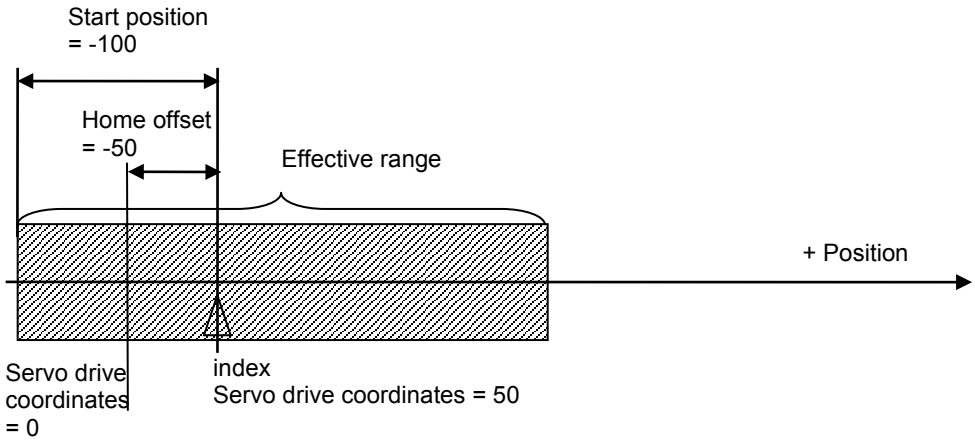
Home Offset	Start Position	Effective Range
0 mm	100 mm	
0 mm	-100 mm	

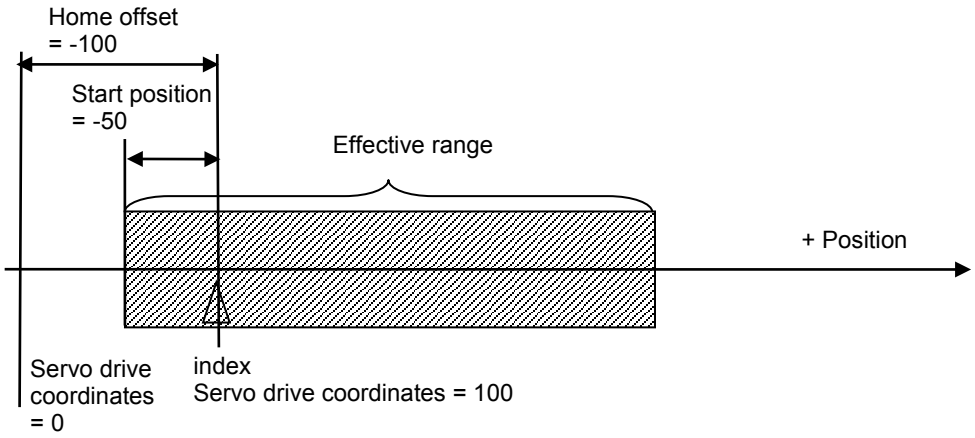
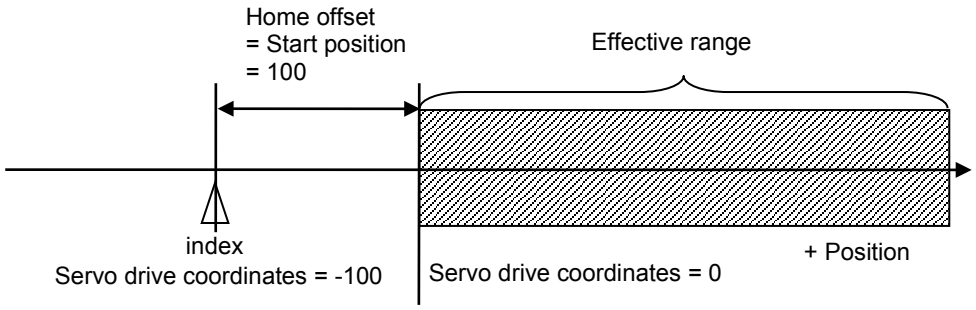
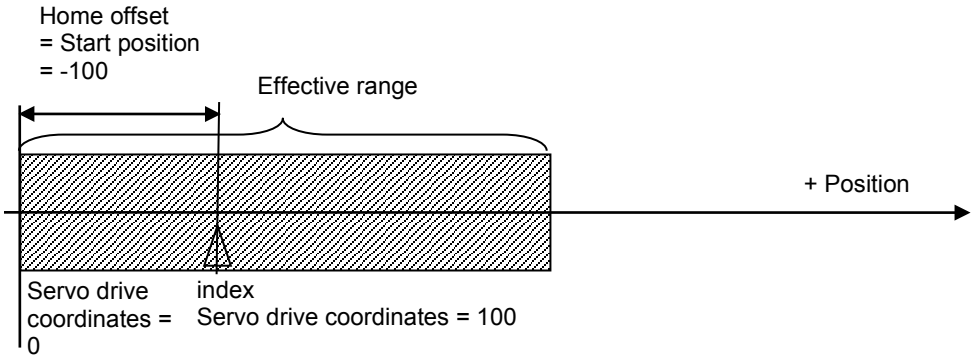
(4) When home offset ≠ 0 and start position ≠ 0

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
50 mm	100 mm	
100 mm	50 mm	
50 mm	-100 mm	

Home Offset	Start Position	Effective Range
100 mm	-50 mm	
-50 mm	100 mm	
-100 mm	50 mm	
-50 mm	-100 mm	

Home Offset	Start Position	Effective Range
-100 mm	-50 mm	
100 mm	100 mm	
-100 mm	-100 mm	

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 users and only needs to be reset when the servo drive or motor is changed.

Note:

The signal compensation function is only available in servo drive which supports resolver signal.

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.

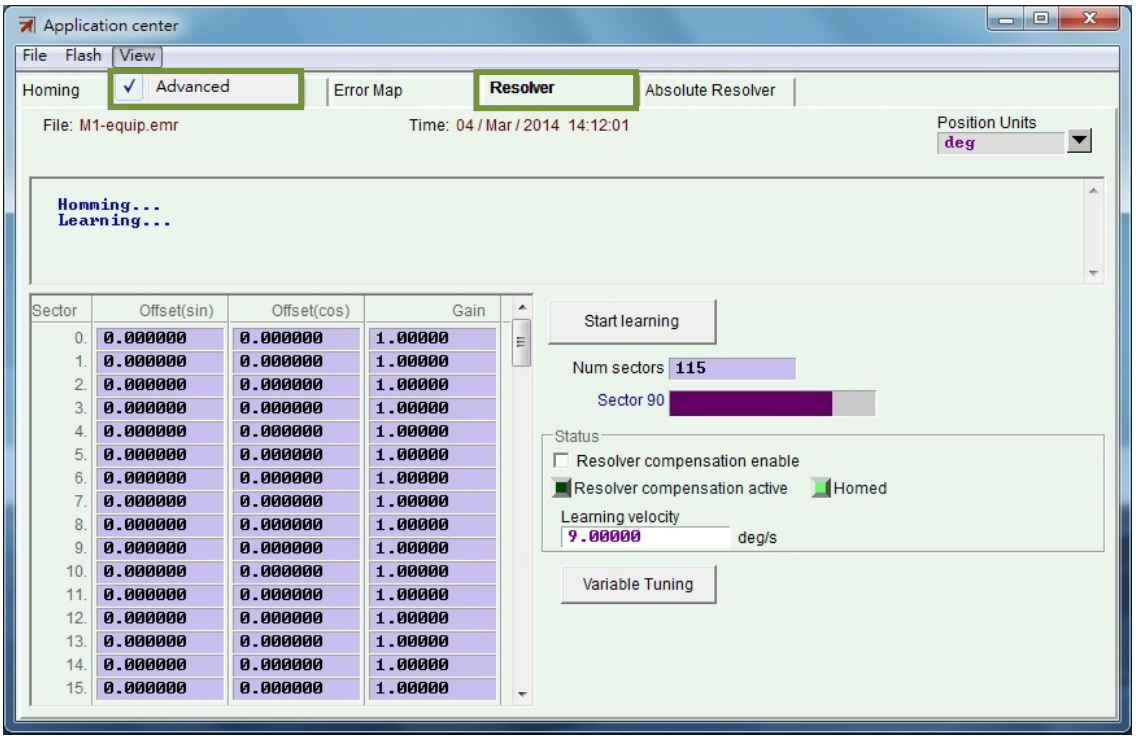


Figure 6.10.1.1

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.

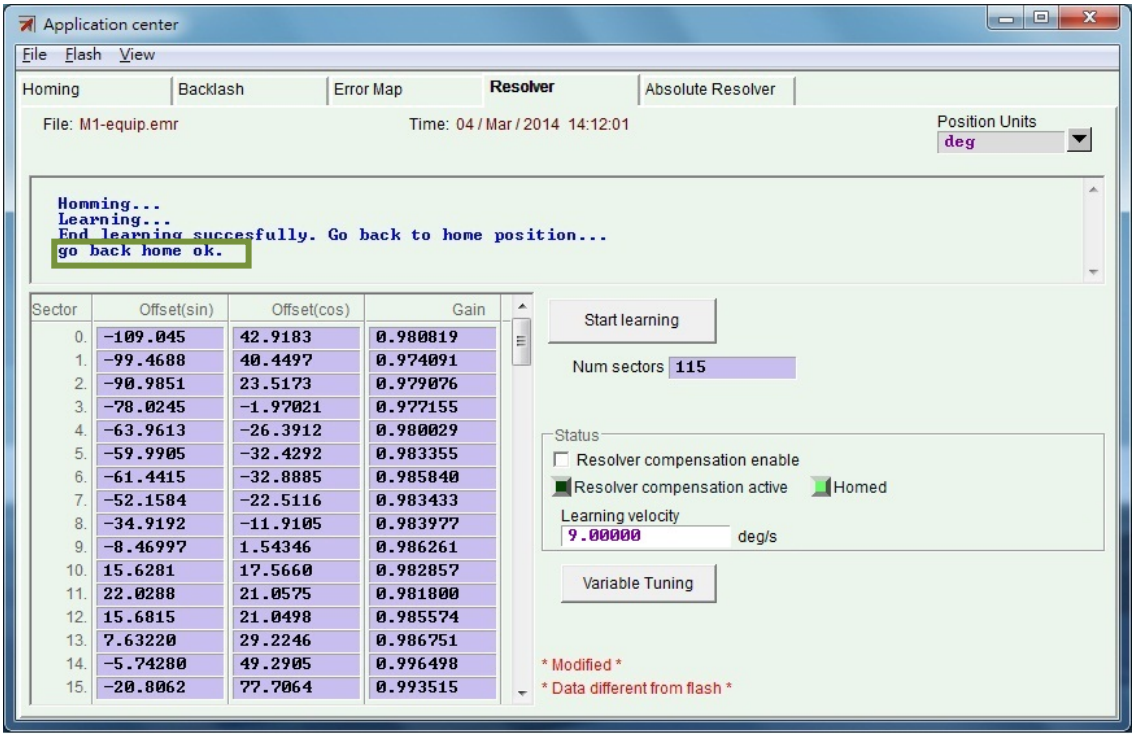


Figure 6.10.1.2

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 users 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) This function is only available in servo drive which supports absolute resolver signal.

(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.

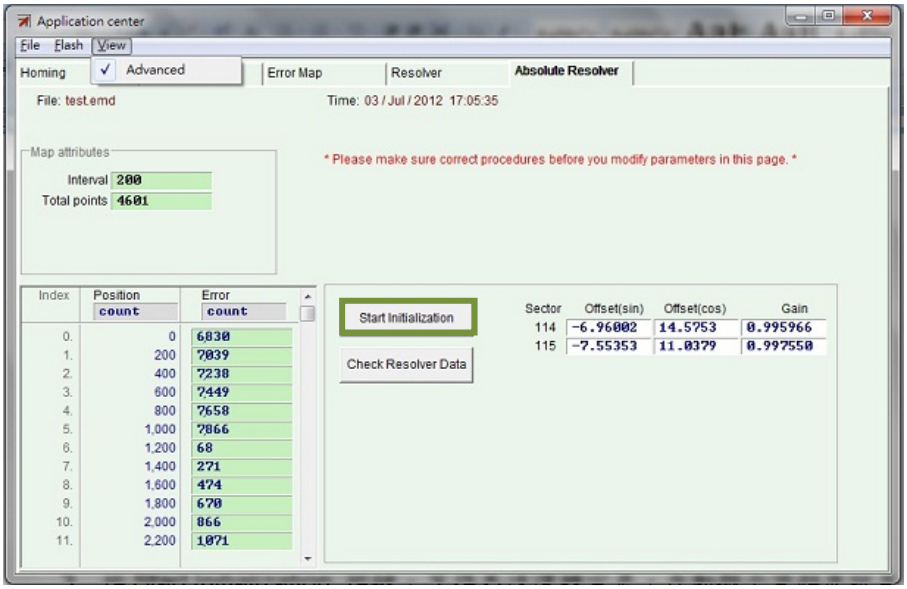


Figure 6.11.1.1

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.

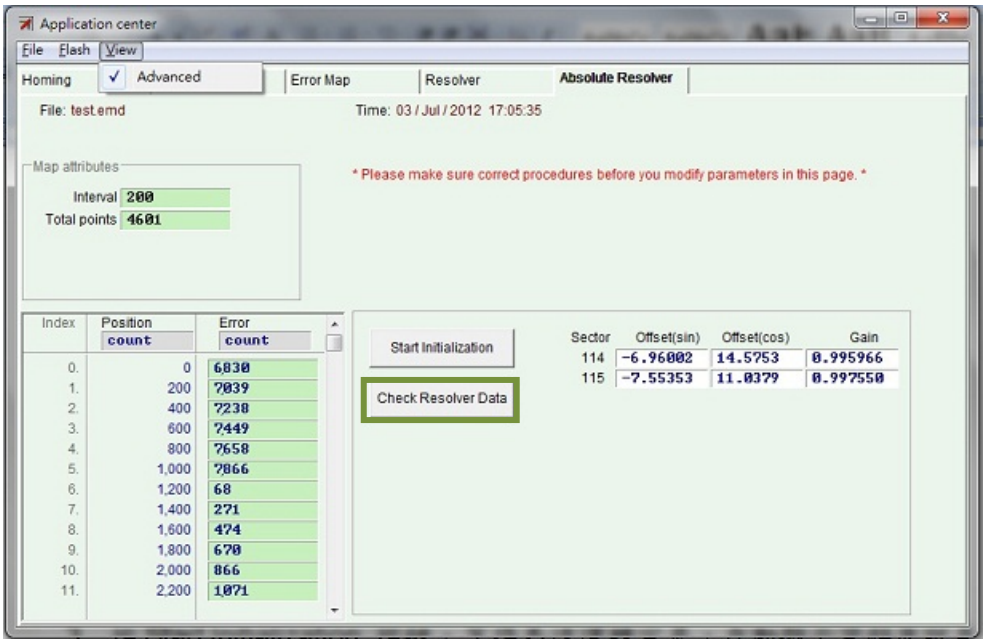


Figure 6.11.1.2

Figure 6.11.1.3

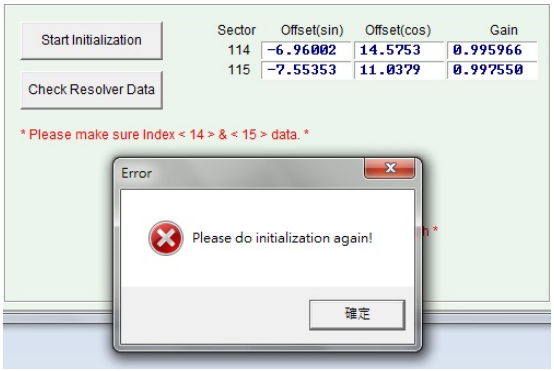


Figure 6.11.1.4

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.

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7. LCD display

7.1 LCD panel

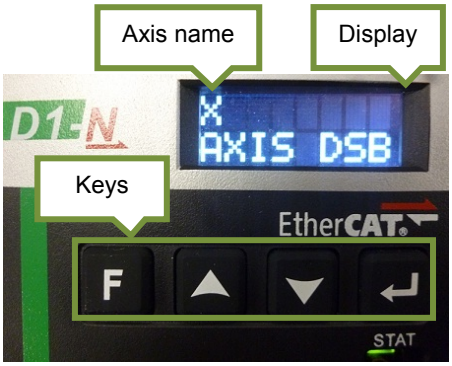


Figure 7.1.1 LCD panel

Table 7.1.1 Function description

Name	Function
Display	Displays servo drive status, error or warning message and axis name.
Axis name	Displays axis name and error or warning message. Axis name can be modified in Lightening, please refer to section 5.1.3.
Keys	Includes **F** key, **Up** key, **Down** key and **Enter** key. The keys on D1-N servo drive have no function.

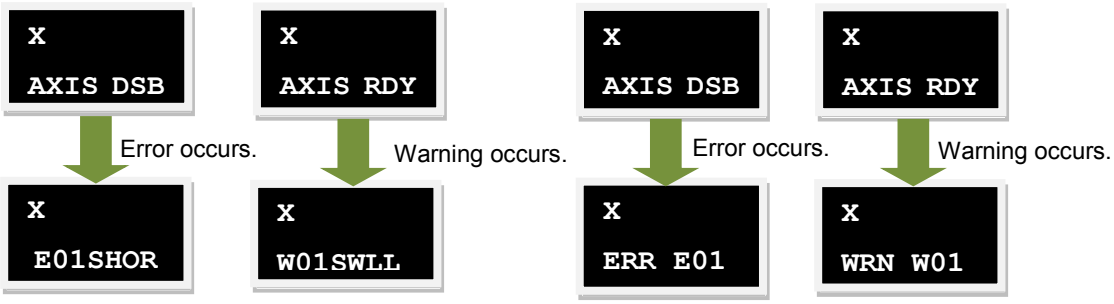
7.2 LCD display description

When power is applied to the servo drive, the LCD display shows the enabling status of the connected motor. If the servo drive has not been configured before, the LCD display shows “NOT CNFG” in the first line of the LCD display.

Table 7.2.1 Enabling status

Displayed Symbol	Description
AXIS RDY	The motor is enabled
AXIS DSB	The motor is disabled.

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 table 7.2.2 and 7.2.3. For D1-N firmware version 0.808, D1-N CoE firmware version 0.513 and previous version, the LCD display shows the abbreviation of error message or warning message. For D1-N firmware version 0.809, D1-N CoE firmware version 0.514 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

Figure 7.2.1

Table 7.2.2

No.	Abbreviation of Error Message	Error Code	Error message in Lightening
1	E01SHORT	ERR E01	Motor short (over current) detected
2	E02OVERV	ERR E02	Over voltage detected
3	E03PEBIG	ERR E03	Position error too big
4	E04ENCOD	ERR E04	Encoder error
5	E05SWHOT	ERR E05	Soft-thermal threshold reached
6	E06UVWCN	ERR E06	Motor maybe disconnected
7	E07D.HOT	ERR E07	Amplifier over temperature
8	E08M.HOT	ERR E08	Motor over temperature sensor activated
9	E09UND.V	ERR E09	Under voltage detected
10	E10V5ERR	ERR E10	5V for encoder card fail
11	E11PHINI	ERR E11	Phase initialization error
12	E12SER.E	ERR E12	Serial encoder communication error
13	E13HAL.E	ERR E13	Hall sensor error
14	E14PHERR	ERR E14	Hall phase check error
15	E15CURER	ERR E15	Current control error
17	E17HYBDV	ERR E17	Hybrid deviation too big
18	E18STO	ERR E18	STO active
19	E19HFLT	ERR E19	HFLT inconsistent error
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-N firmware version 0.808, D1-N CoE firmware version 0.513 and previous version, the LCD display shows the abbreviations of error message and warning message.

(2) For D1-N firmware version 0.809, D1-N CoE firmware version 0.514 and later version, the LCD display shows error code and warning code.

Table 7.2.3

No.	Abbreviation of Warning Message	Warning Code	Warning message in Lightening
1	W01SWLL	WRN W01	Left SW limit
2	W02SWRL	WRN W02	Right SW limit
3	W03HWLL	WRN W03	Left HW limit
4	W04HWRL	WRN W04	Right HW limit
5	W05SVBIG	WRN W05	Servo voltage big
6	W06PE	WRN W06	Position error warning
7	W07VE	WRN W07	Velocity error warning
8	W08CUR.L	WRN W08	Current limited
9	W09ACC.L	WRN W09	Acceleration limited
10	W10VEL.L	WRN W10	Velocity limited
11	W11BOTH	WRN W11	Both HW limits are active
12	W12I2T	WRN W12	I2T warning
13	W13HOM.E	WRN W13	Homing fail
14	W14HOM.C	WRN W14	Pulse command and homing conflict
15		WRN W15	Absolute encoder battery warning
16		WRN W16	Wrong absolute position
17		WRN W17	MECHATROLINK communication warning
18		WRN W18	Absolute encoder position overflow
19		WRN W19	Serial encoder communication warning

Note:

(1) For D1-N firmware version 0.808, D1-N CoE firmware version 0.513 and previous version, the LCD display shows the abbreviations of error message and warning message.

(2) For D1-N firmware version 0.809, D1-N CoE firmware version 0.514 and later version, the LCD display shows error code and warning code.

8. Protection function

8.1 Motion protection

Motion protection limits or specifies the maximum speed, maximum acceleration, maximum deceleration and deceleration of emergency stop of motor. 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.

Table 8.1.1

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 the parameter supports motion protection function. "X" means the parameter does not support motion protection function.

(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.

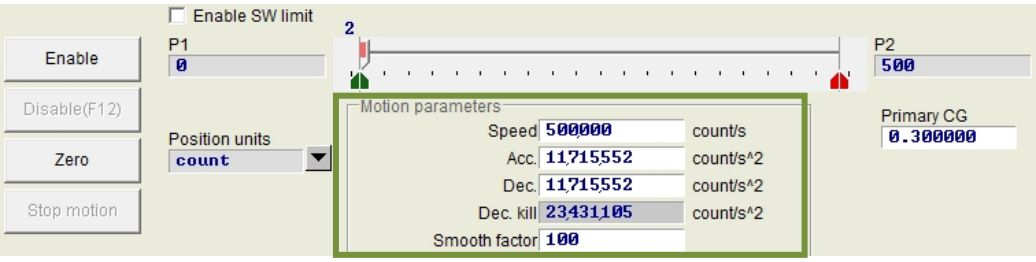


Figure 8.1.1

Table 8.1.2

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_f × I_p / 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_f × I_p / 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 × Acc. Torque motor: 2 × Acc.
Smooth factor	Smooth factor	Linear motor: 100 Torque motor: 100

Note:

(1) [*1]The maximum default setting of **Acc.** and **Dec.** of linear motor is 2 G.

(2) [*2]J_m is the moment of inertia obtained from inertia estimation.

As figure 8.1.1, the maximum speed, maximum acceleration and maximum deceleration of motion can be set in the setting area of **Motion parameters**. Users can select preferred unit from the drop-down list of **Position units**. These settings are used for test run.

Click on to go to Protection center. Motion protection parameters, including **Speed**, **Acc.**, **Dec.** and **Dec. kill** can be set in the setting area of **Motion protection** in **Protection** tab. When the setting values in **Motion parameters** exceed the setting values in **Motion protection**, the setting values in **Motion parameters** will be automatically replaced by the ones in **Motion protection** during operation. In position mode or velocity mode, multiply the setting values of **Acc.** and **Dec.** by 10 so the performance will not be limited by motion protection function. If not, the performance could be limited.

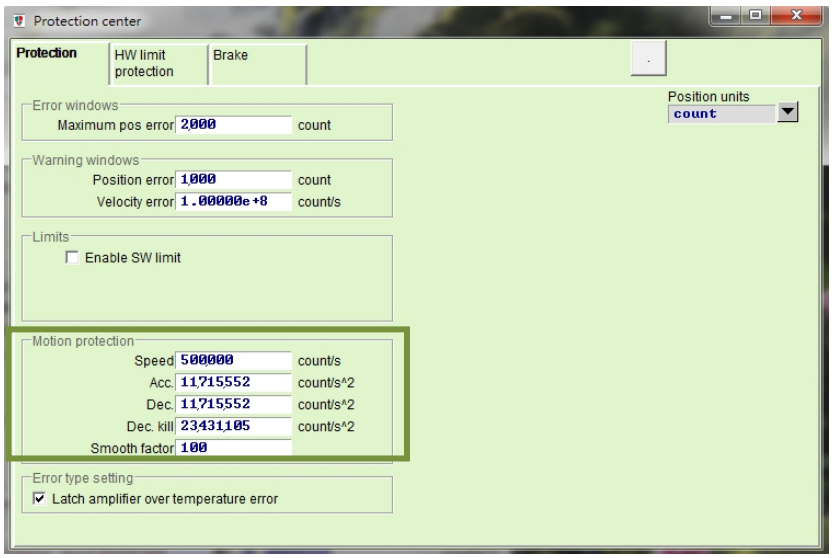


Figure 8.1.2

(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. Users 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. When performing P2P or Relative move in Performance center, **Stop motion** button is clicked on.
C. The deceleration after home position is found
D. The deceleration when jog stops.

Deceleration of emergency stop (Dec. kill) is used when high deceleration is required. It is suggested to use the maximum allowable value of motor to calculate deceleration of emergency stop (Dec. kill). The formula is as below.

Instantaneous current = min (Instantaneous current of motor, instantaneous current of servo drive)

- Linear motion: Dec. kill = (Instantaneous current × Force constant)/Total mass of object to be moved
- Rotary motion: Dec. kill = (Instantaneous current × Torque constant)/Load inertia

(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 is 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.

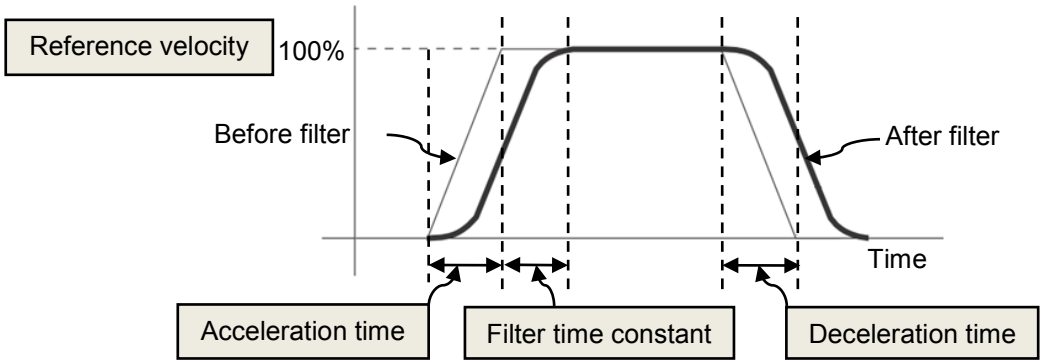


Figure 8.1.3

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-N servo drive allows users 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 windows is shown in figure 8.2.1.1.

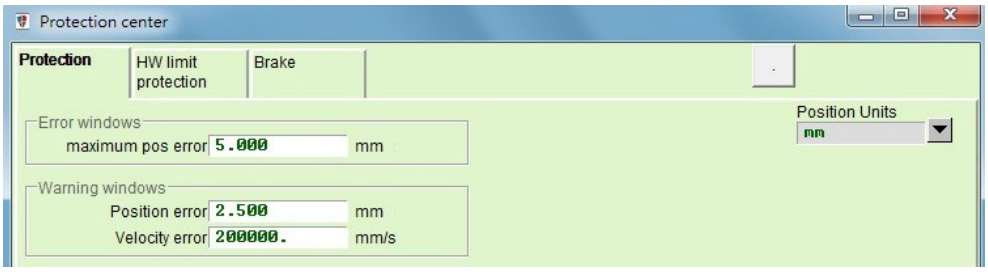


Figure 8.2.1.1

Table 8.2.1.1

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

When using models which support dual loop control, users are allowed to set hybrid deviation error in **Protection** tab of Protection center to prevent excessive error from causing unstable velocity loop or position loop. When error exceeds the setting value of hybrid deviation error, error “Hybrid deviation too big” occurs. If dual loop control is not used, the field of **Hybrid deviation error** is greyed out and cannot be set.

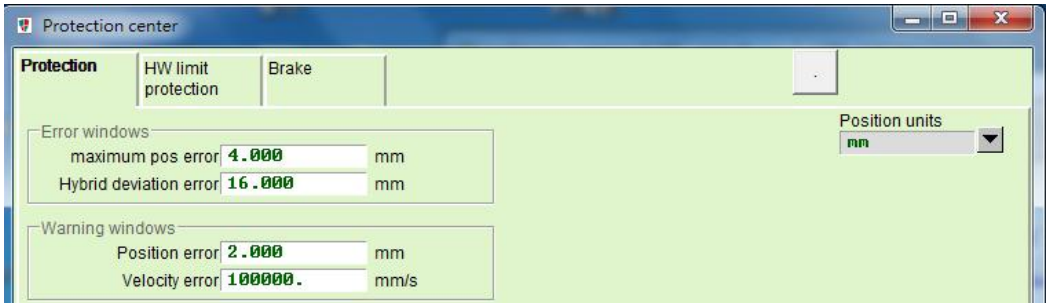


Figure 8.2.1.2

8.2.2 Position error warning and velocity error warning

In addition to the position error limit described in section 8.2.1, D1-N 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 Lightening to inform users.

8.3 Brake protection

D1-N 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-N 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 timing diagram of brake engagement. Click on **Set…** button to open the setting window of I/O center 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.

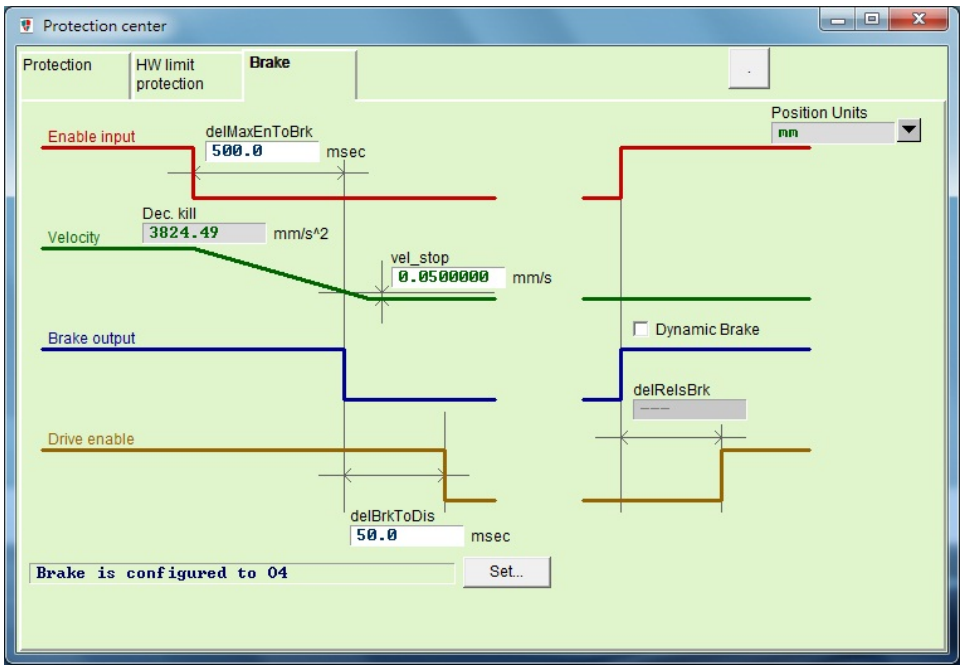


Figure 8.3.1

Table 8.3.1

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, the motor needs to reach this velocity for brake to engage.
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, when dynamic brake is connected, check the checkbox of **Dynamic Brake** and set proper delay time for relay.

8.4 Limit protection

8.4.1 Hardware limit protection

D1-N servo drive supports hardware limit protection. Hardware limit usually means the photoelectric switch or micro switch installed on positioning platform to specify 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 **Set…** button 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.

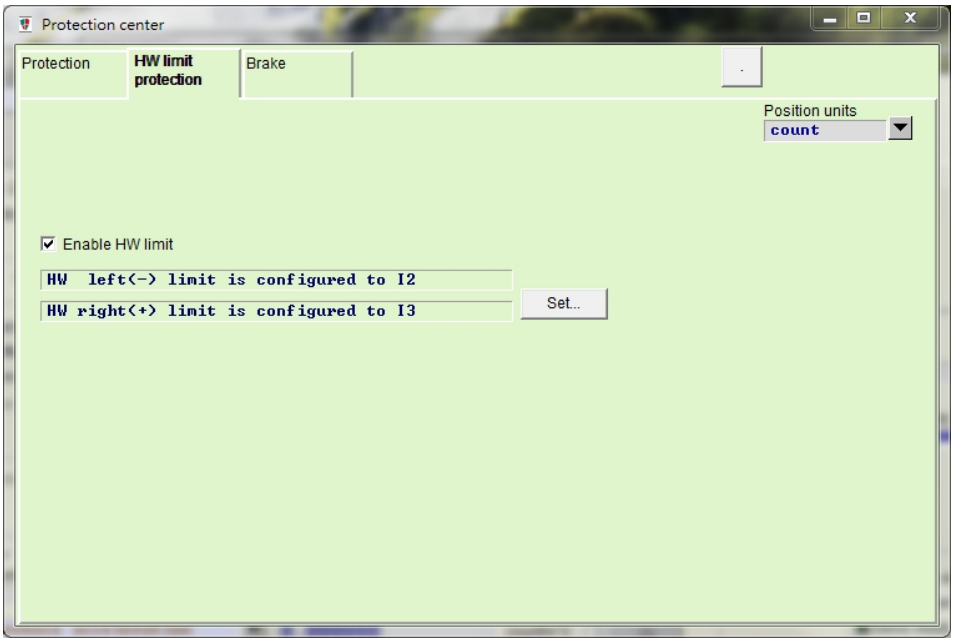


Figure 8.4.1.1

8.4.2 Software limit protection

In addition to hardware limit protection, D1-N 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.

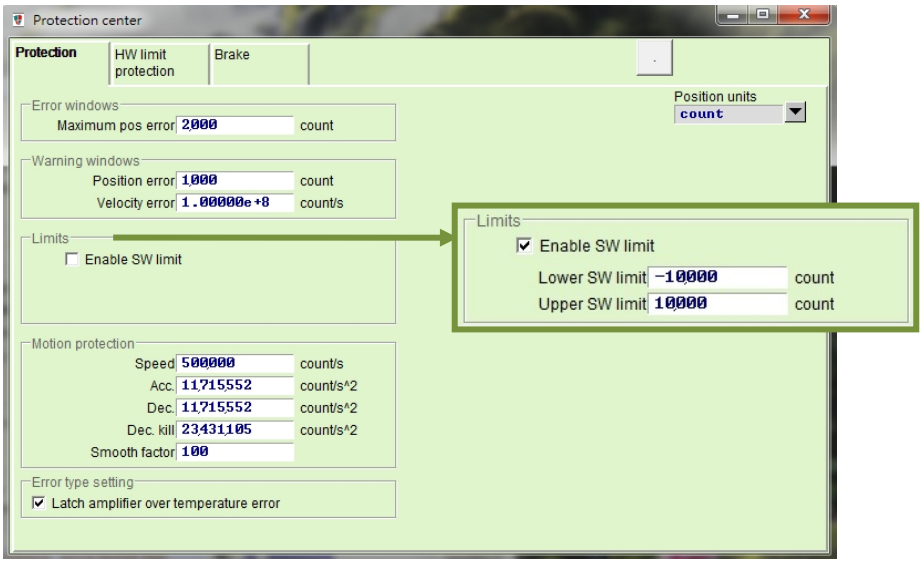


Figure 8.4.2.1

Table 8.4.2.1

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 temperature is too high. Over temperature signal can be connected to the servo drive to protect motor. The connector for motor over temperature protection is X9. 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-N servo drive also provides software over temperature protection for AC servo motor. The estimated temperature is obtained by evaluating the current output from the servo drive. If the estimated temperature reaches the threshold of 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-N servo drive is able to detect servo drive over temperature. When the temperature of the servo drive reaches 80 ^{o}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

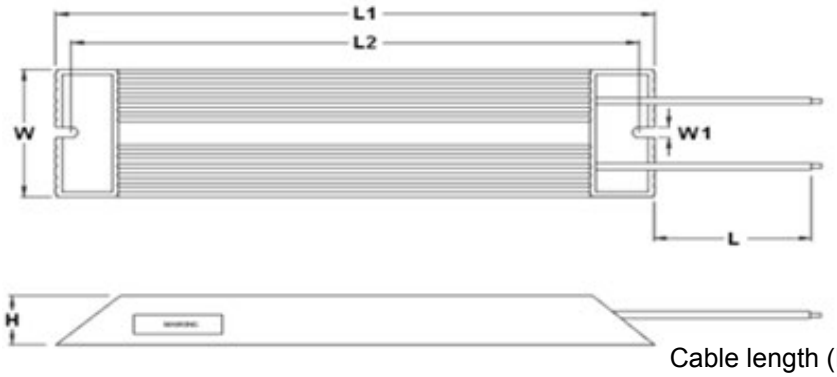
When motor decelerates, it generates energy. The energy returns to the capacitors of the servo drive. When the returned energy exceeds the capacity of the capacitors, regenerative resistor must be installed to protect the servo drive by absorbing the returned energy. For D1-N-09/18/36 servo drive, the voltage threshold for activating regenerative resistor is 390 Vdc; the voltage threshold for deactivating regenerative resistor is 380 Vdc. For D1-N-90 servo drive, the voltage threshold for activating regenerative resistor is 735 Vdc; the voltage threshold for deactivating regenerative resistor is 695 Vdc. Regenerative resistors used in HIWIN standard products are listed in table 8.6.1. Connect them parallelly or serially according to your need.

Table 8.6.1

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/1,500 W
RG3	050100700008	50 Ω	150 W/750 W
RG4	050100700019	50 Ω	600 W/3,000 W

Table 8.6.2

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



Cable length (L): 500 mm

Figure 8.6.1

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9. Errors and warnings

9.1 Error messages and warning messages

If an error occurs, D1-N 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**.

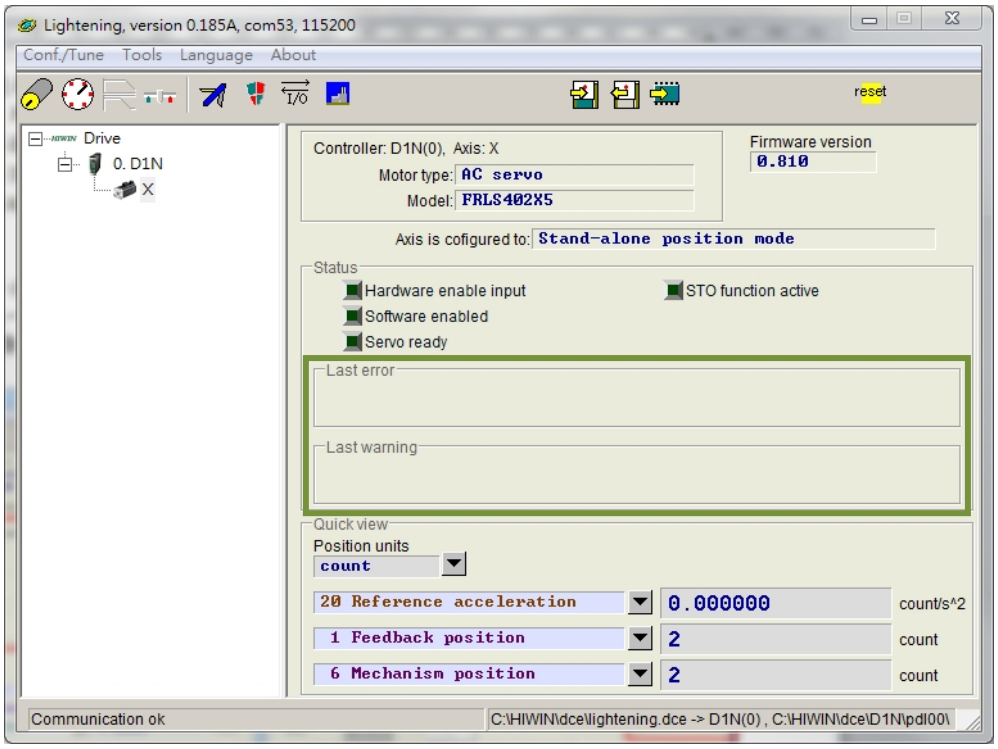

Figure 9.1.1

The errors of D1-N servo drive and their corrective actions are listed in table 9.1.1.

Table 9.1.1

No.	Error	LCD Error Code	Corrective Action
1	Motor short (over current) detected	E01 SHORT or ERR E01	Three-phase motor power is short-circuited.
			(1) Turn off the power of the servo drive and remove the connector of the UVW cable from the servo drive. Measure if there is short circuit between the UVW wires and ground. If short circuit is found, the motor could be burned out. (2) Measure if the line-to-line resistance between the UVW wires is close to the required specification. If the resistance is lower than the required specification, the motor could be burned out. (3) Remove the motor power cable from the motor, use multimeter to check if the motor power cable is short-circuited.
2	Over voltage detected	E02 OVERV or ERR E02	DC bus voltage exceeds the limit.
			If the motor is running with heavy load at high speed, the back EMF could exceed the voltage limit. Check if regenerative resistor is needed. Select regenerative resistor according to load and application.
3	Position error too big	E03 PEBIG or ERR E03	Position error is greater than the setting value of **Maximum pos error** for motion protection.
			(1) Check if the gain tuning is appropriate. (2) Check if the value of **Maximum pos error** is properly set in **Protection** tab of Application center. (3) Check if the motor is obstructed during motion. (4) Check if the load is too heavy. (5) Check if the guideway has not been maintained for a long time. (6) Check if the cable tray is too tight. (7) If warning “W05 SVBIG” continuously occurs before error E03, please change the power supply from 110 V to 220 V.
4	Encoder error	E04 ENCOD or ERR E04	Abnormal encoder signal or alarm pin reports an error.
			(1) Check if all the encoder connectors are firmly connected. (2) Check if the wiring of the encoder is correct. (3) If digital encoder is used, the error could be caused by external interference. Check if the encoder cable is made of anti-interference braided wires and shield. Or add on core.
5	Soft-thermal threshold reached	E05 SWHOT or ERR E05	Motor overload (Software detects motor over temperature.)
			(1) Check if the continuous current and instantaneous current of the motor is within its specification during operation. (2) Check if the motor is obstructed during motion. (3) Reset the servo drive and enable the motor again to clear this error. But if over current is caused by load or motion parameters, it could happen again. (4) Decrease speed, acceleration and deceleration. (5) Check if the motor model or motor current is correctly set.
6	Motor maybe disconnected	E06 UVWCN or ERR E06	Motor power cable and servo drive are not firmly connected.
			(1) Check if the connector of the UVW cable is firmly connected. (2) Check if the motor model is correctly set.
7	Amplifier over temperature	E07 D.HOT or ERR E07	Servo drive 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 has been used with heavy load or for a long operating time, check if heat sink is needed.

No.	Error	LCD Error Code	Corrective Action
8	Motor over temperature sensor activated	E08 M.HOT or ERR E08	Motor over temperature sensor is activated.
			(1) Check if the sensor is correctly connected and set. (2) Check if all the cables are properly grounded. Improper grounding could cause false operation of the sensor.
9	Under voltage detected	E09 UND.V or ERR E09	DC bus is too small.
			Check if the servo drive is connected to the specified AC main power via X1 connector. Use multimeter to check if AC main power is supplied.
10	5V for encoder card fail	E10 V5ERR or ERR E10	5 V voltage supplied to encoder interface card is abnormal.
			(1) Turn off the power of the servo drive. Check if encoder cable is abnormal. (2) Connect the connector of the encoder cable to the servo drive again.
11	Phase initialization error	E11 PHINI or ERR E11	Motor phase initialization fails.
			(1) Check if the UVW cable is connected. (2) Check if the encoder is abnormal or the motor parameters are correctly set. (3) Check if the following situation occurs: • The load is too heavy. • The motor friction is too high. • The motor is obstructed during motion.
12	Serial Encoder Communication Error	E12SER.E or ERR E12	Serial encoder communication error
			(1) Check if encoder cable is connected. (2) Check if the specifications of the encoder extension cable and motor are correct.
13	Hall sensor error	E13 HAL.E or ERR E13	Abnormal Hall sensor (torque motor or linear motor) or less-wire encoder (AC servo motor)
			(1) Check if the cable of the Hall sensor or encoder is correctly connected. (2) Check if the model of the encoder extension cable is correct.
14	Hall phase check error	E14PHERR or ERR E14	Error occurs when executing phase check by digital Hall sensor.
			Check the connection of Hall sensor cable.
15	Current control error	E15CURER or ERR E15	Abnormal current control
			(1) Check if the model of the motor is correctly set. (2) Check if the current loop gain (Kp) and common gain (CG) are properly set. (3) Check if the encoder extension cable is correctly connected.
17	Hybrid deviation too big	E17HYBDV or ERR E17	In dual loop control, the value set for **Hybrid deviation error** is exceeded.
			(1) Check if the parameters of the linear encoder are correctly set. (2) Check if the directions of the linear encoder and rotary encoder are the same or the linear encoder has the problem of signal interference. (3) Check if the following situation occurs: • The coupling is loose. • The gear does not closely engage. • The pitch tolerance or backlash of the screw is too large.
18	STO active	E18STO or ERR E18	STO safety function is triggered.
			Reconnect 24 V for STO safety function after the cause of triggering STO safety function is cleared. Connect DSF+ and DSF- for one second to reset.
19	HFLT inconsistent	E19HFLT	Hardware signal conflict of servo drive

No.	Error	LCD Error Code	Corrective Action
	error	or ERR E19	Check if all the cables are properly grounded.
20	Auto phase center not complete error	E20ATOPH or ERR E20	Phase initialization is not completed yet.
			Execute all the procedures in Auto phase center again.
22	DC bus voltage abnormal	E22BUS.E or ERR E22	DC bus voltage is abnormal.
			Check the input voltage.
23	EtherCAT interface is not detected	E23NOET or ERR E23	Servo drive does not detect EtherCAT interface or servo drive has no EtherCAT interface.
			(1) Turn off the power of the servo drive. Power on the servo drive to detect EtherCAT interface again. (2) The servo drive does not support EtherCAT. Check if the servo drive supports EtherCAT.
24	CiA-402 homing error	E24HOM.E or ERR E24	An error occurs when performing CiA-402 homing and causes homing failure.
			(1) Check if left limit, right limit, near home sensor and index signal are normal. (2) Check if the selected homing method is appropriate.

The warnings of D1-N servo drive and their corrective actions are listed in table 9.1.2.

Table 9.1.2

No.	Error	LCD Warning Code	Corrective Action
1	Left SW limit	WRN W01	The left software limit is reached. The motor cannot move leftward.
2	Right SW limit	WRN W02	The right software limit is reached. The motor cannot move rightward.
3	Left HW limit	WRN W03	Left hardware limit is triggered. The motor cannot move leftward.
			(1) If no hardware limit exists, please disable the function of hardware limit. (2) If it is a false trigger, please check if the wiring or logic setting is correct.
4	Right HW limit	WRN W04	Right hardware limit is triggered. The motor cannot move rightward.
			(1) If no hardware limit exists, please disable the function of hardware limit. (2) If it is a false trigger, please check if the wiring or logic setting is correct.
5	Servo voltage big	WRN W05	The PWM output switch is greater than the limit value. The current output cannot be increased anymore. If this warning continuously occurs in position control, error “E03 PEBIG” may occur.
			(1) Change power supply from 110 V to 220 V. (2) Decrease speed, acceleration or deceleration.
6	Position error warning	WRN W06	Position error is greater than the value set for warning.
			(1) Check if the servo gain is properly set. (2) Check if the warning threshold is set to be too small. (3) Check if the mechanism has been maintained regularly or the mechanism is lack of lubrication.
7	Velocity error warning	WRN W07	Velocity error is greater than the value set for warning.
			(1) Check if the servo gain is properly set. (2) Check if the warning threshold is set to be too small. (3) Check if the mechanism has been maintained regularly or the mechanism is lack of lubrication.

No.	Error	LCD Warning Code	Corrective Action
8	Current Limited	WRN W08	Current reaches the maximum instantaneous current of motor specification. Error "E05 SWHOT" may occur if this is not solved. Then motor will be disabled.
			(1) Decrease speed, acceleration or deceleration. (2) Reduce the load.
9	Acceleration Limited	WRN W09	In position mode or velocity mode, the value set for acceleration protection is reached.
			To increase acceleration, increase the value set for motion protection first.
10	Velocity Limited	WRN W10	In velocity mode or force/torque mode, the value set for speed protection is reached.
			To increase speed, increase the value set for motion protection first.
11	Both HW limits active	WRN W11	Both left and right hardware limits are triggered.
			(1) If no hardware limit exists, please disable the function of hardware limit. (2) If it is a false trigger, please check if the wiring or logic setting is correct.
12	I2T warning	WRN W12	The force of linear motor or torque motor exceeds the threshold of software over temperature protection. The servo drive forcibly decreases current output to avoid motor overheating.
			(1) Check if the load is too heavy. (2) Check if the motor is obstructed during motion. (3) Check if the motor model is correctly set.
13	Homing fail	WRN W13	Homing fails.
			(1) Check if left limit, right limit, near home sensor and index signal are normal. (2) Check if the values of **Time out** and **Search end stop current** are properly set.
14	Pulse command and homing conflict	WRN W14	In position mode, pulse command and homing command are both received.
			Do not send pulse command and execute homing at the same time.
15	Absolute encoder battery warning	WRN W15	The battery of the encoder has no power.
			Replace the battery.
16	Wrong absolute position	WRN W16	The absolute position received from the absolute encoder is incorrect.
			Set home position again.
17	MECHATROLINK Communication Warning	WRN W17	MECHATROLINK communication warning
			Check if the communication cable is correctly connected.
18	Absolute encoder position overflow	WRN W18	Absolute encoder feedback position overflow
			Let the motor move in the opposite direction.
19	Serial encoder communication warning	WRM W19	Serial encoder communication warning
			Check if the connection of the encoder cable is poor.

9.2 Error and warning log

When D1-N 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 users 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.

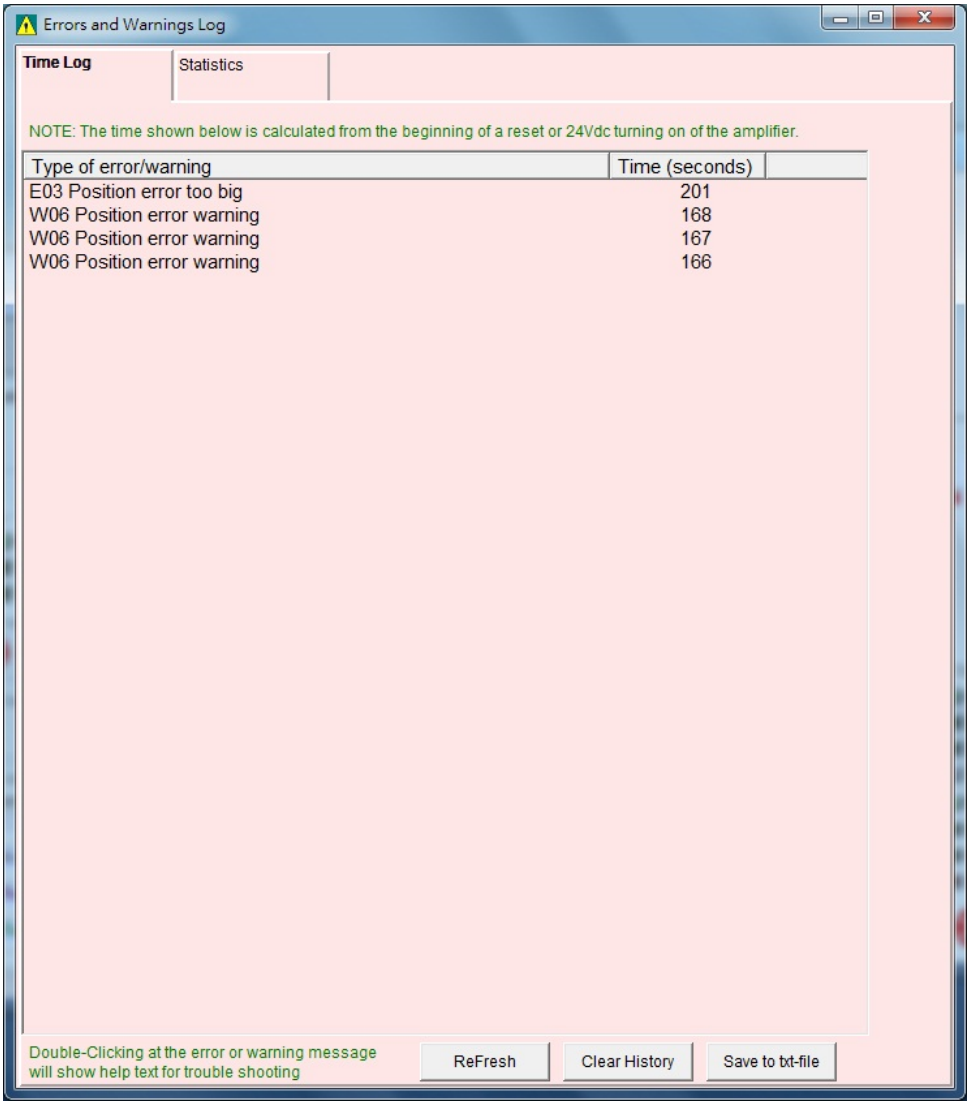

Figure 9.2.1

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

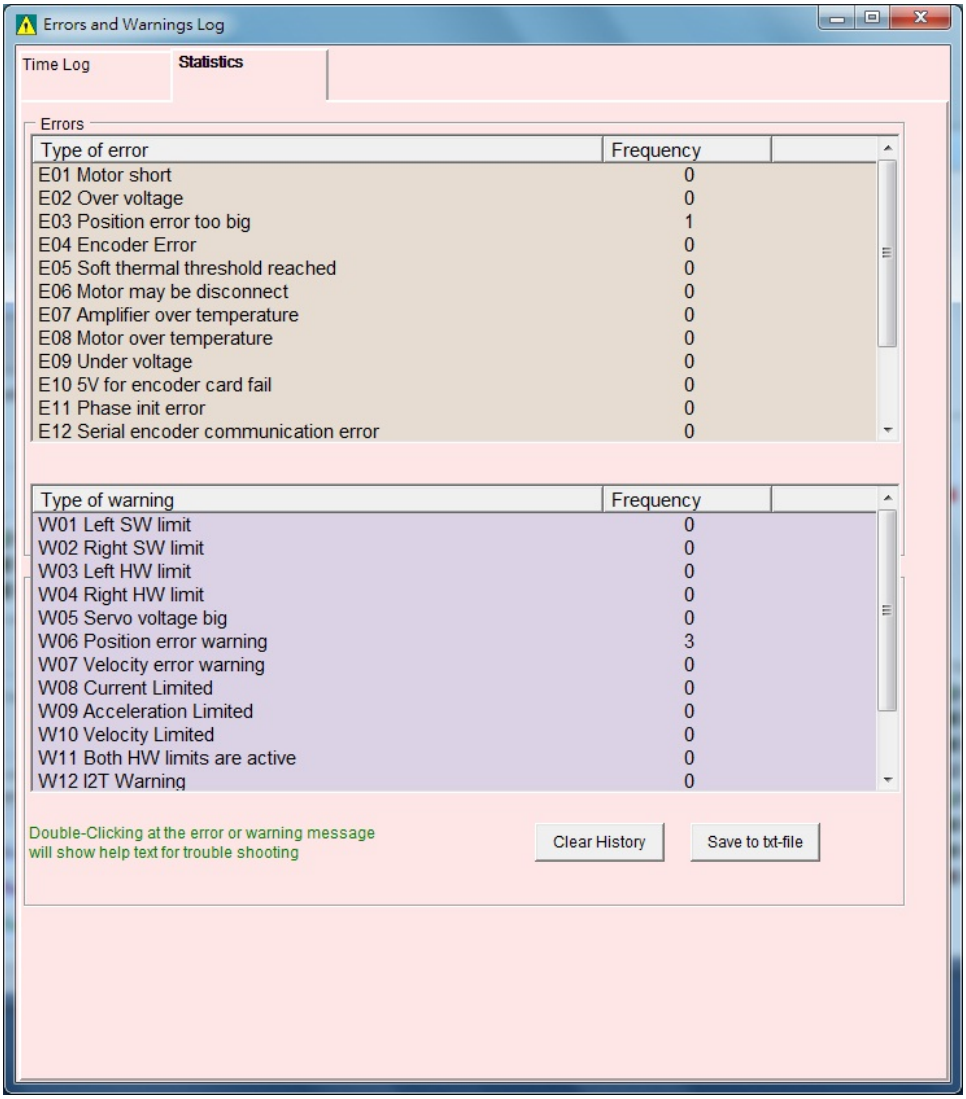

Figure 9.2.2

Besides, users 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.

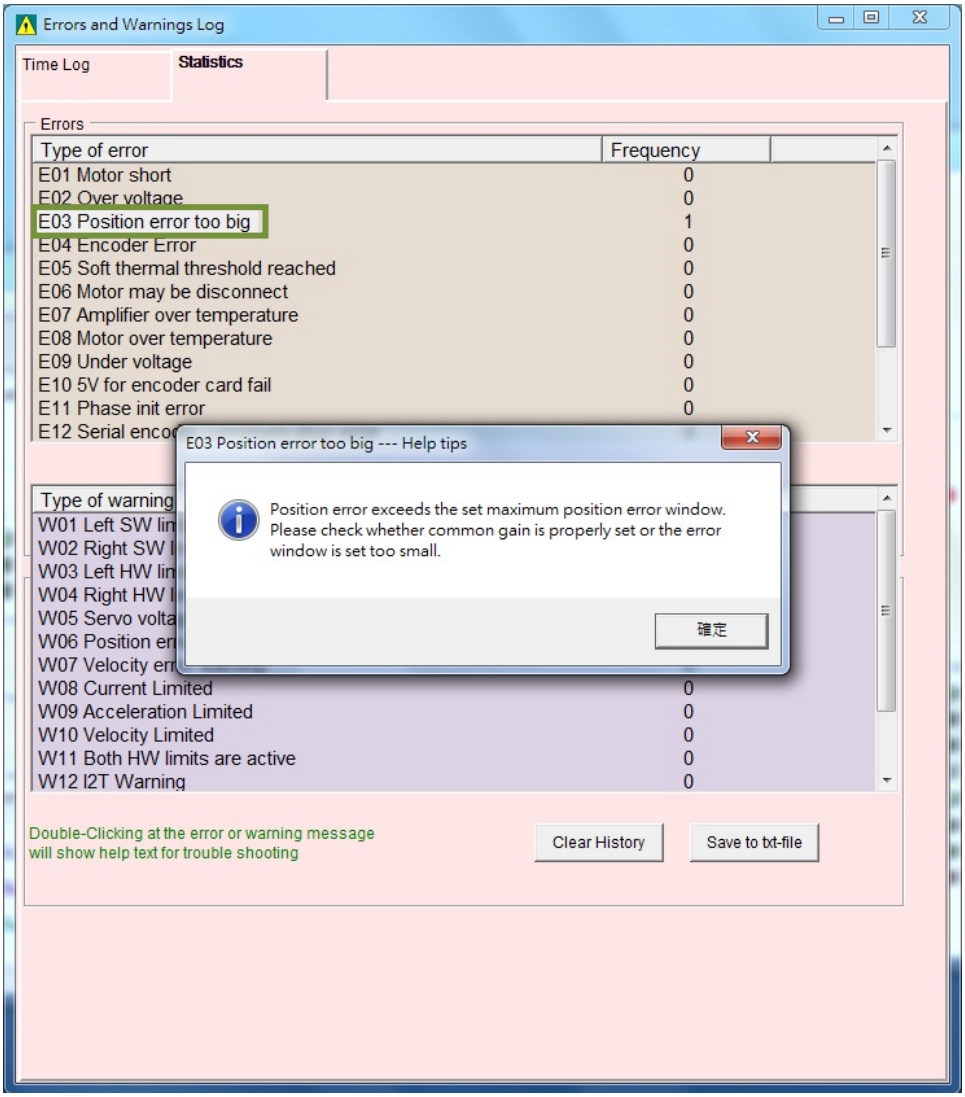
Errors and Warnings Log
Time Log
Statistics
Errors
Type of error
Frequency
E01 Motor short 0
E02 Over voltage 0
E03 Position error too big 1
E04 Encoder Error 0
E05 Soft thermal threshold reached 0
E06 Motor may be disconnect 0
E07 Amplifier over temperature 0
E08 Motor over temperature 0
E09 Under voltage 0
E10 5V for encoder card fail 0
E11 Phase init error 0
E03 Position error too big --- Help tips
Position error exceeds the set maximum position error window.
Please check whether common gain is properly set or the error window is set too small.
確定
Type of warning
W08 Current Limited 0
W09 Acceleration Limited 0
W10 Velocity Limited 0
W11 Both HW limits are active 0
W12 I2T Warning 0
Double-Clicking at the error or warning message will show help text for trouble shooting
Clear History
Save to txt-file

Figure 9.2.3

9.3 Automatic error handling

D1-N servo drive is able to report error and warning in Lightening. Normally when an error occurs, users need to perform troubleshooting and then clear the error in Lightening. For convenience and efficiency, Lightening provides an automatic error handling function. Users can choose whether to enable this function on error “Amplifier over temperature”.

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

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

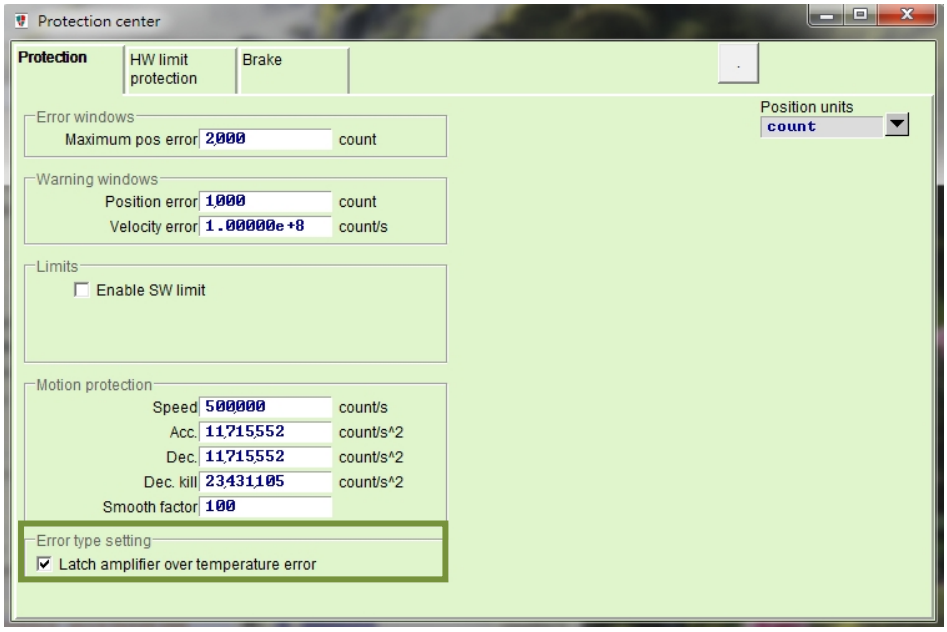

Figure 9.3.1

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** to enable automatic error handling function.

9.4 Troubleshooting

9.4.1 Status indicator

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

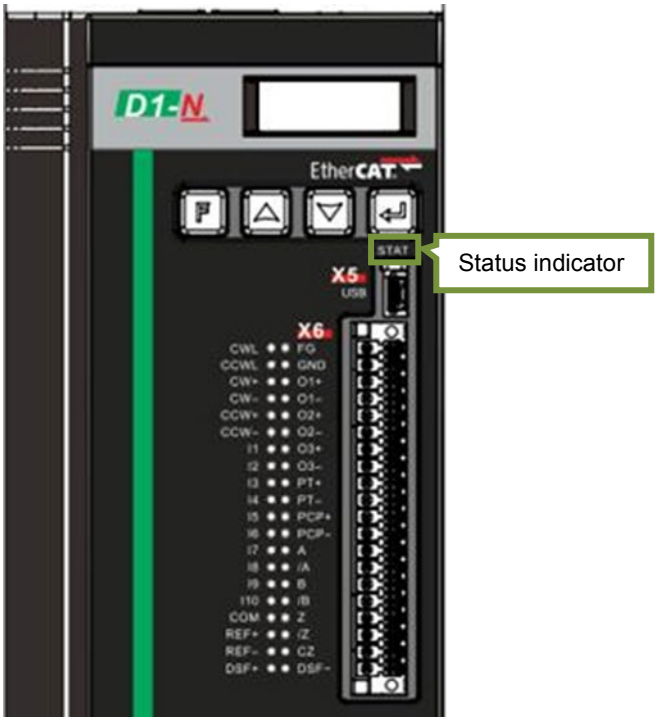

Figure 9.4.1.1

Table 9.4.1.1

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.

Table 9.4.1.2 EtherCAT model

Indicator	Servo Drive Status
No status	Initialization (Int)
Blinking green (200 ms interval)	Pre-Operational (Pre-OP)
Blinking green (1000 ms interval)	Safe-Operational (Safe-OP)
Solid green	Operational (OP)
Blinking red (200 ms and 1000 intervals)	Watchdog Timer (WDT) Timeout
Blinking red (1000 ms interval)	Synchronization Error
Blinking red (200 ms interval)	Communication Setting Error

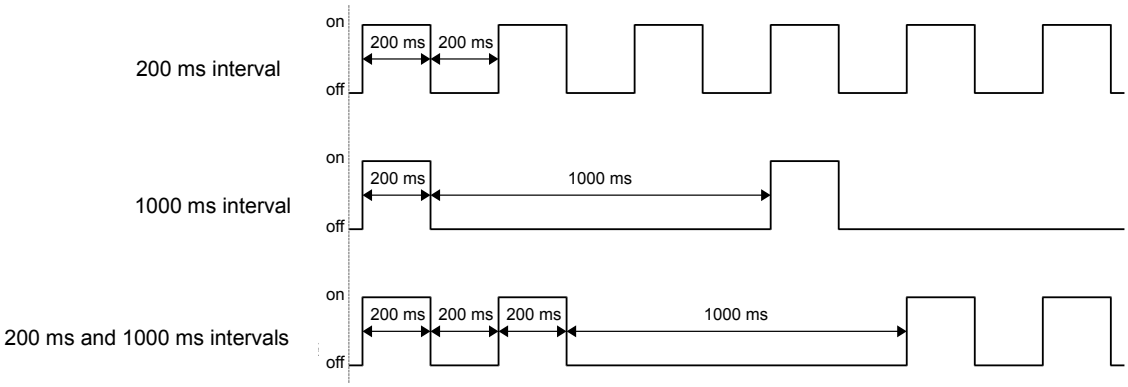

Figure9.4.1.2

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 when sending pulse command or voltage command. (2) The controller already finishes sending pulse command, but the motor is still moving to the target position slowly.	Velocity limited /Acceleration limited	Check if the speed, acceleration and deceleration set for motion protection in Protection center are too small.
2	The moving direction of the 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 the motor. Check the checkbox of **Invert** to invert command.
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	The 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	The motor does not move after command is sent from the controller.	-	(1) Check if the command unit is correct. (2) Check if the speed or acceleration is 0 or not. (3) Check if software limit is 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 the 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	The motor does not move after analog voltage command (V command) is sent from the 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	The motor moves with a loud noise.	-	(1) Decrease the common gain (CG). (2) Set filters in **Filter** tab of **Advanced gains** window.

No.	Description	Error Message	Corrective Action
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 has been used for a long period of time, check if heat sink is needed.
10	The signal of position feedback sensor (reader) is abnormal.	Encoder error	(1) When 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) When 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 the analog reader is not moving, check if the sine wave signal of analog reader is too small. (6) Check if the servo drive and machine are grounded, and the shield is grounded.
11	The motor (forcer) is overheating.	Motor over temperature sensor activated	(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	(1) Check if the servo drive is connected to AC main power 240 Vac. (2) Use multimeter to check if AC main power 240 Vac is supplied.
13	DC bus voltage is too large.	Over voltage detected	(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 according to your load and motion conditions. (3) Check if the load is too heavy. (4) Check if the speed is too high.

No.	Description	Error Message	Corrective Action
14	The position error is greater than the value set for **maximum pos error**.	Position error too big	(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	(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. (4) Check if the motor power cable is too old.
16	The equivalent current that the drive outputs exceeds the maximum continuous current of the 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 required current for the acceleration command of path planning is greater than the rated current of the motor. (3) Check if the motor is obstructed during motion. (4) Reset the 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 drive.	-	Check if transmission rate (BPS) and communication port (Port) are correctly set.
18	Controller receives incorrect position information when using emulated encoder function.	-	When saving parameters ( ) to drive Flash, the emulated encoder function is not available. Therefore, the position information sent to the controller during this time could be incorrect.
19	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.
20	Error “Hall sensor error” occurs when using digital Hall sensor.	Hall sensor error	(1) 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. (2) If the value does not change, check if the encoder cable is correctly connected. (3) If the encoder cable is correctly connected, please replace it with another encoder cable. (4) If the above method does not work, please replace the servo drive. (5) If the above methods cannot clear this error, the digital Hall sensor could be broken, please replace the digital Hall sensor.

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10. Advanced frequency analysis

10.1 Advanced frequency analysis

Frequency analyzer is used for advanced frequency analysis when the values of vpg 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 vpg and st_vpg according to the application. With frequency response figure, users are 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 **Freq analyzer** button to open frequency analyzer.

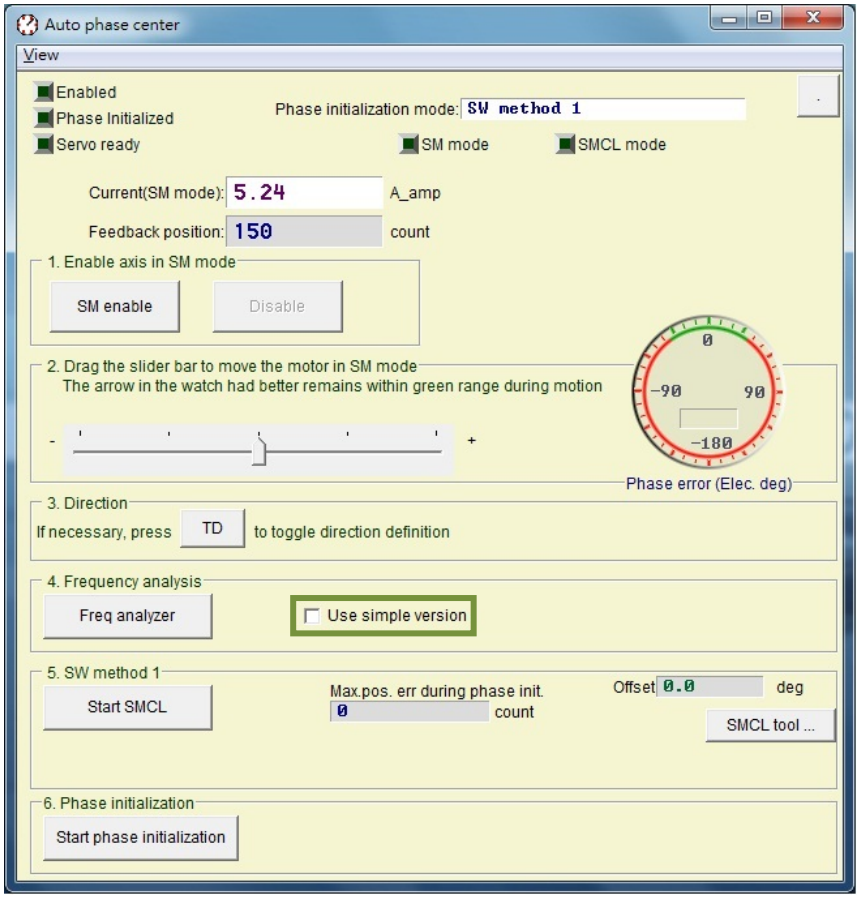


Figure 10.1.1

10.2 Frequency analyzer

When frequency analyzer is opened, its default mode is “Stepper/Dcbl plant”. Click on **Run** button to measure frequency. It is normal to have sound or vibration when 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** button to send these parameters to the servo drive. To save the parameters to the drive Flash, click on in the main window of Lightening.

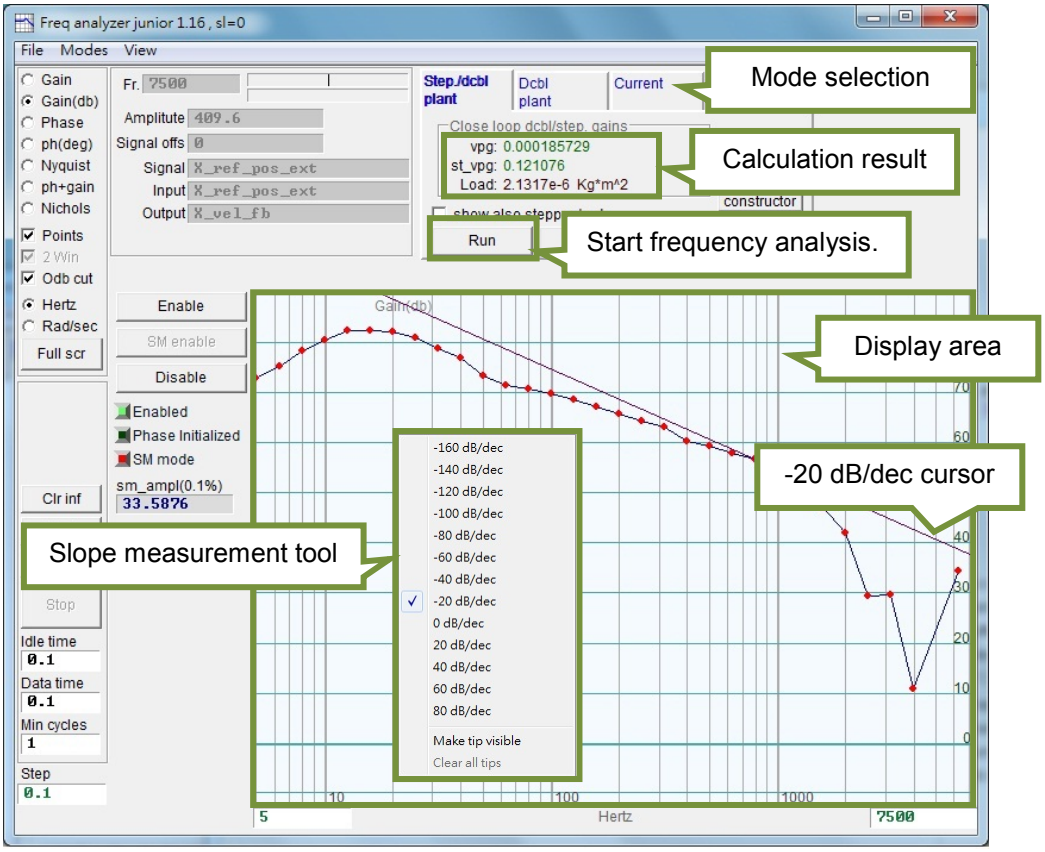


Figure10.2.1

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.

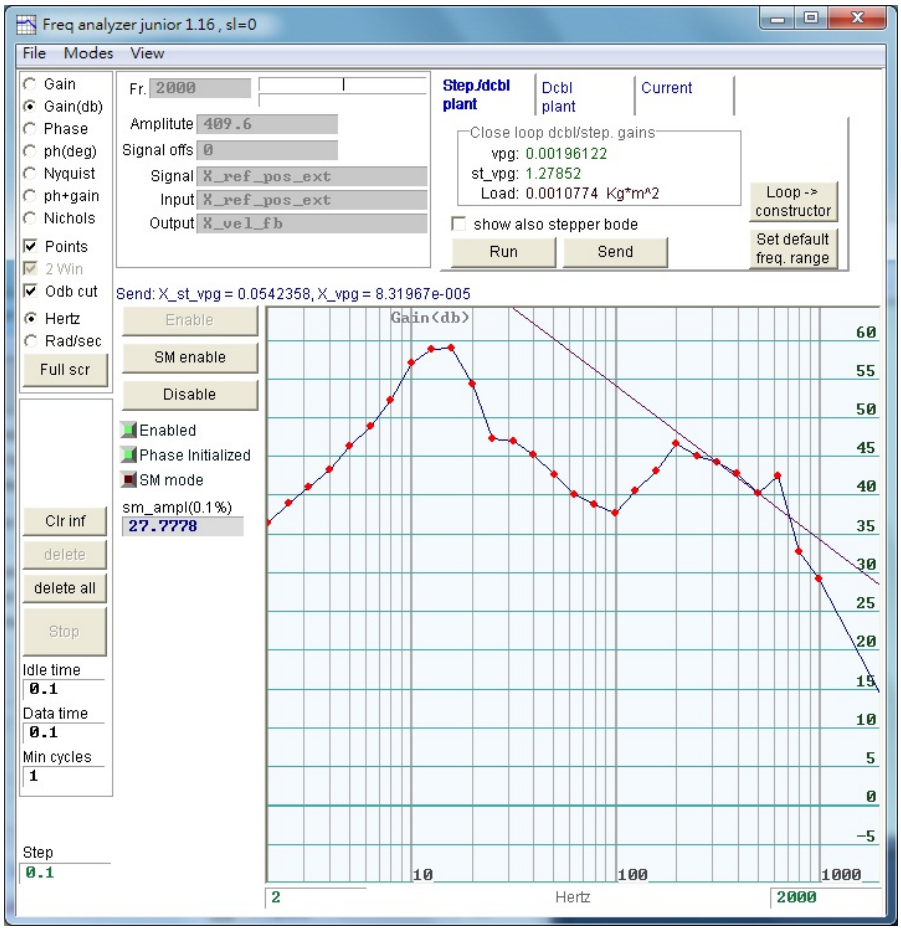


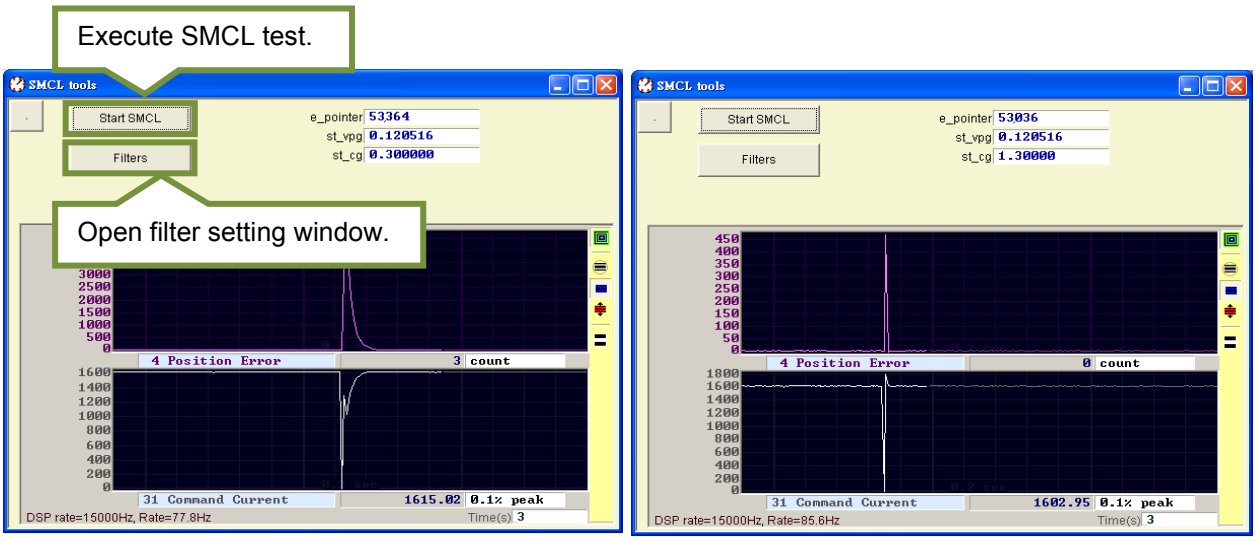
Figure10.2.2

10.3 SMCL tools

When SW method 1 is selected for phase initialization mode, use SMCL tools to adjust st_cg to minimize the movement when performing phase initialization. Click on **SMCL tool** button in figure 10.1.1 to open SMCL tools, as figure 10.3.1. 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.



St_cg=0.3, movement 4500 count St_cg=1.3, movement 450 count

Figure10.3.1

■ 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, screw 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. Users may use the filters according to their requirements. For how to set filters, please refer to section 6.6.1.

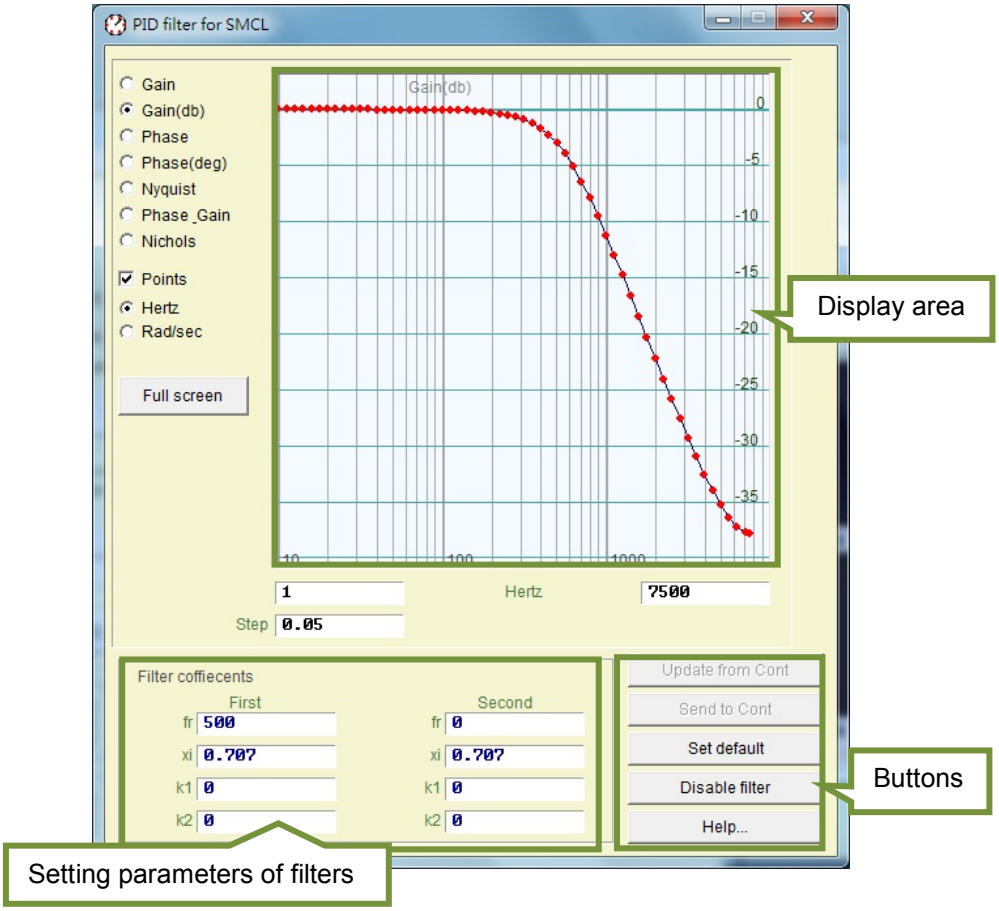


Figure10.3.2

11. Enabling motor

11.1 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 11.1.1.

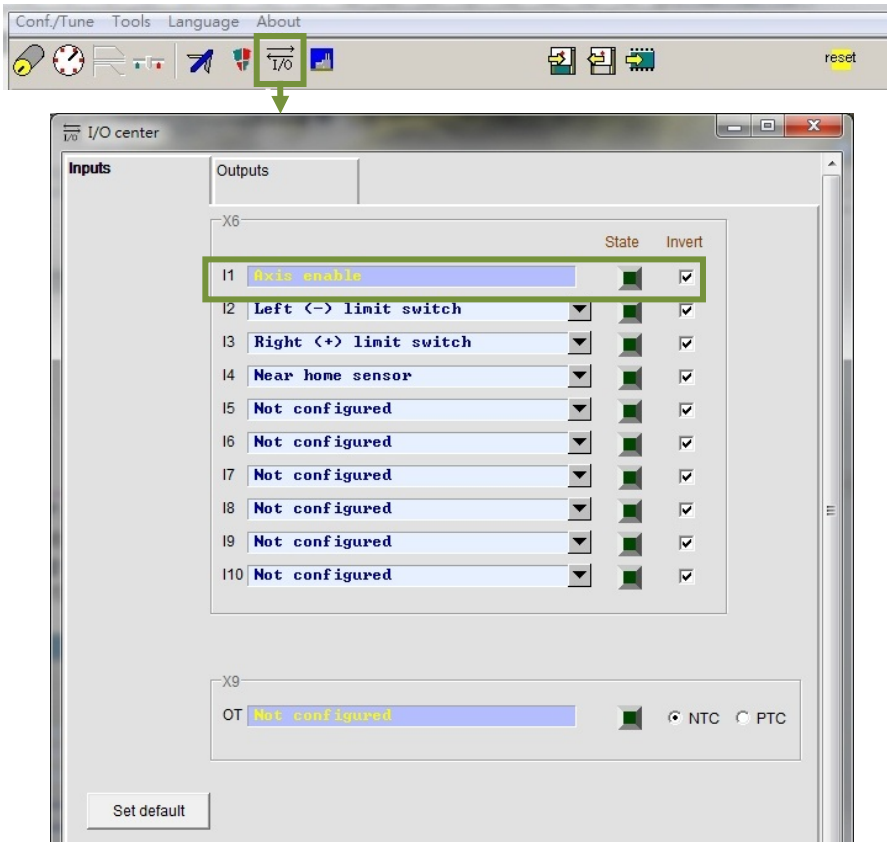


Figure11.1.1

■ 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 11.1.1. 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.

11.2 Checking enabling state from Lightening

When **Hardware enable input** indicator in Lightening becomes green, it means enabling signal is received from controller, as figure 11.2.1.

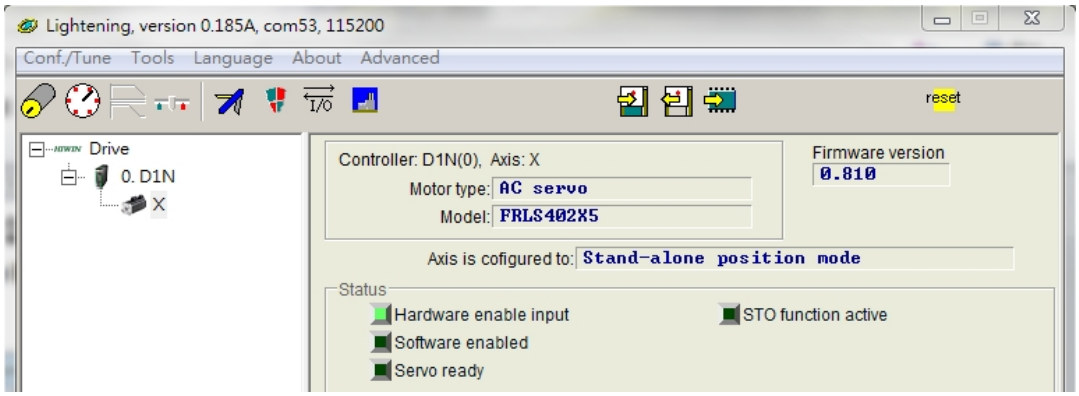


Figure11.2.1

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

(1) When Lightening is an active window, pressing **F12** key can disable the motor. This is usually used for emergency.

(2) Click on **Disable** 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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12. Parameter comparison

12.1 Comparing the parameters in RAM and Flash

When motor parameters are modified but have not been saved to the Flash, **Compare parameters RAM to FLASH** window appears as users are closing Lightening or saving error map parameters to the Flash (Refer to section 6.9.1.), as figure 12.1.1. This window is to remind users that parameters are modified but have not been saved to the Flash.

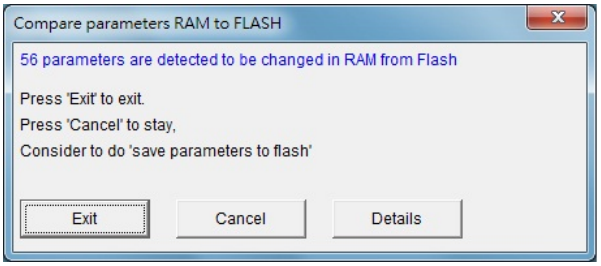

Figure 12.1.1Compare parameters RAM to FLASH window

Click on **Details** button to do further comparison. Users are 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 the **Flash value** column.

(1) =: The value saved in the Flash is the same as the one in the RAM.

(2) ＊＊: Users undid the parameter before. The value in the RAM is changed to the one saved in the Flash.

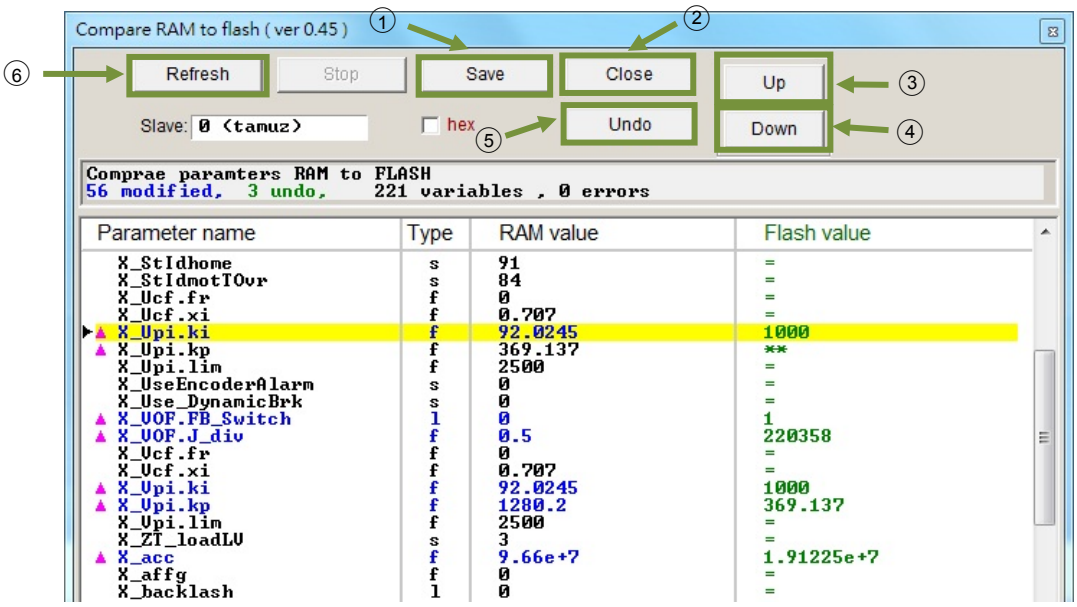

Figure 12.1.2**Compare RAM to flash** window

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

① Save: Save parameter to the drive Flash

② Close: Close the window.

③ Up: Go to the previous parameter which has different settings in the RAM and Flash.

④ Down: Go to the next parameter which has different settings in the RAM and Flash.

⑤ Undo: Change the value of the selected parameter. Its value in the RAM is changed to the one saved in the Flash.

⑥ Refresh: Compare the parameters in the RAM and Flash again.

⑦ Redo：Cancel Undo of the selected parameter.

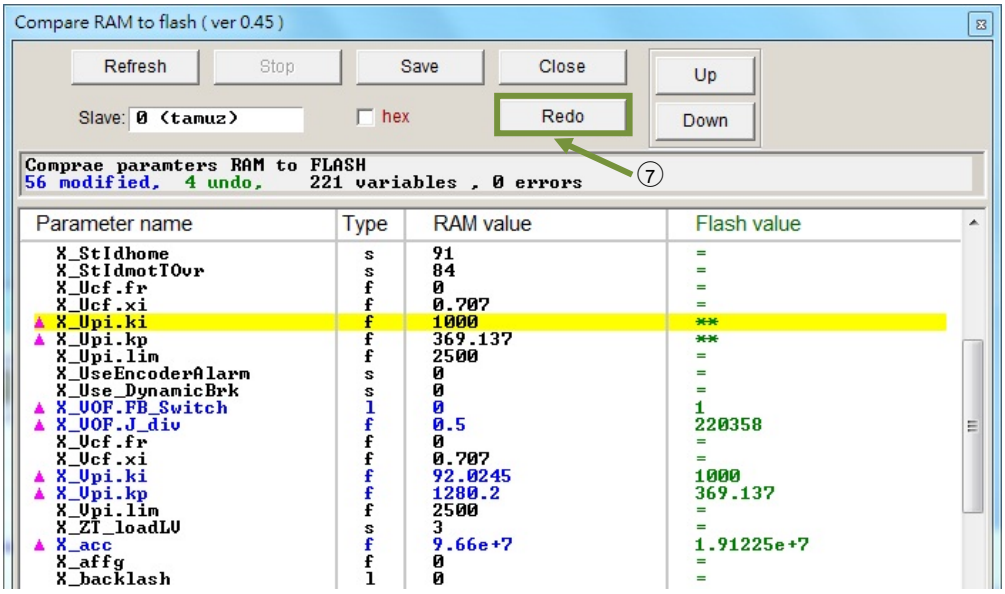

Figure 12.1.3**Compare RAM to flash** window

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13. Updating firmware and loading PDL

13.1 Updating servo drive firmware

To update the firmware of the servo drive, click on **Tools** in the main window of Lightening. Select **Upgrade/downgrade firmware** from the submenu, as figure 13.1.1. Then window in figure 13.1.2 appears.

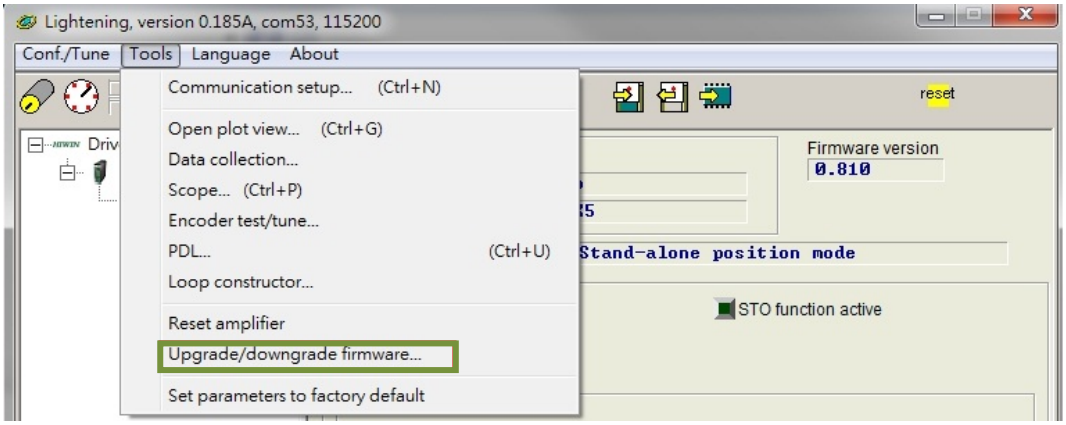

Figure13.1.1

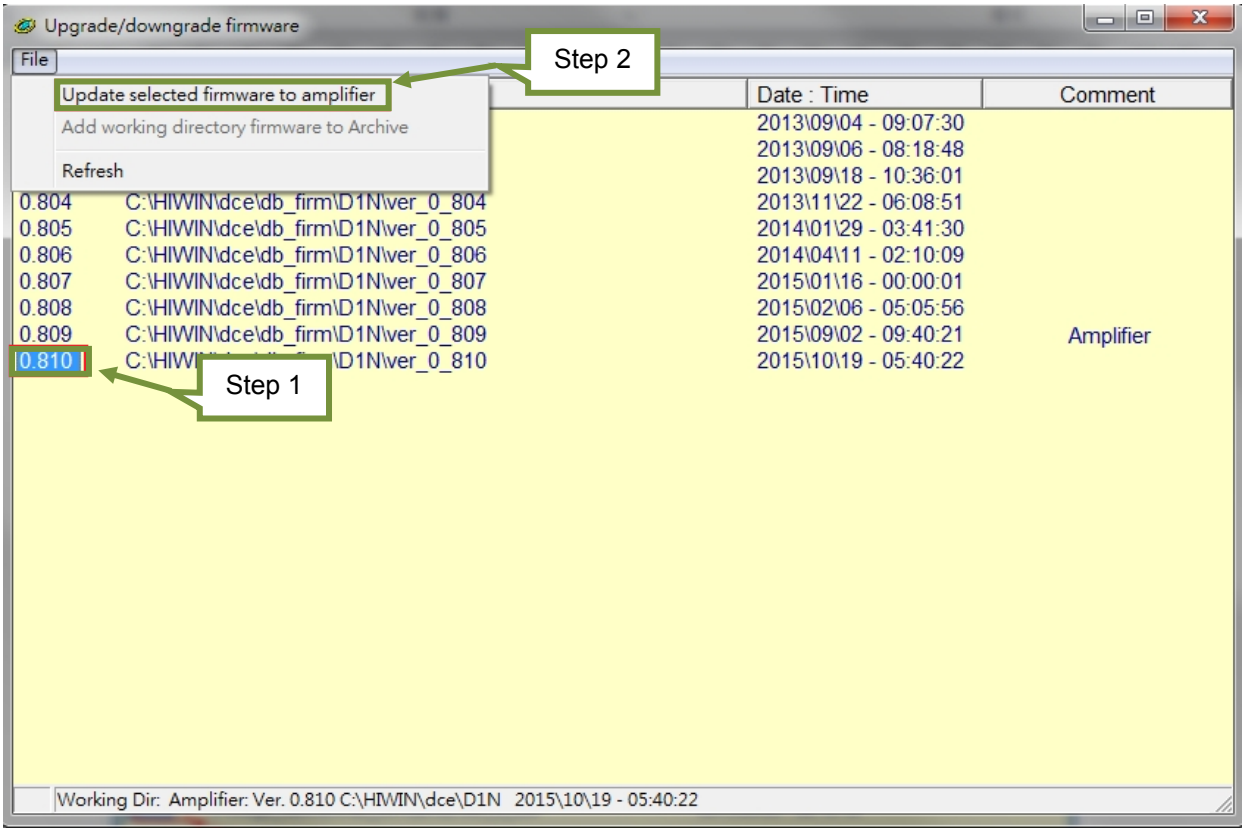

Figure13.1.2 **Upgrade/downgrade firmware** window

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 13.1.3 appears.

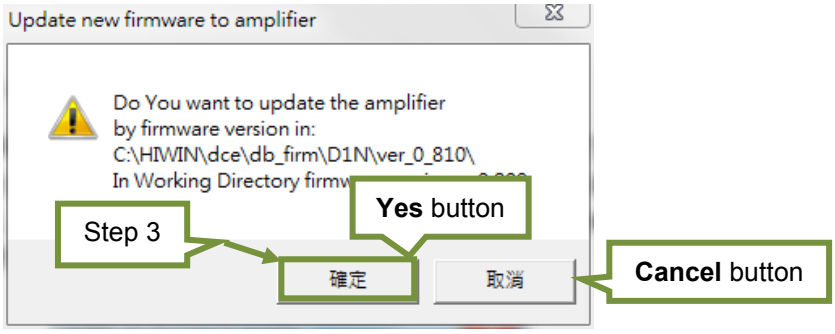

Figure13.1.3

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

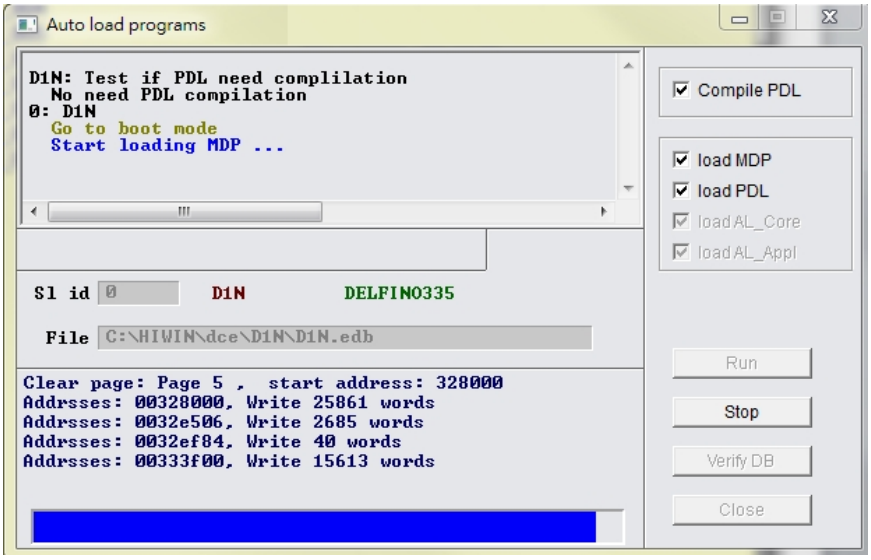

Figure13.1.4

Step 4: After the firmware is updated, a window shown as figure 13.1.5 appears. Click on **Yes** button.

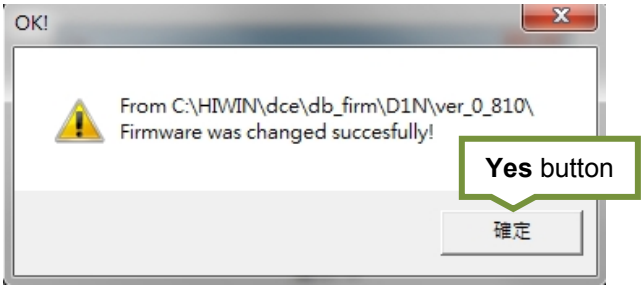

Figure13.1.5

Note:

If power failure or communication interruption occurs during firmware update, Lightening stays in “Boot mode” and cannot be changed after power is supplied again or communication cable is reconnected, as figure 13.1.6. If this occurs, please contact local distributor.

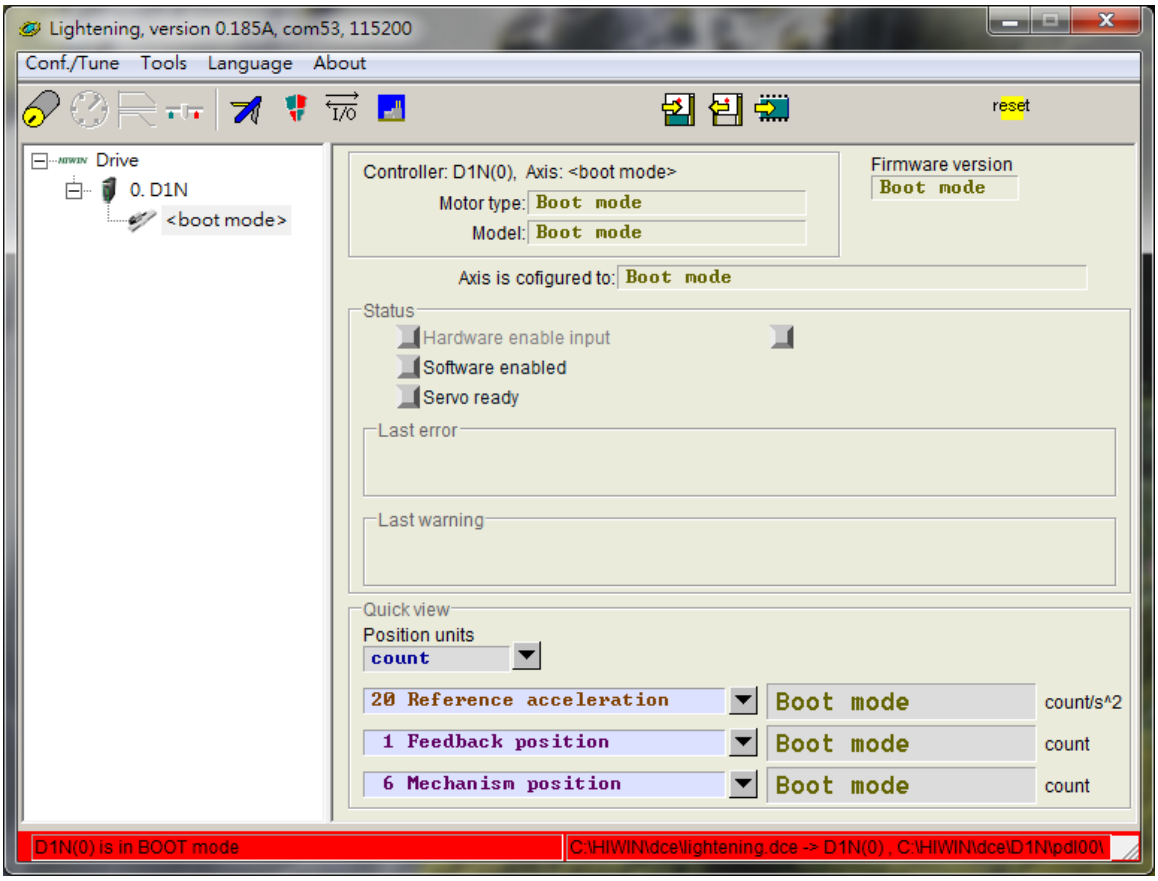

Figure13.1.6

13.2 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.

Step 1: To open **PDL** window, click on the icon ( ) indicated in figure 13.2.1.

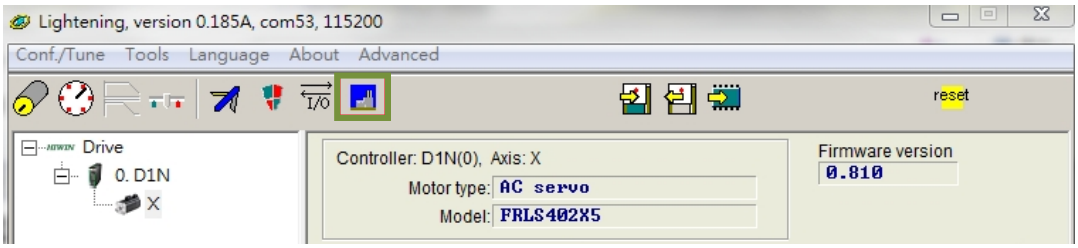

Figure13.2.1

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

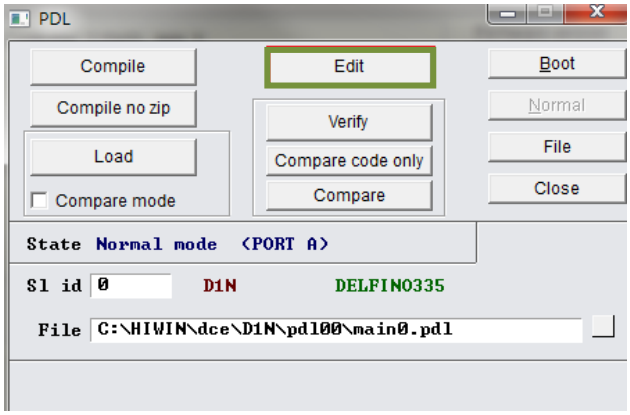

Figure13.2.2

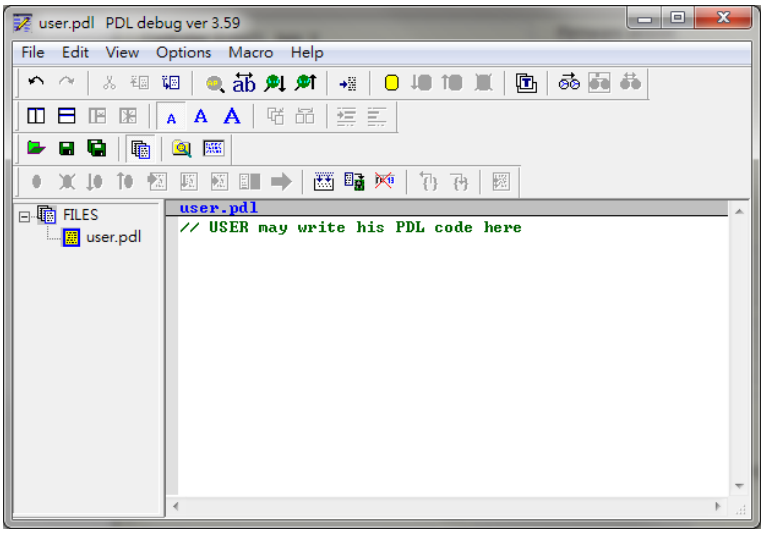

Figure13.2.3

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

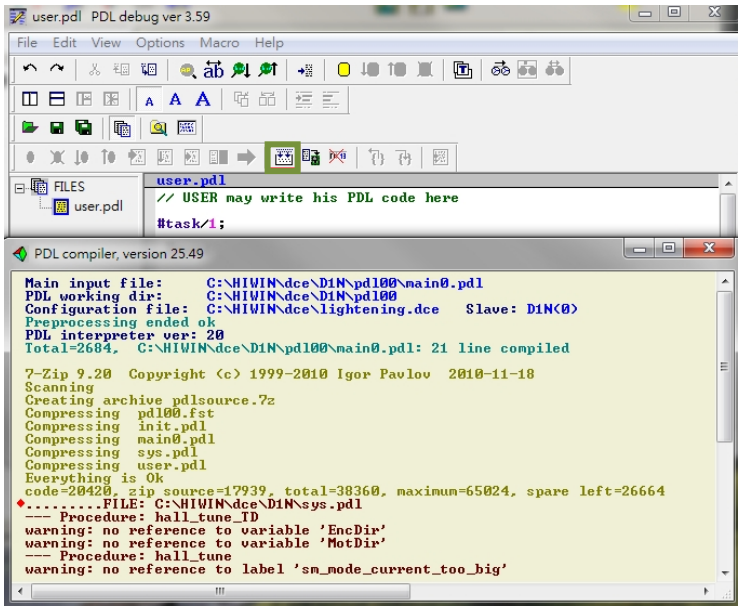

Figure13.2.4

Step 4: Click on (Send to slave) after compilation finishes. Click on **Yes** button when the dialog shown in figure 13.2.5 appears. Then a window with progress bar appears and closes as PDL program is loaded, as figure 13.2.6.

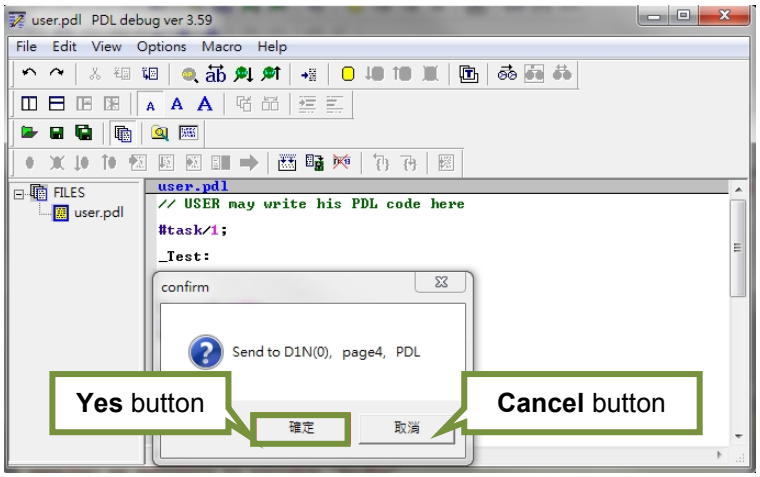

Figure13.2.5

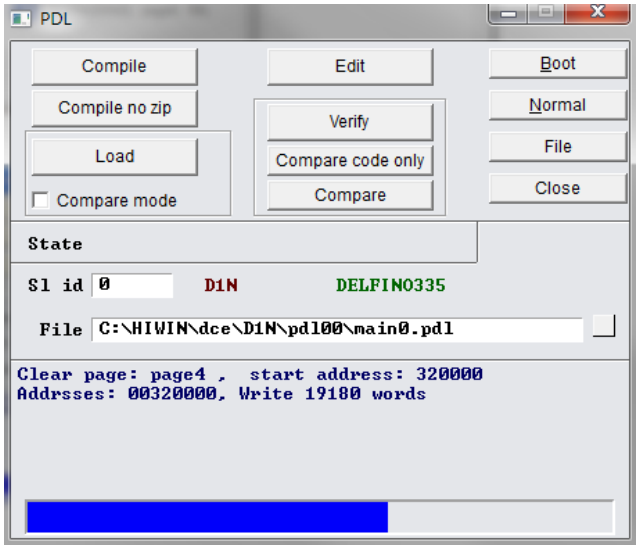

Figure13.2.6

13.3 Updating motor parameters

Follow the steps below to update the motor parameters used in Lightening.

Step 1: Download parameter patch from our download center.

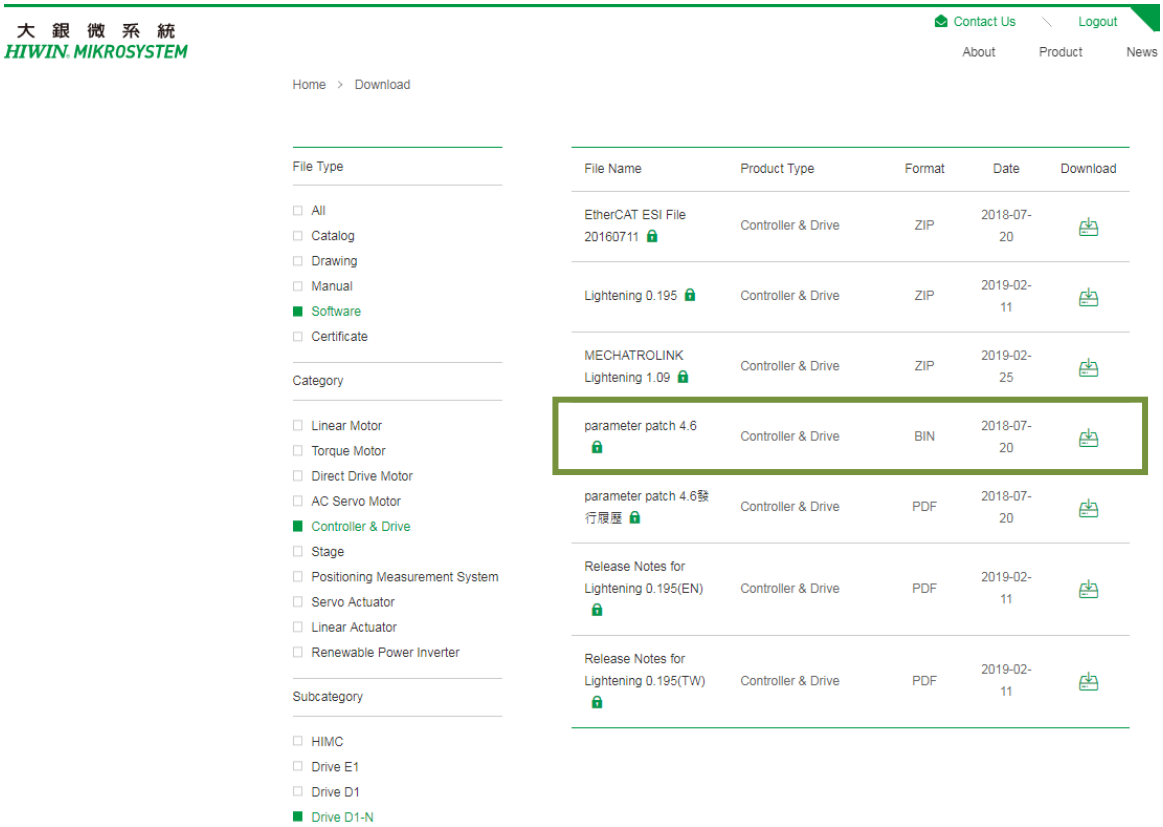

Figure13.3.1

Step 2: Extract the parameter patch.

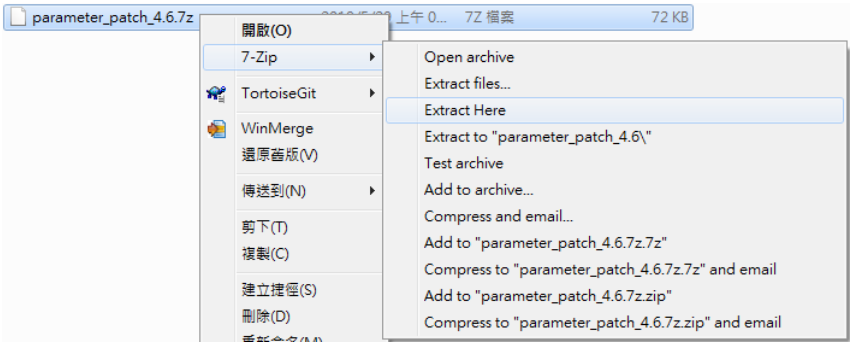

Figure13.3.2

Step 3: Execute parameter_patch.exe. Then **HIWIN .mot generator** window appears. Click on **(Y)** button. The update completes after all the execution windows disappear.

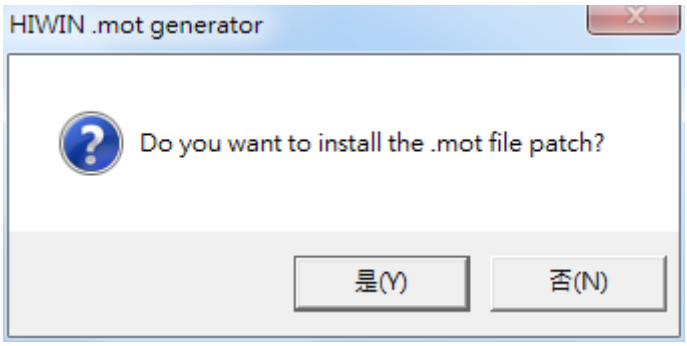

Figure13.3.3

Note:

If Lightening is not installed, a warning window appears as figure 13.3.4. To see if Lightening has been installed, check if Lightening.exe exists in path C:\HIWIN\dce\toolswin\winkmi\.

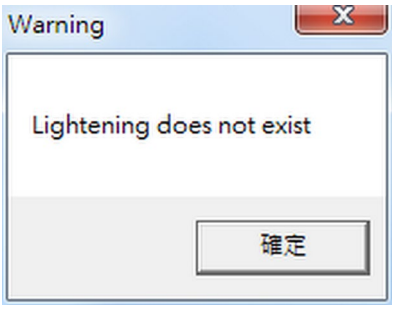

Figure13.3.4

14. Modbus communication

14.1 Modbus communication specification

The Modbus communication specification of D1-N servo drives is listed in table 14.1.1.

Table14.1.1

Interface	RS-485 2W-cabling	
Communication Cycle	Asynchronous (Half-duplex)	
Communication Parameters	Baud Rate	2,400, 4,800, 9,600 (default), 14,400, 19,200, 38,400 bps
	Communication Protocol	RTU (default), ASCII
	Data Length (Note1)	8 bits (default), 7 bits
	Parity	Even (default), odd, none
	Start bit	1 bit
	Stop bit (Note 2)	1 bit (default), 2 bits
	Station Number	1 ~ 247

Note:

(1) The data length of RTU communication protocol is 8 bits. The data length of ASCII communication protocol is 7 bits.

(2) The stop bits for odd parity and even parity must be 1 bit. The stop bit for none parity must be 2 bits.

14.2 Function codes

D1-N series drives provide three types of Modbus function codes.

Table14.2.1

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

Note:

The message length of exception response is 5 bytes.

(1) Read holding registers (03h)

This function is used to read the contents of the contiguous blocks of holding registers. The content of each register is divided into 8 high bits and 8 low bits. 125 registers at most can be read at the same time.

Table14.2.2

Request	Data Length	Value
Function Code	1 Byte	03h
Starting Address	2 Bytes	0x0000~0xFFFF
Register Number	2 Bytes	1~125
Response	Data Length	Value
Function Code	1 Byte	03h
Byte Count	1 Byte	2 x N
Register Value	2 x N Bytes	
Error	Data Length	Value
Error Code	1 Byte	83h
Exception Code	1 Byte	01h, 02h, 03h, 04h

Note:

N is the number of registers.

Table14.2.3

Exception Code	Definition	Description
01h	Illegal function	The function code is not supported.
02h	Illegal data address	Try to read an illegal register.
03h	Illegal data value	The number of registers is over 125.
04h	Servo device failure	The request contains incomplete data. For instance, the controller only requests 16 bits of a 32-bit parameter.

Table 14.2.4 is an example of reading registers 0x006B ~ 0x006D. The content of register 0x006B is 2 bytes. Its value is 02 2Bh. The content of 0x006C is 2 bytes. Its value is 00 00h. The content of 0x006D is 2 bytes. Its value is 00 64h.

Table14.2.4

Command			Response			Error		
Slave address		01h	Slave address		01h	Slave address		01h
Function code		03h	Function code		03h	Error code		83h
Starting address	Hi	00h	Byte count		06h	Exception code		02h
	Lo	6Bh	Register 0x006B	Hi	02h	CRC	Lo	C0h
Register number	Hi	00h		Lo	2Bh		Hi	F1h
	Lo	03h	Register 0x006C	Hi	00h			
CRC	Lo	74h		Lo	00h			
	Hi	17h	Register 0x006D	Hi	00h			
				Lo	64h			
			CRC	Lo	05h			
				Hi	7Ah			

(2) Read input registers (04h)

This function is used to read the contents of the contiguous blocks of input registers. The content of each register is divided into 8 high bits and 8 low bits. 125 registers at most can be read at the same time.

Table14.2.5

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

Note:

N is the number of registers.

Table14.2.6

Exception Code	Definition	Description
01h	Illegal function	The function code is not supported.
02h	Illegal data address	Try to read an illegal register.
03h	Illegal data value	The number of registers is over 125.
04h	Servo device failure	The request contains incomplete data. For instance, the controller only requests 16 bits of a 32-bit parameter.

Table14.2.7 is the example of reading register 0x0008. The content of register 0x0008 is 2 bytes. Its value is 00 0Ah.

Table14.2.7

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

(3) Writing multiple registers (10h)

This function is used to write data to the contiguous blocks of registers. 123 registers at most can be written at the same time.

Table14.2.8

Request	Data Length	Value Range
Function code	1 Byte	10h
Starting address	2 Bytes	0x0000~0xFFFF
Register number	2 Bytes	1~123
Byte count	1 Byte	2 x N
Register value	2 x N Bytes	
Response	Data Length	Value Range
Function code	1 Byte	10h
Starting address	2 Bytes	0x0000~0xFFFF
Register number	2 Bytes	1~123
Error	Data Length	Value Range
Error code	1 Byte	90h
Exception code	1 Byte	01h, 02h, 03h, 04h

Note:

N is the number of registers.

Table14.2.9

Exception Code	Definition	Description
01h	Illegal function	The function code is not supported.
02h	Illegal data address	Try to read an illegal register.
03h	Illegal data value	The number of registers is over 123.
04h	Servo device failure	The request contains incomplete data. For instance, the controller only requests 16 bits of a 32-bit parameter.

Table 14.2.10 is the example of writing two registers. The starting address is 0x0001. The values are 00 0Ah and 01 02h.

Table14.2.10

Command			Response			Error		
Slave address		01h	Slave address		01h	Slave address		01h
Function code		10h	Function code		10h	Function code		90h
Starting address	Hi	00h	Starting address	Hi	00h	Exception code		02h
	Lo	01h		Lo	01h	CRC	Lo	CDh
Register number	Hi	00h	Register number	Hi	00h		Hi	C1h
	Lo	02h		Lo	02h			
Byte count		04h	CRC	Lo	10h			
Register 0x0001	Hi	00h		Hi	08h			
	Lo	0Ah						
Register 0x0002	Hi	01h						
	Lo	02h						
CRC	Lo	92h						
	Hi	30h						

14.3 Modbus object

The data types of Modbus objects are listed in table 14.3.1.

Table14.3.1

Code	Data Type	Data Range
INT16	Signed 16 bit	-32,768~+32,767
INT32	Signed 32 bit	-2,147,483,648~+2,147,483,647
UINT16	Unsigned 16 bit	0~65,535
UINT32	Unsigned 32 bit	0~4,294,967,295
REAL32	Float 32 bit	-

14.3.1 Input register

The data length of readable input register is 32 bits.

Table14.3.1.1

Object	Register Address	Description		Type	Unit
1	0x0000	Feedback position	Lower data	INT32	counts
	0x0001		Higher data		
2	0x0002	Reference position	Lower data	INT32	counts
	0x0003		Higher data		
4	0x0006	Position error	Lower data	INT32	counts
	0x0007		Higher data		
10	0x0012	Feedback velocity	Lower data	REAL32	count/s
	0x0013		Higher data		
11	0x0014	Reference velocity	Lower data	REAL32	count/s
	0x0015		Higher data		
12	0x0016	Velocity error	Lower data	REAL32	count/s
	0x0017		Higher data		
30	0x003A	Actual current	Lower data	REAL32	A_{amp}
	0x003B		Higher data		
31	0x003C	Command current	Lower data	REAL32	A_{amp}
	0x003D		Higher data		
40	0x004E	Analog command	Lower data	REAL32	mV
	0x004F		Higher data		
41	0x0050	Bus voltage	Lower data	REAL32	V
	0x0051		Higher data		
51	0x0064	Soft-thermal accumulator	Lower data	REAL32	%
	0x0065		Higher data		
61	0x0078	Status 5	Lower data	UINT32	-
	0x0079		Higher data		
81	0x00A0	Status 4	Lower data	UINT32	-
	0x00A1		Higher data		
90	0x00B2	Status 6	Lower data	UINT32	-
	0x00B3		Higher data		
91	0x00B4	Status 0	Lower data	UINT32	-
	0x00B5		Higher data		
2001	0x0FA0	Mode of operation display	Lower data	INT32	-
	0x0FA1		Higher data		
2002	0x0FA2	Drive error events 1	Lower data	UINT32	-
	0x0FA3		Higher data		
2003	0x0FA4	Drive error events 2	Lower data	UINT32	-
	0x0FA5		Higher data		
2004	0x0FA6	Status 1	Lower data	UINT32	-
	0x0FA7		Higher data		
2005	0x0FA8	Status 2	Lower data	UINT32	-
	0x0FA9		Higher data		
2006	0x0FAA	Status 3	Lower data	UINT32	-
	0x0FAB		Higher data		
2008	0x0FAE	Feedback position of second encoder	Lower data	INT32	count
	0x0FAF		Higher data		
2009	0x0FB0	Hybrid deviation error	Lower data	REAL32	count
	0x0FB1		Higher data		

(1) Object 61 - Status 5

Table14.3.1.2

Bit	Definition
0	I1
1	I2
2	I3
3	I4
4	I5
5	I6
6	I7
7	I8
8	I9
9	I10
10~15	-

(2) Object 81 - Status 4

Table14.3.1.3

Bit	Definition
0~3	-
4	O1
5	O2
6	O3
7	O4
8	O5
9~11	-
12	CW/CCW input
13	Buffer encoder invert
14	Buffer/emulated encoder output
15	-

(3) Object 90 - Status 6

Table14.3.1.4

Bit	Definition
0	-
1	Index
2~15	-

(4) Object 91 - Status 0

Table14.3.1.5

Bit	Definition
0	Moving
1	Encoder error
2	-
3	In position
4	Right hardware limit
5	Left hardware limit
6	Position error too big
7	Soft thermal threshold reached
8	Axis disable
9	-
10	Homed
11	-
12	Both hardware limits are active
13	Serial encoder communication error
14	Motor over temperature
15	Amplifier over temperature

(5) Object 2002 - Drive error events 1

Table14.3.1.6

Bit	Definition
0	-
1	Encoder error
2~5	-
6	Position error too big
7	Soft-thermal threshold reached
8~12	-
13	Serial encoder communication error
14	Motor over temperature sensor activated
15	Amplifier over temperature
16~17	-
18	Motor short (over current) detected
19	Over voltage detected
20	Under voltage detected
21	Motor maybe disconnected
22~30	-
31	5 V for encoder card fail

(6) Object 2003 - Drive error events 2

Table14.3.1.7

Bit	Definition
0	-
1	Phase initialization error
2~4	-
5	Hall sensor error
6	Hall phase check error
7~15	-
16	Current control error
17	HFLT inconsistent error
18	Auto phase center not complete error
19	-
20	Hybrid deviation too big
21~22	-
23	DC bus voltage abnormal
24~29	-
30	EtherCAT interface disconnected
31	CiA-402 home failed

(7) Object 2004 - Status 1

Table14.3.1.8

Bit	Definition
0~1	-
2	Motor short
3	Over voltage
4	Under voltage
5	Motor may be disconnect
6	Left software limit
7	Right software limit
8	Current limited
9	Acceleration limited
10	Velocity limited
11	Servo ready
12	Servo voltage big
13	Position error warning
14	Velocity error warning
15	5 V for encoder card fail

(8) Object 2005 - Status 2

Table14.3.1.9

Bit	Definition
0	Emulated index
1	Phase initialization error
2~4	-
5	Hall sensor error
6	Hall phase check error
7~8	-
9	Zero speed detected
10~13	-
14	I2T warning
15	Pulse command and home conflict

(9) Object 2006 - Status 3

Table14.3.1.10

Bit	Definition
0	Current control error
1	HFLT inconsistent error
2~4	-
5	Homing fail
6	Absolute encoder battery warning
7	DC bus voltage abnormal
8	Wrong absolute position
9~15	-

14.3.2 Holding register

The data length of readable/writable holding register is 32 bits.

Table14.3.2.1

Object	Register Address	Description		Type	Unit
0	0x0000	Maximum acceleration	Lower data	REAL32	count/s^2
	0x0001		Higher data		
1	0x0002	Maximum deceleration	Lower data	REAL32	count/s^2
	0x0003		Higher data		
2	0x0004	Kill deceleration	Lower data	REAL32	count/s^2
	0x0005		Higher data		
3	0x0006	Maximum velocity	Lower data	REAL32	count/s
	0x0007		Higher data		
39	0x004E	Home velocity (Index search speed)	Lower data	INT32	count/s
	0x004F		Higher data		
40	0x0050	Homing time out	Lower data	INT32	1s/15,000
	0x0051		Higher data		
50	0x0064	Maximum following error	Lower data	REAL32	A_{amp}
	0x0065		Higher data		
79	0x009E	AC servo gear ratio	Lower data	REAL32	-
	0x009F		Higher data		
81	0x00A2	Numerator of output electronic gear ratio	Lower data	INT32	-
	0x00A3		Higher data		
82	0x00A4	Denominator of output electronic gear ratio	Lower data	INT32	-
	0x00A5		Higher data		
83	0x00A6	Velocity scale for external command	Lower data	REAL32	count/s = 1V
	0x00A7		Higher data		
85	0x00AA	Current scale for external command	Lower data	REAL32	(A_{amp}×1,000)/ (curr_drv_peak) = 1 V
	0x00AB		Higher data		
115	0x00E6	Smooth factor	Lower data	UINT32	-
	0x00E7		Higher data		
129	0x0102	Pulse mode	Lower data	INT32	-
	0x0103		Higher data		
130	0x0104	Pulse command inversion	Lower data	UINT32	-
	0x0105		Higher data		
212	0x01A8	Operation mode	Lower data	UINT32	-
	0x01A9		Higher data		
216	0x01B0	Encoder output setting	Lower data	INT32	-

Object	Register Address	Description		Type	Unit
	0x01B1		Higher data		
219	0x01B6	CW/CCW logic	Lower data	UINT32	-
	0x01B7		Higher data		
241	0x01E2	Input signal logic	Lower data	INT32	-
	0x01E3		Higher data		
280	0x0230	Output signal logic	Lower data	UINT32	-
	0x0231		Higher data		
355	0x02C6	Output emulated index per revolution	Lower data	INT32	-
	0x02C7		Higher data		
2000	0x0FA0	Target position	Lower data	INT32	count
	0x0FA1		Higher data		
2001	0x0FA2	Target Velocity	Lower data	INT32	count/s
	0x0FA3		Higher data		
2002	0x0FA4	Target current	Lower data	INT32	0.1%A
	0x0FA5		Higher data		
2003	0x0FA6	Stop motion	Lower data	UINT32	--
	0x0FA7		Higher data		
2007	0x0FAE	Jog velocity	Lower data	REAL32	count/s
	0x0FAF		Higher data		

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15. Motor power cable shielding and grounding

15.1 Motor power cable shielding

Noise could affect the servo drive via conduction and radiation while motor is operating. If unshielded motor power cable is used, noise could be transmitted to the ground via stray capacitance and form common-mode signal voltage. The common-mode noise on the motor power cable couples with other signals by stray capacitance. To avoid interference, the motor power cable must be shielded.

(1) Put a 1.5 cm heat shrink outside of the cable. Cut the plastic sheath of the cable for 4.5 to 5.5 cm and expose the shield and wires inside.

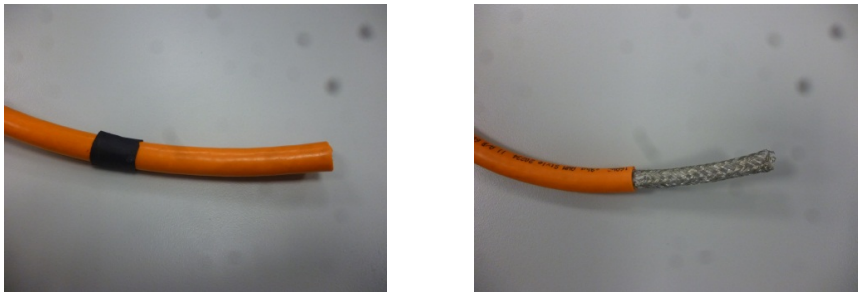

Figure15.1.1

(2) Put copper foil tape (10 cm) on the plastic sheath. Spread the shield and fold it back. Wind the shield around the plastic sheath. Put copper foil tape (10 cm) on the plastic sheath and shield.

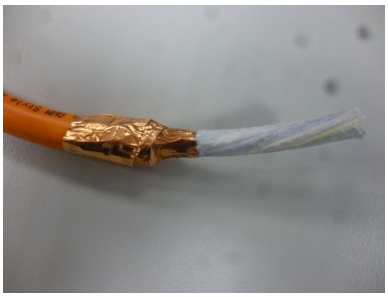

Figure15.1.2

(3) Cut the insulation (1 cm) and expose the copper core.

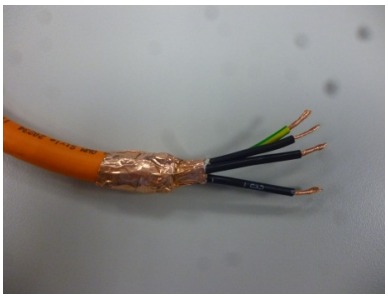

Figure15.1.3

(4) Put a 2 cm heat shrink to fix copper foil tape and wires.

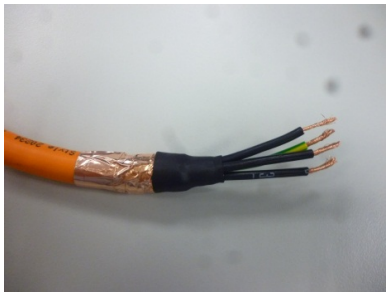

Figure15.1.4

(5) Fix the wires with the terminal block by referring to the symbols indicated on the servo drive X3 connector. Ensure the shield plate is in contact with the exposed copper foil tape.

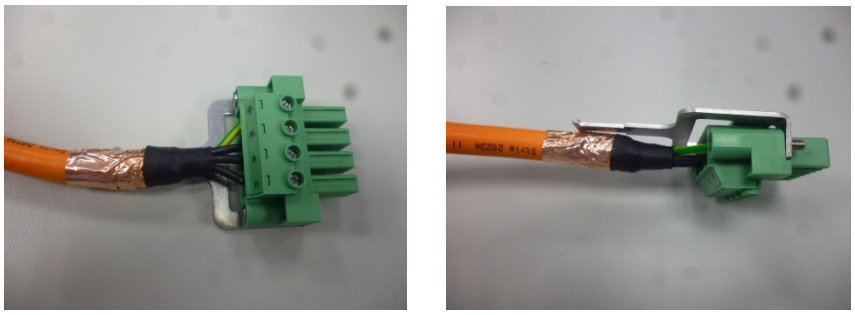

Figure15.1.5

(6) Use the clamp provided in the accessory kit to tighten the shield plate and the cable by the part covered by copper foil tape. Ensure they are securely tightened.

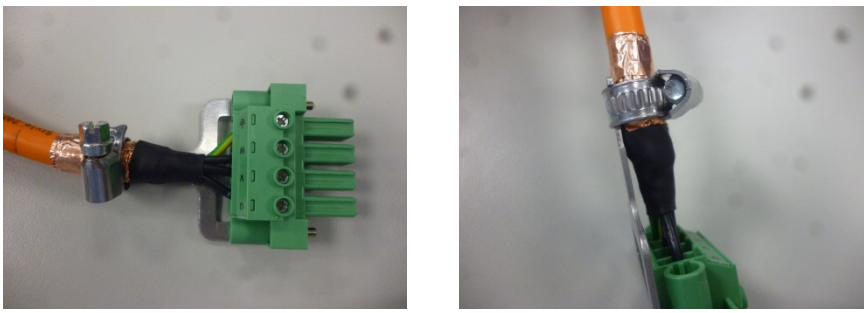

Figure15.1.6

(7) Move the heat shrink in step 1 to the part covered by copper foil tape and fix it. Ensure the copper foil tape does not loosen.

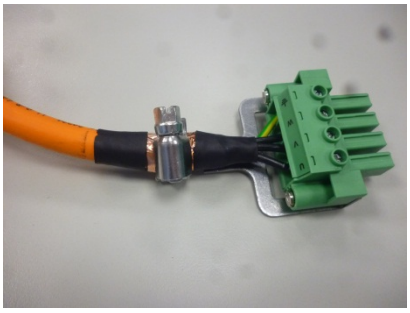

Figure15.1.7

15.2 Grounding

To avoid noise, the servo drive must be correctly grounded.

(1) Before connecting to the servo drive, the ground wire (green and yellow wire, 15 AWG) must be crimped with M4 ring terminal (with insulating tube) to prevent contact with adjacent terminal. Refer to figure 15.2.1.

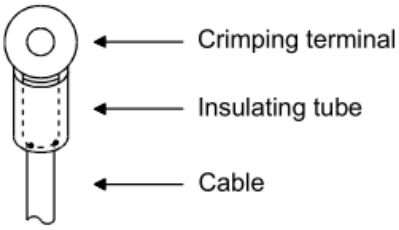

Figure15.2.1

(2) To avoid electric shock, the ground (PE) (symbol ⏚) terminal of the servo drive must be connected to the ground (PE) terminal of the electric box.

(3) In normal application, it is prohibited to connect two ground wires to the same ground terminal, as figure 15.2.2 and 15.2.3.

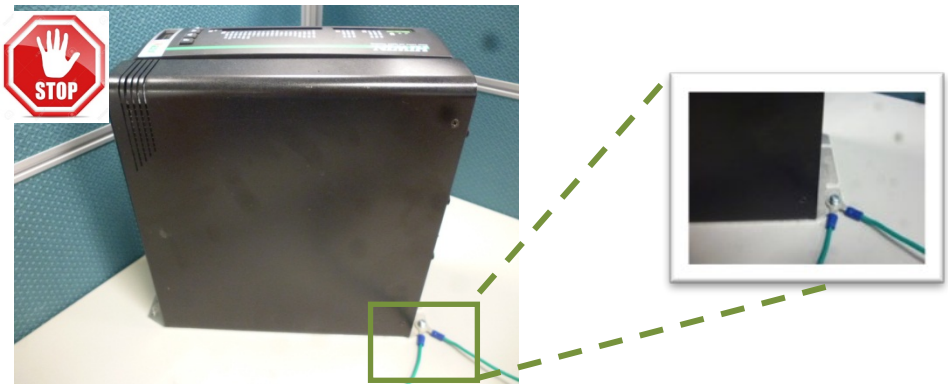

Figure15.2.2 Prohibited wiring method of D1-N-90

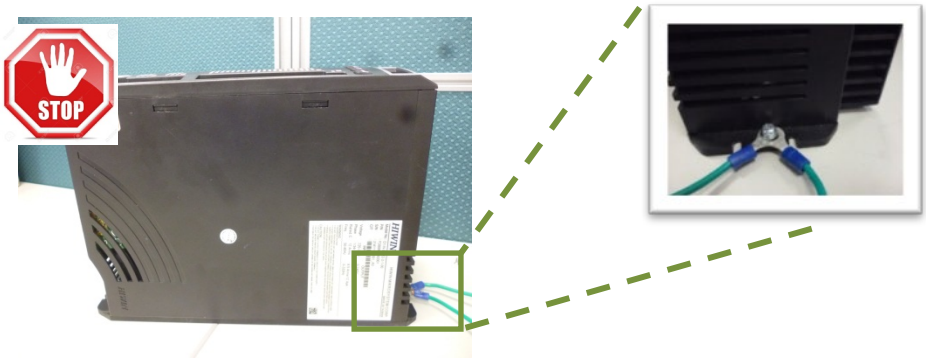

Figure15.2.3 Prohibited wiring method of D1-N-09/18/36

(4) If it is necessary to connect two ground wires, please connect them to the separate ground terminals, as figure 15.2.4 and 15.2.5.

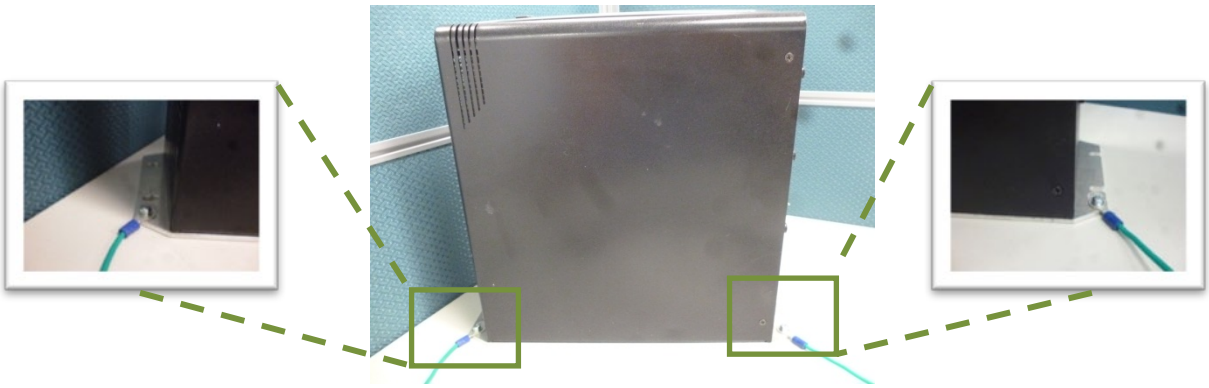

Figure15.2.4 Grounding of D1-N-90

Figure15.2.5 Grounding of D1-N-09/18/36