HIWIN®

D2T-LM Series Servo Drive

User Manual

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MD11UE01-2202_V1.3

Revision History

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

MD11UE01-2202_V1.3

- V1.3 — Version
- 2202 — Release Date

Release Date	Version	Applicable Product	Revision Contents
Feb. 11th, 2022	1.3	D2T-LM series servo drive	1. Add the precaution of switch. 2. Add the related information of derated value. 3. Add drive specifications: inrush current of main power, weight.
Jun. 3rd, 2020	1.2	D2T-LM series servo drive	Modify the input power for servo drive. The suggested input power is 220V.
Jun. 24th, 2019	1.1	D2T-LM series servo drive	First edition.

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1. About this User Manual

1.1 General precautions

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

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

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

⚠ ATTENTION

- The maximum ambient temperature for the product is 55°C.
- The drive can only be installed in the environment that the degree of contamination is below 2.
- The rated input voltage of the product is 240V. The power supply voltage cannot exceed 240V, and the short-circuit current cannot be over 5000A.
- The drive provides neither motor over-temperature sensor, nor motor over-temperature protection.
- The short-circuit protection of the drive cannot be used as a shunt-circuit protection. The shunt-circuit protection should be selected based on US National Electrical Code (NEC) and local regulations.
- Power off and wait at least five minutes before examining the drive. To avoid electric shock, please use a multi-meter or a similar apparatus to check if the residual voltage between P and N terminals has dropped to the safety level (50Vdc or lower).
- To avoid accelerating the aging of internal electronic power components, do not switch the power on and off frequently. If there is a need to continuously switch the power on and off, the time interval should be more than 3 minutes.

⚠ WARNING

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

1.2 Safety precautions

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

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

Warning DANGER

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

■ Operation

⚠ Warning	◆ Do not touch the terminals and the internal part of the product when power on, or it may cause electric shock. ◆ Do not touch the terminals and internal part of the product within 10 minutes after power off, or the residual voltage may cause electric shock. ◆ Do not modify wiring when power on, or it may cause electric shock. ◆ Do not damage, apply excessive force to, place any heavy object on the cable or put the cable between two objects, or it may cause electric shock or fire.
⚠ Attention	◆ Do not use the product in location which is subject to humidity, corrosive materials, flammable gas or flammable materials. ◆ To avoid accelerating the aging of internal electronic power components, do not switch the power on and off frequently. If there is a need to continuously switch the power on and off, the time interval should be more than 3 minutes.

■ 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 manual. Use cooling fan if the ambient temperature is too high. ◆ Do not install the product in location which is subject to direct sunlight. ◆ The product is not drip-proof or waterproof, so do not install or operate the product outdoor or in location which is subject to water or liquid. ◆ Install the product in location with less vibration. ◆ Motor generates heat when running for a period of time. Use cooling fan or disable the motor when it is not in use, so the ambient temperature will not exceed product specification.

- 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. ◆ When installing the product, take the product weight into consideration. Improper installation may cause damage. ◆ Install the product on noncombustible objects, such as metal to avoid fire.

- Wiring

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

- 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 yourself when it malfunctions, please contact HIWIN for help.

2. Specifications

2.1 Drive information

2.1.1 Safety certificates

The drive complies with the following safety standards.

Table 2.1.1.1

CE Compliance	
EMC	EN 61800-3:2004 (Category C2)
	EN 61000-3-2:2006 / A1:2009 / A2:2009
	EN 61000-3-3:2008
	IEC CISPR 11:2009 / A1:2010
	IEC 61000-4-2:2008
	IEC 61000-4-3:2006 / A1:2007 / A2:2010
	IEC 61000-4-4:2004
	IEC 61000-4-5:2005
	IEC 61000-4-6:2008
	IEC 61000-2-1:1990
	IEC 61000-2-4:2003
	IEC 60146-1-1:1993
Low Voltage Directives (LVD)	IEC 61800-5-1:2007 (PD2, OVC III)
	EN 61800-5-1:2007 (PD2, OVC III)

2.1.2 Nameplate information

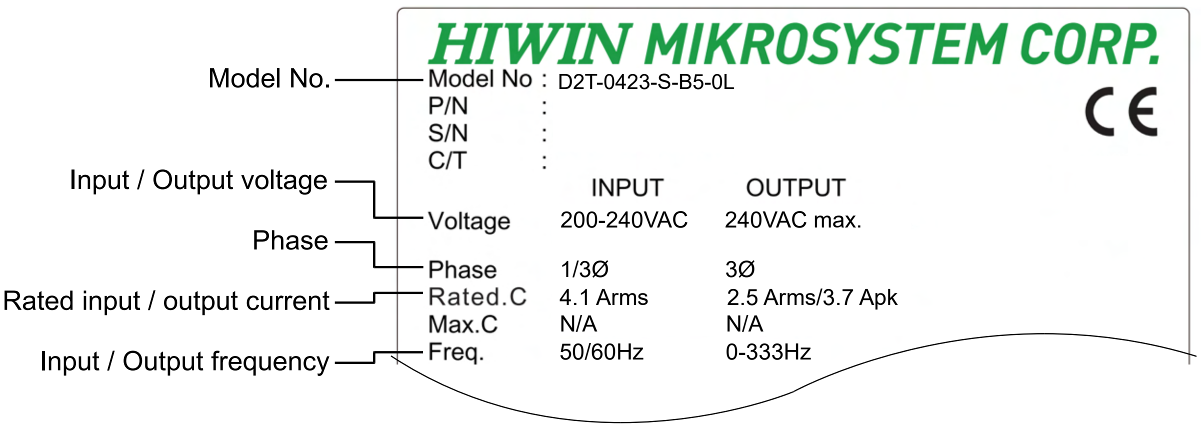


Figure 2.1.2.1

2.1.3 Model explanation

Table 2.1.3.1

Code	1	2	3		4	5	6	7		8		9	10		11	12
Example	D	2	T	-	0	4	2	3	-	S	-	B	5	-	0	L
1, 2, 3: D2T series servo drive	D2T															
4, 5: Rated output	04 = 400W 10 = 1.0KW															
6, 7: Input AC power	23 = Single/Three-phase, 220V															
8: Control interface	Standard S = Voltage command and pulse Fieldbus E = EtherCAT (CoE) Fieldbus F = mega-ulink															
9: Frame	B = Frame B (400W) C = Frame C (1.0KW)															
10: Encoder interface	5 = Digital TTL (AqB)															
11, 12: Special code	0L = Only for linear motor															

Note 1: The drive can only match with linear motor.

Note 2: Standard model contains pulse input interface and +/-10V input interface.

Note 3: The drive does not support Hall sensor signal and over-temperature signal (OT, PTC).

Note 4: The encoder only supports digital AqB format.

2.2 Drive specifications

Basic specifications	Input power	220V	Main power	Frame B, C	Single/Three-phase, 200~240Vac 50/60Hz
			Control power	Frame B, C	Single-phase, 200~240Vac 50/60Hz
		Inrush Current of Main Power			Frame B: 0.71Apk; Frame C: 21.7Apk
	Output power	Wattage			Frame B: 400W; Frame C: 1.0KW
		Continuous current			Frame B: 2.5A_{rms}; Frame C: 5.1A_{rms}
		Peak current			Frame B: 7.5A_{rms}; Frame C: 15.3A_{rms}
		Sustainable durartion of peak current			Maximum 1 second
	Environment	Temperature			Operation temperature: 0~45°C (45~50°C is acceptable when derated value is applied. Please refer to section 2.5. If it is over 55°C, forced ventilation is needed.) Storage temperature: -20~65°C
		Humidity			0 to 90% RH (non-condensing)
		Altitude			Below 1000 meters (1000~3000 meters is acceptable when derated value is applied. Please refer to section 2.5.)
		Vibration			1G (10~500Hz)
	Weight			Standard	Frame B: 0.8kg; Frame C: 1.6kg
				Fieldbus	Frame B: 0.9kg; Frame C: 1.7kg
	Installation pollution level				II
	Control method				IGBT PWM space vector modulation
	Encoder input	Feedback resolution			Digital TTL
		Frequency			5M pulse/sec (before Quadrature) 20M count/sec (after Quadrature)
		Other			Linear encoder should be digital AqB encoder.
	Parallel I/O connector	Control signal	Input		10 (general purpose)
			Output		5 (general purpose)
		Analog signal	Input		1 (12-bit A/D)
			Output		1 (analog monitor)
		Pulse signal	Input		2 (low-speed channel, high-speed channel)
			Output		4 (line driver: 3 outputs; open collector: 1 output)
	Brake connector	Control signal	Output		It can be used with brakes (1Adc max), and also be programmed with general-purpose output.
	Dynamic brake				There is no built-in dynamic brake.

				External relay and brake resistor are needed.
	Communication function		USB	Connect with PC; 115,200bps
	Front panel			LCD status display (dot matrix 8*2 characters with 4 buttons) LED status indicator (green, red)
	Control mode			Switchable control modes (1) Position control (4) Position / Velocity control (2) Velocity control (5) Position / Torque control (3) Torque control (6) Velocity / Torque control
Function specifications	Position control	Control input		(1) Command pulse inhibit (2) Axis enable (3) Switch between primary and secondary CG (4) Electronic gear selection (5) Left limit switch (6) Switch between primary and secondary mode (7) Clear error (8) Right limit switch, etc.
		Control output		(1) Servo ready (2) Errors (3) In-position (4) Zero speed detected, etc.
		Pulse input	Maximum input pulse frequency	Photo-coupler interface (single-ended input): 250kpps Line driver interface (differential input): 4Mpps (16M cnt/s with AqB)
			Signal format of input pulse	(1) Pulse/direction (Pulse/Dir) (2) Pulse up/pulse down (CW/CCW) (3) Quadrature (AqB)
			Electronic gear (Division / Multiplication of command pulse)	Gear ratio: pulses/counts pulses: 1~2,147,483,647；counts：1~2,147,483,647
			Smoothing filter	Smooth factor: 1~500
		Vibration suppression feature (VSF)		VSF can remove the vibration frequency that occurs during the movement. It can also reduce the vibration caused by the system’s structure to enhance productivity.
	Velocity control	Control input		(1) Zero speed clamp (2) Axis enable (3) Switch between primary and secondary CG (4) Left limit switch (5) Switch between primary and secondary mode (6) Clear error (7) Right limit switch, etc.
		Control output		(1) Servo ready (2) Errors (3) In-velocity

				(4) Zero speed detected, etc.
		PWM input	Velocity command input	Velocity commands can be provided by the duty cycle of PWM input. Parameters are used to set the scale and the direction of the command.
		Analog input	Velocity command input	Velocity commands can be provided by analog voltage. Parameters are used to set the scale and the direction of the command. (+/-10Vdc, 12-bits resolution)
		Zero speed clamp		It is possible to input zero speed clamp.
	Torque control	Control input		(1) Axis enable (2) Switch between primary and secondary CG (3) Left limit switch (4) Switch between primary and secondary mode (5) Clear error (6) Right limit switch, etc.
	Torque control	Control output		(1) Servo ready (2) Errors (3) In-velocity (4) Zero speed detected, etc.
	Torque control	PWM input	Torque command input	Torque commands can be provided by the duty cycle of PWM input. Parameters are used to set the scale and the direction of the command.
	Torque control	Analog output	Torque command input	Torque commands can be provided by analog voltage. Parameters are used to set the scale and the direction of the command. (+/-10Vdc, 12-bits resolution)
	Torque control	Speed limit function		Parameters for speed limit can be set.
	Common	Auto tune		After the execution of the procedure, auto tune runs automatically and confirms load inertia
	Common	Emulated encoder feedback output		Can be arbitrarily set (The maximum frequency of Frame B and Frame C is 18M count/s)
	Common	Protective function		(1) Motor short (over current) detected (2) Over voltage detected (>390Vdc±5%) (3) Position error too big (4) Encoder error (5) Soft-thermal threshold reached (6) Motor maybe disconnected (7) Amplifier over temperature (IGBT>80°C±3°C) (8) Under voltage detected (9) 5V for encoder card fail (10) Phase initialization error (11) Serial encoder communication error

		Error log		Errors and warnings are saved in non-volatile memory.
		Program Design Language (PDL)		Maximum code capacity: 32KBytes
				Variable storage capacity: 800Bytes
				Supporting variable types: (1) Float type: 32 bits (2) Integer type: 16 and 32 bits (3) Array and pointer
				Execution cycle: 66.67us
				Four tasks can be executed simultaneously.
				Support if, else, while loop, for loop, goto, till, and other commands to control program flow.
				Support arithmetic operators, logical operators, and comparison operators.
				Support lock and unlock commands to control the synchronization of multi-tasks.
				Maximum length of user-defined names: (1) variable: 17 characters (2) label: 24 characters (3) proc: 24 characters
		Error Mapping		Method: Establish error map to compensate the encoder errors by adopting linear interpolation.
				Samples: Maximum 5,000 points
				Storage location: Flash ROM; disc file
				Unit: um; count
				Enable method: after the internal index is reset; activated by an external input signal
		Regeneration	Resistor	need external connection, no built-in regenerative resistor
			Cut-in voltage	+HV > 370Vdc
			Drop-out voltage	+HV < 360Vdc
			DC link capacity	Frame B: 820uF; Frame C: 1,410uF
		Others		Friction compensation

2.3 Drive dimensions

The dimensions and locations of installation holes of D2T-LM series servo drives (Standard and Fieldbus) are provided in the following figures. The dimensions are shown in millimeters (mm). The diameter of installation hole is 4 mm.

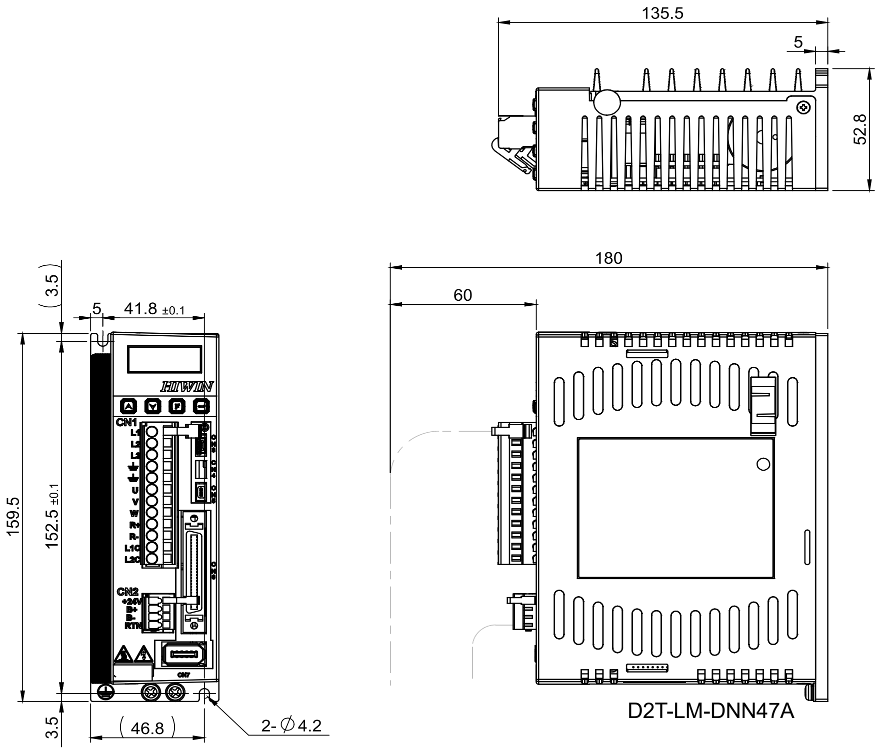


Figure 2.3.1 Dimensions of D2T-LM Frame B (Standard)

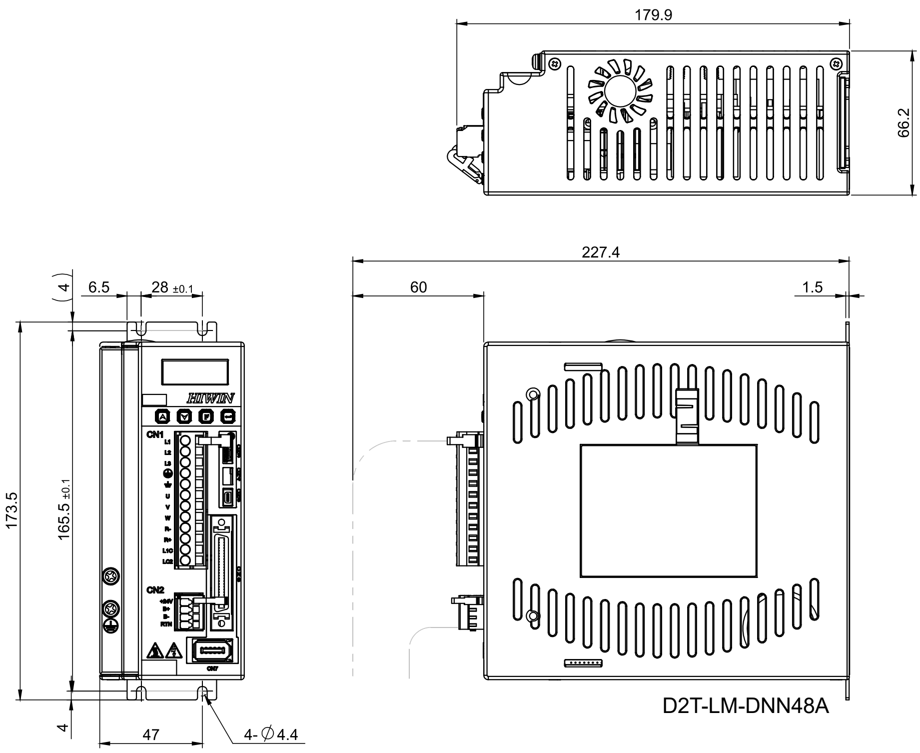


Figure 2.3.2 Dimensions of D2T-LM Frame C (Standard)

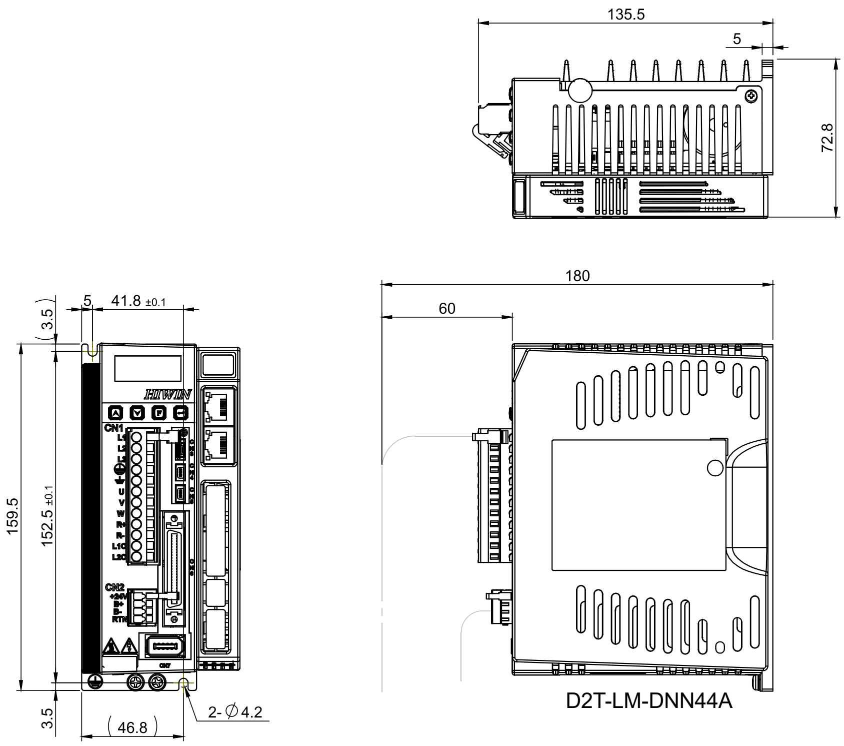


Figure 2.3.3 Dimensions of D2T-LM Frame B (Fieldbus)

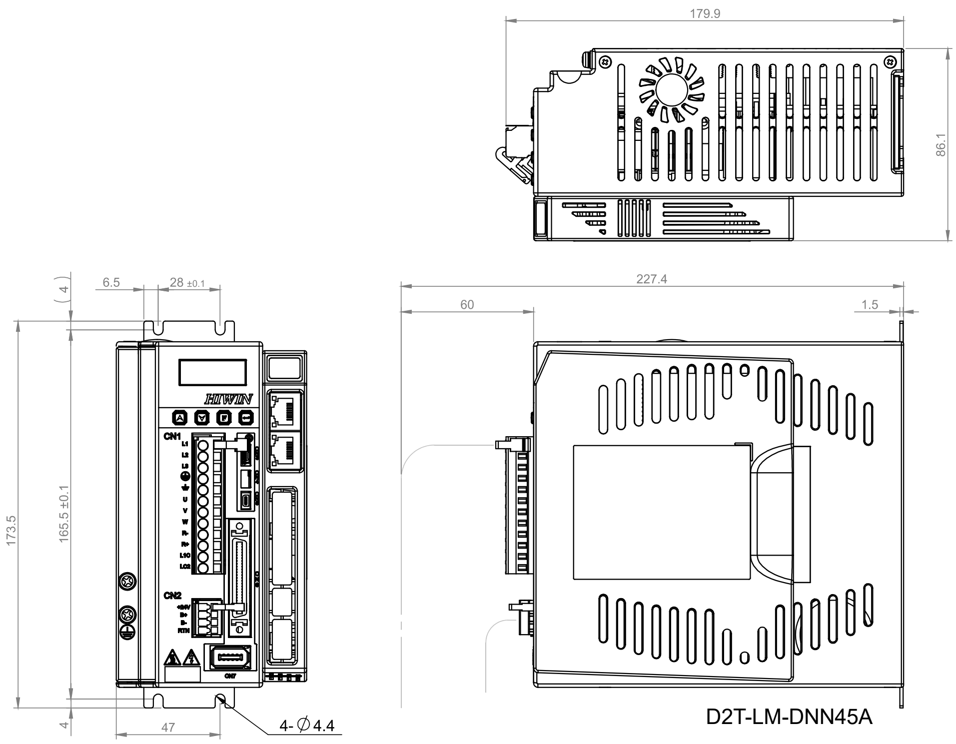


Figure 2.3.4 Dimensions of D2T-LM Frame C (Fieldbus)

2.4 Drive installation

If the servo drive is installed in a control box, ensure it is mounted with conductive screws. The insulating materials on the contact surface of the control box, such as paint, must be removed for grounding the servo drive through the control box. When the input power of the servo drive is 220V, the grounding resistance must be lower than 50Ω. The suction hole and vent hole of the servo drive must not be obstructed. Install the servo drive according to the specified orientation; otherwise, it may malfunction.

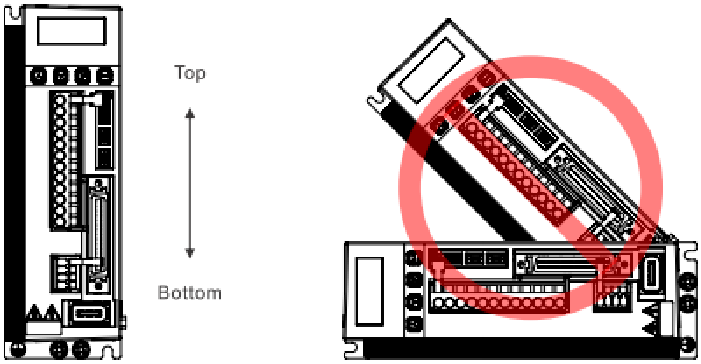


Figure 2.4.1 Correct and incorrect mounting directions

For well cooling and circulation effect, there must be enough clearance between the servo drive and the adjacent objects or baffle plates. While installing multiple servo drives, the clearance between two servo drives must be at least 20mm. Install a fan in the control box to facilitate heat dissipation.

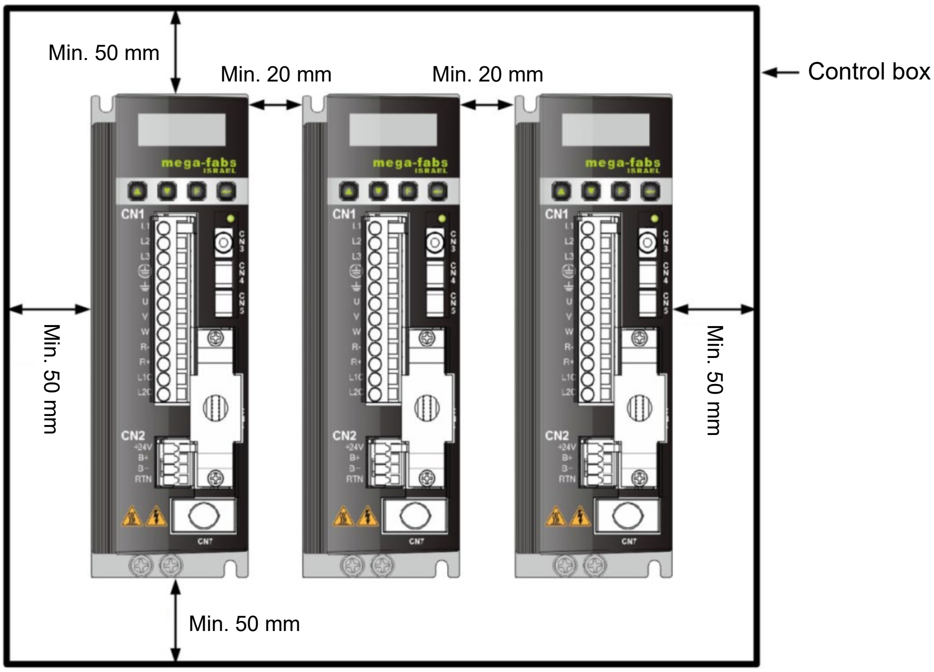


Figure 2.4.2 Installing multiple servo drives

2.5 Derated value

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

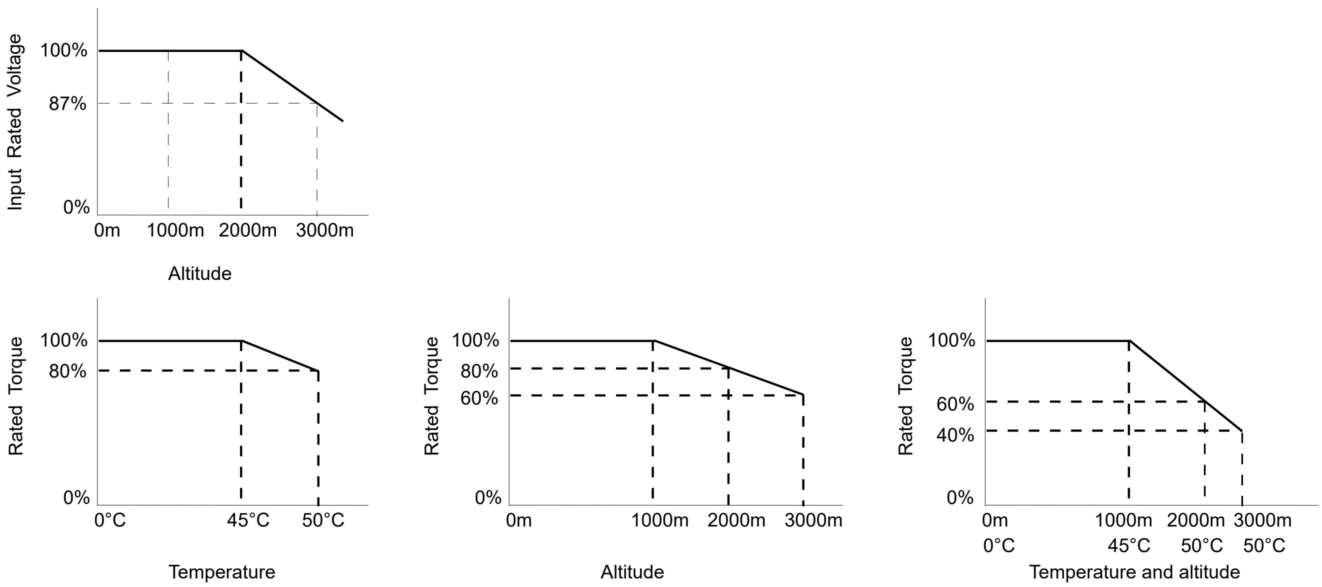


Figure 2.5.1

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

2.6 Computer requirements

Table 2.6.1

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

3. Operation Principles

3.1 Operation modes

Four operation modes can be used to implement the interface between a standard D2T-LM series drive and the host controller.

- Position mode
- Velocity mode
- Force / Torque mode
- Stand-alone mode

Each mode is described as follows.

3.1.1 Position mode

The host controller sends pulses, corresponding to position commands, to the drive. When the drive receives a pulse, it moves a specified distance accordingly. The host controller is responsible for path planning. The frequency of the sending pulses becomes higher in acceleration phase, while it remains the same in constant speed phase. In Figure 3.1.1.1, there are three types of pulse signal: pulse/direction (pulse/dir), pulse up/pulse down (CW/CCW), and quadrature (AqB). Based on hardware wiring, pulse signal can be classified into differential and single-end TTL logic signals.

The electronic gear can be set on position mode. Normally, one input pulse corresponds to one encoder count. For example, the gear ratio is 2:3, that is, two input pulses correspond to three encoder counts.

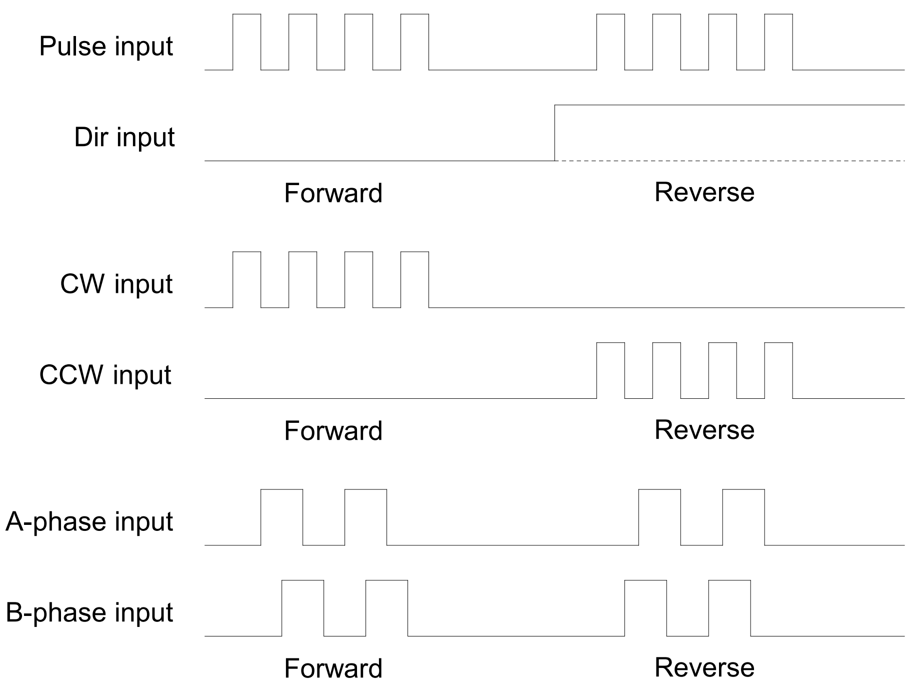


Figure 3.1.1.1

3.1.2 Velocity mode

Through voltage, also known as V command, the drive can receive commands from the host controller. The input voltage ranges from -10V to +10V. The drive converts received external voltage to the corresponding velocity commands to drive the motor. Besides voltage, the host controller can also send velocity commands via PWM signal, also called PWM command. It utilizes different duty cycles to correspond to different velocity commands. There are two types of PWM command, single-line type (PWM 50%) and dual-line type (PWM 100%). The single-line type (PWM 50%) is based on duty cycle 50%. If the duty cycle of PWM command is less than 50%, the motor performs reverse movement; if it is more than 50%, the motor performs forward movement. As for dual-line type (PWM 100%), one pin is for transmitting PWM command, and another one is added for controlling the direction of the motor.

- **Use voltage command**
  To control the speed of the motor movement, the drive converts analog voltage signal to velocity command. The higher the voltage is, the faster the output speed is. The maximum output speed should not exceed the maximum speed of the drive. The lower the voltage is, the slower the output speed is. When the voltage value is negative, the output speed becomes negative for the motor to move in a reverse direction. The drive can set speed command corresponding to the voltage per unit.

- **Use PWM command**
  To control the speed of the motor movement, the drive converts PWM signal to velocity command. The drive can set speed command corresponding to “Full PWM”.

3.1.3 Force / Torque mode

On force / torque mode, the drive can receive V command and PWM command from the host controller, which are the same as those on velocity mode. After receiving these two commands, the drive converts them to the corresponding current to drive the motor.

- **Use voltage command**
  To control force and torque of the motor movement from the controlling output current of the drive, the drive converts the analog voltage signal to current command. The higher the voltage is, the larger the output current is. The maximum output current should not exceed the maximum current of the drive. The lower the voltage is, the smaller the output current is. When the voltage value is negative, the output current becomes negative for the motor to move in a reverse direction. The drive can set current command corresponding to the voltage per unit.

- **Use PWM command**
  To control force and torque of the motor movement from the controlling output current of the drive, the drive converts PWM signal to current command. The drive can set current command corresponding to "Full PWM".

3.1.4 Stand-alone mode

With the help of high speed DSP, D2T-LM series drive is capable of path planning. If users only need to test alone the drive or execute the plan without any host controller (e.g. only the servo motor and the drive), stand-alone mode can be selected to let the drive take care of all control loops.

3.2 Encoder type

An encoder usually plays an important role in servo motor control. It provides the information of positions or angles for the drive to control servo loop. There are two common types of encoder, digital type and analog type. So far D2T-LM series drive only supports digital type.

A digital encoder, also known as an incremental encoder, generally outputs TTL RS422 differential signal. Two digital pulses with 90°-phase difference is the main feature of this signal. The definition of the resolution for this signal is shown in Figure 3.2.1.

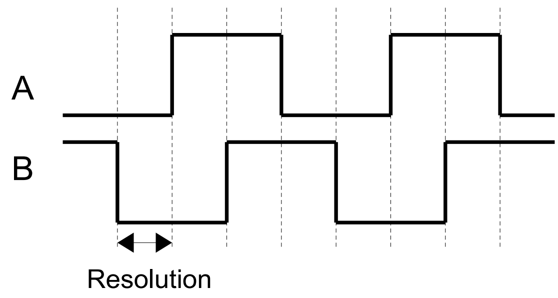


Figure 3.2.1

3.3 Encoder signal output

The servo drive needs input signals of the encoder when performing servo control. The host controller also has the requirement of receiving position signals when cooperating with the drive. Generally, the drive will transmit position or angle signals received from the encoder to the host controller. D2T-LM series drive provides the following two encoder output modes.

- **Buffered encoder output**
  When this mode is selected, the drive directly sends the received encoder signals to the host controller. Users can also choose the “Invert” option to make the drive send the received encoder signals back.
- **Emulated encoder output**
  When this mode is selected, the drive multiplies the information of the received encoder positions by “Scaling” and sends it out to the host controller. In some cases, the ratio can be set to lower the frequency of the encoder output. For example, the host controller cannot receive the encoder signal with a too high frequency. In addition, the ratio can also be set to lower the resolution of the encoder output when the multiplier factor of the analog encoder is set too high.

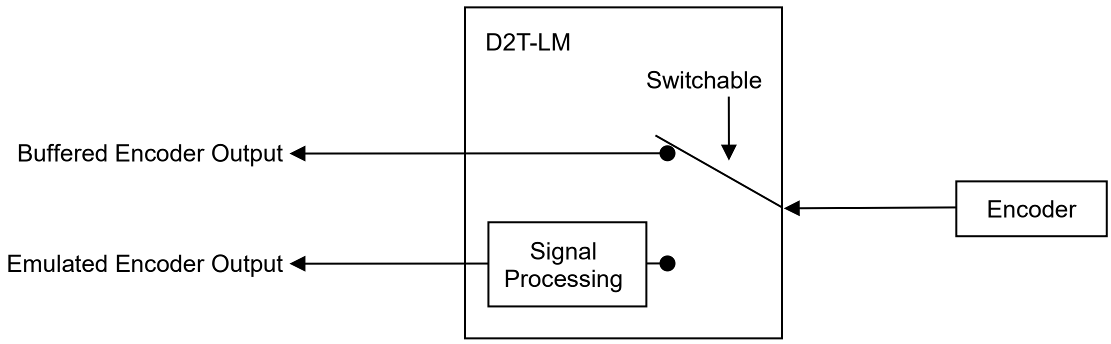


Figure 3.3.1

3.4 Path planning

The main purpose of path planning is that the host controller calculates suitable motion commands based on users' actual requirement of distance, velocity, acceleration, and smooth factor. These commands (pulse or V command) can be sent to the drive by the host controller, or calculated by the drive itself (stand-alone mode). The configuration depends on the application.

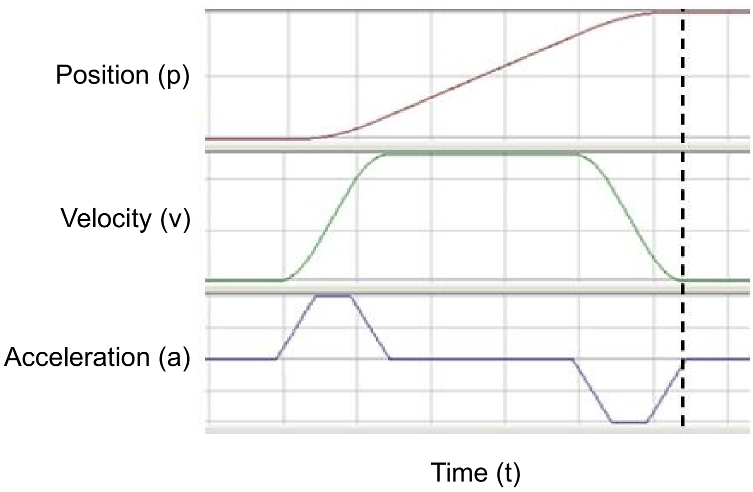


Figure 3.4.1

- **Position**

  The encoder provides the position information of the motor to the drive, so the drive can analyze the present position of the motor. For linear motion, common position units are um, mm, and m; for rotary motion, common position unit is encoder count. For D2T-LM series drive, "Reference position" equals position commands, calculated by the path generator based on the related parameters. On the other side, "Target position" is the target position set by users or the host controller. To make the motor move, it usually needs to go through the calculation of the path generator after being sent to the drive.

- **Velocity**

  Velocity is defined as the displacement variation per unit of time. For linear motion, velocity units are um/sec, mm/sec, and m/sec; for rotary motion, velocity units are count/sec, rps, and rpm.

- **Acceleration**

  Acceleration is defined as the velocity variation per unit of time. For linear motion, acceleration units are um/sec^2, mm/sec^2, and m/sec^2; for rotary motion, acceleration unit is rps^2.

- **Smooth factor**

When acceleration is rapidly increased or decreased in a short time, it indicates the force applying to the moving object is suddenly increased or decreased. Sometimes, to reduce such influence, implementing the technique of smooth motion in the motion control loop is helpful to enhance the performance. D2T-LM series drive adopts the technique of Smooth factor to achieve the effect. Through Smooth factor, the motion trajectory can be planned as S-type curve or T-type curve. The value ranges from 1 to 500. If the value is larger, the trajectory is closer to S-type curve, which means the influence is less. On the other hand, if the value is smaller, the trajectory is closer to T-type curve. When the value is 1, there is no effect on smooth function. Increasing the value of Smooth factor reduces the influence on motor force. In some cases, it enhances the settling performance during the process of positioning. However, the Move time of path planning will unavoidably increase when the motion becomes smoother. Users have to test on the machine to find the balance between them.

- **Emergency stop**

D2T-LM series drive comes with emergency stop function. When the drive removes the signal of "Axis Enable" on the pin I3, the function is activated. At this moment, the drive will immediately stop the motor in any motion with emergency stop deceleration to guarantee safety.

3.5 Servo loops and gains

■ **Servo loops**

To control the servo motor, D2T-LM series drive comes with three types of control loops, current loop, velocity loop and position loop. The architecture of servo loops is shown in Figure 3.5.1. On position mode, these three servo loops are connected in sequence to control the position of the motor. On velocity mode, velocity loop drives the motor through current loop. On current mode, current loop only controls the phase commutation mechanism of the motor. Its command is controlled by the voltage command from the host controller. To simplify the gain parameters of the servo loops, D2T-LM series drive only uses one common gain (CG) to set and adjust the overall control-loop architecture.

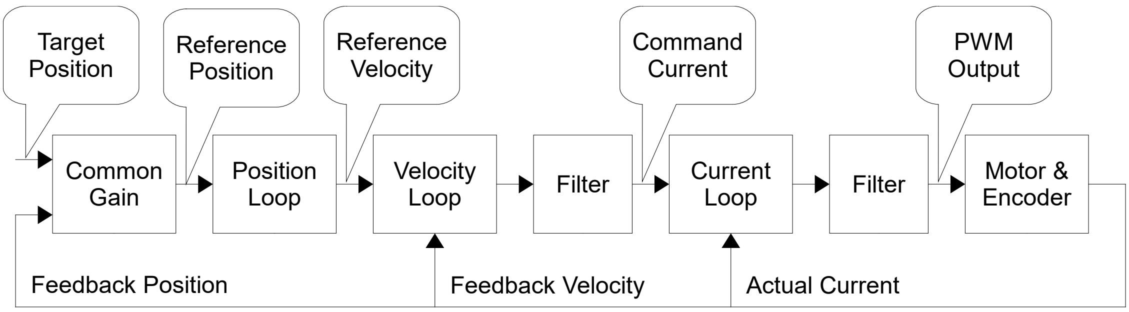


Figure 3.5.1

■ **Servo gains**

D2T-LM series drive uses one high-speed DSP to implement the motor control. Generally, it needs to adjust lots of servo gains when the servo loops are controlled by digital method. However, to significantly enhance convenience, the drive adopts an ingenious control design to simplify servo gains as one common gain (CG).

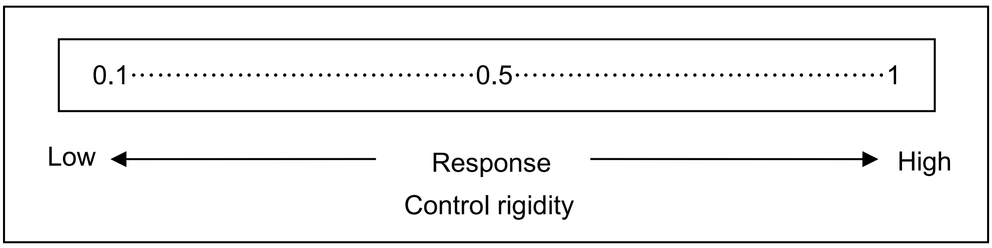


Figure 3.5.2

3.6 Gain margin and phase margin

3.6.1 Nyquist plot

Gain margin (GM) is the amount of the increasing loop gain calculated by decibel (dB) before the close-loop system becomes unstable. On the other hand, Phase margin (PM) is the amount of the increasing phase delay before the close-loop system becomes unstable.

- **Gain margin**

  G(jωp) is the relative distance from the intersection of the negative real axis for Nyquist plot to the point (-1, j0), and ωp is the frequency of the phase crossover. In Figure 3.6.1.1, ∠G(jωp)=180°. For the transfer function G(s) in a loop system,

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

  The following conclusions can be drawn from Figure 3.6.1.1 and the characteristics of Nyquist plot.

  a. If G(jω) does not intersect with the negative real axis, |G(jωp)|=0 and GM=∞dB. When Nyquist plot does not intersect with the negative real axis at any non-zero finite frequency, GM=∞dB. Theoretically, the loop gain can be increased to infinite before the system becomes unstable.

  b. If G(jω) intersects with the negative real axis between 0 and -1, 0<|G(jωp)|<1 and GM>0dB. When Nyquist plot intersects with the negative real axis between 0 and -1 at any frequency, the loop gain is increased and the system is stable.

  c. If G(jω) is at the point (-1, j0), |G(jωp)|=1 and GM=0dB. When Nyquist plot G(jω) is at the point (-1, j0), GM=0dB. This indicates the system reaches the unstable boundary and the loop gain cannot be increased any more.

  d. If G(jω) passes the point (-1, j0), |G(jωp)|>1 and GM<0dB. When Nyquist plot G(jω) passes the point (-1, j0), GM<0dB. At this moment, GM must be decreased to reach the steady state of the loop gain.

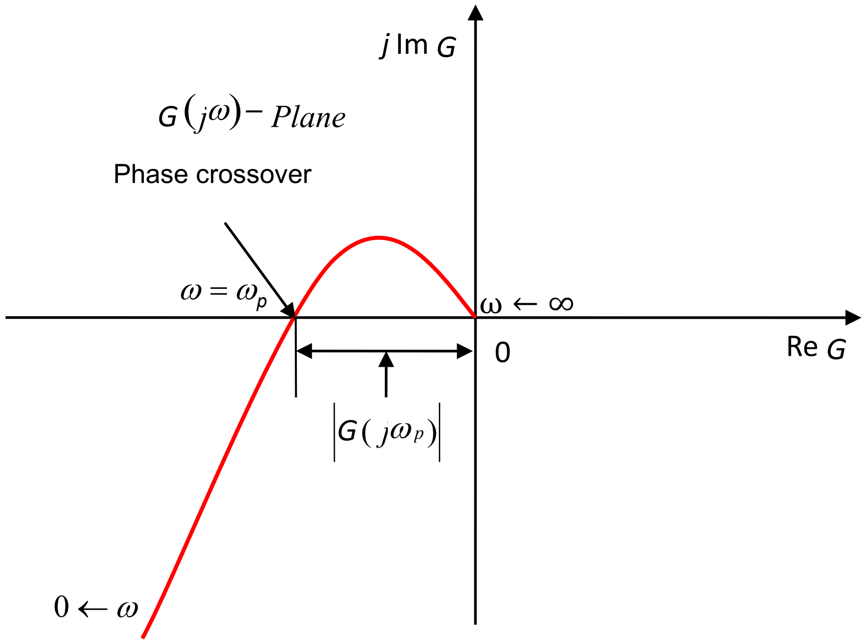


Figure 3.6.1.1 Gain margin of Nyquist plot

■ **Phase margin**

As Figure 3.6.1.2 shows, phase margin is the angle between the straight line passing through gain crossover and the negative real axis of G(jω)-plane.

Phase margin = PM = ∠G(jωg)—180°

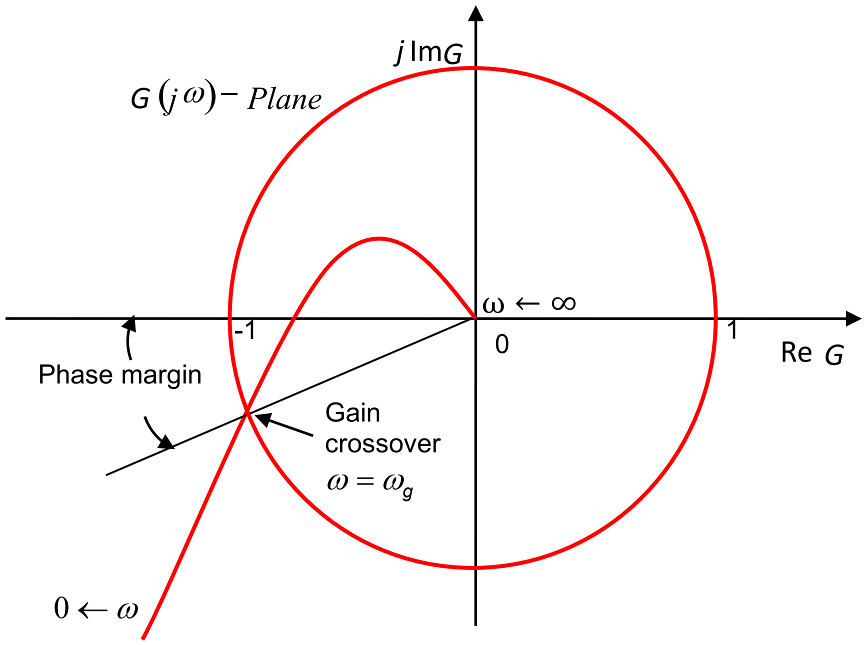


Figure 3.6.1.2 Phase margin of Nyquist plot

3.6.2 Bode plot

Gain margin and phase margin of Bode plot are shown in Figure 3.6.2.1.

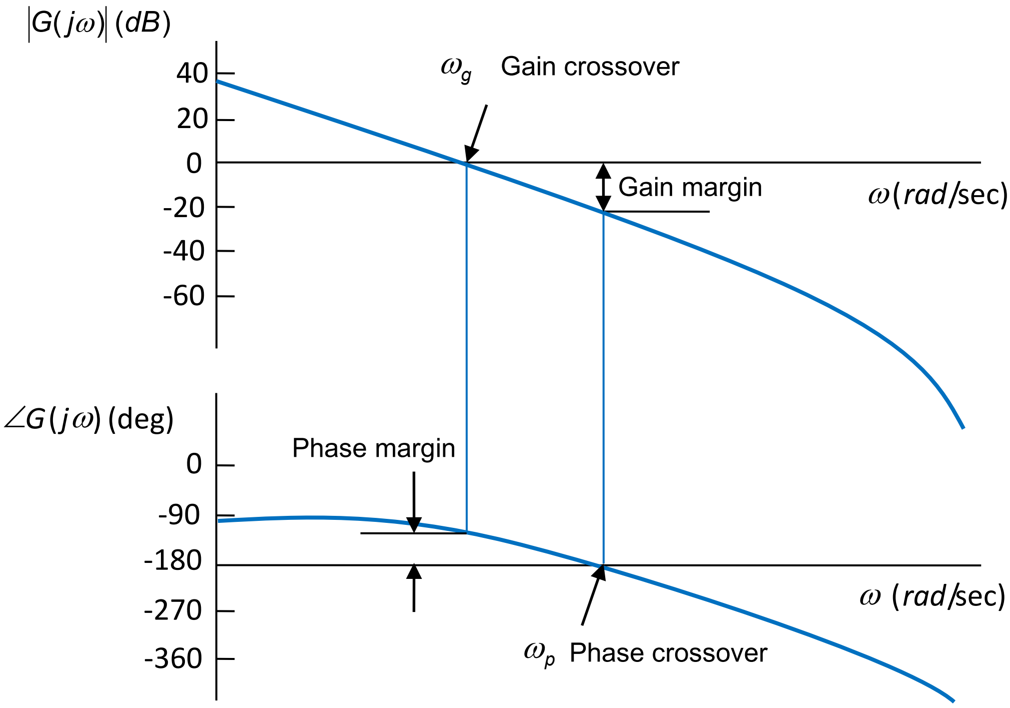


Figure 3.6.2.1 Gain margin and phase margin of Bode plot

Bandwidth of Bode plot is defined as -3dB, shown in Figure 3.6.2.2.

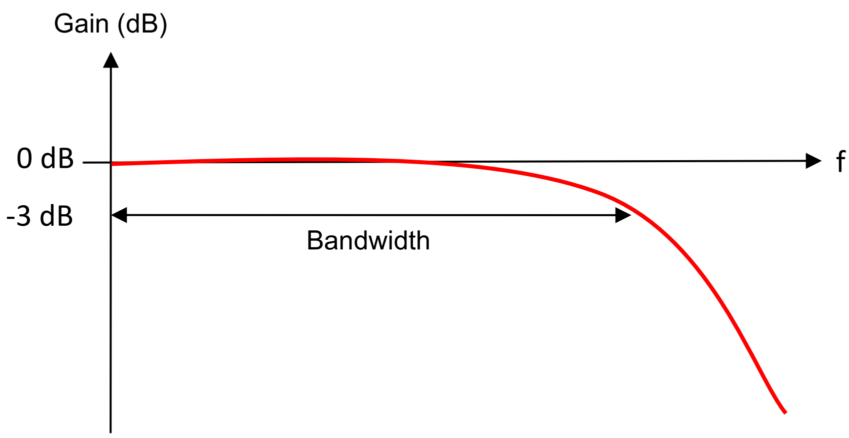


Figure 3.6.2.2 Bandwidth of Bode plot

3.7 Move and settling

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

- **Position error**

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

- **Target radius**

  After the motor arrives at the target position, the difference between the feedback position and the target position must be controlled and kept within a specific positive/negative tiny range, called target radius.

- **Total time of move and settling**

  As Figure 3.7.1 shows, after the motor arrives at the target position, the position error should be smaller than the set target radius and keep for a period of time (debounce time). After that, the "In-Position" signal is set, called in position. If the position error is continuously out of the radius, then it is called not yet in position. Total time, the start of the motion to the achievement of the settling, is the sum of move time and settling time.

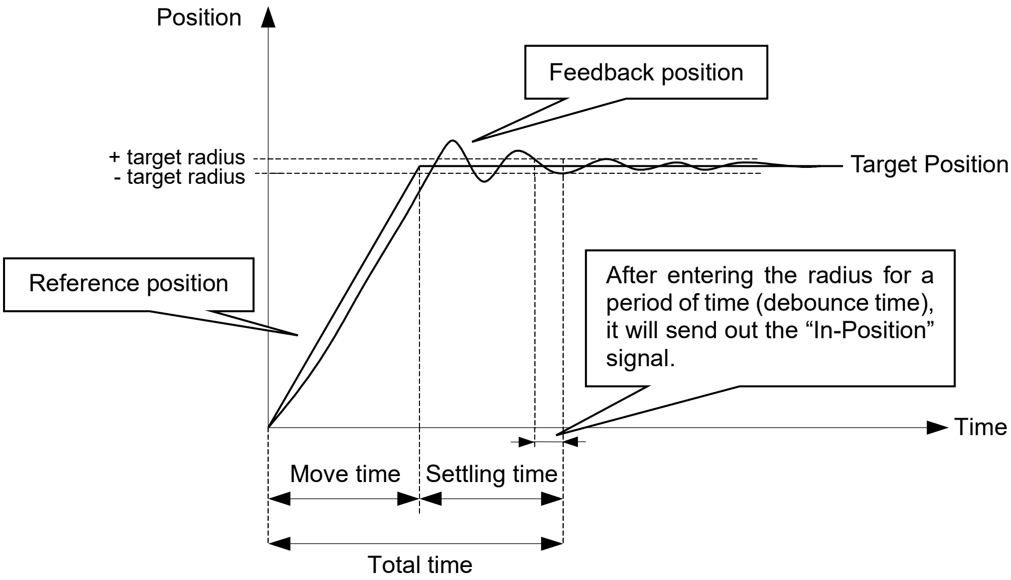


Figure 3.7.1

3.8 Error compensation

Generally, the positioning accuracy of the drive is determined by the performance of the encoder. However, sometimes the encoder cannot completely meet the requirement of the accuracy. In this case, apparatus with higher level of accuracy (e.g. laser interferometer) can be applied to measure the error of the system. D2T-LM series drive comes with a high-performance controlling method. It saves the measured error data in error map of the drive (shown in Figure 3.8.1), and uses the data during the motion. To enhance the positioning accuracy, it calculates the value of error compensation by adopting linear interpolation between fixed distances.

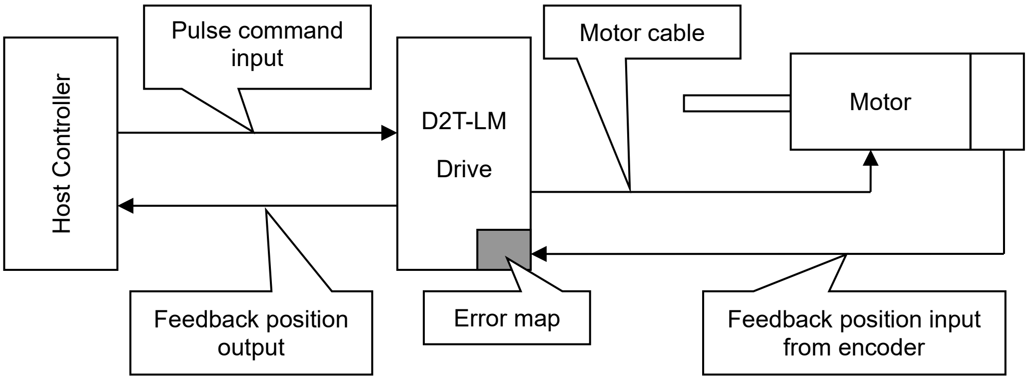
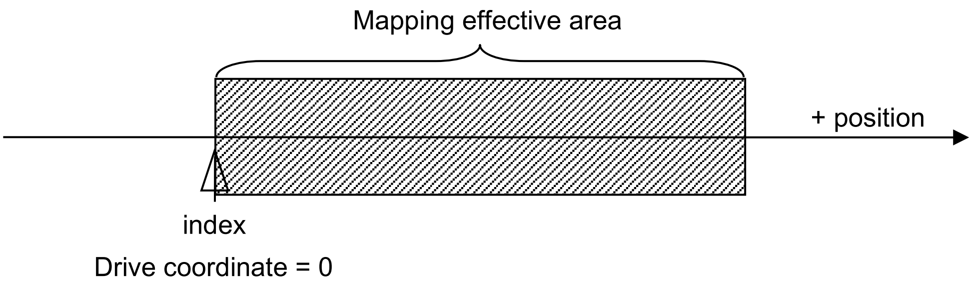


Figure 3.8.1

The mapping effective area is determined by the index signal. The area from index toward positive direction is the mapping effective area, while the area from index toward negative direction is not. As Figure 3.8.2 shows, the mapping effective area for non-zero home offset is the same as that for zero home offset.

(1) Home offset = 0



(2) Home offset = 100

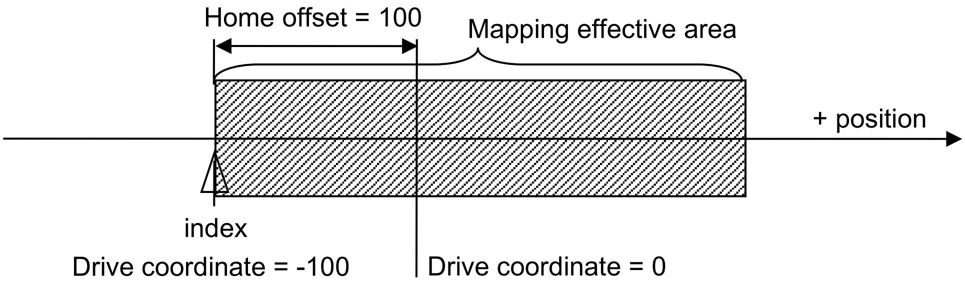


Figure 3.8.2

3.9 Velocity ripple

Generally, in motion control, it would be great if the motion in constant velocity phase is as steady as possible. Motion stability can be estimated by the index of velocity ripple. Cogging force of the motor, cable chain, air pipeline, and friction of the guideway are the main factors that cause the variation in constant velocity phase. Scanning or detecting machines that require high stability in constant velocity phase usually apply velocity ripple. The equation of velocity ripple is:

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

V_{target} is the target velocity, V_{max} is the maximum velocity in constant velocity phase, and V_{min} is the minimum velocity in constant velocity phase. As Figure 3.9.1 shows, (a) (with larger velocity ripple) is less steady, while (b) (with smaller velocity ripple) indicates better steadiness.

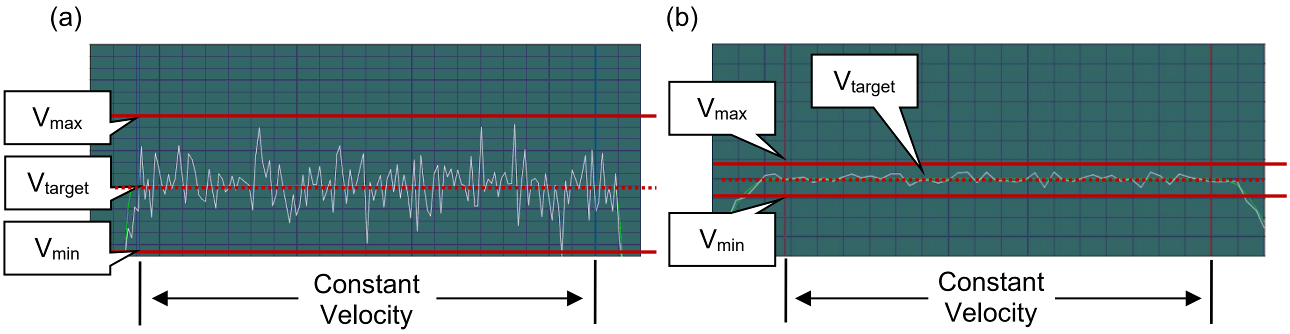


Figure 3.9.1

3.10 Enable

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

- **Step motion mode**
  Step motion (SM) mode is an open-loop architecture. On this mode, the behavior of the motor is similar to the stepping motor, it does not adopt the signal of feedback position in the enable state. This mode is used to ensure that the force direction of the motor is consistent with the direction of encoder feedback. If it is not, it will cause the failure of phase initialization.

- **Phase initialization**
  For the drive with incremental encoder, it needs to find the electrical angle, also known as phase initialization, on first power on. For HIWIN servo motors, after the drive is booted, it is able to find the electrical angle almost without any movement in the first enable process. To achieve the same effect, installing Hall sensor is the other common way of phase initialization. Generally, the host controller sends an output signal (e.g. the input I3 of D2T-LM series drive) to the drive to complete phase initialization and the enable process.

3.11 Common physical quantities

No.	Physical quantity	Description
1	Feedback Position	Feedback position
2	Reference Position	Position command
3	Target Position	Target position
4	Position Error	Position error
10	Feedback Velocity	Feedback velocity
11	Reference Velocity	Velocity command
12	Velocity Error	Velocity error
20	Reference Acceleration	Acceleration command
30	Actual Current	Actual current
31	Command Current	Current command
32	Current effective value	Effective value of current during calculation period
40	Analog Command	Voltage command (from the host controller)
41	Bus Voltage	Line voltage
42	Servo Voltage Percentage	Servo voltage
45	PWM Command	Torque / Force / Velocity command (from the host controller)
51	Soft-Thermal Accumulator	Temperature estimation via software
52	I2T Accumulator	I2T estimation
53	Average load ratio	Average load ratio during calculation period
54	Peak load ratio	Peak load ratio during calculation period
61	I1	Input 1
62	I2	Input 2
63	I3	Input 3
64	I4	Input 4
65	I5	Input 5
66	I6	Input 6
71	I7	Input 7
72	I8	Input 8
67	I9	Input 9
68	I10	Input 10
81	O1	Output 1
82	O2	Output 2
83	O3	Output 3

84	O4	Output 4
86	O5	Output 5
85	CN2/BRK	Brake signal output

4. Wiring

4.1 System configuration and wiring

The system configuration of the drive and the function of each connector are described in this chapter.

4.1.1 System wiring diagram

The following figures show the name, function, and specification of each connector.

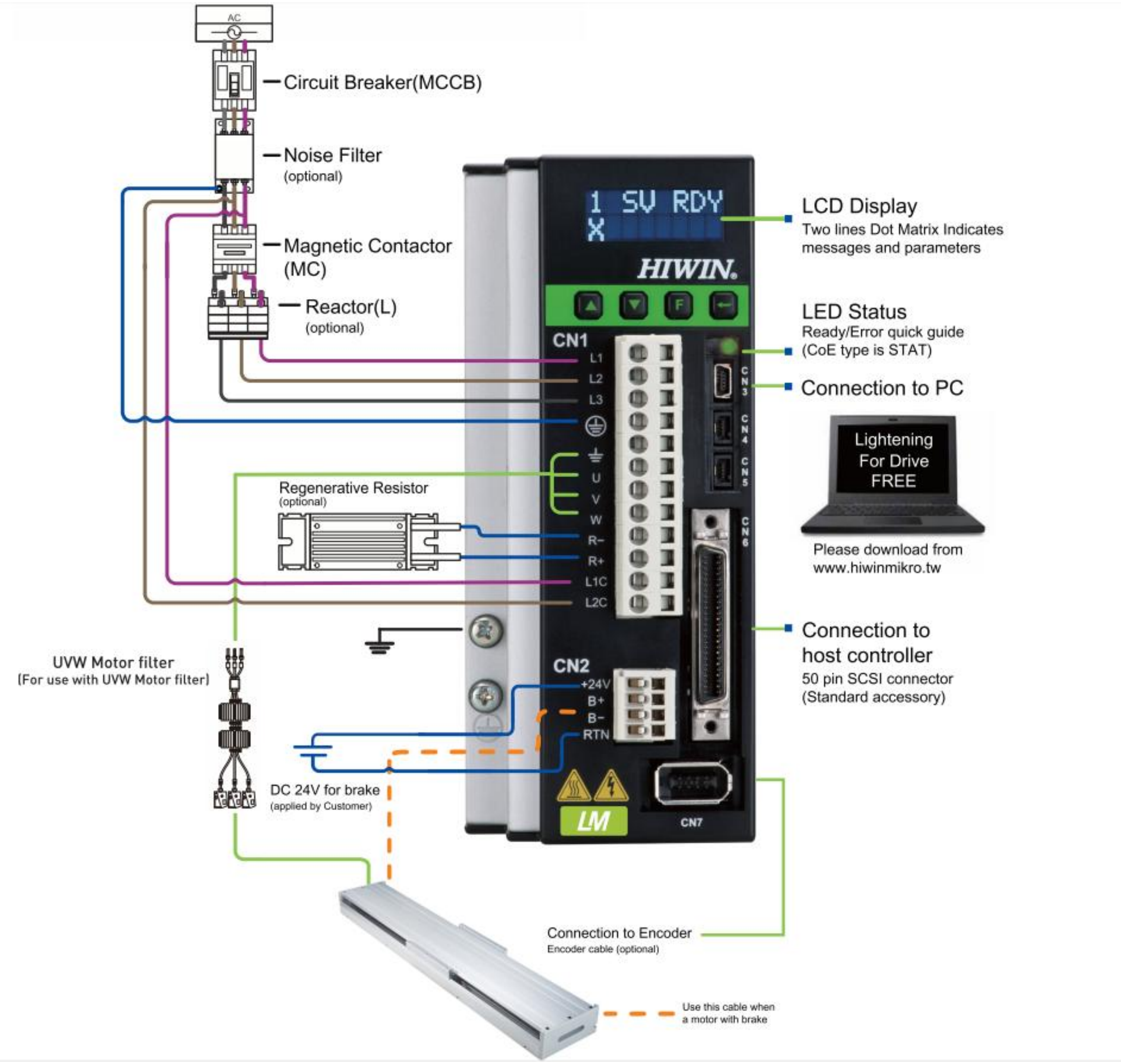
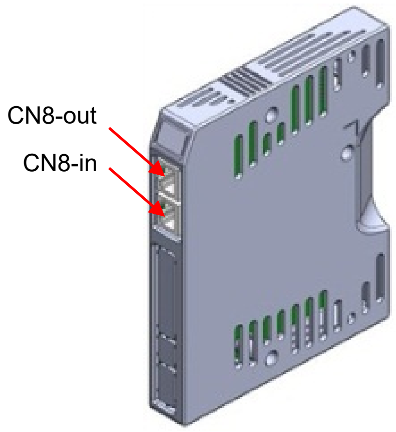


Figure 4.1.1.1



Fieldbus

Figure 4.1.1.2

Table 4.1.1.1

Item No.	Name	Connector	Description
1	AC main power cable	Frame B, C: CN1	L1, L2: Single-phase 200~240Vac, 50/60Hz L1, L2, L3: Three-phase 200~240Vac, 50/60Hz
2	Motor power cable	Frame B, C: CN1 (⏚, U, V, W)	Connect to motor, three-phase motor power
3	Regenerative resistor	Frame B, C: CN1 (R-, R+)	Connect to regenerative resistor (optional equipped / installed according to actual application)
4	Control power cable	Frame B, C: CN1 (L1C, L2C)	Drive control and I/O power (L1C, L2C: Single-phase 200~240Vac, 50/60Hz)
5	Brake	Frame B, C: CN2 (B-, B+)	Connect to brake (optional equipped / installed according to actual application)
6	Mini USB communication	Frame B, C: CN3	Connect to PC (for parameter setting; please remove it after the setting) By connecting mini USB to PC, monitoring the drive, doing operational tests, and writing parameters can be done.
7	Control signal	Frame B, C: CN6	Connect to host controller
8	Feedback signal	Frame B, C: CN7	Connect to motor encoder
9	EtherCAT communication	Frame B, C: CN8	Connect to host controller through EtherCAT communication protocol
10	Extension I/O signal	Frame B, C: CN13, CN14	Extension I/O module

4.1.2 CN1 power

Single/Three-phase power input, motor power output (Frame B, C), regenerative resistor wiring and single-phase control power input are included in the descriptions of CN1 power wiring.

4.1.2.1 Power wiring

Ensure that the drive is properly grounded before connecting it to the main circuit of the drive.
Connector model: Wago 721-112/026-000 (female)

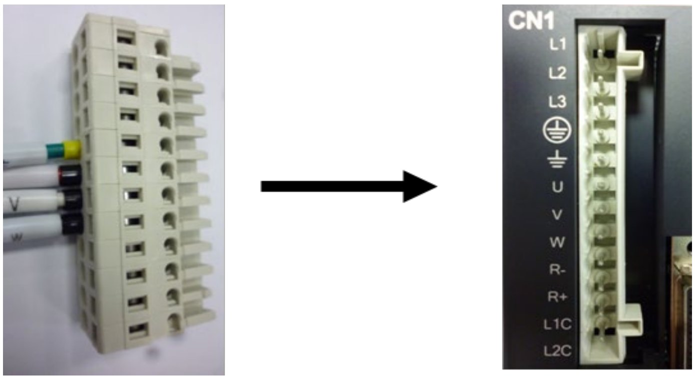


Figure 4.1.2.1.1 CN1 connector

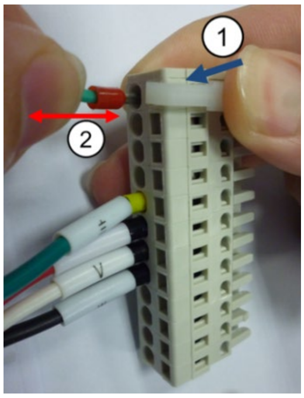


Figure 4.1.2.1.2 Installation and removal

Table 4.1.2.1.1 CN1 pin assignment

Pin	Signal	Function
1	L1	AC main power, 220Vac (50/60 Hz) Single/Three-phase
2	L2	
3	L3	AC main power, 220Vac (50/60 Hz) Three-phase
4	(⏚)	AC main power ground input
5	⏚	Motor ground input
6	U	Motor U-phase input
7	V	Motor V-phase input
8	W	Motor W-phase input
9	REG-	Negative terminal of regenerative resistor
10	REG+	Positive terminal of regenerative resistor
11	L1C	Control power, 220Vac (50/60 Hz) Single-phase
12	L2C	

4.1.2.2 Motor wiring

Correctly ground the drive and the motor.

The following motor wiring is only suitable for Frame B and C models.

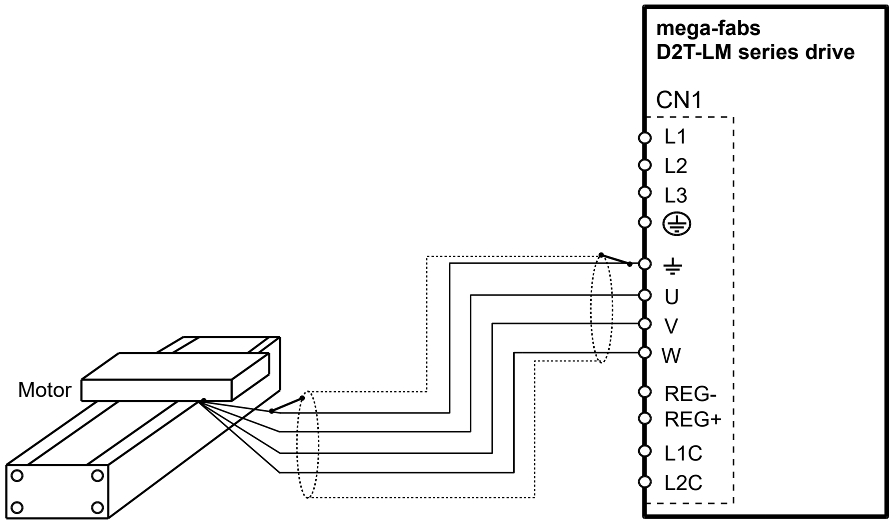


Figure 4.1.2.2.1

4.1.2.3 Regenerative resistor wiring

Regenerative resistor is optional. Install it according to actual application.

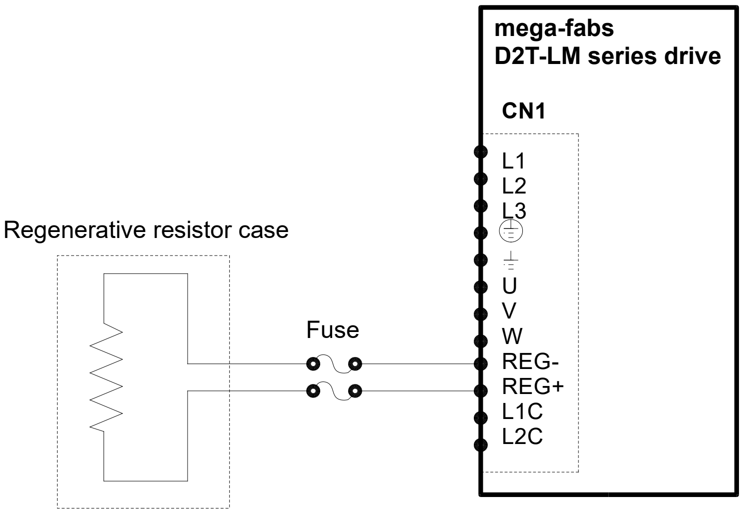


Figure 4.1.2.3.1

⚠ ATTENTION

- Wiring and the related inspections must be done by professional technicians.
- Power off before wiring or inspections to avoid electric shock or other dangers.
- Do not touch the terminals for power supply within 5 minutes after power off. The voltage in the drive remains high.
- Correctly conduct wiring, or it may cause uncontrolled motor operation, injury to people, machine malfunction, or other unexpected accidents.
- Do not connect U, V, or W terminal of the motor to power supply.
- Fasten the connectors of the power supply and the motor, or it may cause fire.
- Ensure that the drive and the motor are properly grounded.
- Install the drive and the motor before wiring, or it may cause electric shock.
- Do not damage, pull, or squeeze the wire, or it may cause electric shock.
- The drive may interfere with nearby electronic equipment. A noise filter could be used to reduce the effect of electromagnetic interference.
- Do not make any modification to the drive.
- Do not put the main circuit cable, I/O signal cable, and encoder cable in the same duct, or tie them together. The distance among them should be more than 30cm when wiring.
- Please observe the following instructions when wiring main circuit terminals.
  - ※ Do not insert two wires or more in the same socket.
  - ※ Check if there is a short circuit between the wire and its adjacent wires after inserting it.
  - ※ Use the specific power voltage, or it may cause fire or damage to drive.
- If the drive is used in the condition of poor or significantly fluctuating power, ensure that the power is supplied within the specified range of voltage fluctuation. Otherwise, it may cause damage to drive.
- Install safety devices, such as breaker, to prevent the short circuit of external wiring from damaging the drive.
- Adopt appropriate isolation and shielding measures when using the drive in the following environments. Otherwise, it may cause poor operation of the drive.
  - ※ Environment with the interference generated by static electricity.
  - ※ Environment with a strong electric or magnetic field.
  - ※ Environment with radiation emitting.
- To avoid accelerating the aging of internal electronic power components, do not switch the power on and off frequently. If there is a need to continuously switch the power on and off, the time interval should be more than 3 minutes.

4.1.3 CN2 brake power

CN2 is the brake connector for Frame B and C models. Check the pin assignment before usage. Instead of sharing the same power source with others, the brake power is suggested to be independent.

Use the brake wiring with a relay to connect 24Vdc power supply of the drive and the brake.
Connector model: WAGO 734-104

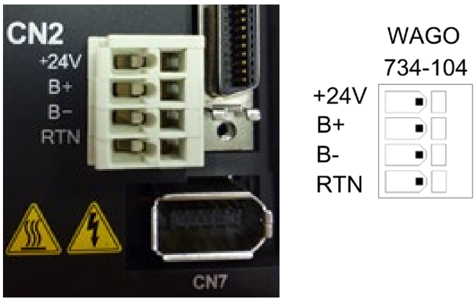


Figure 4.1.3.1

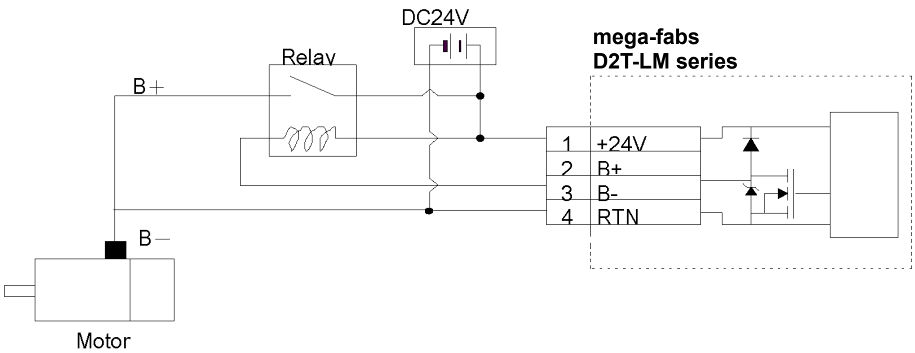


Figure 4.1.3.2 CN2 brake wiring (with a relay)

4.1.4 CN3 USB communication

By connecting mini USB to PC, monitoring the drive, doing operational tests, and writing parameters can be done. Please refer to Chapter 5 for the corresponding operation.

Wiring diagrams for mini USB communication

Use HIWIN shielded network cable, “USB 2.0 Type A to mini-B 5PIN (1.8M)”.

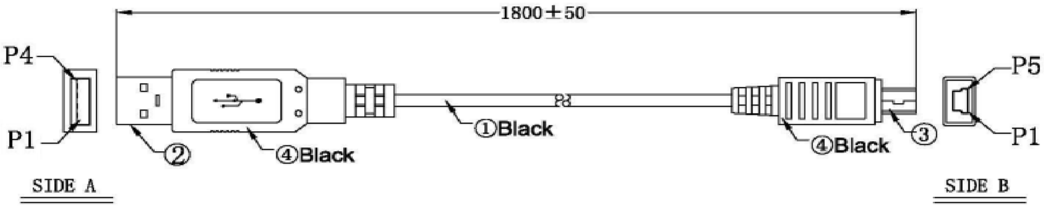


Figure 4.1.4.1

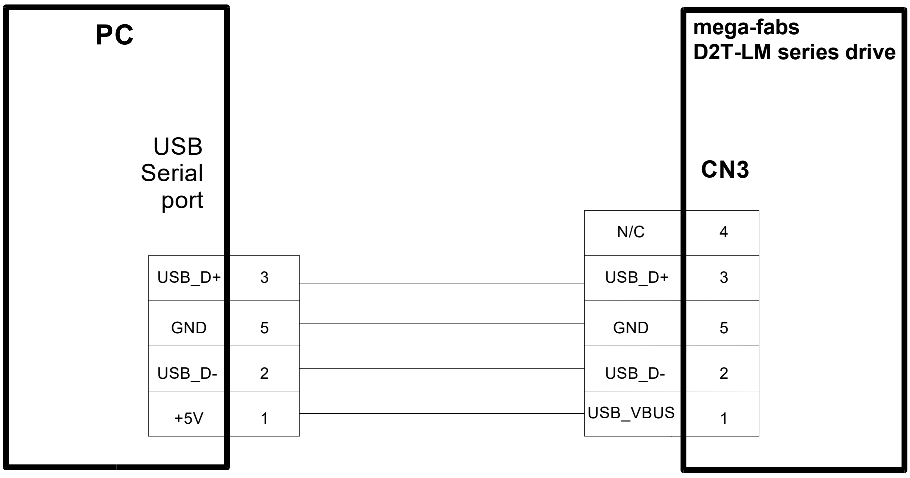
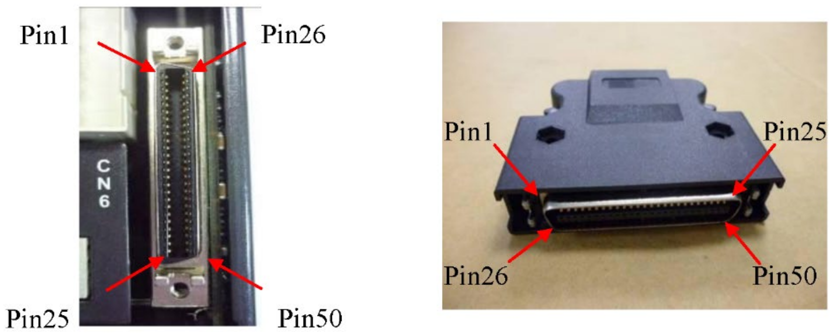


Figure 4.1.4.2

4.1.5 CN6 control signal

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



(a) SCSI 50PIN (female) (b) SCSI 50PIN (male)

Figure 4.1.5.1

Table 4.1.5.1 CN6 pin assignment

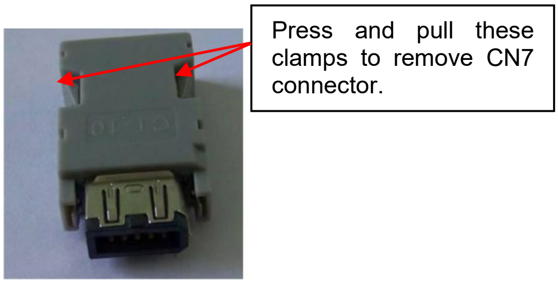
Pin	Signal	Function
1	CWL	Low-speed (single-ended: 250Kpps; differential: 500Kpps) pulse command Channel 1: Pulse, CW, A-phase
3	CWL+	
4	CWL-	
2	CCWL	Low-speed (single-ended: 250Kpps; differential: 500Kpps) pulse command Channel 2: Dir, CCW, B-phase
5	CCWL+	
6	CCWL-	
13	SG	Digital ground reference
21	A	Feedback pulse output (buffered encoder or emulated encoder) RS422
22	/A	
48	B	
49	/B	
23	Z	
24	/Z	
25	SG	Digital ground reference
19	CZ	Z-phase output (open collector)
14	ADC0+	Analog command input for velocity / torque (+/-10V)
15	ADC0-	

16	ADC1+	N/A
17	ADC1-	
18	ADC2+	
20	ADC2-	
43	AO1	Analog voltage output (+/-10V) for monitoring motor torque
44	CWH+	High-speed (4Mpps) pulse command
45	CWH-	Channel 1: Pulse, CW, A-phase
46	CCWH+	High-speed (4Mpps) pulse command
47	CCWH-	Channel 2: Dir, CCW, B-phase
7	COM	Common point for general-purpose input signal (Sink or Source)
33	I1	General-purpose input signal (programmable function)
30	I2	
29	I3	
27	I4	
28	I5	
26	I6	
32	I7	
31	I8	
9	I9	
8	I10	
35	O1+	General-purpose output signal (programmable function)
34	O1-	
37	O2+	
36	O2-	
39	O3+	
38	O3-	
11	O4+	
10	O4-	
40	O5+	
12	O5-	
41	AGND	Analog ground reference
50	FG	Frame ground reference

4.1.6 CN7 encoder

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

(a) SCR connector 10PIN (male)



(b) SCR connector 10PIN (female)

Figure 4.1.6.1

Table 4.1.6.1 CN7 pin assignment

Pin	Signal	Description
Encoder type	13-bit	
1	+5Vdc	Encoder +5Vdc power output
2	SG	Digital ground and +5Vdc ground
3	N/A	N/A
4	N/A	
5	A	digital incremental: TTL signal transmission (A, /A, B, /B, Z, /Z)
6	/A	
7	B	
8	/B	
9	Z	
10	/Z	
Shield	FG	Frame ground reference

4.1.7 CN8 EtherCAT communication

Please select the connector with shield function for the network cable of EtherCAT module.

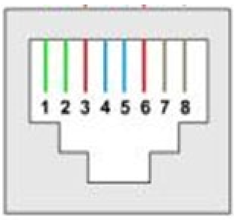


Figure 4.1.7.1 CN8 RJ45

Table 4.1.7.1 CN8 pin assignment

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

4.2 Drive accessories

■ Motor power cable

Part name	Part No.	Description
Motor power cable	HVPS04AA□□MB	Suitable for 200W~1KW motor, without brake, flexible

□□ denotes cable length. The corresponding table is as follows.

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

■ Encoder cable

Part name	Part No.	Description
Encoder cable	LMACF□□K	Suitable for digital encoder, flexible

□□ denotes cable length. The corresponding table is as follows.

□□	02	03	05	07	10
Cable length (m)	2	3	5	7	10

■ Signal cable

Part name	Part No.	Description
Control signal cable	LMACF02D	2m in length, connect to the host controller. The terminal of the cable is free, which can be soldered based on the connector of the host controller.

■ Communication cable

Part name	Part No.	Description
USB communication cable	051700800366	USB 2.0 Type A to mini-B 5PIN, 1.8m in length. The terminal of the drive is mini-B connector.

■ Connector kit

D2T-LM series drive model	Part No.	Description	Quantity
Frame B, C	D2-CK3	CN1: Connectors of AC power, motor power, regenerative resistor, and drive control power. 12 pins, pitch 5 mm, Wago 721-112/026-000	1
		CN2: Brake connector. 4 pins, pitch 3.5 mm	1
		CN6: Control signal connector. 50 pins welded type, EUMAX XDR-10350AS	1
		CN1 connector fixture tool: Wago 231-131	1
		CN2 connector fixture tool: Wago 734-230	1

■ EMC accessory kit

Part name	Part No.	Description	Quantity
D2T-LM EMC accessory kit for single-phase	D2-EMC1	Single-phase filter: FN2090-6-06, for Frame B (Rated current: 6A, leakage current: 0.67mA)	1
		EMI core KCF-130-B	2
	D2-EMC3	Single-phase filter: FN2090-10-06, for Frame C (Rated current: 10A, leakage current: 0.67mA)	1
		EMI core KCF-130-B	2
D2T-LM EMC accessory kit for three-phase	D2-EMC2	Three-phase filter: FN3025HL-20-71 (Rated current: 20A, leakage current: 0.4mA)	1
		EMI core KCF-130-B	2

Note: EMI magnetic ring can reduce noise interference. It can be applied to main power cable, motor power cable, encoder cable, or pulse control cable based on requirement.

■ Regenerative resistor

Part name	Part No.	Resistance value	Rated power / Peak power
Regenerative resistor	RG1	68Ω	100W / 500W
	RG2	120Ω	300W / 1500W

■ Connector specifications

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

Note 1: The accessory kit includes connectors of CN1, CN2, and CN6 (with 733-130 fixture tool).
HIWIN P/N: 051800200070

Note 2: Turn off all power supply and use fixture tools to avoid electric shock when wiring.

4.3 Main power wiring

⚠ ATTENTION

- Wiring and the related inspections must be done by professional technicians.
- Power off before wiring or inspections to avoid electric shock or other dangers.
- Do not touch the terminals for power supply within 5 minutes after power off. The voltage in the drive remains high.
- Correctly conduct wiring, or it may cause uncontrolled motor operation, injury to people, machine malfunction, or other unexpected accidents.
- Do not make any modification to the drive.
- To avoid accelerating the aging of internal electronic power components, do not switch the power on and off frequently. If there is a need to continuously switch the power on and off, the time interval should be more than 3 minutes.

4.3.1 AC power wiring (single-phase)

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

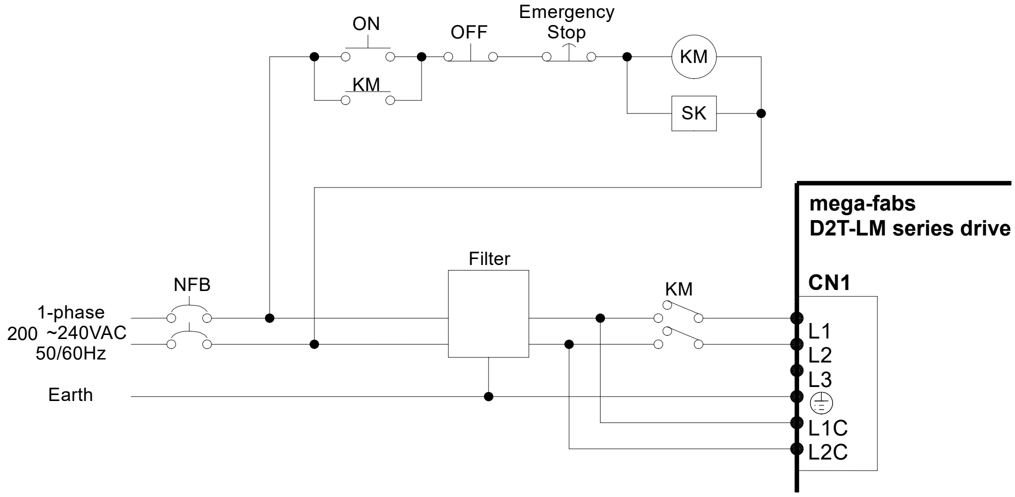


Figure 4.3.1.1

Table 4.3.1.1

FN2090-6-06 filter	
Maximum continuous operation voltage	250Vac, 50/60Hz
Operation frequency	DC to 400Hz

Rated current	1~30A @40°C
Surge pulse protection	2KV, IEC 61000-4-5

4.3.2 AC power wiring (three-phase)

It is recommended to use three-phase filter of FN3025HL-20-71.

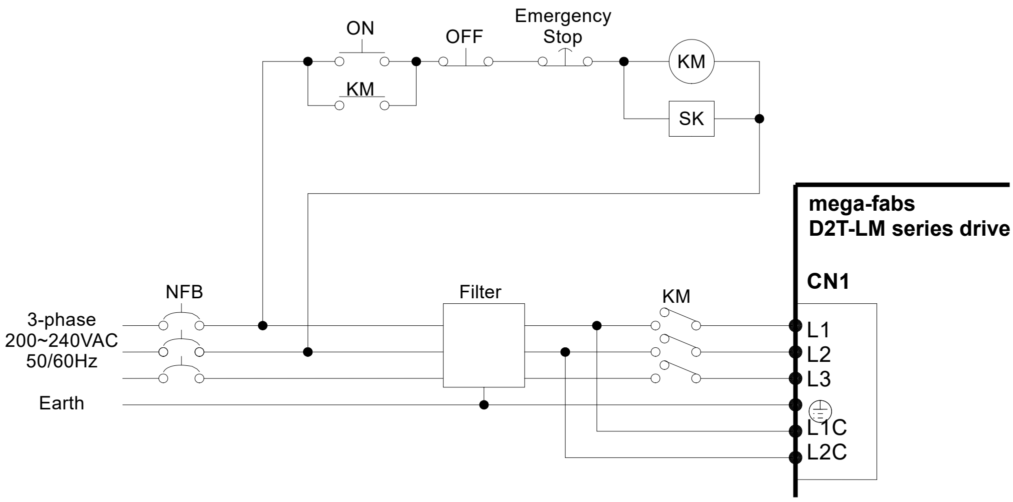


Figure 4.3.2.1

Table 4.3.2.1

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

4.4 Multiple drives connection

Caution:

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

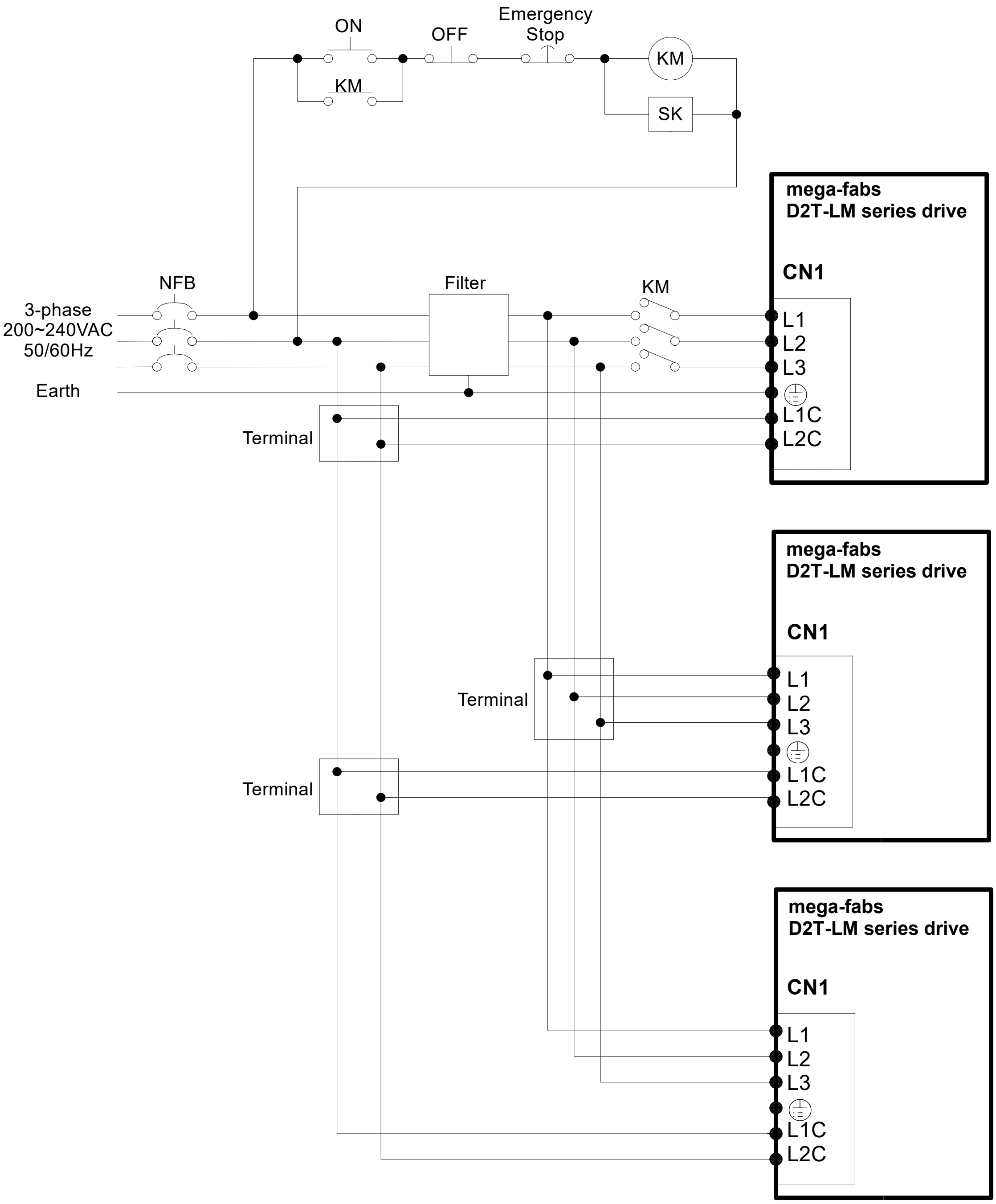


Figure 4.4.1

■ Selection of no-fuse breakers (NFBs)

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

One drive: $I_B = C \times I_n$
Two or more drives not started at the same time: $I_B = (\Sigma I_n - I_{nMAX}) \times K + C_{MAX} \times I_{nMAX}$
Two or more drives started at the same time: $I_B = C_1 \times I_{n1} + C_2 \times I_{n2} + \ldots\ldots + C_N \times I_{nN}$

【Note】
I_B: Rated NFB current
I_n: Rated drive current
I_{nMAX}: The maximum rated current among different drives
C: Multiple of rated current, generally 1.5~2.5, or 1.5 if it cannot be determined
C_{MAX}: Multiple of rated current for the maximum rated current among drives
K: Demand rate; 1 if it cannot be determined

Example:
If five D2T-0423-◊-B□ and one D2T-1023-◊-C□ drives are used (assuming that C and C_{MAX} are 2)

Not started at the same time: $I_B = (4.1 \times 5 + 7.5 - 7.5) \times 1 + 7.5 \times 2 = \underline{35.5}\ A_{rms}$
Started at the same time: $I_B = 2 \times 4.1 + 2 \times 4.1 + 2 \times 4.1 + 2 \times 4.1 + 2 \times 4.1 + 2 \times 7.5 = \underline{56}\ A_{rms}$

Table 4.4.1 Rated input current of D2T-LM series drive

Drive model	Rated input current
D2T-0423-◊-B□	$4.1A_{rms}$
D2T-1023-◊-C□	$7.5A_{rms}$

4.5 I/O signal wiring

Users can configure the function of each I/O through software. CN6 connector of D2T model provides 10 general-purpose inputs and 5 general-purpose outputs. The following figures only show part of the wiring.

4.5.1 Digital input wiring

General-purpose inputs of D2T-LM series drive adopt optical-coupler input interface suitable for voltage system between 12Vdc and 24Vdc. D2T-LM model has 10 general-purpose inputs with one COM port, suitable for both Sink and Source connection. The default function of I3 is “Axis Enable”; others can be set by human-machine interface (HMI) based on users’ requirement.

4.5.1.1 Sink input wiring examples

- Sink input wiring example via switches or relays

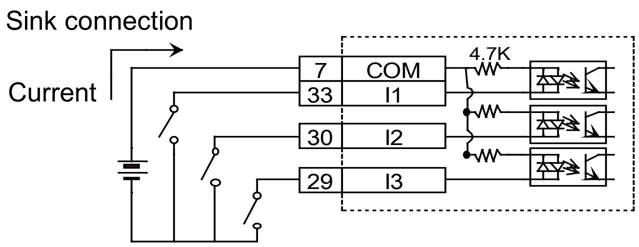


Figure 4.5.1.1.1

- Sink input wiring example via transistors

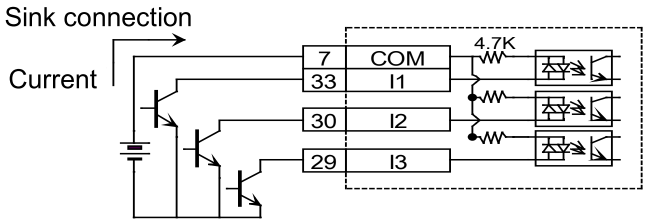


Figure 4.5.1.1.2

4.5.1.2 Source input wiring examples

- Source input wiring example via switches or relays

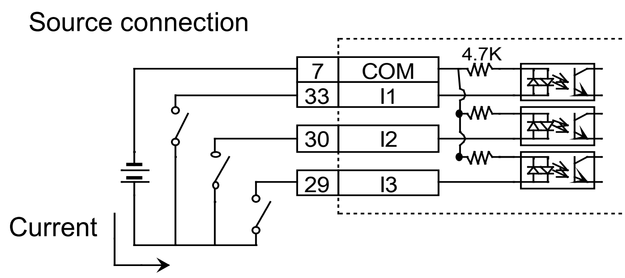


Figure 4.5.1.2.1

- Source input wiring example via transistors

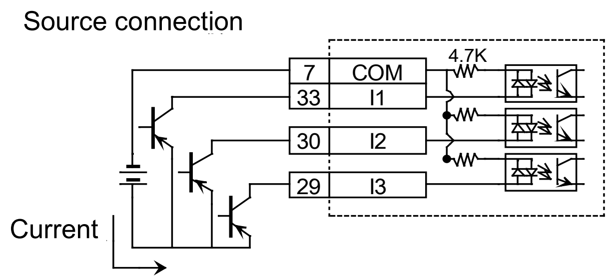


Figure 4.5.1.2.2

4.5.2 Digital output wiring

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

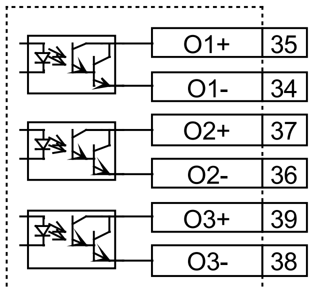


Figure 4.5.2.1

- Output wiring example via relays

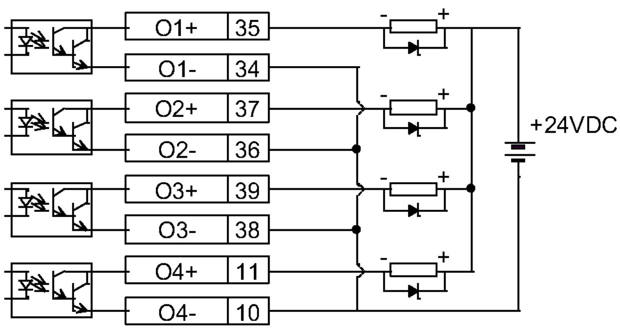


Figure 4.5.2.2

- Output wiring example via optical couplers

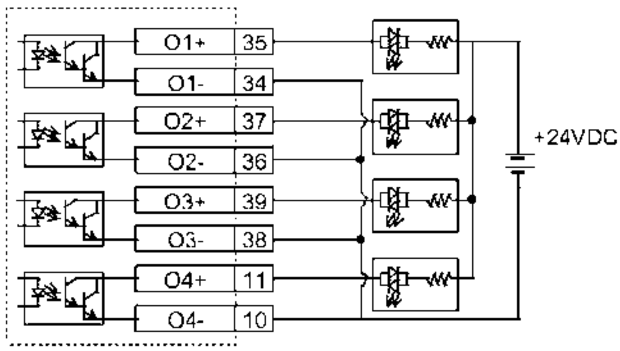


Figure 4.5.2.3

4.6 Wiring examples for control commands

The following figures only show part of the wiring.

4.6.1 System wiring diagram for pulse command

Position mode can accept three types of pulse command from the host controller.
Please refer to Section 3.1.1 for more information.

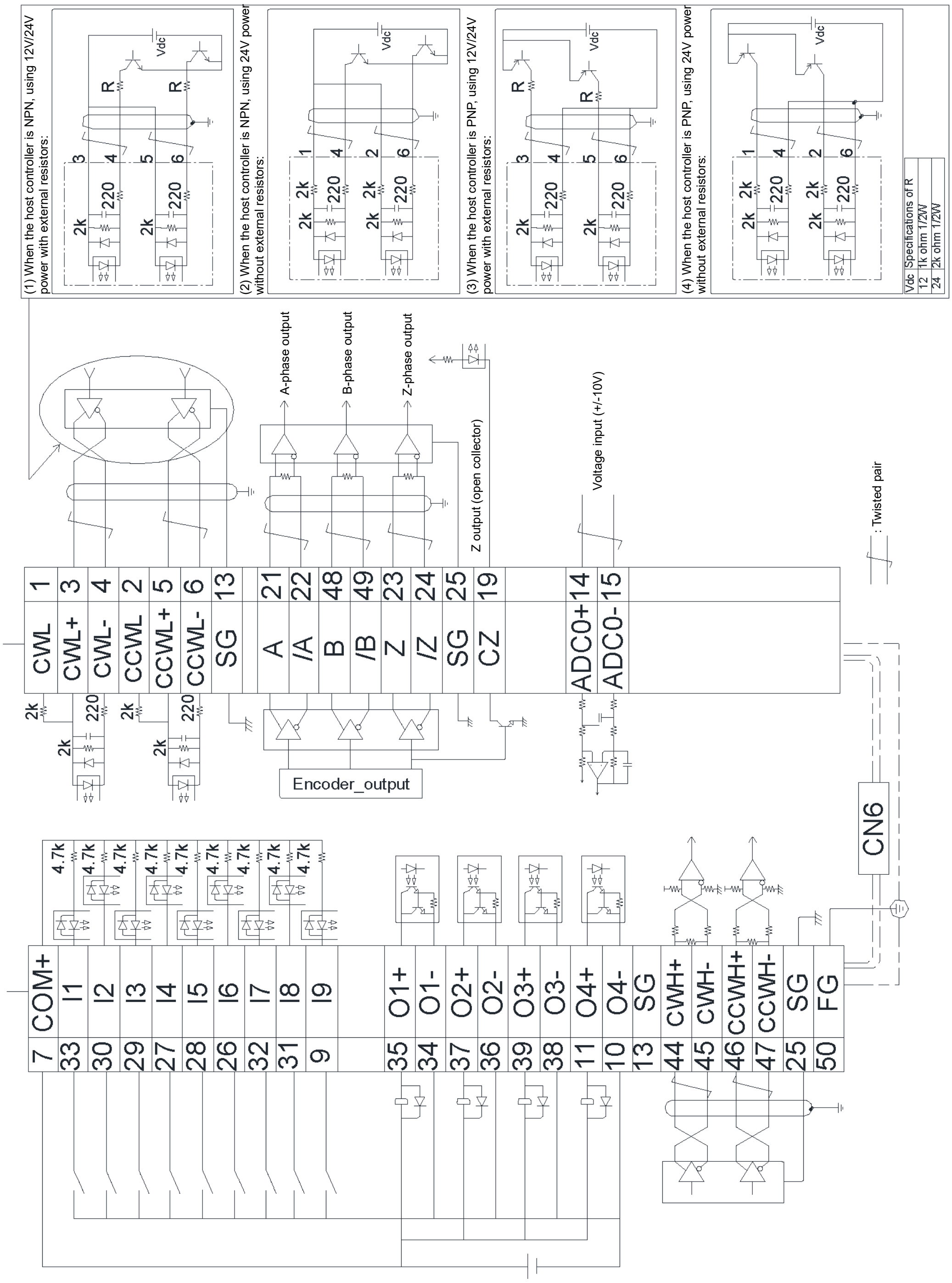


Figure 4.6.1.1

4.6.1.1 Differential interface

Wiring example for the host controller having differential interface:

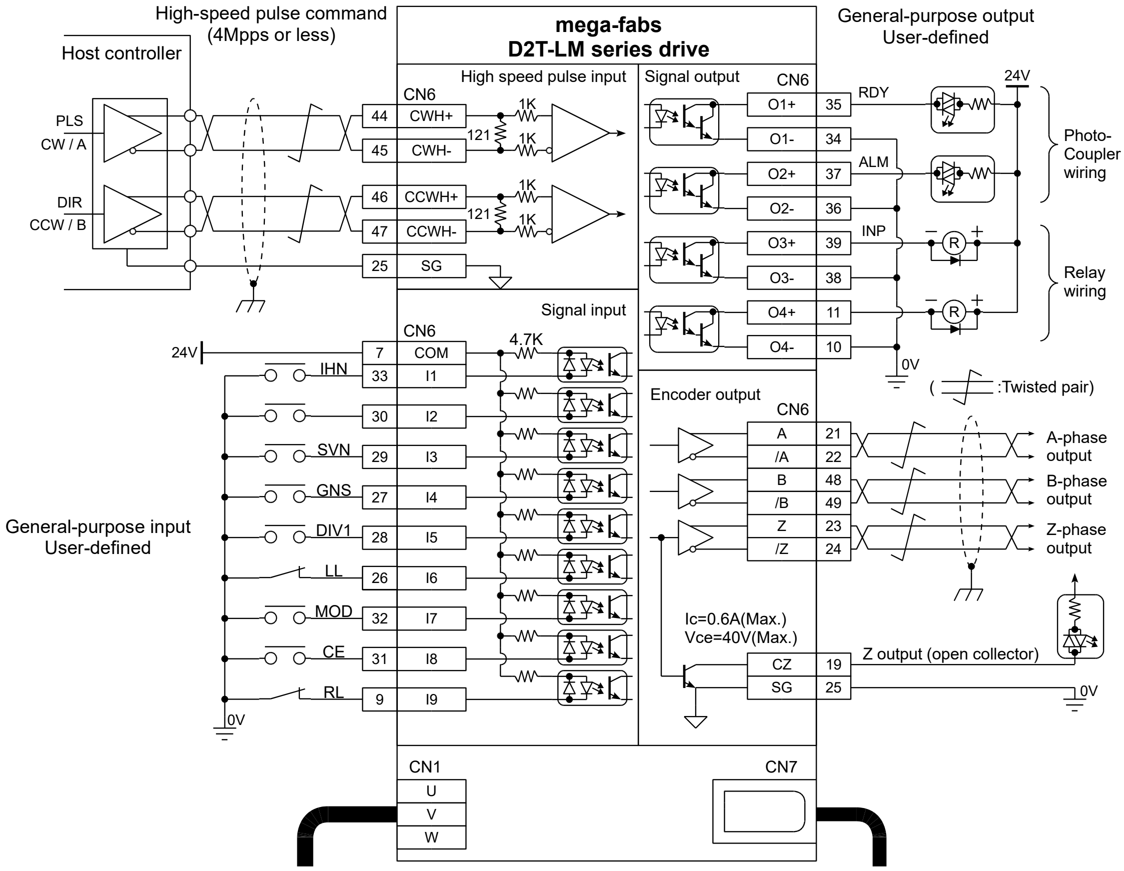


Figure 4.6.1.1.1

4.6.1.2 Sink (NPN) interface with current-limit resistances

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

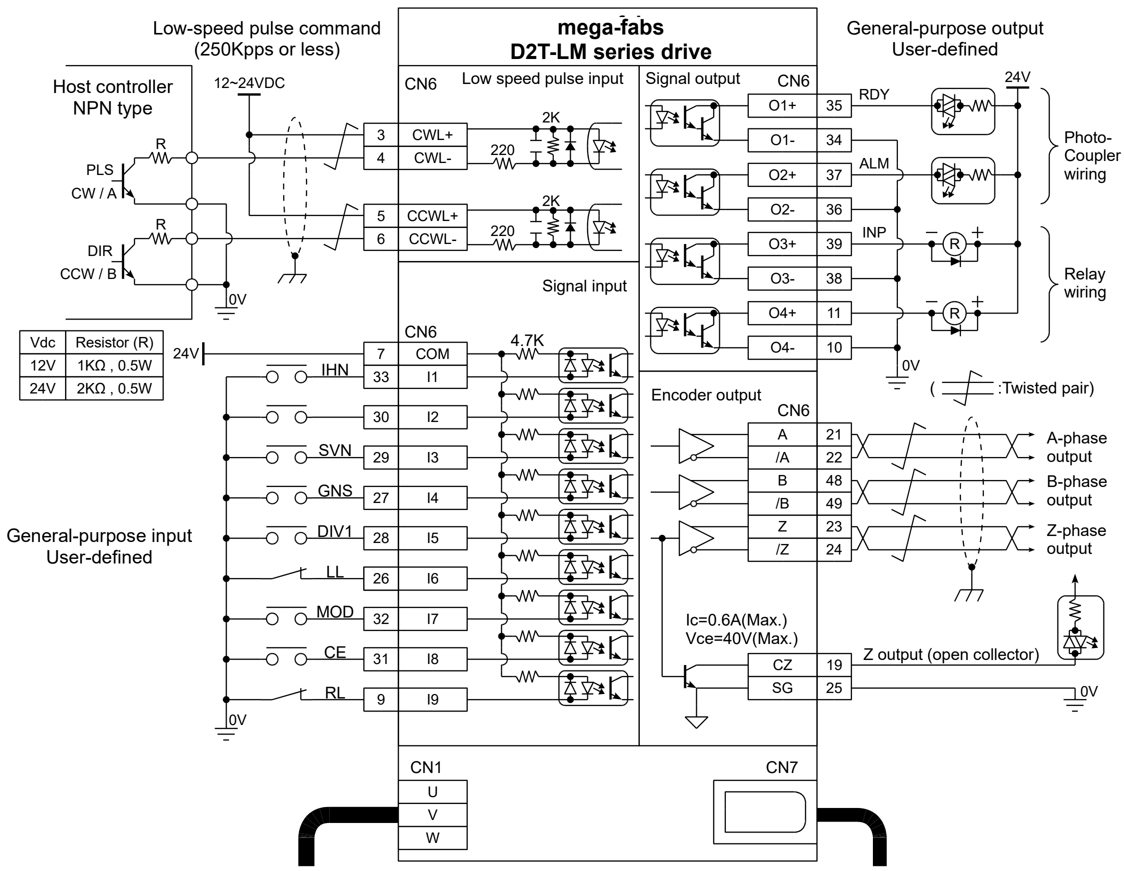


Figure 4.6.1.2.1

4.6.1.3 Sink (NPN) interface without current-limit resistances

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

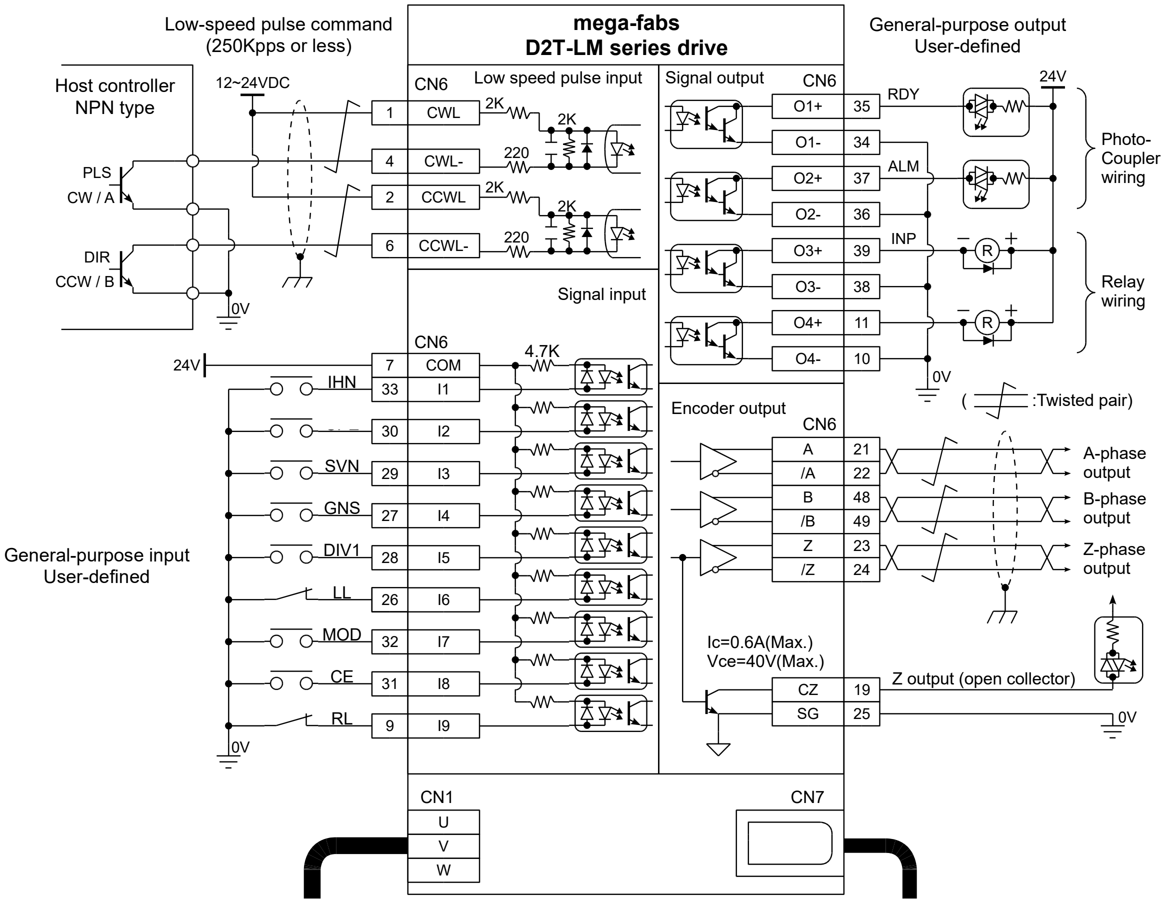


Figure 4.6.1.3.1

4.6.1.4 Source (PNP) interface with current-limit resistances

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

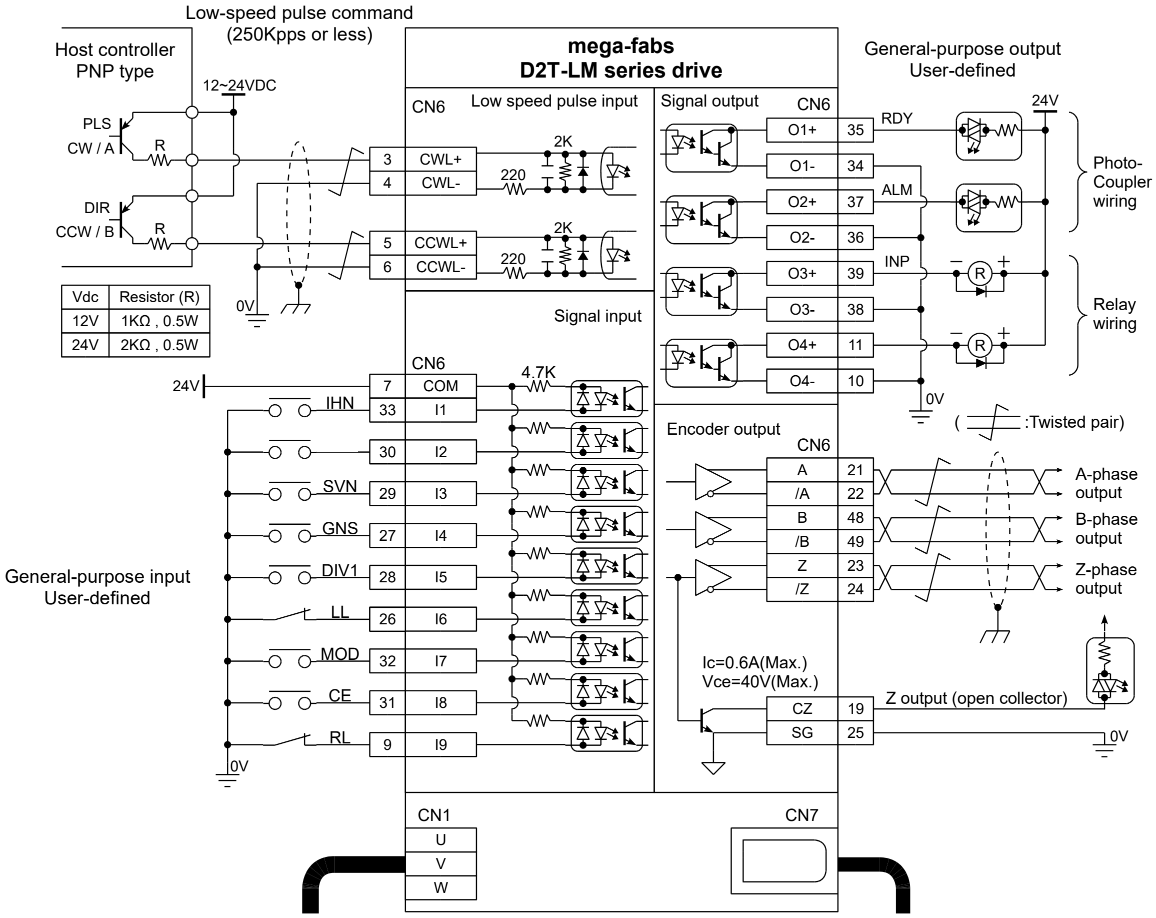


Figure 4.6.1.4.1

4.6.1.5 Source (PNP) interface without current-limit resistances

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

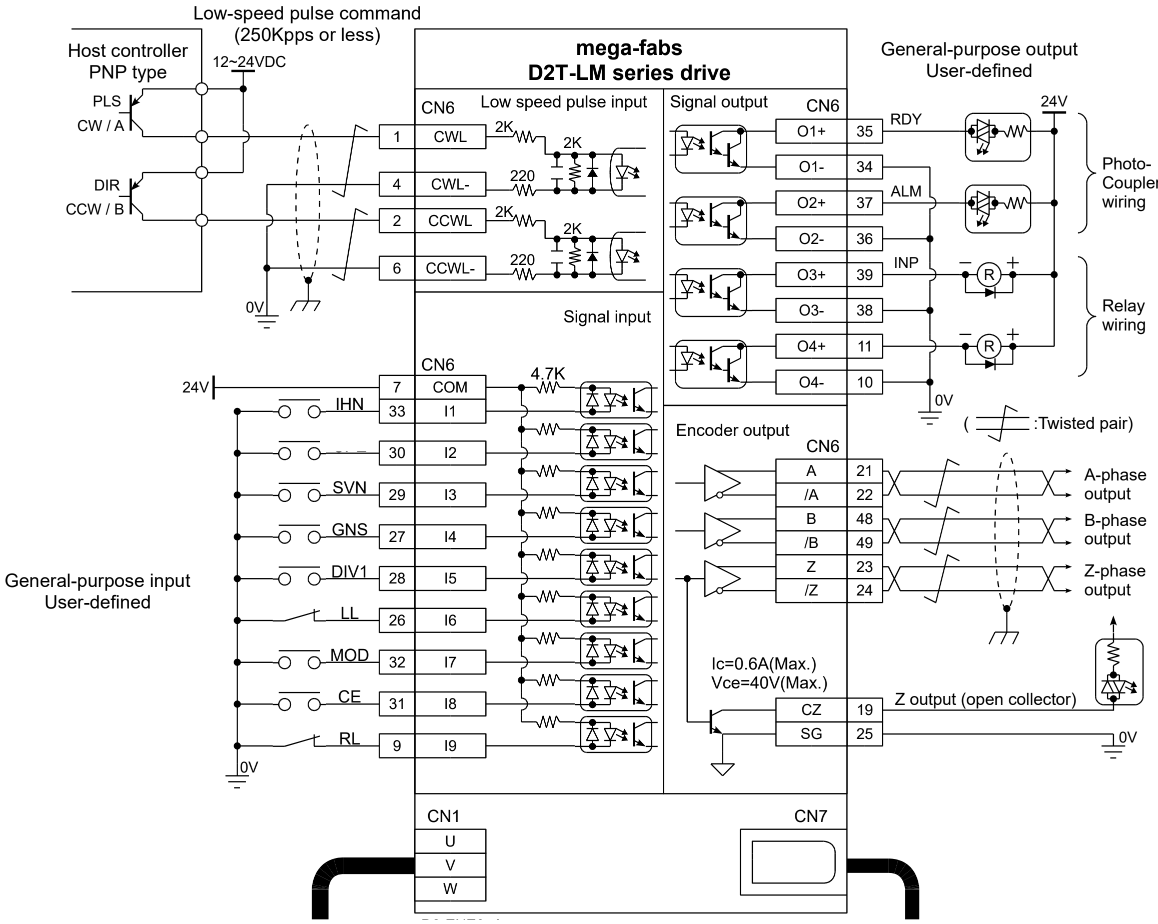


Figure 4.6.1.5.1

4.6.1.6 5V TTL interface

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

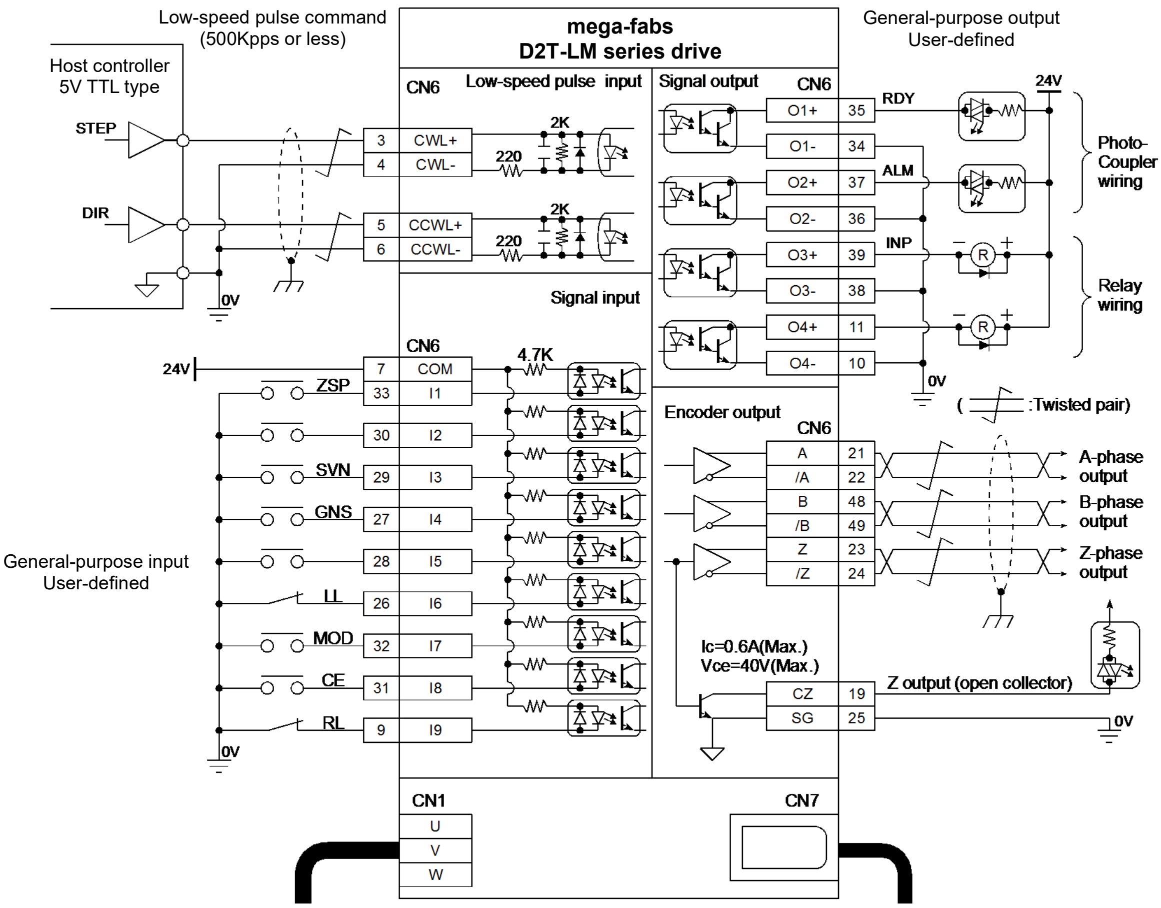
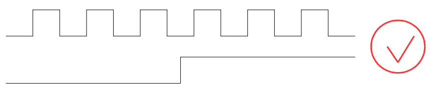
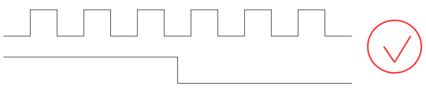
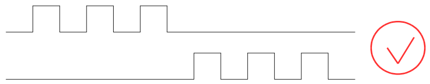
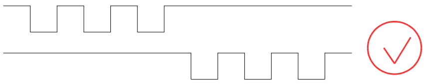
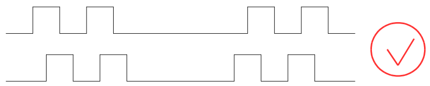
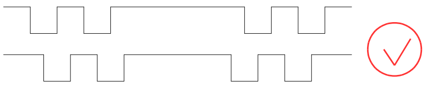


Figure 4.6.1.6.1

The signal logic of pulse command accepted by D2T-LM series drive is shown as follows.

Table 4.6.1.6.1

Pulse command	Positive logic	Negative logic
Pulse Dir		
CW CCW		
A B		

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

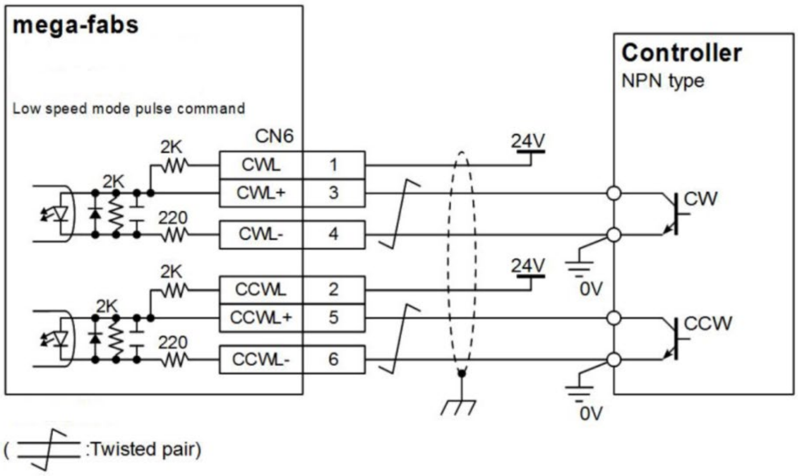


Figure 4.6.1.6.2 Wiring example for converting single-ended negative logic to positive logic CW/CCW signal

4.6.2 System wiring diagram for voltage command

The drive can accept voltage command form the host controller on velocity and force/torque modes. Please refer to Section 3.1.2 and Section 3.1.3 for more information.

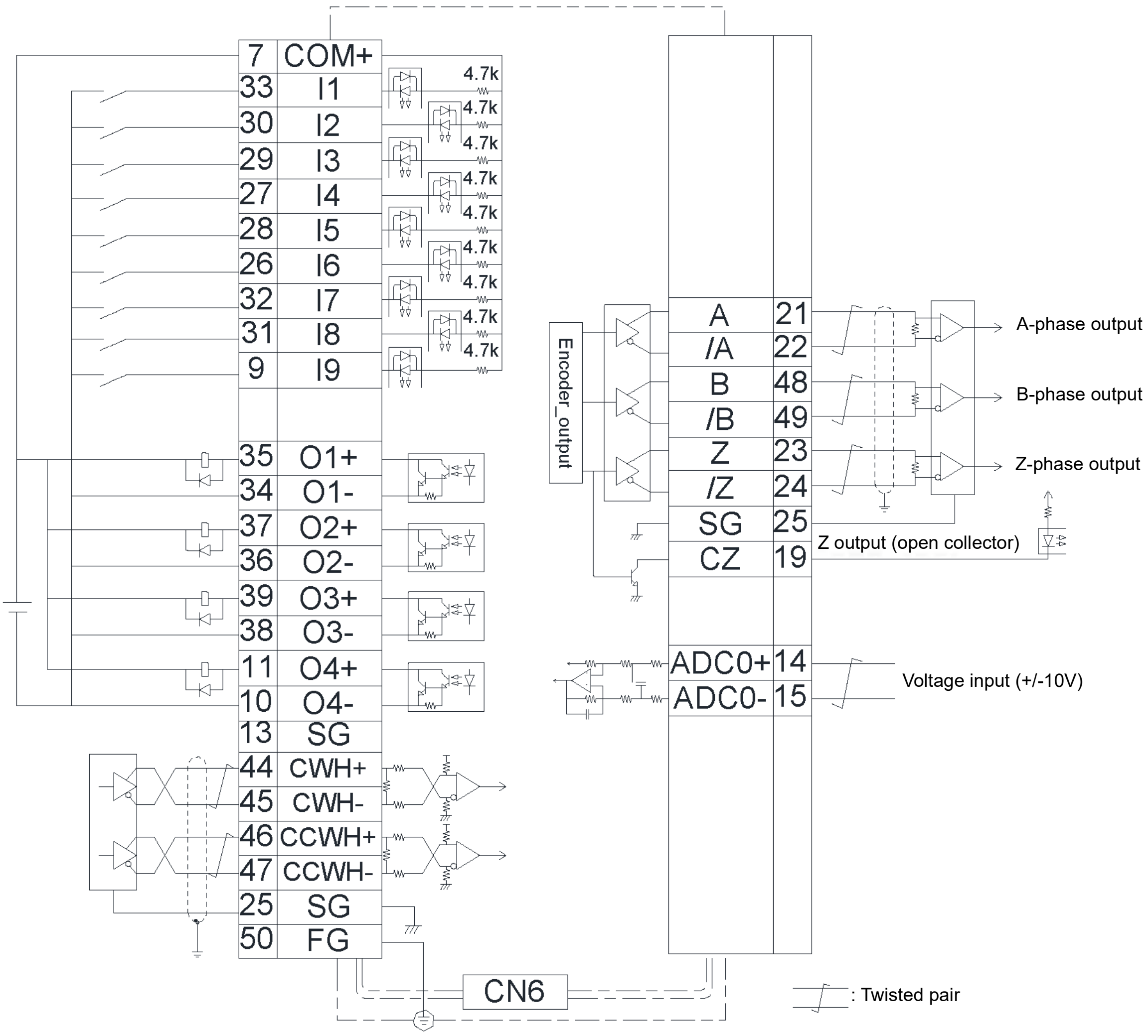


Figure 4.6.2.1

Wiring example for the host controller having the interface between -10V and +10V:

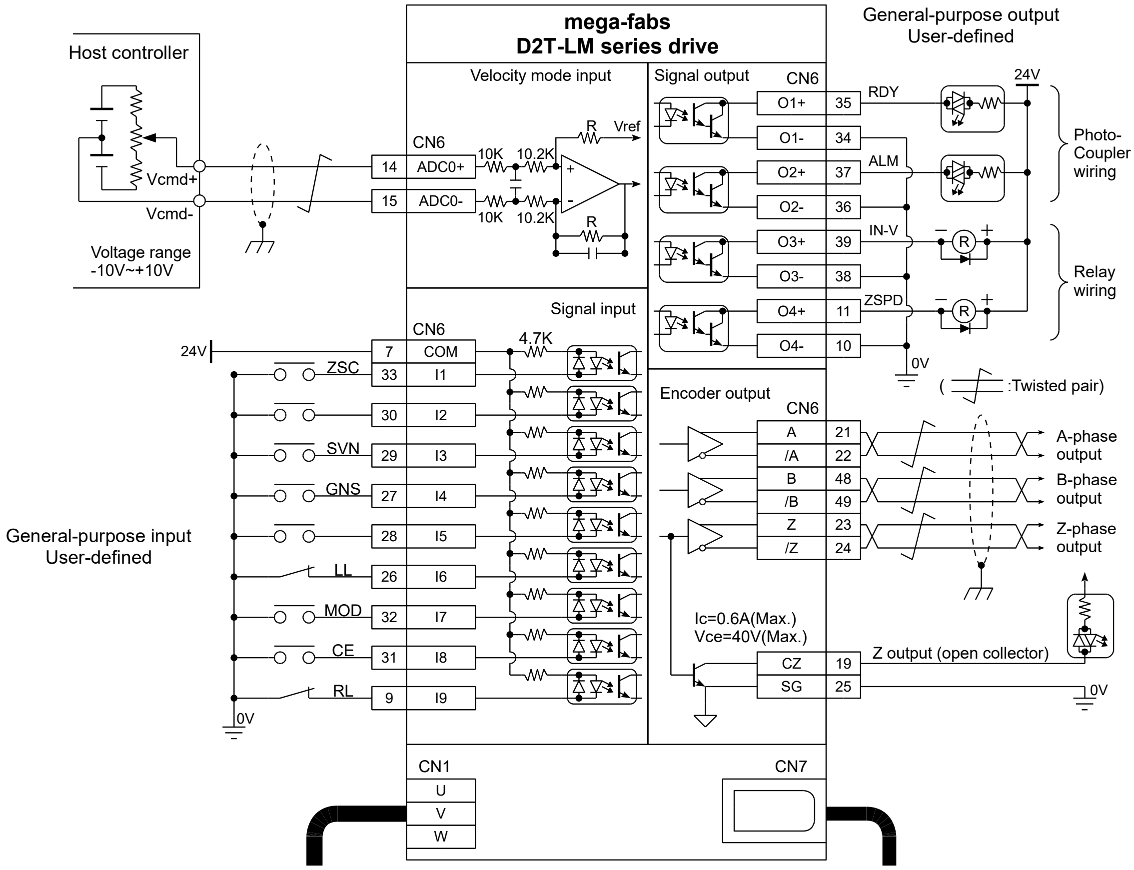


Figure 4.6.2.2

4.6.3 System wiring diagram for PWM command

Besides analog voltage command, D2T-LM series drive can also accept PWM command on velocity and force/torque modes. PWM command is classified into two types, single-line (PWM 50%) and dual-line (PWM 100%). Please refer to Section 3.1.2 and Section 3.1.3 for more information.

4.6.3.1 NPN interface with PWM 50%

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

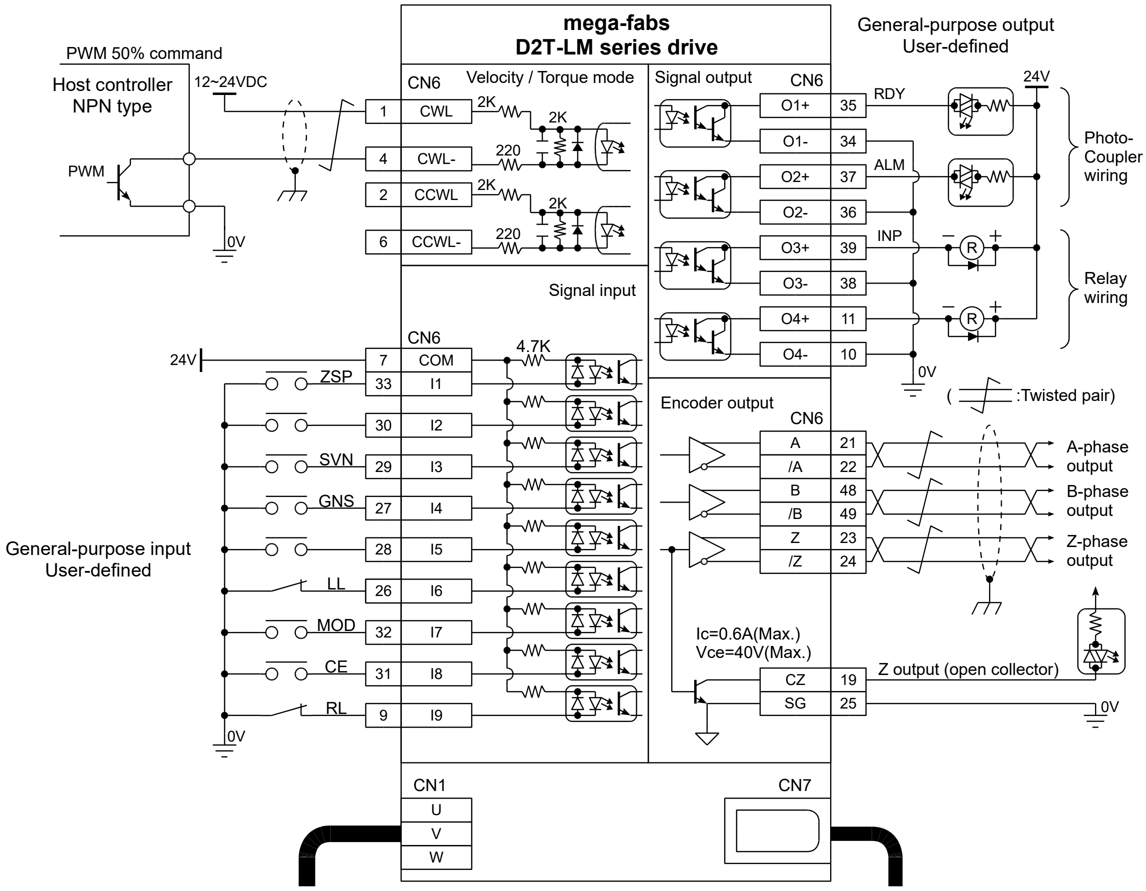


Figure 4.6.3.1.1

4.6.3.2 NPN interface with PWM 100%

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

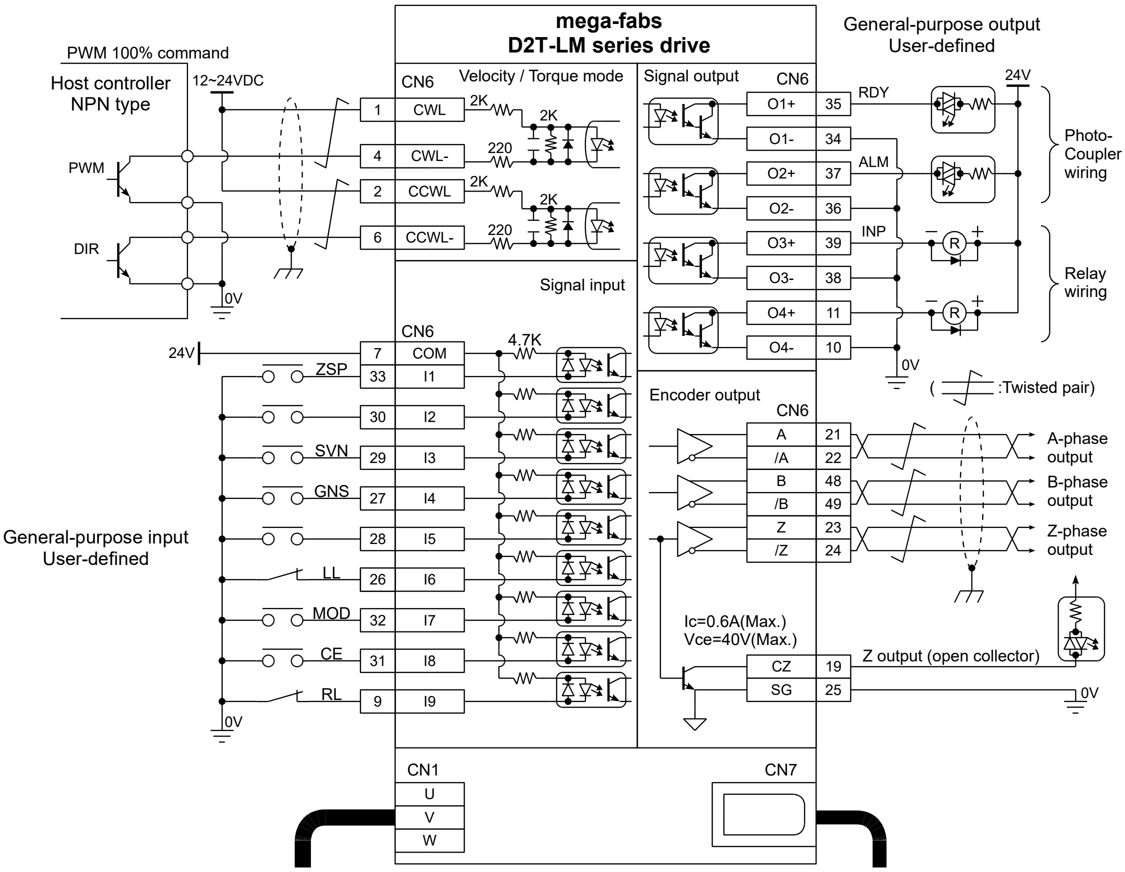


Figure 4.6.3.2.1

4.6.3.3 5V TTL interface with PWM 50%

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

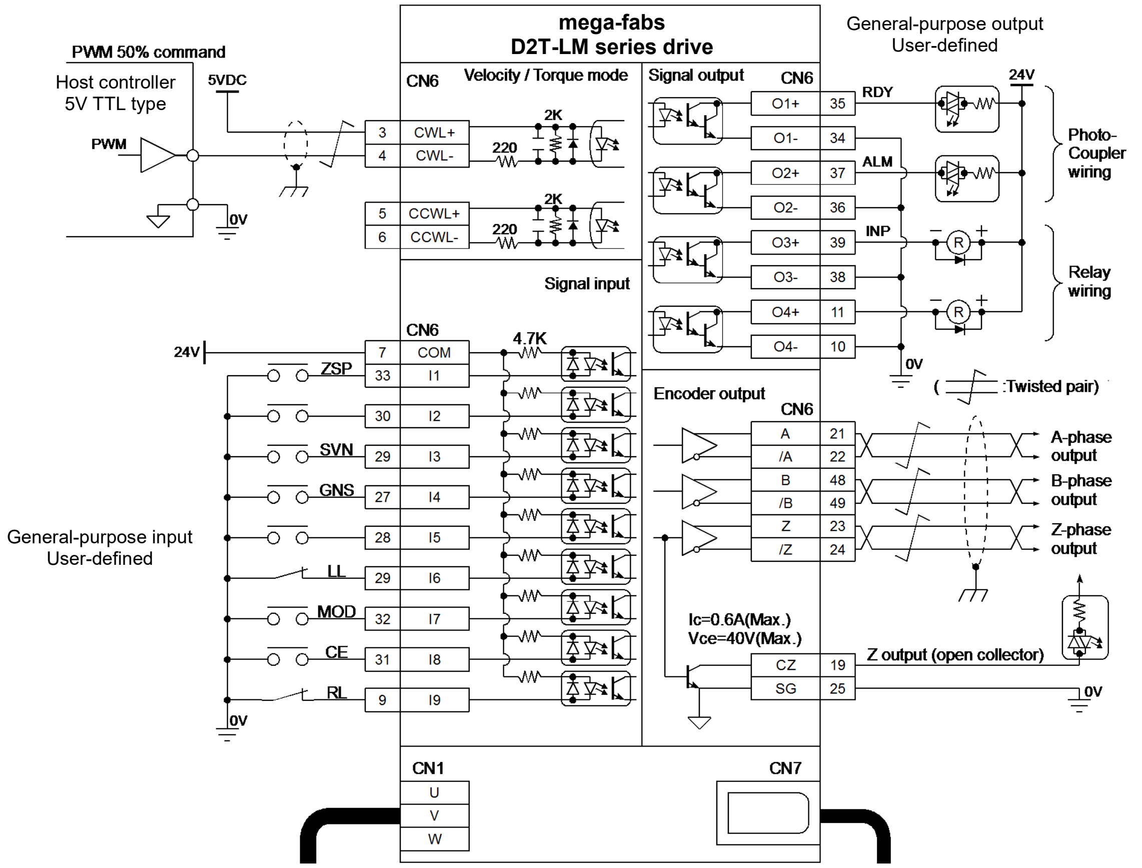


Figure 4.6.3.3.1

4.6.3.4 5V TTL interface with PWM 100%

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

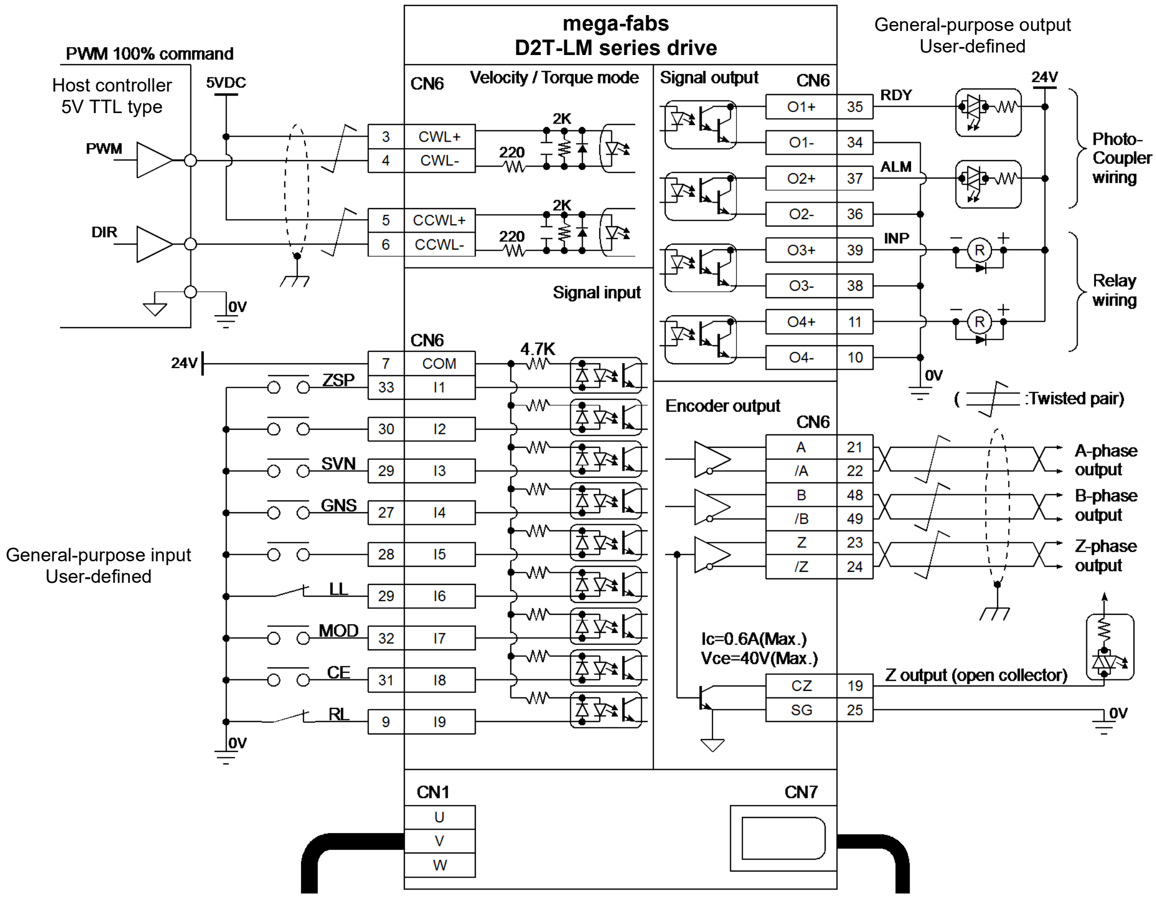


Figure 4.6.3.4.1

5. Drive Configuration

5.1 Installation and communication

The human-machine interface (HMI) for D2T-LM series drive is called Lightening. Through mini USB, Lightening which connects PC and the drive can perform functions like initialization, configuration, operation, test run, parameters saving, etc. This section is about how to install Lightening and set up the communication with the drive.

Note: D2T-LM model is only suitable for the version Lightening 0.194B or above.

5.1.1 Setup files

Files in the Lightening setup folder are shown in Figure 5.1.1.1, including an auto execution file "setup.exe" and a firmware folder "dce".

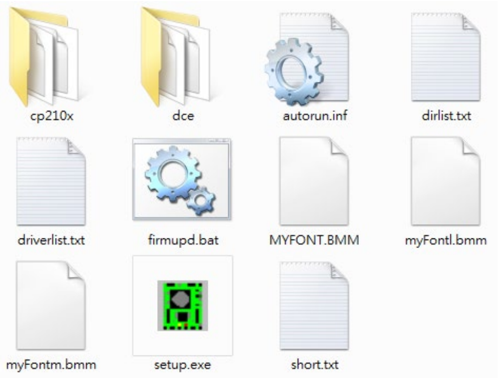


Figure 5.1.1.1

Download the setup files from HIWIN official website after logging in, unzip the files and execute "setup.exe". The default installation path is "C:\HIWIN\". Do not change this path without authorization. The installation window is given in Figure 5.1.1.2. Click the "Start" button to run the automated installation procedure. When the procedure is completed, the message window will appear (as Figure 5.1.1.3 shows), which indicates the software installation is ended successfully.

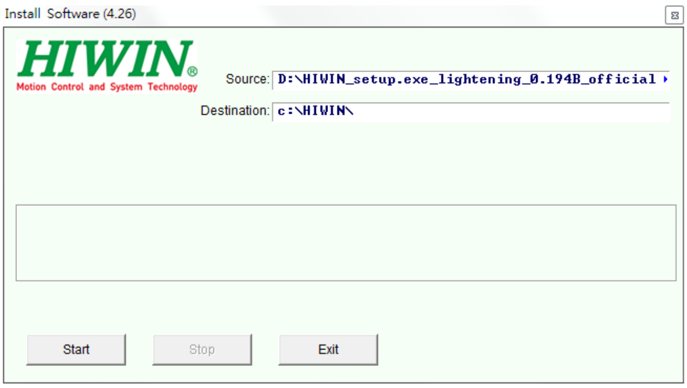


Figure 5.1.1.2

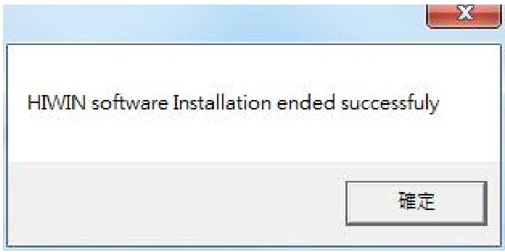


Figure 5.1.1.3

The execution shortcut of Lightening will appear on the PC desktop after the installation procedure is completed, as Figure 5.1.1.4 shows. Its path 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 drive, USB communication, mega-ulink communication, and CoE communication. The former two methods are introduced in this section. As for the last one, please refer to “HIWIN CoE Drive User Guide”. (Users can download it from HIWIN official website after logging in.) If mega-ulink or CoE communication is used to communicate with the drive, it is recommended to adopt the network card of REALTEK.

- **Use USB communication**

  Connect the drive via USB and turn on the control power before starting the program. Generally, Lightening will automatically connect to the drive when it is opened. If not, click “Communication setup…” in the “Tools” option to change the communication setup.

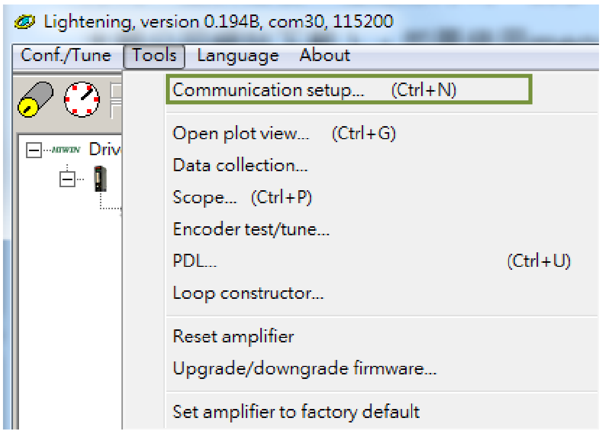


Figure 5.1.2.1

The window for communication setup is shown in Figure 5.1.2.2. The “BPS” column shows the transmission rate of the connection. Users do not need to change its default value (115,200 bps). The “Port” column shows the communication port. It will display all the existing PC ports. Select the port actually connected to the drive. Use the default values for the rest columns, and then Lightening will successfully communicate with the drive.

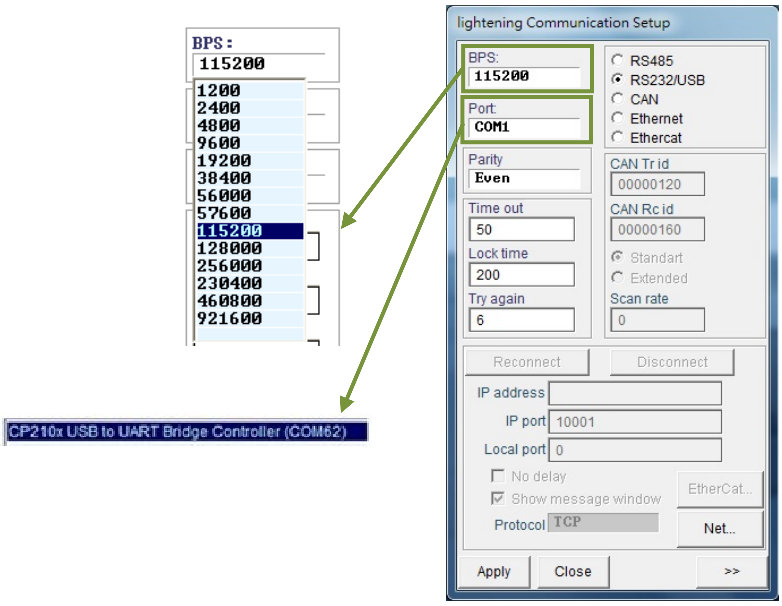


Figure 5.1.2.2

■ Use mega-ulink communication

Download and install WinPcap for the first time usage of mega-ulink communication. When the installation is done, open the “lightening Communication Setup” window described in the previous subsection (as Figure 5.1.2.2 shows). Select the radio button of “EtherCAT” and click the “EtherCAT…” button, as Figure 5.1.2.3 shows.

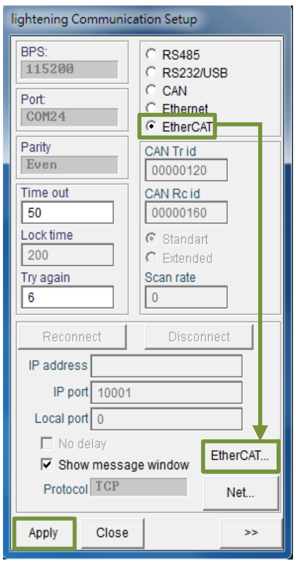


Figure 5.1.2.3

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

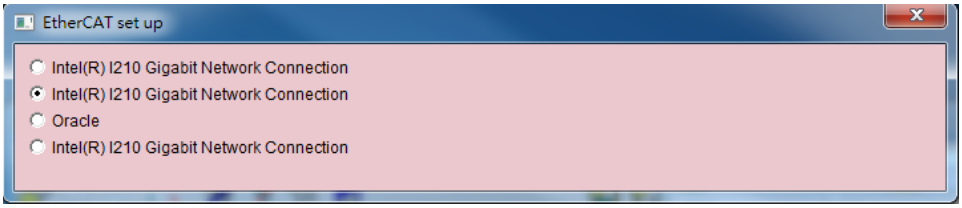


Figure 5.1.2.4

When the setting is done, the window of Figure 5.1.2.5 will appear. Users can get the number of connected slaves from the information in the window. After going back to HMI main window, the connection is established, and “EtherCAT” is shown in the title (as Figure 5.1.2.6 shows).

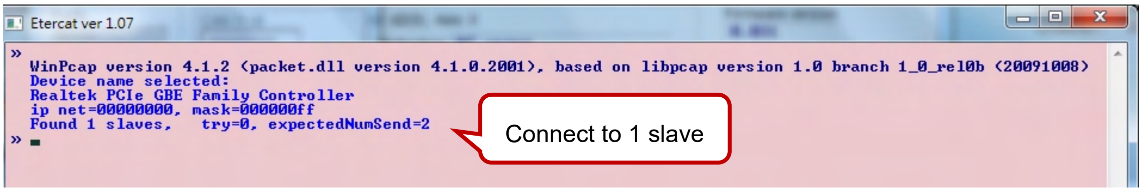


Figure 5.1.2.5

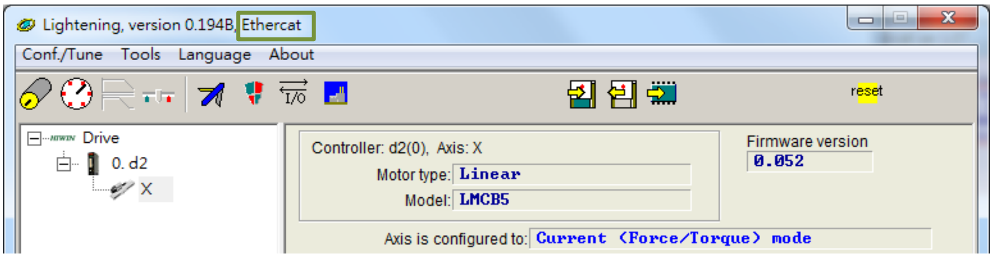


Figure 5.1.2.6

5.1.3 HMI main window

After successful connection, HMI main window will look like Figure 5.1.3.1. To modify the axis name, right click the axis name and choose "Rename…", or directly click the axis name.

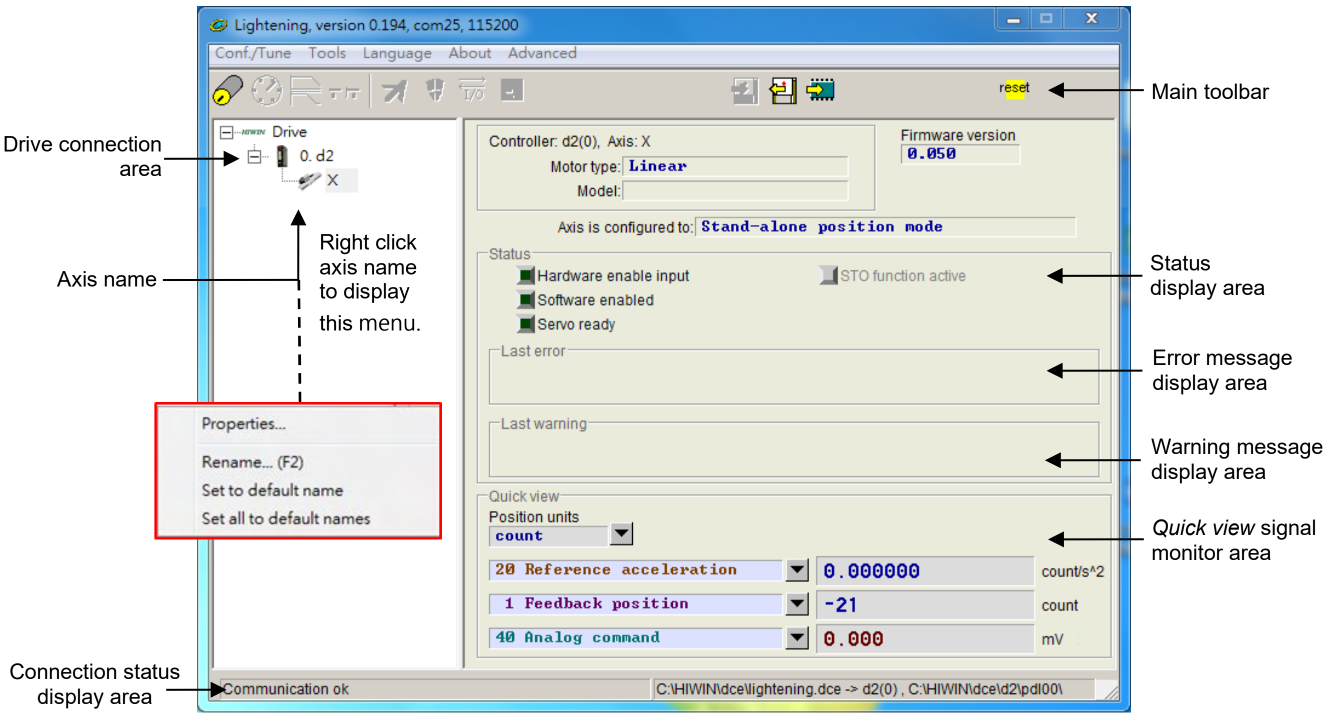


Figure 5.1.3.1

- **Main toolbar**

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

- **Status display light**

  - Servo ready : The light is off when the drive is at the disable state; it is green when the drive is at the enable state.
  - Hardware Enable Input : The light is green when the drive hardware is enabled. If the hardware is not enabled, the drive cannot enable the motor. Please refer to Section 5.4.1 and Chapter 10 for the external input setting method of enabling the hardware.
  - Software Enabled : The light is green when the drive software is enabled. The drive cannot enable the motor unless both hardware and software are enabled. Click the "Enable" button in the

"Performance center" to enable the software. Click the "Disable" button to cancel the enabled software. If there is no connection between PC and the drive, the status of the enabled software will change according to the status of the enabled hardware. If there is a connection between PC and the drive, close the window. After that, Lightening HMI will ask the users whether the software is enabled or not.

■ Drive property

Right click the axis name and choose "Properties…", users can get the drive properties, as Figure 5.1.3.2 shows.

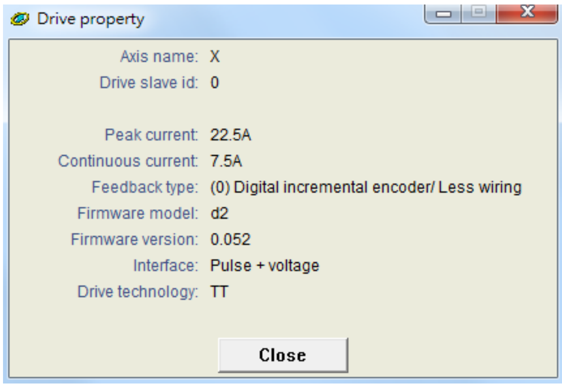


Figure 5.1.3.2

Note: When Lightening 0.194A (included) or older version is used to connect with D2T-LM model, the window of Figure 5.1.3.3 will appear. Since these HMI versions do not come with the firmware version for these drives, Lightening cannot identify them. Please download the latest version of Lightening from HIWIN official website.

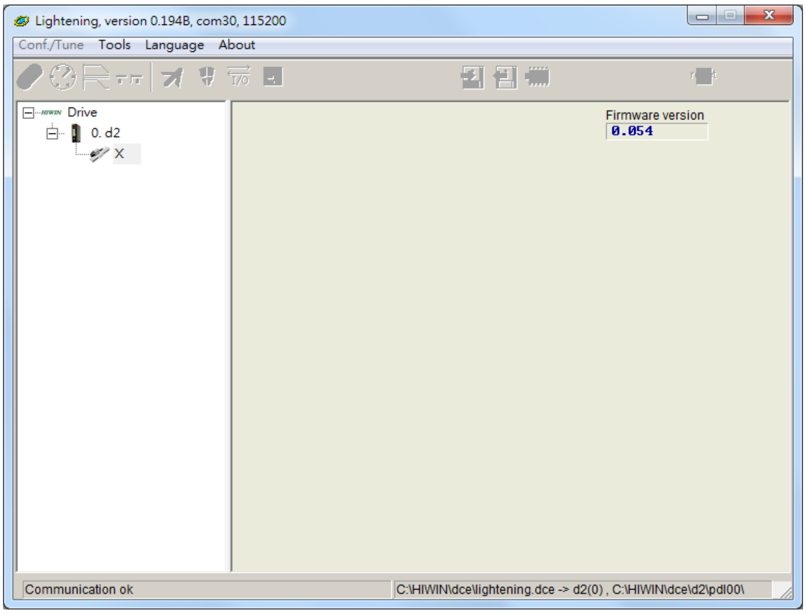


Figure 5.1.3.3 Wrong firmware version installation

5.2 Configuration center

When using a new drive or a new motor, users need to reset the relevant parameters based on the actual application through Configuration center. By clicking  in the main toolbar (as Figure 5.2.1 shows), users can open Configuration center.

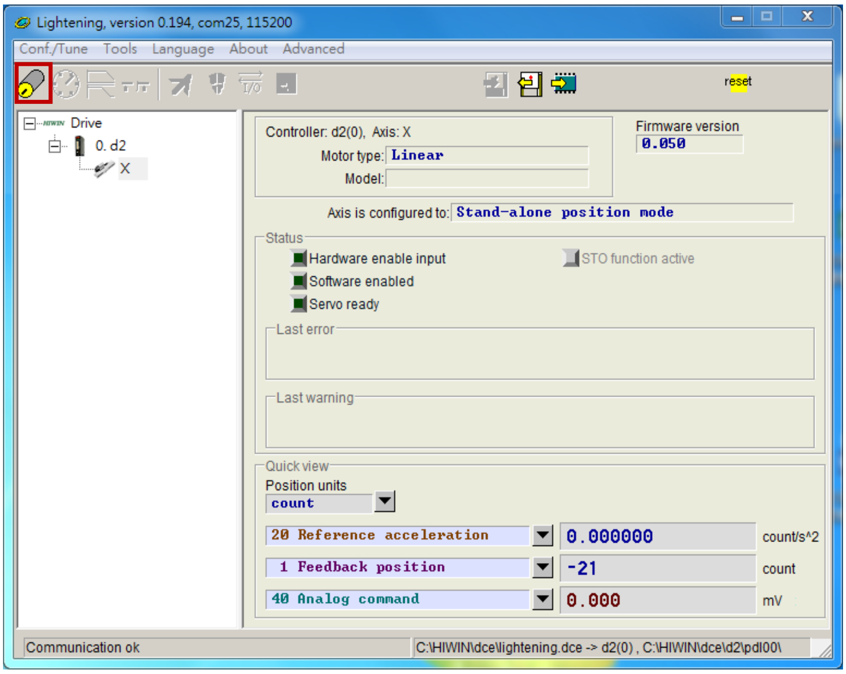


Figure 5.2.1

To help D2T-LM series drive successfully drive the motor, complete the following setting steps.

(1) Linear motor type: Set the linear motor type in use and the corresponding parameters.

(2) Encoder parameter: Set the encoder type in use and its resolution.

(3) Operation mode: Set the operation mode of the drive.

5.2.1 Motor configuration

Motor configuration is on the first page of Configuration center. HIWIN Linear motor supported by D2T-LM series drive can be found under Motors . For Lightening 0.194B (included) or above, motor configuration page is shown in Figure 5.2.1.1.

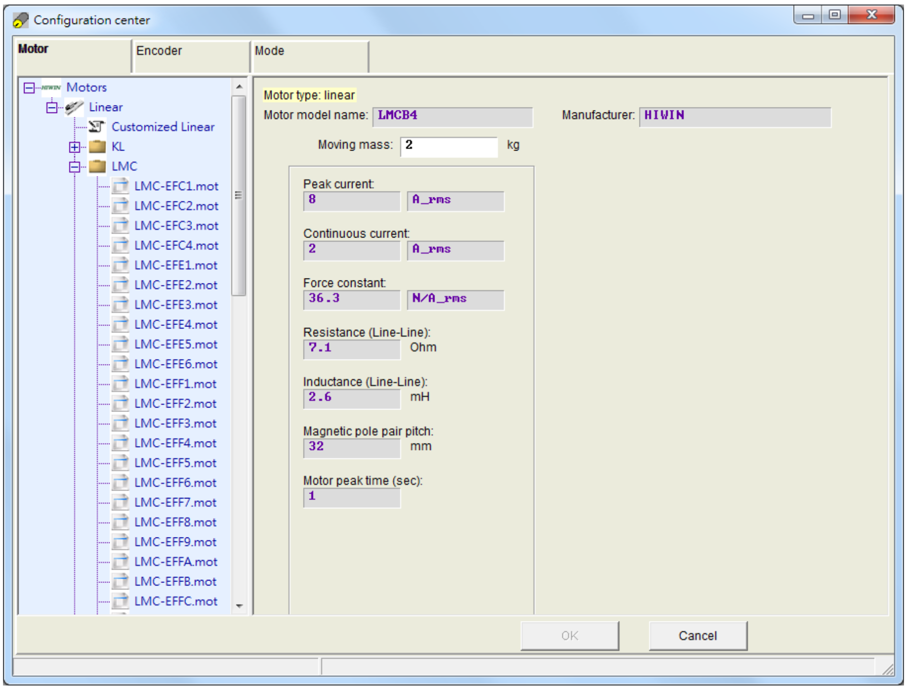


Figure 5.2.1.1 Motor configuration page for Lightening 0.194B or above

- **Motor parameters**

  Directly click HIWIN linear motor type to set and display motor parameters. If it is not a HIWIN standard linear motor, click any of the standard ones first, click "Customized Linear", and key in necessary parameters according to motor specification. After the setting is completed, the save function can be used to establish motor parameters. Users can load the established file for motor parameters (*.mot) at any time.

- **Operation parameter**

  Moving mass: Set the load mass of the linear motor (including rotor and outer casing); unit: Kg.

5.2.2 Encoder configuration

The drive generally receives a feedback signal from the position encoder to execute servo control. The encoder configuration page is shown in Figure 5.2.2.1. Select or set the correct type and parameters of the encoder on this page. To work with the host controller, D2T-LM series drive can not only receive but also output encoder signals. It provides either buffered encoder output or emulated encoder output. When it comes to emulated encoder output, the output resolution can be modified by setting “Scaling”. Please refer to Section 5.2.2.3 for more information.

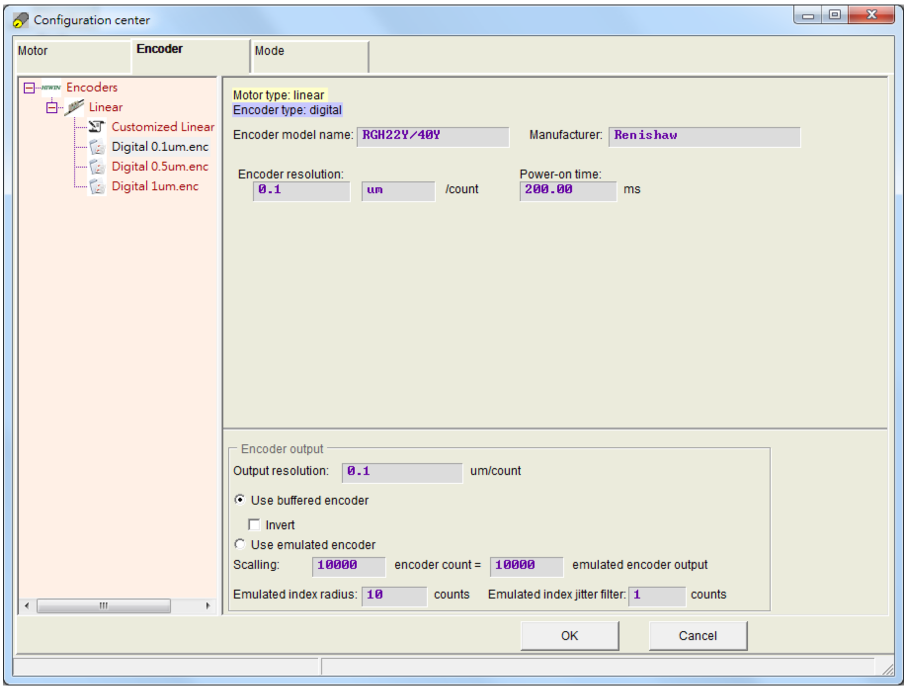


Figure 5.2.2.1 Encoder configuration page

5.2.2.1 HIWIN standard encoder

The specifications for HIWIN standard encoder are digital 0.1um, digital 0.5um and digital 1um. The setting window is shown as follows.

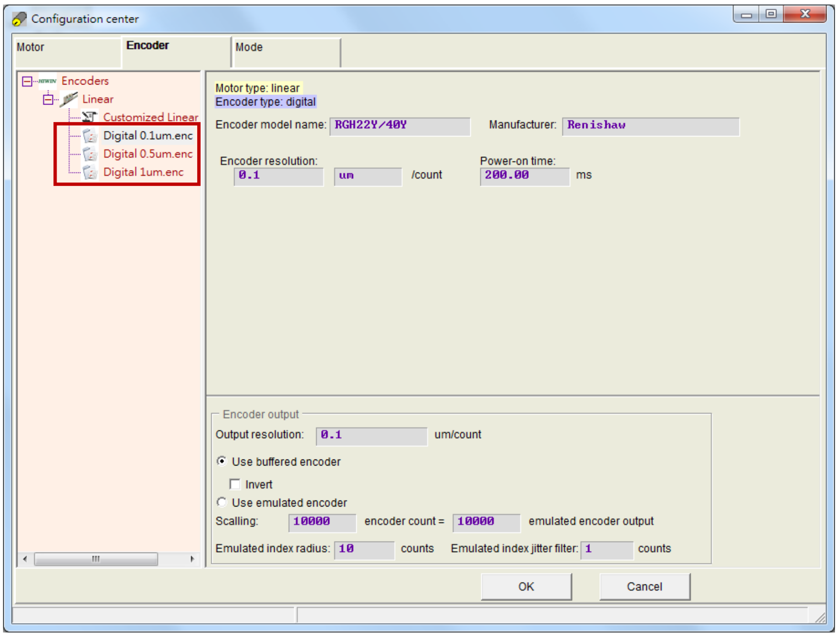


Figure 5.2.2.1.1 Encoder configuration page for standard encoder

5.2.2.2 Customized digital incremental encoder

Besides choosing encoder parameters with common resolution suitable for HIWIN linear motor, users can also key in parameters for various encoder brands in the customized setting area. Choose “Customized Linear”, users can key in the resolution parameter according to the specification. Enter motor resolution in “Encoder resolution” column, and enter “Power-on time” according to the power-on delay time. After the setting is completed, the save function can be used to establish encoder parameters. Users can load the established file for encoder parameters (*.enc) at any time.

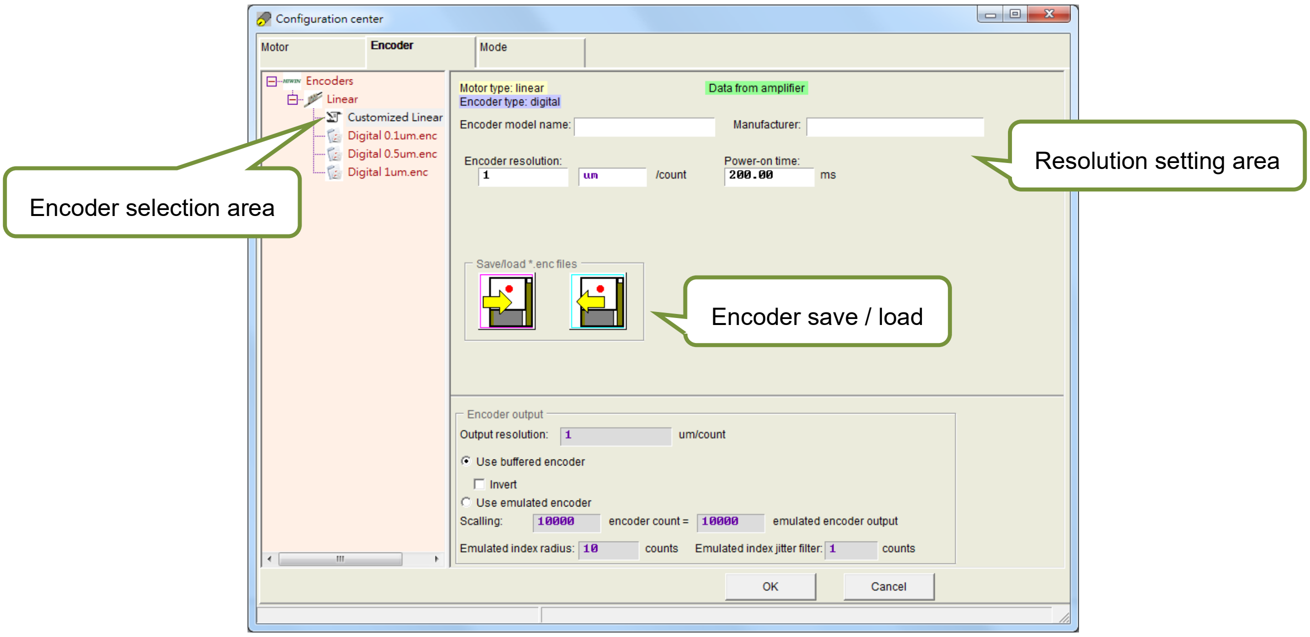


Figure 5.2.2.2.1 Encoder configuration page for customized encoder

5.2.2.3 Encoder output setting

D2T-LM series drive sends out the encoder signal with AqB square wave via CN2. It can be connected to the host controller if needed. Check “Use buffered encoder” or “Use emulated encoder” in the “Encoder output” area (as Figure 5.2.2.3.1 shows), the value in “Output resolution” column will be updated according to the selected output mode.

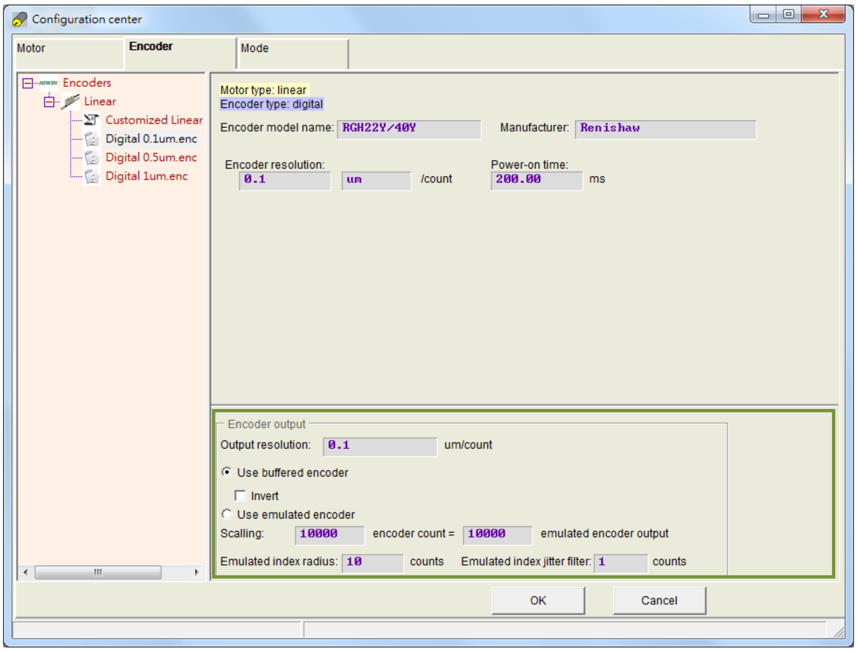


Figure 5.2.2.3.1 Encoder output setting

- **Buffered encoder output**

  When this option is selected, the drive directly sends the received encoder signals to the host controller. Users can also choose the “Invert” option to make the drive send the received encoder signals back. The resolution of the output signal is also displayed in the window for reference.

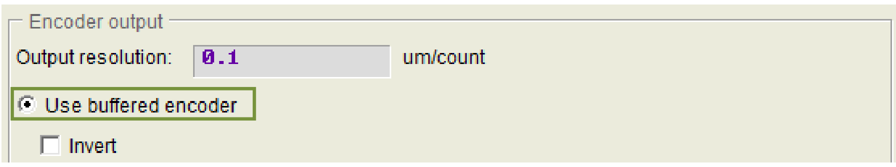


Figure 5.2.2.3.2 Buffered encoder output

■ **Emulated encoder output**

When this option is selected, the drive multiplies the information of the received encoder positions by "Scaling" and sends it out to the host controller. If the ratio is 1:1, the drive will directly output the encoder signal based on the adopted encoder and the set resolution. In some cases, the host controller cannot receive the encoder signal with a high frequency. A different ratio can be set to lower the frequency of the encoder output, e.g. 5 encoder count = 1 emulated encoder output. If the multiplier factor of analog encoder is set too high, "Scaling" might also be needed to reduce the resolution of encoder output. By setting 1 encoder count = -1 emulated encoder output, the output direction can be changed. Take the encoder resolution being 1 um/count as an example. If the scaling for emulated encoder output is set as 5 encoder count = 1 emulated encoder output, the "Output resolution" will be enlarged to be 5 um/count.

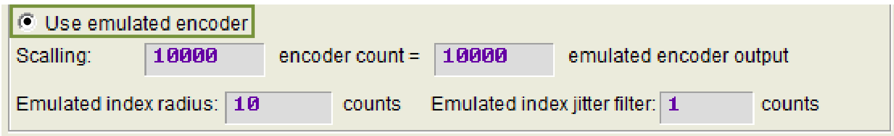


Figure 5.2.2.3.3 Emulated encoder output

Note: The function of emulated encoder output will be temporarily invalid when parameters are saved to Flash.

■ **Output emulated Z-phase signal to the host controller**

Emulated Z-phase signal can be sent out to the host controller by setting the encoder output as "Use emulated encoder", as Figure 5.2.2.3.3 shows.

Besides the "Use emulated encoder" setting, the following two parameters should also be set.

a. Emulated index radius: the output range of emulated Z-phase signal (as Figure 5.2.2.3.4 shows)
b. Emulated index jitter filter: reduce the bounce phenomenon of emulated Z-phase signal

Note: If the sampling speed of the host controller is too slow, or the speed of homing is too fast, the host controller may not receive emulated Z-phase and make homing fail. When this happens, please modify "Emulated index radius".

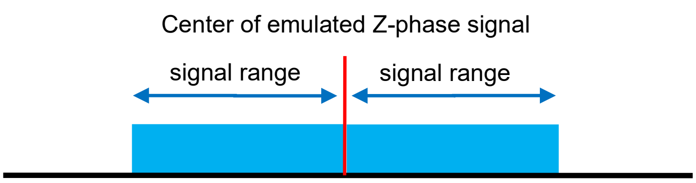


Figure 5.2.2.3.4

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

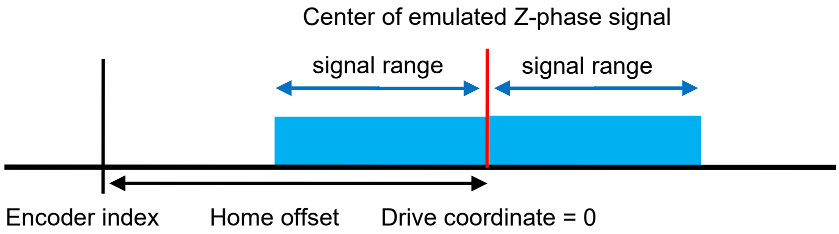


Figure 5.2.2.3.5

5.2.3 Operation mode configuration

The operation mode configuration page is shown in Figure 5.2.3.1. Setting the operation mode for the drive is the last thing to do after the parameters of the previous two steps are done.

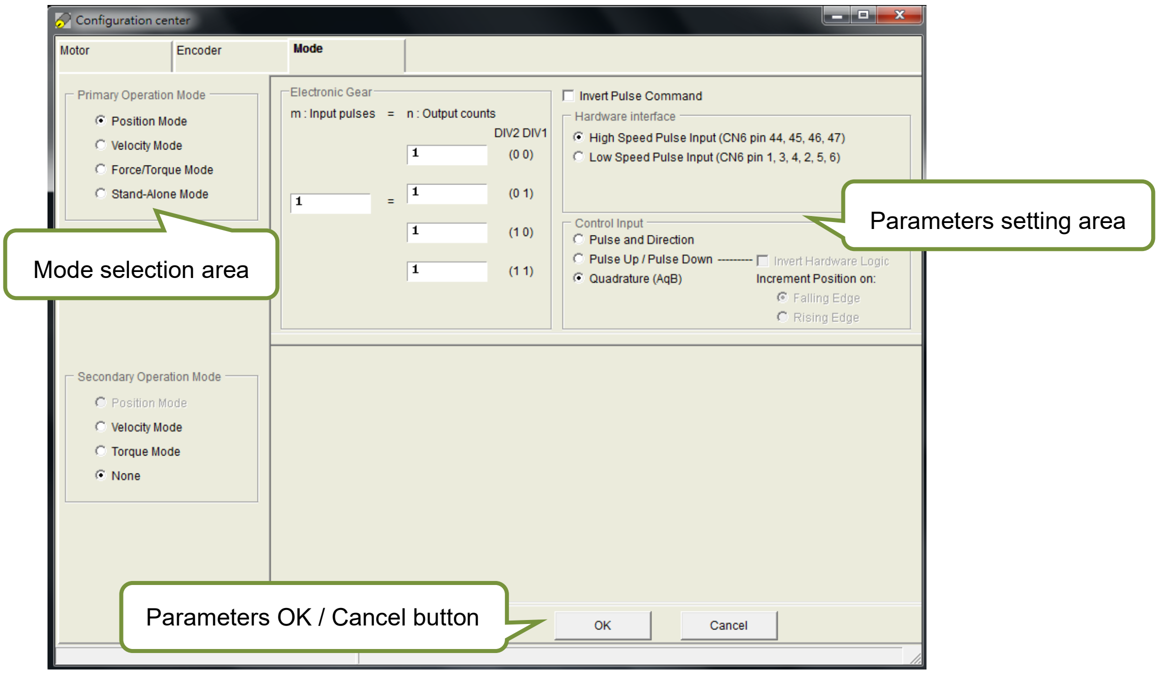


Figure 5.2.3.1 Operation mode configuration page

■ Position Mode

To work with the host controller only sending pulse commands, the position mode should be chosen to receive the external pulse command for the motion. The closed-loop control is done by the drive. D2T-LM series drive supports three types of pulse command, and the electronic gear ratio is allowed to be set for high-speed application.

Note: The drive will not accept the pulse command sent by the host controller unless it is at servo ready state.

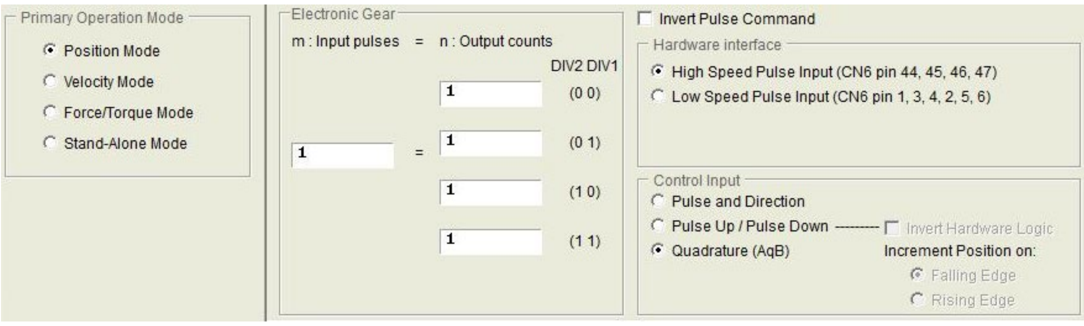


Figure 5.2.3.2

■ Velocity Mode

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

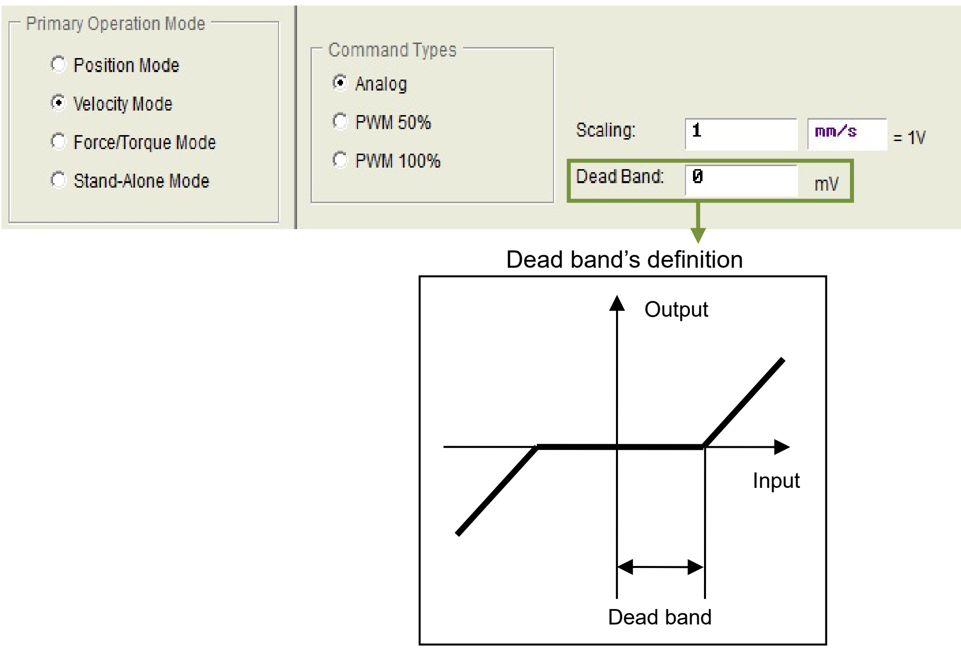


Figure 5.2.3.3

- **Force / Torque Mode**

To work with the host controller sending analog commands or PWM commands, the force/torque mode is another choice. Users only need to set the ratio ("Scaling") between the external command and current, the unit is the corresponding relationship between 1V and Ampere, or between Full PWM and the maximum current. If the value of "Scaling" is negative, the motor will move in a reverse direction.

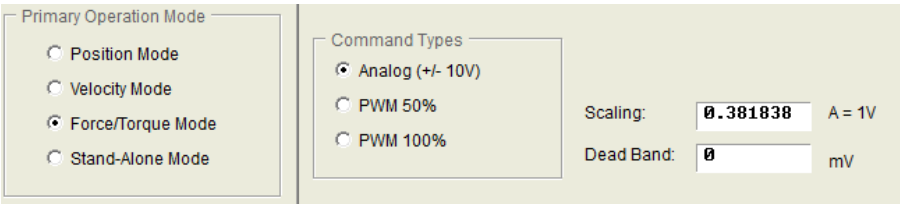


Figure 5.2.3.4

- **Stand-Alone Mode**

If users only need to test alone the drive or execute the plan without any host controller (e.g. only the servo motor and the drive), the stand-alone mode can be selected to let the drive take care of all control loops.

5.2.4 Completing configuration procedure

After completing motor, encoder, and operation mode configurations, click the “OK” button to show the window of Figure 5.2.4.1, which gives the comparison of old and new parameters. After confirming parameters, click the “Send to RAM” button to send parameters to drive. If users click the “Cancel” button, it will go back to Configuration center.

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

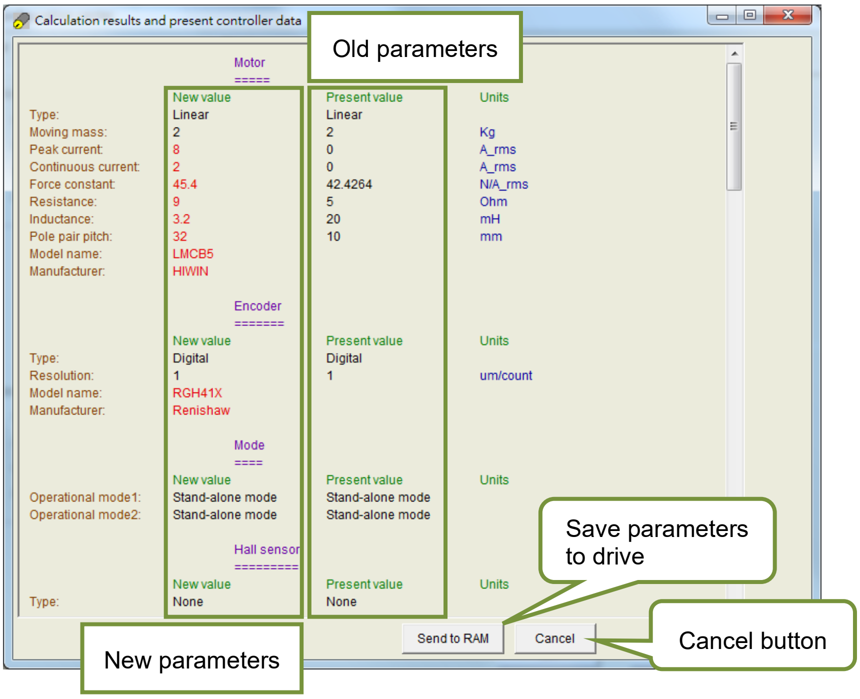


Figure 5.2.4.1

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

5.3 Auto phase center

5.3.1 Mode explanation

Click in the main toolbar of HMI main window to open auto phase center. D2T-LM series drive can only match with linear motor; therefore, the step must be done to get the motor into closed-loop control.

SW method 1

It is one of the built-in methods for phase initialization in the drive. Without any hall sensors, the motor can accomplish phase initialization via subtle displacement. Two parameters, st_cg and st_vpg, must be adjusted before using the method. Please refer to the frequency analyzer for their settings and adjustments. If the load of the system changes, the parameters must be adjusted again.

If the drive is not on stand-alone mode, the host controller is suggested to send out the external command after receiving the “Ready” signal from the drive. If the host controller cannot receive the “Ready” signal, wait for three seconds. If “check the accuracy offset” is checked, the program will check whether the found electronical angle is correct first when executing “Start phase initialization”.

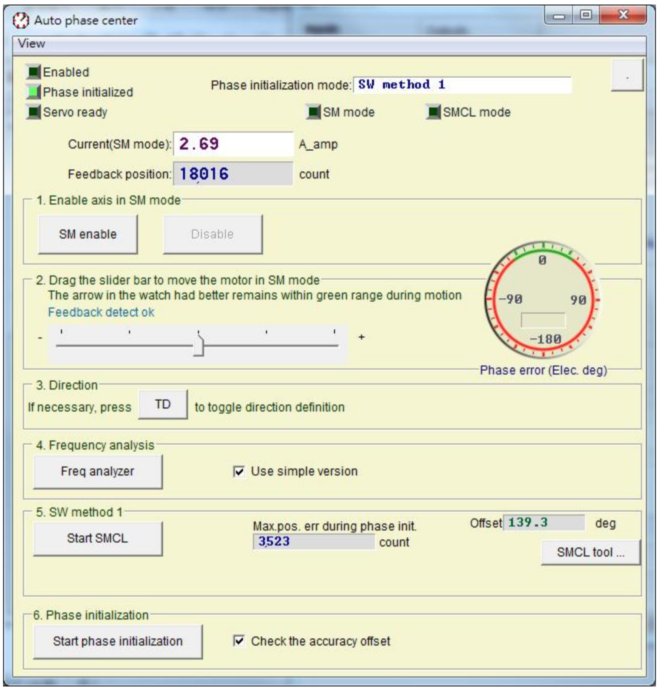


Figure 5.3.1.1 Auto phase center (SW method 1)

5.3.2 Pre-operation

※ Ensure that the connection to the motor is correct.

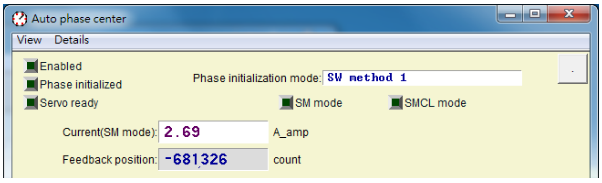
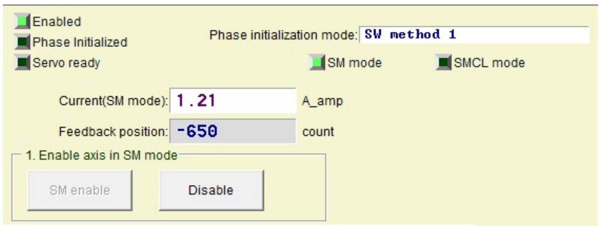
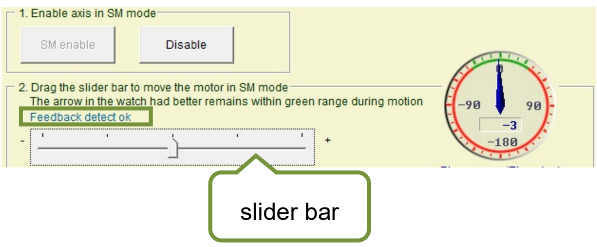
※ Ensure that the encoder signal is correct.

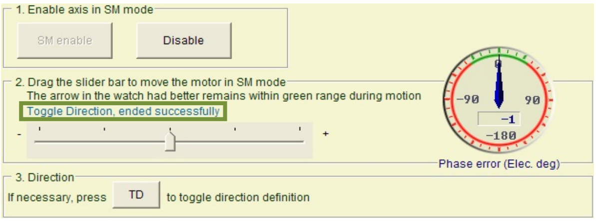
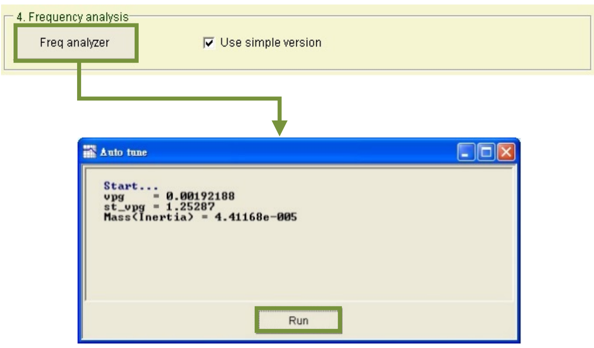
※ Ensure that the drive can receive "Hardware enable" signal. If there is no physical wiring, open "I/O center" and check "Invert" in I3 Axis Enable to simulate hardware enable input.

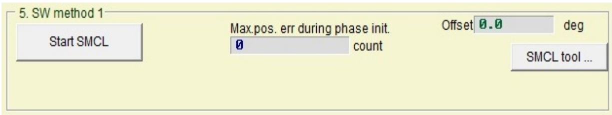
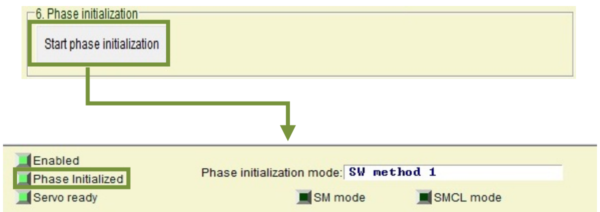
※ Ensure that the AC main power is turned on.

5.3.3 Setting procedure

The procedure of auto phase initialization for SW method 1 is described in this section.

Step	Graphical (HMI) description	Operation
1		**Method setting for phase initialization:** D2T-LM series drive only offers "SW method 1" as the method for phase initialization.
2		**Enable the motor on step motion mode:** Press the "SM enable" button. At this time, "Enabled" lights up in green. --- <Notice> Enabling the motor on step motion mode, the drive will continuously output the current set in "Current (SM mode)". Therefore, the time should not be too long, or it will make the motor overheat. <Notice> The step must trigger the enable signal of the host controller.
3		**Motion direction test on step motion mode:** Hold the slider bar and drag it left and right, the motor will start moving. The right side is for the positive movement; the left side is for the negative movement. Under normal circumstances, the arrow of the "Phase error (Elec deg)" should stay in the green range (-30°~+30°). Release the slider bar after dragging it left and right, if "Feedback detect ok" appears, the step is done. If the arrow rotates freely, let go the slider bar first,

		hold it again, and drag it left and right. -- <Notice> If the arrow still rotates freely after users follow the instructions above, please make sure the following two things: (1) Motor cable and encoder feedback signal cable are well connected. (2) Go to “Configuration center” to check if there is something wrong on the parameter setting for the encoder or the motor, such as encoder resolution or number of motor pole pairs. <Notice> The step must trigger the enable signal of the host controller.
4		**Confirm the definition of motion direction:** If the motion direction in the previous step does not meet the actual requirement, press the “TD” button to toggle the definition of motion direction. After “Toggle Direction, ended successfully” appears, go back to step 3 to confirm the definition of motion direction again.
5		**Auto tune function:** Check “Use simple version” and press the “Freq analyzer” button to open the “Auto tune” window. As users click “Run”, frequency response analysis will be automatically performed and parameters will be automatically calculated. This function can be used to set the system loop gains easily and quickly. However, if the stiffness of the mechanism is too low, load mechanism changes, or load inertia ratio exceeds 20 times, the calculated values of the parameters may not be applicable to the actual system. -- <Notice> If the mechanism resonance occurs during the execution, immediately stop the hardware enable signal, or press the software shortcut key **F12** in HMI. <Notice> If this function cannot meet the requirement for application, users can adjust the parameters “vpg” and “st_vpg” in SMCL tool.

6		**Performance adjustment:** The advantage of the method is that the motor can accomplish phase initialization via subtle displacement. Its performance is tuned at the previous step “Auto tune function”. To check the result, follow the steps below. (a) Press the “Start SMCL” button to execute electrical angle test. (b) Observe the values of “Offset” and “Max. pos. err during phase init.”, which are respectively the result of finding electrical angle and the maximum displacement in the process. (c) Repeat step (a) and (b). Observe if the difference among these “Offset” values is within +/-15 deg. (d) If the difference among these “Offset” values is too big, press the “SMCL tool…” for advanced tuning.
7		**Execute phase initialization:** Press the “Start phase initialization” button. When “Phase Initialized” lights up in green, phase initialization is done, and the drive can drive the motor (get into close-loop control).

5.3.4 Troubleshooting

※ Ensure that the motor power cable and the encoder feedback signal cable are well connected.

※ Ensure that the parameter setting for the encoder or the motor is correct, such as encoder resolution or number of motor pole pairs.

※ Ensure that the grounding system is suitable.

※ Ensure that the enable signal of the host controller in the drive is triggered.

※ Ensure that the software enable signal in the drive is triggered.

※ Ensure that there is no mechanical interference.

※ Ensure that the motor resistance is normal.

5.4 I/O center

5.4.1 Digital input

Click from the main toolbar in the main window to open I/O center. Click the dropdown button ( ) on the input function menu to select the digital input pin and its function (as Figure 5.4.2.1 shows). D2T-LM model has 10 digital inputs.

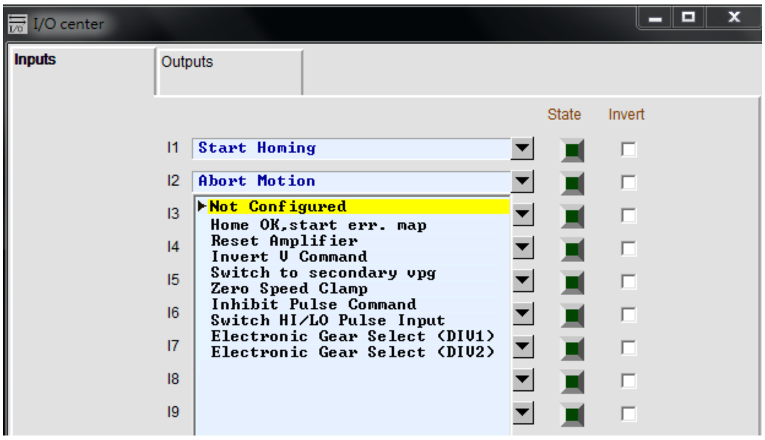


Figure 5.4.1.1 Input function menu

- **State indicator light (State)**
  If the state indicator light is green, the corresponding input pin has been activated. If the light is off, the corresponding input pin has not been activated.

- **Logic inverse setting (Invert)**
  When the "Invert" option is checked, the trigger condition will be inverted.

Table 5.4.1.1

No.	Hardware Symbol	Input function	Description	Trigger
1	SVN	Axis Enable	Enable/Disable; the default is set at I3	Level Trigger
2	LL	Left Limit Switch	Left hardware limit; the default is set at I6	Level Trigger
3	RL	Right Limit Switch	Right hardware limit; the default is set at I9	Level Trigger
4	MAP	Home OK, start err. map	The homing completed command from the host controller	Edge Trigger
5	RST	Reset amplifier	Reset the drive	Edge Trigger
6	DOG	Near home sensor	Near home sensor	Level Trigger
7	CE	Clear Error	Clear error	Edge Trigger
8	INVC	Invert V Command	Reverse the analog voltage command on velocity or force / torque mode	Level Trigger

9	GNS	Switch to secondary CG	Switch to secondary common gain	Level Trigger
10	JSEL	Switch to secondary vpg	Switch to secondary vpg gain	Level Trigger
11	ZSC	Zero Speed Clamp	Zero speed clamp. On velocity mode, the motor will be locked at a fixed position when the drive receives this signal and the motor speed is less than the set value.	Level Trigger
12	INH	Inhibit Pulse Command	Inhibit pulse command.	Level Trigger
13	PSEL	Switch HI/LO Pulse Input	Switch between the high-speed and low-speed pulse input channels	Level Trigger
14	EMG	Abort Motion	Emergency stop. The drive will get into the emergency stop procedure after receiving this signal during motor motion.	Level Trigger
15	MOD	Switch to secondary mode	Switch from the primary operation mode to the secondary operation mode	Level Trigger
16	HOM	Start Homing	Start the built-in homing procedure of the drive	Edge Trigger
17	DIV1	Electronic Gear Select (DIV1)	Select the electronic gear ratio on position mode	Level Trigger
18	DIV2	Electronic Gear Select (DIV2)	Select the electronic gear ratio on position mode	Level Trigger

Table 5.4.1.2 Input functions supported by each operation mode

	Not CoE model				CoE model
Operation mode / Input function	Position mode	Velocity mode	Force / Torque mode	Stand-alone mode	Stand-alone mode
Axis Enable	V	V	V	V	V
Left (-) Limit Switch	V	--	--	V	V
Right (+) Limit Switch	V	--	--	V	V
Home OK, start err. map	V	V	V	V	V
Reset amplifier	V	V	V	V	V
Near home sensor	V	V	V	V	V
Clear error	V	V	V	V	--
Invert V command	--	V	V	--	--
Switch to secondary CG	V	V	V	V	--
Switch to secondary vpg	V	V	V	V	--
Zero speed clamp	--	V	--	--	--
Inhibit pulse command	V	--	--	--	--
Switch HI/LO pulse input	V	--	--	--	--
Abort motion	--	--	--	V	--
Switch to secondary mode	V	V	V	V	--
Start homing	V	V	V	V	--
Select electronic gear (DIV1)	V	--	--	--	--
Select electronic gear (DIV2)	V	--	--	--	--

Note:

"V" indicates that the input function can be used on the corresponding mode, and can be arbitrarily set at I1~I10.

Table 5.4.1.3 Default input setting for D2T-LM series drive

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

*Only for D2T-LM model

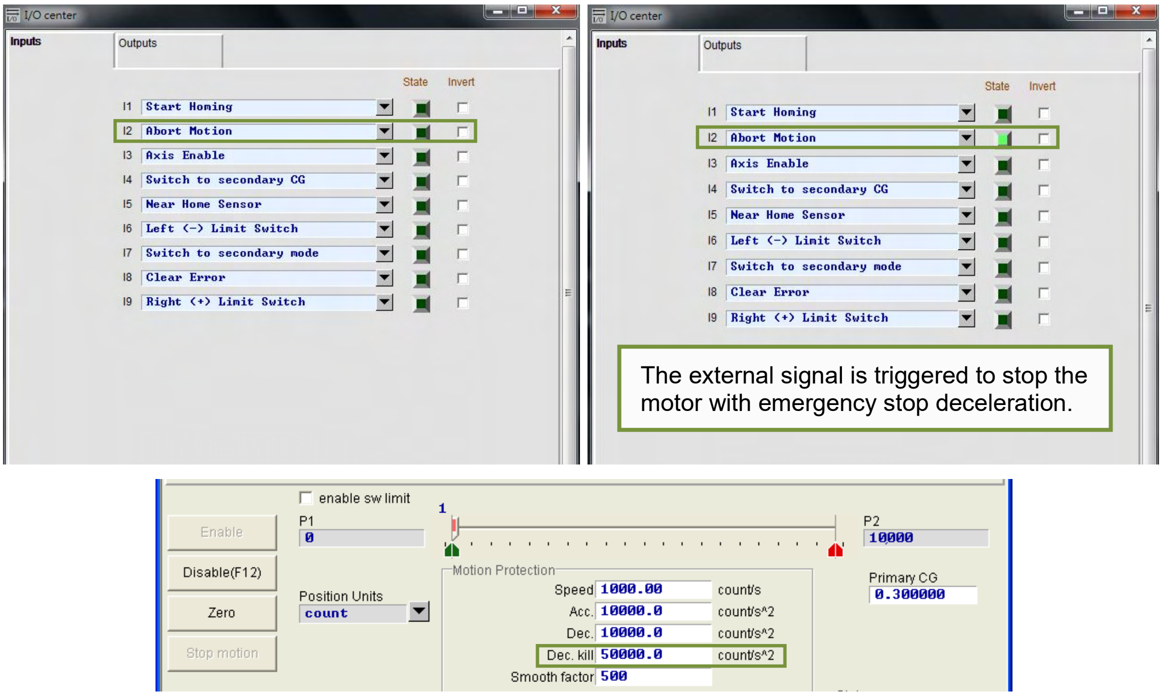
<table>
<tr><td>Input function</td><td colspan="2">Abort Motion</td><td colspan="2">Operation mode</td><td>Pos</td><td>Vel</td><td>Trq</td><td>Std</td></tr>
<tr><td>Symbol</td><td>EMG</td><td>Default input</td><td>I2</td><td>Circuit</td><td colspan="4">Refer to Section 4.5.1</td></tr>
</table>

Function description:

On stand-alone mode, when the input signal is triggered by the button, the drive makes the motor decelerate to stop with emergency stop deceleration (Dec. kill). The value of emergency stop deceleration can be set in Performance center.

Instruction:

Select "Abort Motion" in the "Inputs" tab of I/O center (default is I2). Utilize the external trigger signal to stop the motor with emergency stop deceleration.



When the input state of “Abort Motion” is True (the state indicator light is green), the drive will make the motor decelerate to stop with emergency stop deceleration (Dec. kill).

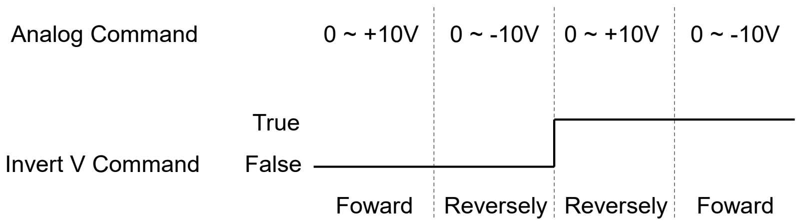
Input function	Invert V Command		Operation mode		Pos	Vel	Trq	Std
Symbol	INVC	Default input	None	Circuit	Refer to Section 4.5.1			

Function description:

Invert voltage command sent by the host controller.

Instruction:

Assign input function to “Invert V Command” on velocity or force / torque mode. When the input state of “Invert V Command” is False, the analog input voltage between 0 to +10 V that the drive receives makes the motor rotate forward, and the voltage between -10 to 0 V makes it rotate reversely. On the other hand, when the input state of “Invert V Command” is True, the voltage between 0 to +10 V makes the motor rotate reversely, and the voltage between -10 to 0 V makes it rotate forward.



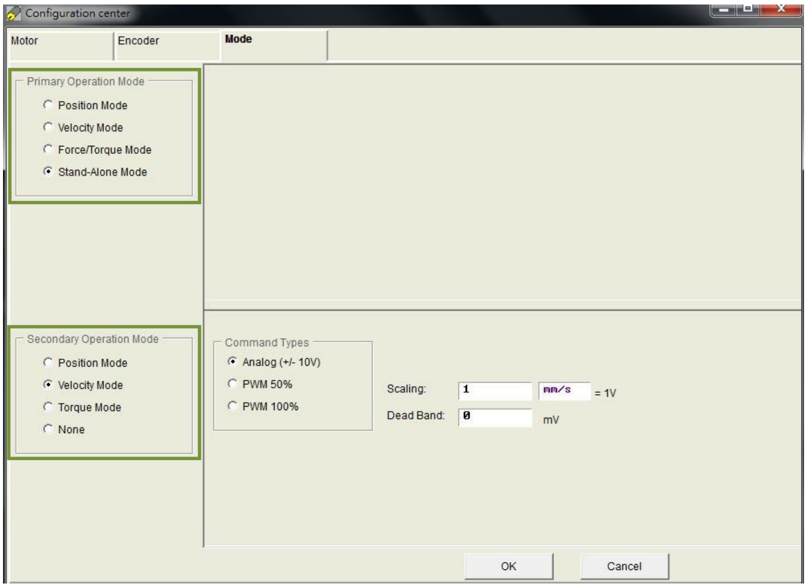
Input function	Switch to secondary mode		Operation mode		Pos	Vel	Trq	Std
Symbol	MOD	Default input	I7	Circuit	Refer to Section 4.5.1			

Function description:

Switch the operation mode via the I/O signal from the host controller.

Instruction:

Set the operation mode in the “Mode” tab of Configuration center, as the following figure shows.



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

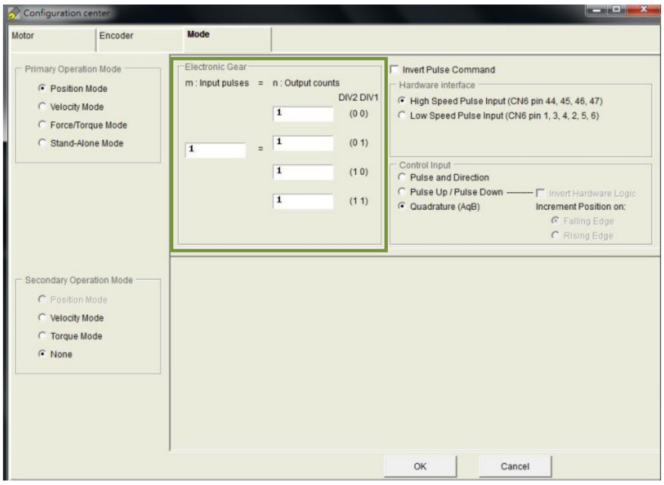
Input function	Electronic Gear Select (DIV1, DIV2)		Operation mode		Pos	Vel	Trq	Std
Symbol	DIV1, DIV2	Default Input	I5	Circuit	Refer to Section 4.5.1			

Function description:

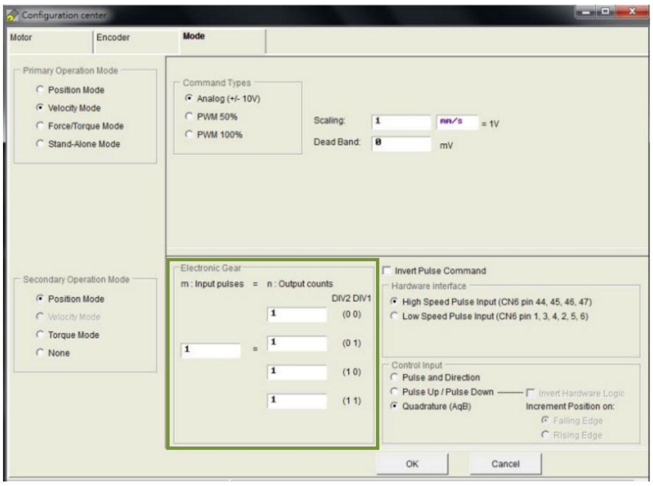
Switch among the four sets of electronic gear ratio.

Instruction:

Go to the “Mode” tab of Configuration center, and select “Position Mode” in “Primary Operation Mode” or “Secondary Operation mode” to set the four sets of electronic gear ratio (as the following figures show).



electronic gear ratio (Primary Operation Mode)



electronic gear ratio (Secondary Operation Mode)

Users can select the required electronic gear ratio based on different combination of DIV1 and DIV2. The corresponding combinations are shown in the following table. For example, to use the third electronic gear ratio, users should set “Electronic Gear Select (DIV2)” to be True and “Electronic Gear Select (DIV1)” to be False.

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

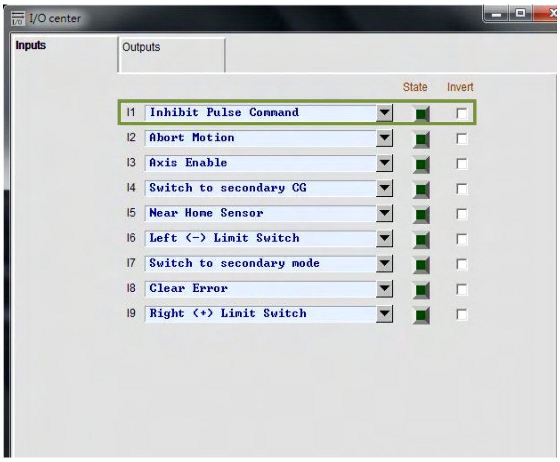
Input function	Inhibit Pulse Command		Operation mode		Pos	Vel	Trq	Std
Symbol	INH	Default input	I1	Circuit	Refer to Section 4.5.1			

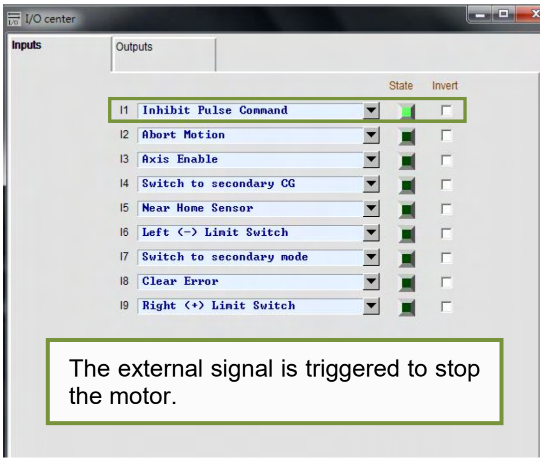
Function description:

Inhibit the drive from receiving the pulse command sent by the host controller.

Instruction:

Assign input function to "Inhibit Pulse Command" on position mode. If the input signal is True, the drive stops receiving the pulse command from the host controller. If it is False, the drive receives the pulse command from the host controller to make the motor move.





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

Function description:

Execute the homing procedure.

Instruction:

When the state of "Start homing" is changed from False to True, the homing procedure will be executed based on the homing method set in Application center.

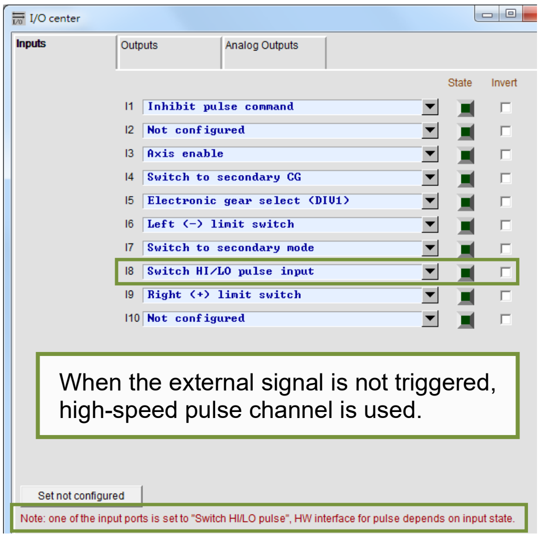
Input function	Switch HI/LO Pulse Input		Operation mode		Pos	Vel	Trq	Std
Symbol	PSEL	Default input	None	Circuit	Refer to Section 4.5.1			

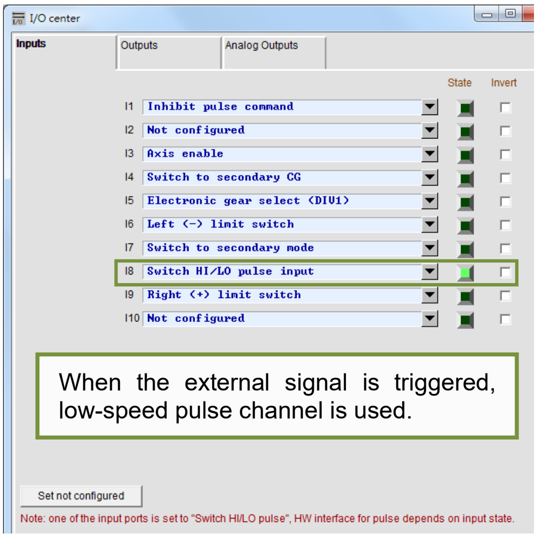
Function description:

On position mode, trigger the input signal through the host controller to switch between high-speed and low-speed pulse input channels.

Instruction:

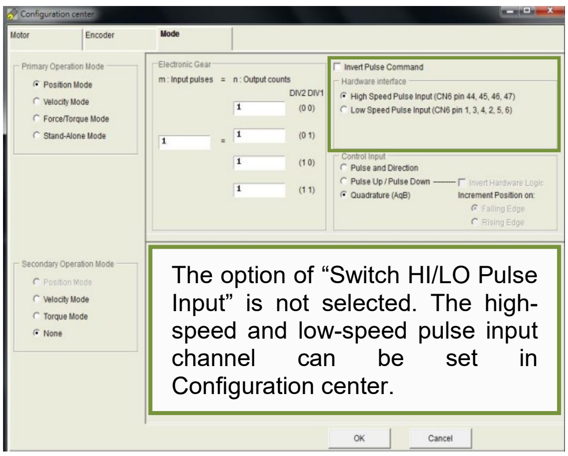
Select “Switch HI/LO Pulse Input” in the “Inputs” tab of I/O center, as the following figures show. I1 to I10 are selectable. (The following figures take I8 for example.) Use an external trigger signal to switch between high-speed and low-speed pulse input channels.

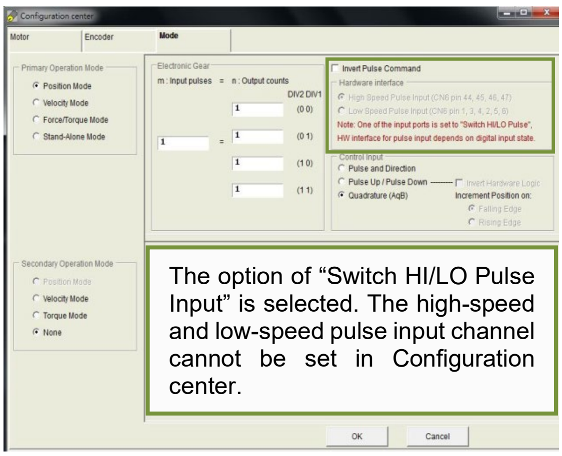




When the input state of “Switch HI/LO Pulse Input” is False (the light is off), high-speed pulse input channel is used. When the input state is True (the light is on), low-speed pulse input channel is used.

Note: When users select the input (I1~I10) to be “Switch HI/LO Pulse Input”, high-speed and low-speed pulse input channels cannot be set in the “Position Mode” of the “Mode” tab in Configuration center.





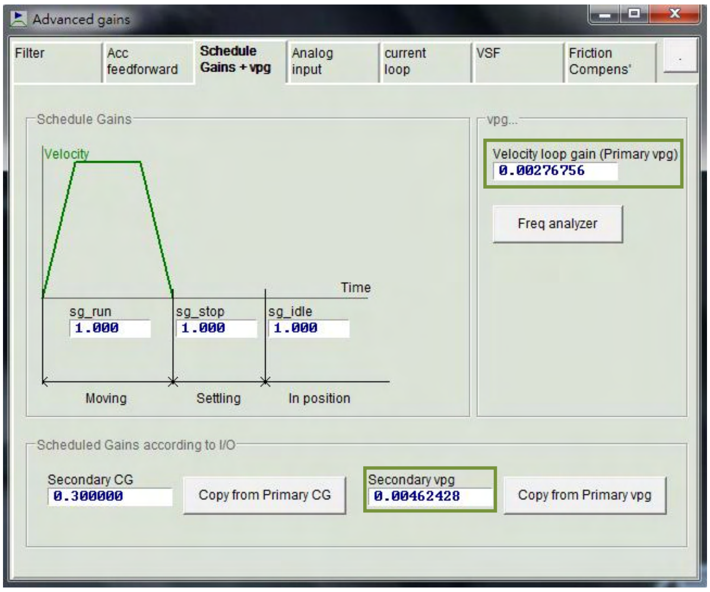
Input function	Switch to secondary vpg		Operation mode		Pos	Vel	Trq	Std
Symbol	JSEL	Default input	None	Circuit	Refer to Section 4.5.1			

Function description:

Switch between velocity loop gains.

Instruction:

Different velocity loop gains can be set in the "Schedule Gains + vpg" tab of "Advanced gains" window, as the following figure shows.

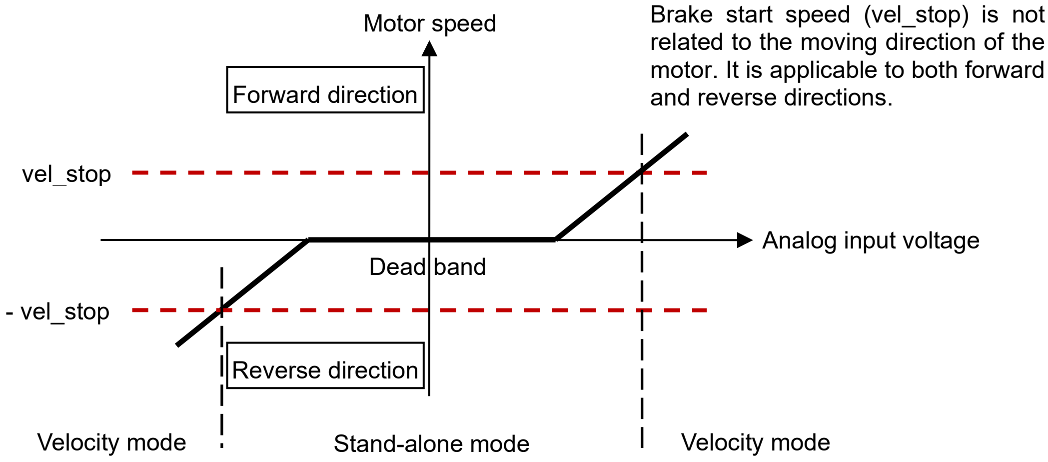


When the input state of "Switch to secondary vpg" is True (the light is on), "Secondary vpg" is used. When it is False (the light is off), "Primary vpg" is used.

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

Function description:

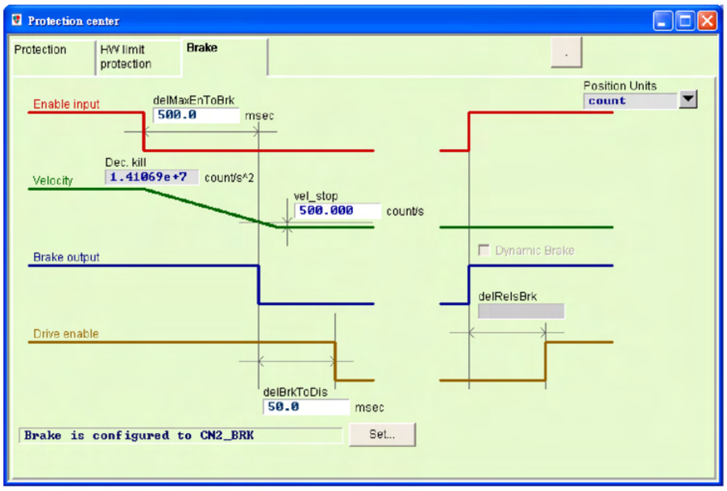
This input function is only suitable for velocity mode, and it is level triggered. When the input state of "Zero Speed Clamp" is True, if the motor speed corresponding to the analog input voltage command is equal to or less than the brake start speed, the operation mode will automatically be switched to stand-alone mode. At the same time, the motor will be locked at the current position. Until the motor speed corresponding to the analog input voltage command is larger than the brake start speed, the operation mode will automatically switch to velocity mode to make the motor keep moving, as the following figure shows.



Instruction:

In the case where operation mode is set to velocity mode, go to the I/O center and set input function as "Zero Speed Clamp". The following figure takes I1 as an example.

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



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

Input function	Clear Error		Operation mode		Pos	Vel	Trq	Std
Symbol	CE	Default input	I8	Circuit	Refer to Section 4.5.1			

Function description:

Clear error message.

Instruction:

When the input state of “Clear Error” is changed from False to True, the error message will be cleared.

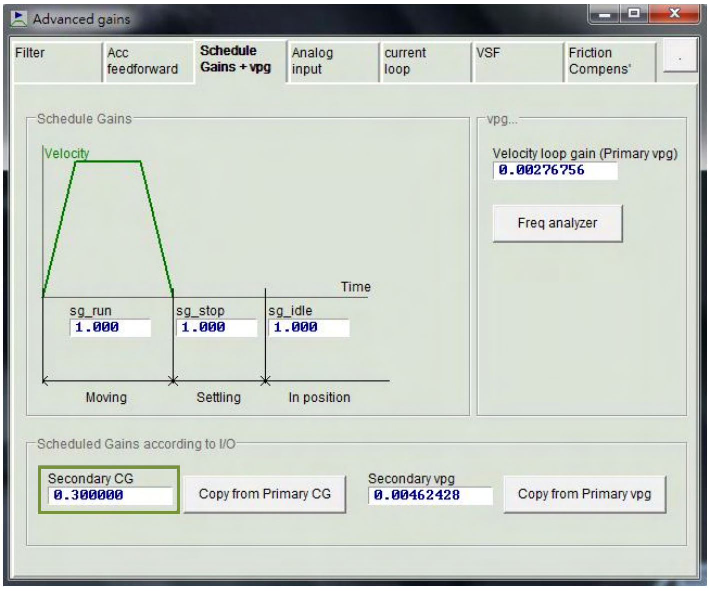
Input function	Switch to secondary CG		Operation mode		Pos	Vel	Trq	Std
Symbol	GNS	Default input	None	Circuit	Refer to Section 4.5.1			

Function description:

Switch between common gains.

Instruction:

“Secondary CG” can be set in the “Schedule Gains + vpg” tab of “Advanced gains” window, as the following figure shows.



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

5.4.2 Digital output

D2T-LM model provides six sets of programmable digital output. Five sets (O1~O5) are general-purpose outputs located on CN6 connector. The sixth set (CN2 BRK) is specially designed as brake output, and it can also be used as general-purpose output.

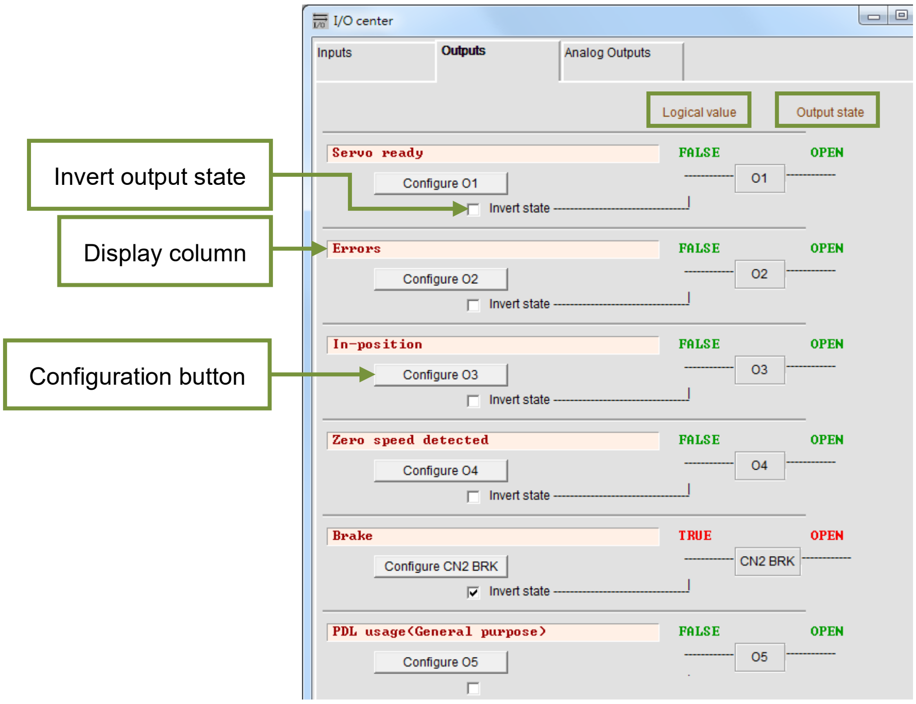


Figure 5.4.2.1 Digital output

- **Logical value**

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

- **Display column**

  When any item in Configuration function menu (as Figure 5.4.2.2 shows) is checked, the item name is shown in the display column. If two or more items are checked, it shows “Customized”. If all error items are checked, it shows “Errors”. If no item is checked, it shows “PDL usage (General Purpose)” for the usage of general-purpose output. This indicates that the output function is controlled by PDL program language.

- **Output state**

  The current state of the drive’s output pin is displayed here to be CLOSE or OPEN (the transistor is conducted or not conducted). This helps users know the state of the hardware signal on the drive output to assist wiring debugging.

- **Invert state**

  Based on the requirement, this option can be checked to invert the polarity of the output state to match the host controller.

  Note: The internal logic of the drive is not affected by this "Invert state" setting at all.

- **Configuration button**

  Each output pin has one corresponding configuration button. Take O1 as an example, click the "Configure O1" button to open Configuration function menu. This menu can be divided into three categories, "Statuses", "Errors", and "Warnings" (as Figure 5.4.2.2 shows). If two or more items are selected in the same menu, the output function works when one of these items is triggered. To cancel all checked options, click the "Not Configured" button. After selecting the desired functions, click the "Apply" button to complete the setting, or click the "Cancel" button to discard the setting. In the "Errors" category, there is a "Set all errors" button. It is recommended to click this button to select all errors in the "Errors" category for faster setting up.

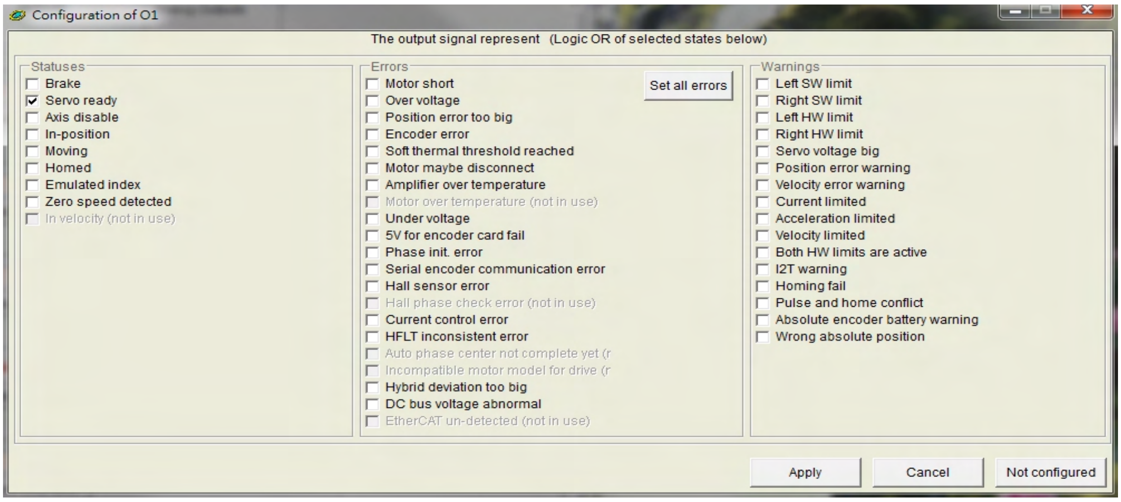


Figure 5.4.2.2 Configuration function menu

Table 5.4.2.1

Item	Symbol	Output function	Description
Statuses			
1	BRK	Brake	Brake signal (If it is checked, it is impossible for users to set other statuses, errors, or warnings.)
2	RDY	Servo Ready	Servo at the enable state
3	DIS	Axis Disable	Servo at the disable state
4	INP	In-Position	In-Position signal
5	MOV	Moving	Moving
6	HOMD	Homed	Homing completed
7	EMI	Emulated Index	Emulated Z-phase index signal

8	ZSPD	Zero Speed Detected	Zero speed detected signal
Errors			
1	ALM	Errors	Generally, all errors are checked (by clicking the “Set all error” button). Users can change the combination of errors to meet the requirement.
Warnings			
1	LS	Left Software Limit	Left software limit is triggered.
2	RS	Right Software Limit	Right software limit is triggered.
3	LH	Left Hardware Limit	Left hardware limit is triggered.
4	RH	Right Hardware Limit	Right hardware limit is triggered.
5	SVB	Servo Voltage Big	PWM command is greater than the set warning value.
6	PEW	Position Error Warning	Position error is greater than the set warning value.
7	VEW	Velocity Error Warning	Velocity error is greater than the set warning value.
8	CUL	Current Limited	Current is saturated. The specification of motor peak current is reached.
9	ACL	Acceleration Limited	When the motor is moving, the protection setting for acceleration is reached.
10	VL	Velocity Limited	When the motor is moving, the protection setting for velocity is reached.
11	BOHL	Both HW limits are active	Both left and right hardware limits are triggered.
12	HOMF	Homing fails	The homing process fails.
13	PCHC	Pulse command and homing conflict	On position mode, pulse command and homing command are received at the same time.
14	AEBW	Absolute encoder battery warning	The encoder battery is dead. Replace the battery.
15	WAP	Wrong absolute position	The absolute encoder gives a wrong feedback of an error absolute position. Reset the home position.

Table 5.4.2.2 Default output setting for D2T-LM series drive

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

*Only for D2T model

#Only for Frame B and C

Table 5.4.2.3 Output functions supported by each operation mode

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

Note: “V” indicates that the output function can be used on the corresponding mode.

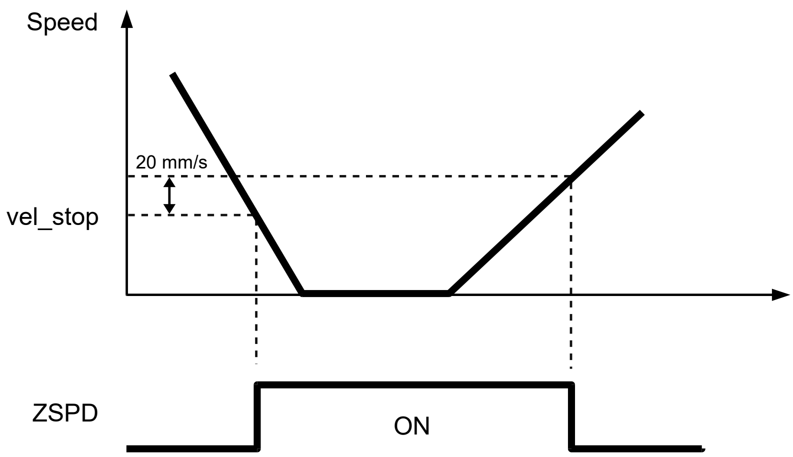
Output function	Zero Speed Detected		Operation mode		Pos	Vel	Trq	Std
Symbol	ZSPD	Default output	O4	Circuit	Refer to Section 4.5.2			

Function description:

The drive outputs this signal when the motor speed is close to zero.

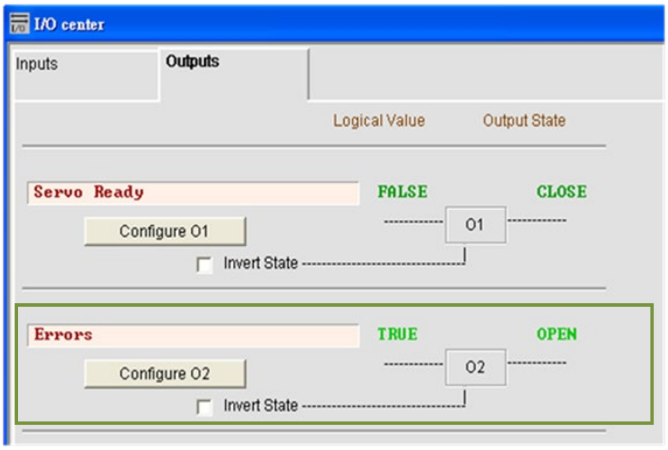
Instruction:

The so-called “speed closed to zero” means that the motor speed is less than the threshold set by the parameter “vel_stop”. This feature also has the hysteresis of 20 mm/s to avoid the bounce of ZSPD output signal. Please refer to Section 8.3 for parameter “vel_stop”.

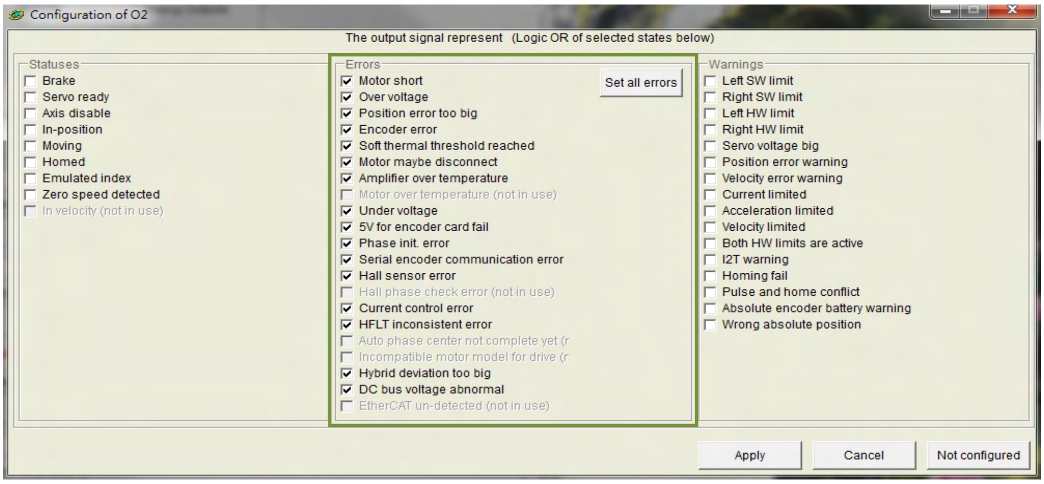


<table>
<tr><td>Output function</td><td colspan="2">Errors</td><td colspan="2">Operation mode</td><td>Pos</td><td>Vel</td><td>Trq</td><td>Std</td></tr>
<tr><td>Symbol</td><td>ALM</td><td>Default output</td><td>O2</td><td>Circuit</td><td colspan="4">Refer to Section 4.5.2</td></tr>
<tr><td colspan="9">Function description:
Output the error status.

Instruction:
“Errors” can be set in the “Outputs” tab of I/O center (The default is O2).</td></tr>
</table>



Click the “Configure O2” button to get the “Configuration of O2” window. Click the “Set all errors” button to check all options in the “Errors” category, as the green box in the following figure shows. At this time, the output in use displays “Errors”. However, if users select several errors instead of all errors, the output in use displays “Customized”.



5.4.3 Analog output

D2T-LM model comes with one analog output located on CN6 connector, which can be used to monitor motor torque (pin 43). The output voltage ranges from -10V to 10V, and the output resolution is 16 bits. The configuration page for analog output is shown in Figure 5.4.3.1.

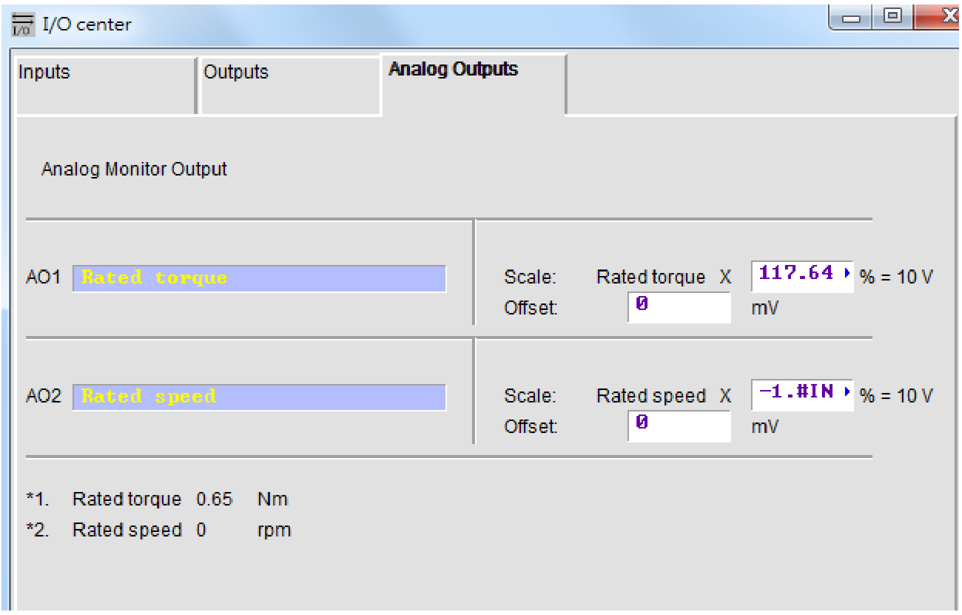


Figure 5.4.3.1 Analog output configuration page

- **AO1 Rated torque**

  Set the motor torque (Rated torque x ☐%) at the maximum output voltage of pin 43 on CN6 being 10V, where “Rated torque” = “motor continuous current” x “motor torque constant”. The value of ☐ is up to users (the input ranges from 1 to 300; the default value is 100). “Offset” is the offset of output voltage (the input ranges from -10,000mV to 10,000mV; the default value is 0).

- **AO2 Rated speed**

  D2T-LM model does not support AO2 Rated speed.

Note: D2T-LM model can only match with linear motor. Thus, motor torque (Rated torque) can be viewed as motor force (Rated force).

5.5 In-position signal setting

In the servo system, there is a certain following error between the target position and the encoder feedback position. When the motor moves to the target position, there is a short period of time for settling, called the settling time. After that, the motor enters the target radius. D2T-LM series drive provides the functional interface of in-position. By setting “Target radius” and “Debounce time”, users can observe whether the motor has got to the target position or not. This function is supported only when the drive is operated on position mode or stand-alone mode. The “In-Position” status can be sent to the host controller via digital output signal.

Function setting

Click to open Performance center. The “In-Position” configuration page is displayed in the “Position” tab. Click the “Set scope…” button to open the “Scope” window if users need to capture the waveform. The default of “In-Position” signal is set at O2. Please refer to Section 5.4.2 for setting digital output.

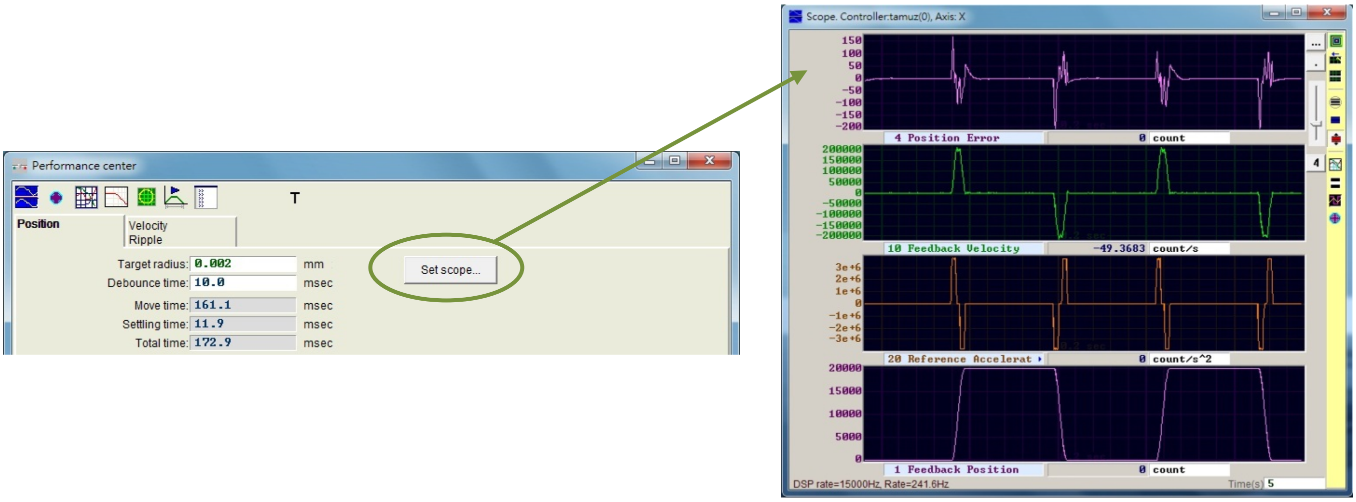


Figure 5.5.1

Table 5.5.1

Parameter	Description
Target radius	Target radius for the position error. After the position error gets into “Target radius” and continues “Debounce time”, “In-Position” is valid. The default value is 100 times the encoder resolution.
Debounce time	Debounce time. After the position error gets into “Target radius” of “In-Position”, it needs to last a while to make In-Position valid.
Move time	Path planning time
Settling time	Settling time
Total time	Total time (move time + settling time)

Debounce time setting

When it comes to motor positioning, there might be the overshoot phenomenon, which makes the "In-Position" signal instable before the motor gets to the target position. This can be resolved by setting "Debounce time". The "In-Position" signal will not be sent until the position error enters "Target radius" and continues for a period of "Debounce time". The larger "Debounce time" is, the more stable the "In-Position" signal will be, and the larger the time delay will be. Through observing the "In-Position" signal on the oscilloscope, "Debounce time" can be appropriately set.

(1) After fixing "Target radius" and setting "Debounce time" as 0ms, make the motor move a distance and observe the "In-Position" signal on the scope, as Figure 5.5.2 shows. When "In-Position" is valid, it is a high-level signal; when it is invalid, it is a low-level signal. From Figure 5.5.2, it is easy to observe that six protruding pulses appear (the latter two are shorter) when the motor moves close to the target position. As for the high-level duration of each protruding pulse, the first one is about 1.5ms, the second one is about 1.4ms, the third one is about 1.4ms, the fourth one is about 1.3ms, and the fifth and the sixth one are about 1ms.

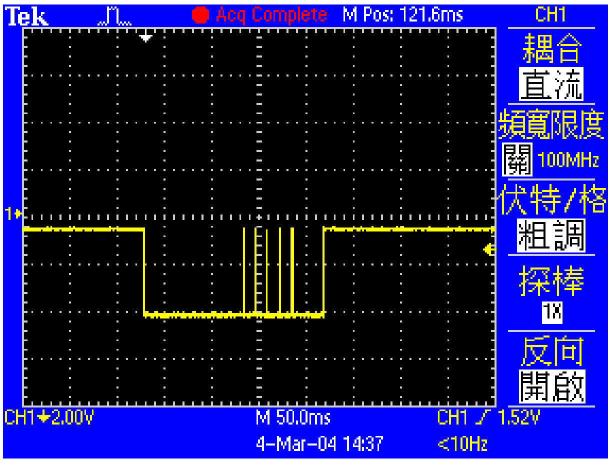


Figure 5.5.2 In-Position signal ("Debounce time" being 0ms)

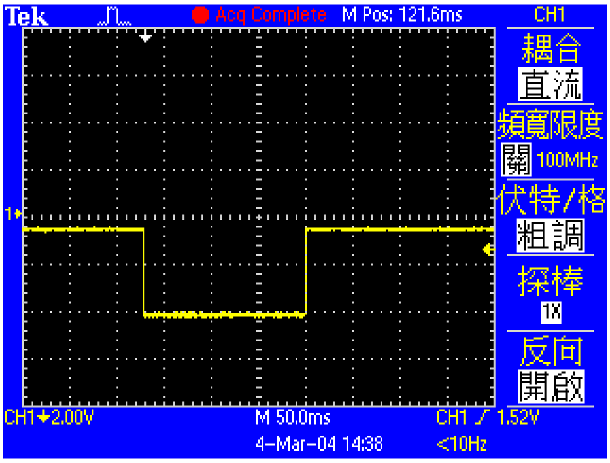


Figure 5.5.3 In-Position signal ("Debounce time" being 3ms)

(2) The widest protruding pulse in Figure 5.5.2 is 1.5ms. Users can set "Debounce time" to be a bit larger than this value. Considering about the safety factor, set "Debounce time" as 3ms. Make the motor move a distance, and the new "In-Position" signal is shown in Figure 5.5.3. As you can see, the instability of "In-Position" signal is improved.

5.6 Homing configuration

Click to open Application center. The first tab is the configuration page of “Homing”, as Figure 5.6.1 shows.

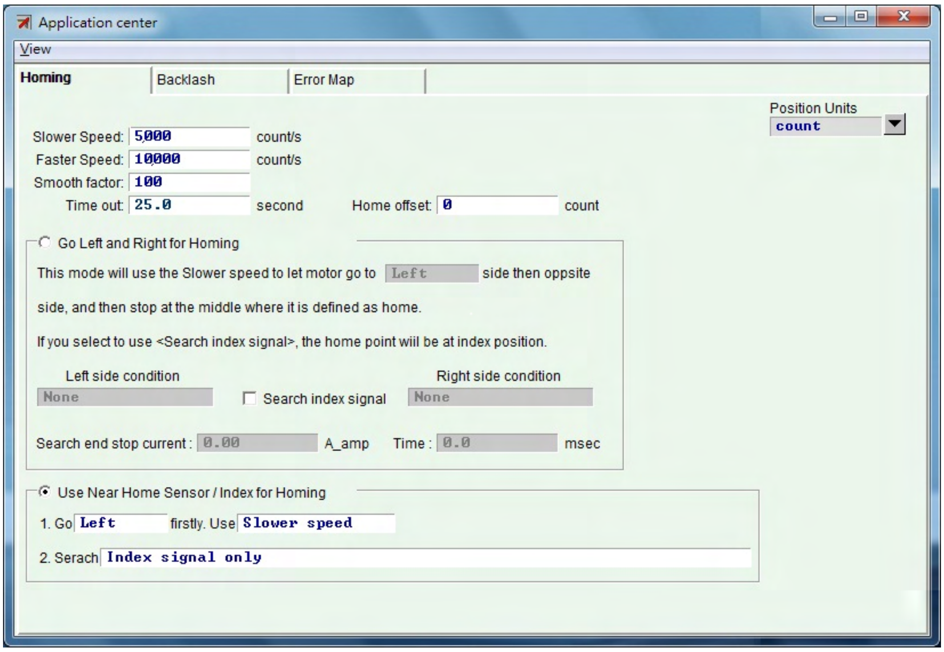


Figure 5.6.1 Homing configuration page

There are five basic parameters for homing configuration, as the following table shows.

Table 5.6.1

Parameter	Description
Slower Speed	Slower homing speed
Faster Speed	Faster homing speed
Smooth factor	The homing-specific smooth factor parameter; the setting range is from 1 to 500
Time out	The maximum searching time for homing procedure
Home offset	Home offset

There are three modes for homing configuration.

(1) Go left and right for homing: refer to Section 5.6.1

(2) Use near home sensor / index for homing: refer to Section 5.6.2

(3) Use homing methods in CiA 402 protocol: refer to Section 5.6.3

Homing mode (1) and (2) are suitable for motor with incremental encoder; homing mode (3) is for CoE model.

After setting homing mode, click the "Home" button at the bottom of Performance center to start the homing procedure. The "Homed" status light in Performance center window continues flashing green during the process. When the homing is done, the "Homed" status light remains green (

) to show its success. When "Time out" time is up but the home position is not found, the "Homed" status light remains red (

) to show its failure.

Home offset

- **Homing method for incremental encoder**

  This method is only applicable to homing mode (1) and (2) described above. When "Home offset" is set as a non-zero value, the home position found in the original condition is offset by a distance. This new position is taken as the origin of coordinates, and the motor will move to this new home position, as Figure 5.6.2 shows. If the left and the right conditions are not "None", the drive will take the position, the home position found in the original condition offset by a distance, as the new home position. If "Home offset" is positive, the origin of coordinates is on the right side of the home position found in the original condition. If "Home offset" is negative, the origin of coordinates is on the left side of the home position found in the original condition.

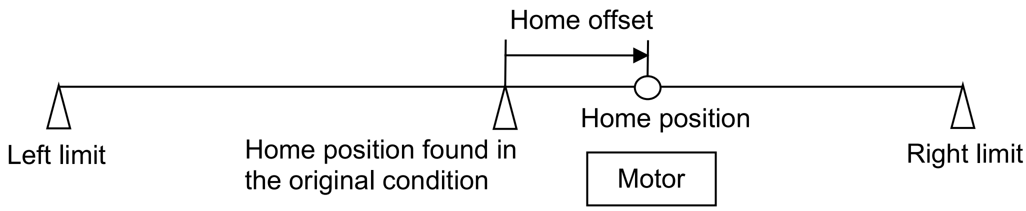


Figure 5.6.2

- **Homing method for CiA 402**

  This method is only applicable to homing mode (3) described above. When "Home offset" is set as a non-zero value, the drive sets the home position found in the original condition as the value of "Home offset", as Figure 5.6.3 shows. If "Home offset" is positive, the origin of coordinates is on the left side of the home position found in the original condition. If "Home offset" is negative, the origin of coordinates is on the right side of the home position found in the original condition.

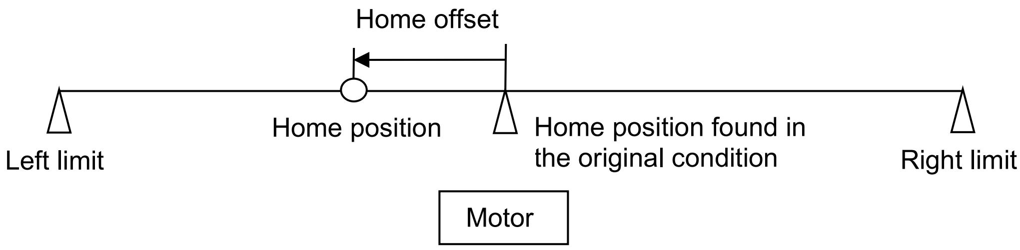


Figure 5.6.3

5.6.1 Go left and right for homing

This function is a kind of multi-function homing mode built-in D2T-LM series drive. By searching the left and the right conditions, the home position can be determined. The main method is to find the midpoint of the two boundaries as the home position. For the left and the right conditions, users can choose either the left and the right limit switches or End Stop, the way of searching the left and the right conditions by the current generated as the motor touches the mechanical stop. To make the index found in the stroke become the home position, users can click the “Search index signal” option.

Homing procedure:

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

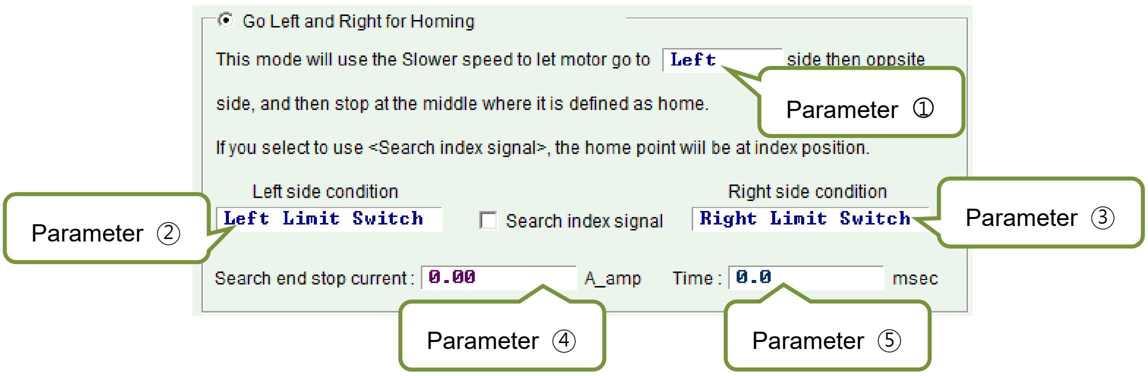


Figure 5.6.1.1

Table 5.6.1.1

No.	Parameter	Option	Description
①	Direction of initial movement	Left	Search the left side first
		Right	Search the right side first
②	Left side condition	None	Do not use the left side condition
		End Stop	Search the left end stop
		Left Limit Switch	Search the left limit switch
③	Right side condition	None	Do not use the right side condition
		End Stop	Search the right end stop
		Right Limit Switch	Search the right limit switch
④	Current for searching End Stop		
⑤	Time for searching End Stop		

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

(1) None: Not searching

(2) End Stop: Search end stop

(3) Limit Switch: Search limit switch

Searching end stop should be carried out with parameter ④ and ⑤. Parameter ④ is used to set the force for searching end stop, and parameter ⑤ is used to set the duration of the force. If the time is too short, the drive may make a misjudgment before end stop is found. If the time is too long, the force on the end stop will increase, or the warning message of “I2T warning” will occur. The current for searching end stop can be set by the following steps.

Step 1. Open the “Scope” window to set the physical quantity of observing “Actual Current”, as Figure 5.6.1.2 shows.

Step 2. Use the “Slower Speed” setting to move in the entire stroke.

Step 3. Observe the change of “Actual Current”, and record the maximum value. As Figure 5.6.1.2 shows, the maximum value of “Actual Current” is about 0.2A. Therefore, users can set “Search end stop current” a little bit more than 0.2A. In this case, it can be set as 0.23A.

Note: To avoid the error of “Position error too big” during searching end stop, the slower speed and time for searching end stop should meet the following condition: **“Slower Speed” x “Time” < “maximum pos error”**

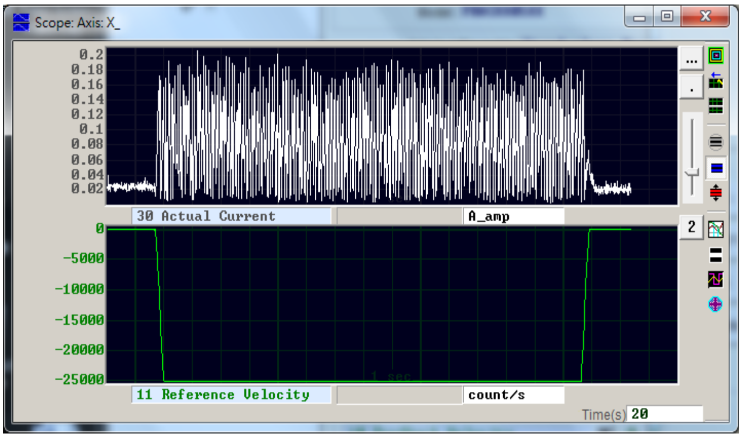


Figure 5.6.1.2

Exceptions:

(1) As Figure 5.6.1.3 shows, “Left side condition” is set as “None”, “Right side condition” is set as “End Stop” or “Right Limit Switch”, and the direction of initial movement (parameter ①) is set as “Left”. When the homing is executed, the homing procedure is judged to be a failure, and the status light of “Homed” remains red, vice versa. (This case is an unreasonable setting, so the homing fails.)

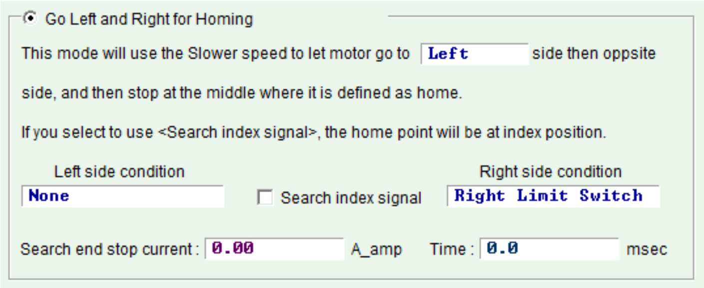


Figure 5.6.1.3

(2) If users click the “Search Index Signal” option but find out that there are multiple indexes in the stroke, the drive will take the closest index to “End Stop” or “Right Limit Switch” as the home position.

Homing example:

According to the setting of Figure 5.6.1.4, when starting the homing procedure, the motor moves along the negative direction with the slower homing speed to search the left limit switch. After the left limit switch is found, the motor searches the first index signal with the slower homing speed along the positive direction. The action process is shown in Figure 5.6.1.5.

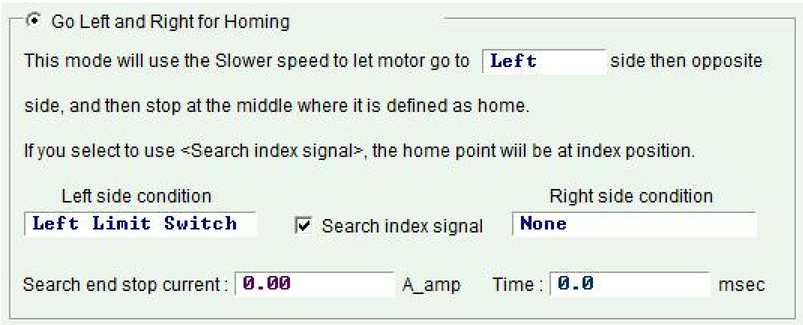


Figure 5.6.1.4

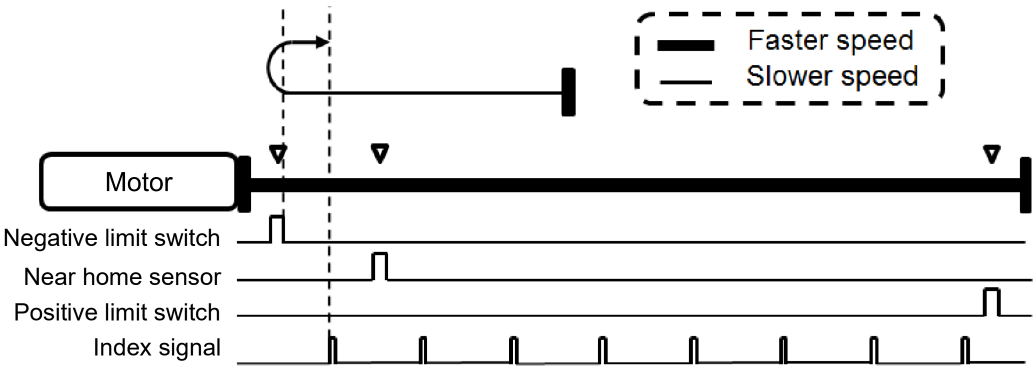


Figure 5.6.1.5

5.6.2 Use near home sensor / index for homing

Searching "Near Home Sensor" or encoder index signal to determine the home position is another homing mode. "Near Home Sensor" is set by a digital input in I/O center, and it is triggered via an external switch. After finding out "Near Home Sensor", search the encoder index signal on the left or the right side for the home position to get better accuracy.

Homing procedure:

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

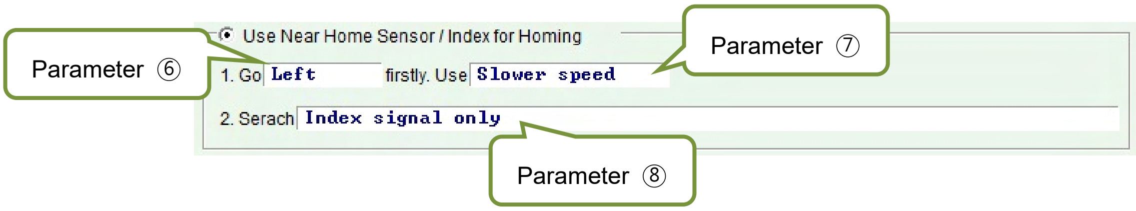


Figure 5.6.2.1

Table 5.6.2.1

No.	Parameter	Option	Description
⑥	Initial movement direction	Left	Search the left side first
		Right	Search the right side first
⑦	Initial movement speed	Slower speed	Search with the slower homing speed; set the speed in the "Slower Speed" column given in Figure 5.6.1
		Faster speed	Search with the faster homing speed; set the speed in the "Faster Speed" column given in Figure 5.6.1
⑧	Searching home position method	Index signal only	Search encoder index signal only
		Near Home Sensor only	Search near home sensor only
		Near Home Sensor then change to lower speed, move left, search index	After finding out the near home sensor, change to search the encoder index signal with the slower homing speed on the left side.
		Near Home Sensor then change to lower speed, move right, search index	After finding out the near home sensor, change to search the encoder index signal with the slower homing speed on the right side.

When "Near Home Sensor" is used for homing, the photoelectric switch or mechanical switch can be connected to the digital input of the drive. Here takes I2 as an example, setting I2 as "Near Home Sensor" in the I/O center (as Figure 5.6.2.2 shows).

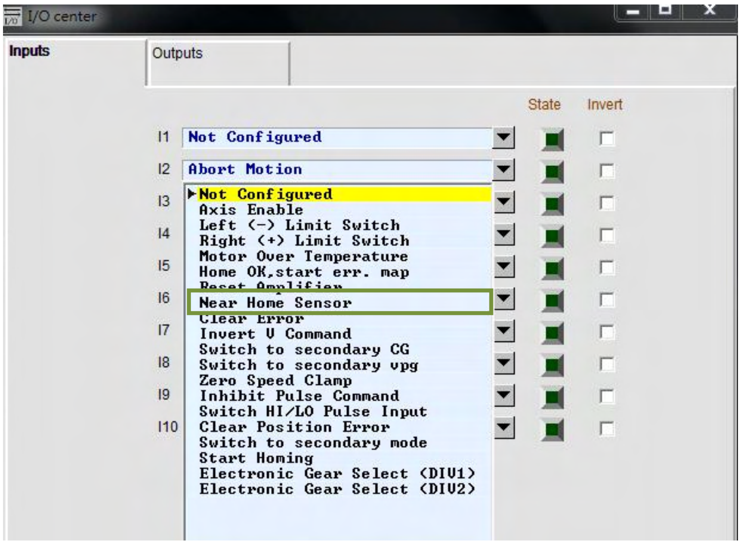


Figure 5.6.2.2

Homing example:

According to the setting of Figure 5.6.2.3, when starting the homing procedure, the motor moves along the negative direction with the faster homing speed to search “Near Home sensor”. After “Near Home sensor” is found, the motor searches the first index signal with the slower homing speed along the negative direction. The action process is shown in Figure 5.6.2.4.

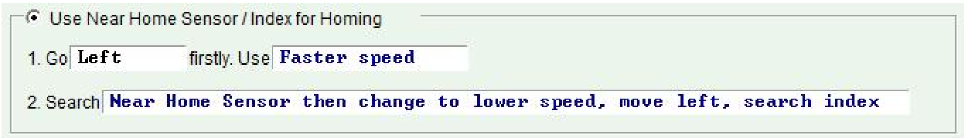


Figure 5.6.2.3

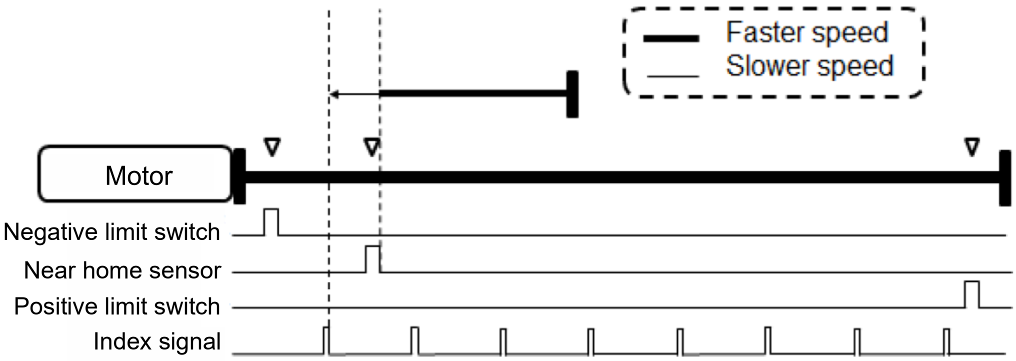


Figure 5.6.2.4

5.6.3 Use homing methods in CiA 402 protocol

For CoE model, the software version of Lightening 0.185 or above supports this homing mode. The configuration page is shown in Figure 5.6.3.1, where the green line represents the faster homing speed, and the orange line represents the slower homing speed. Homing methods for this mode are summarized in Table 5.6.3.1.

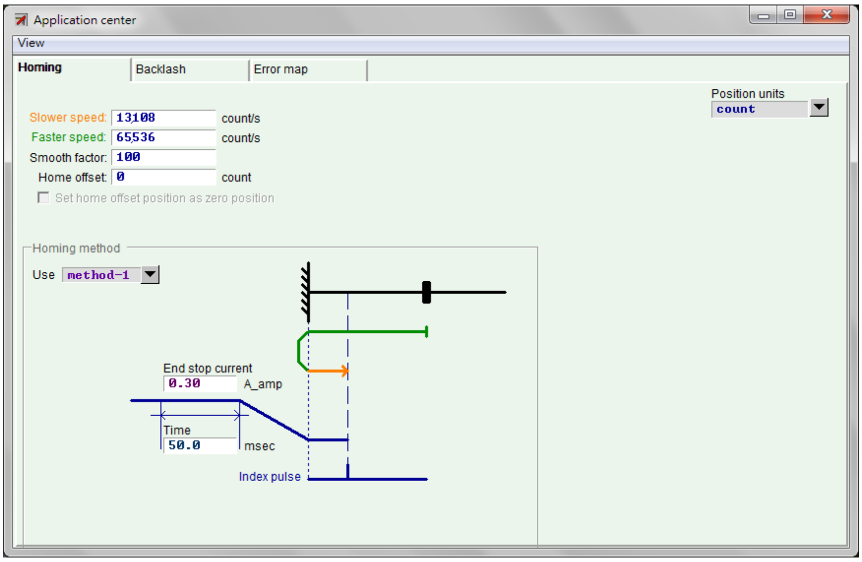
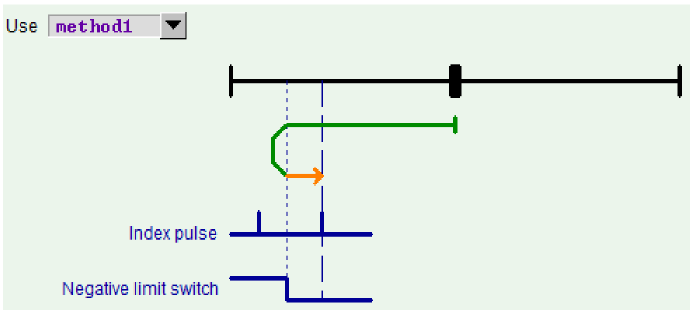
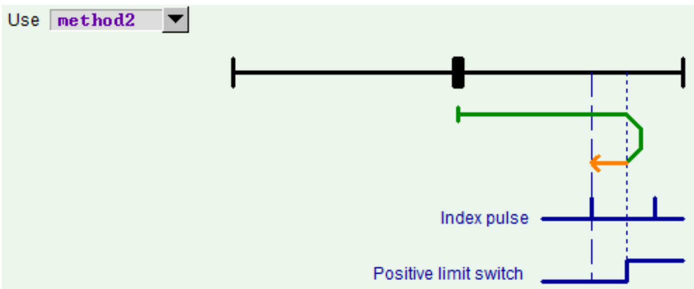
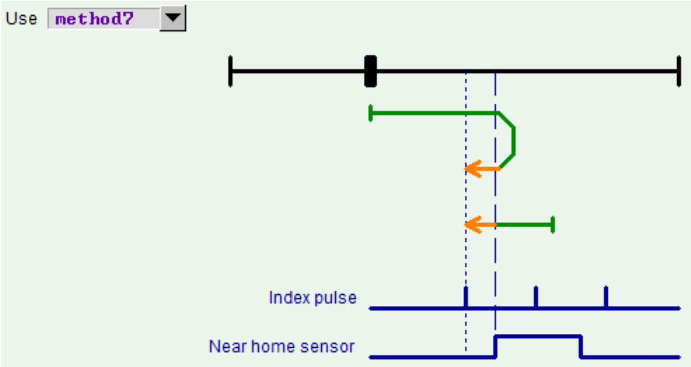
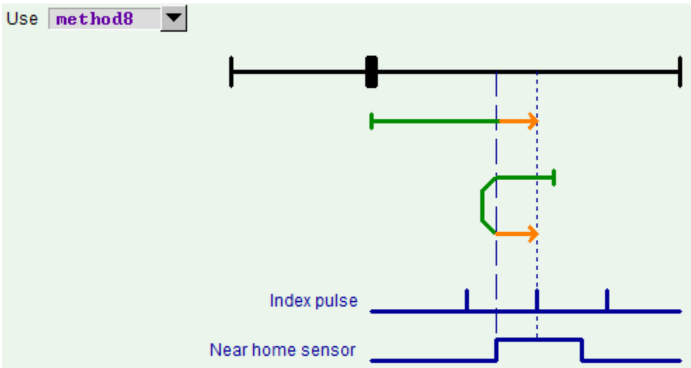
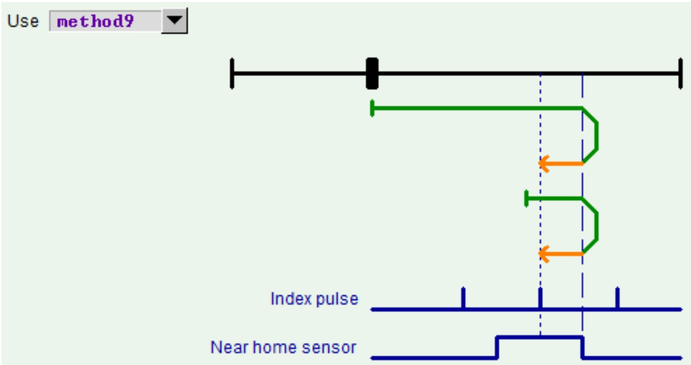
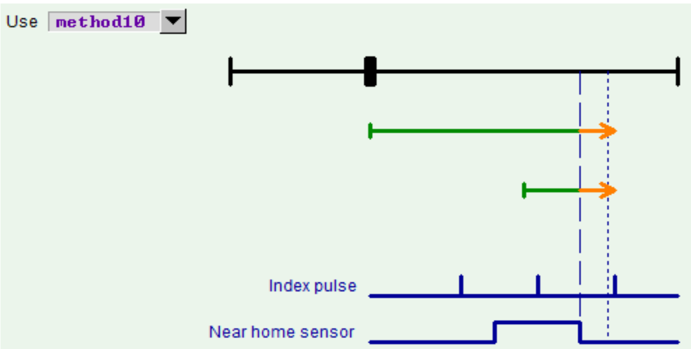
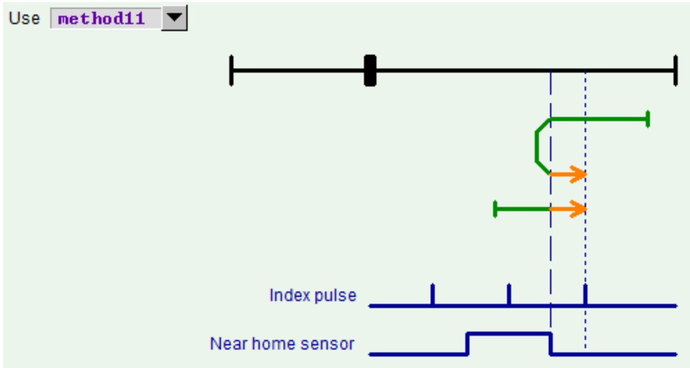
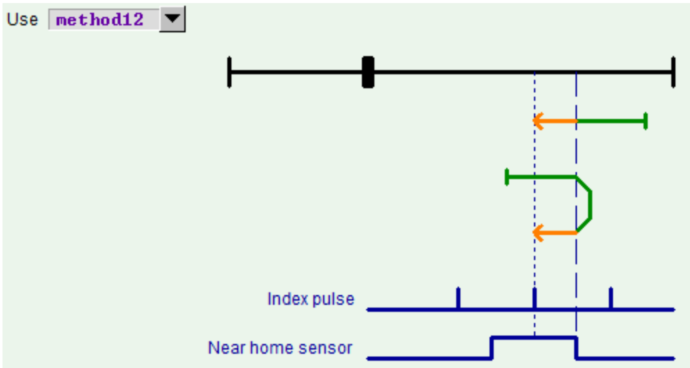
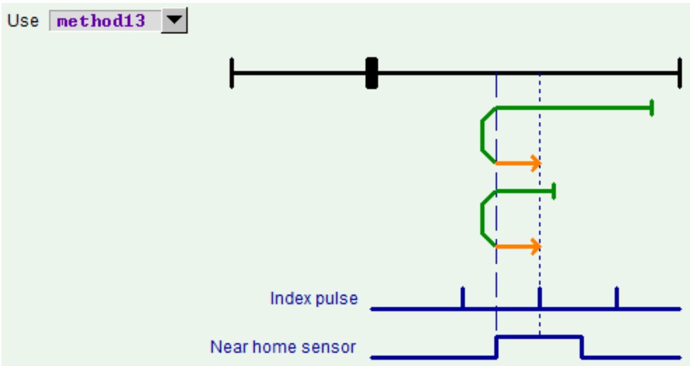
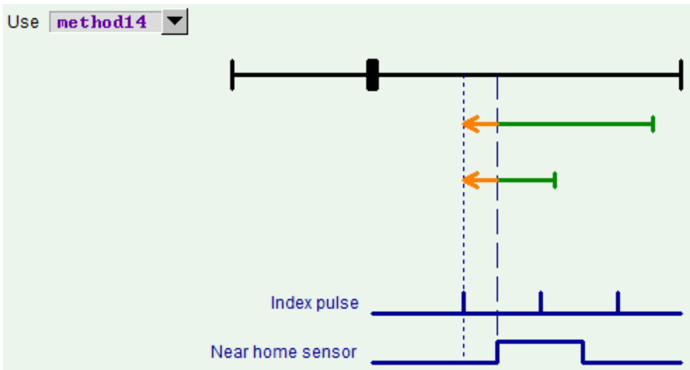


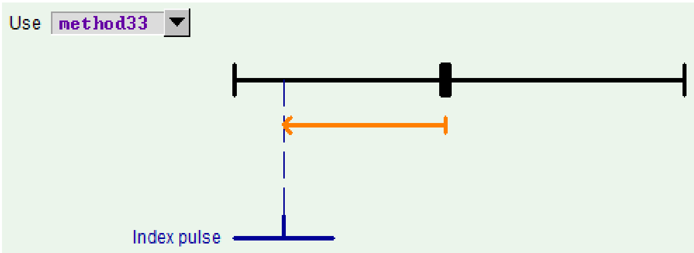
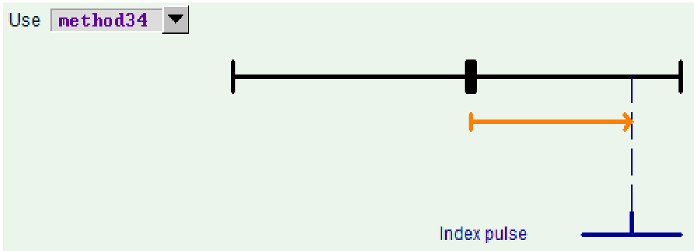
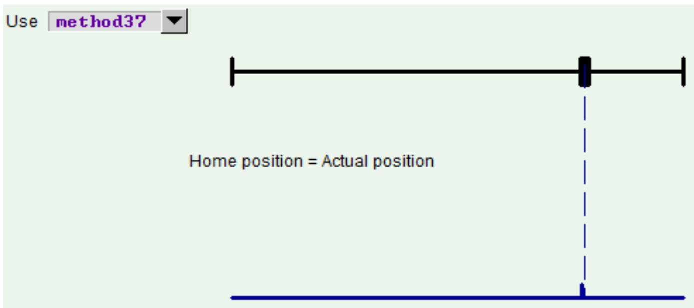
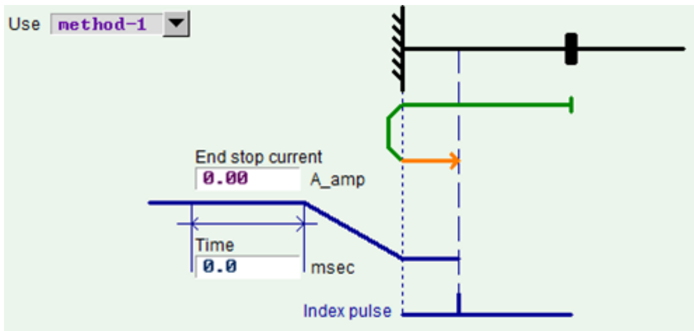
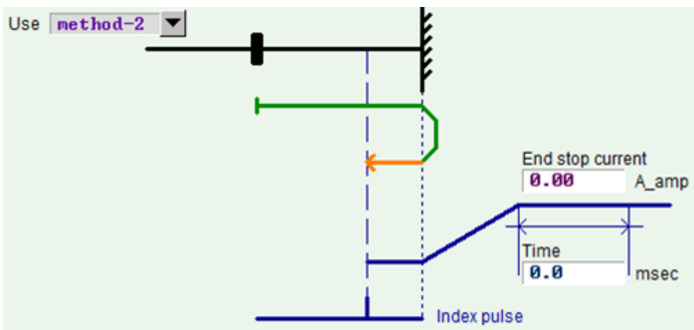
Figure 5.6.3.1

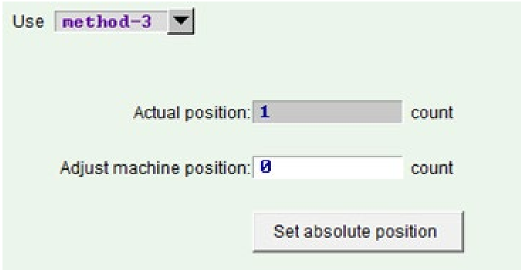
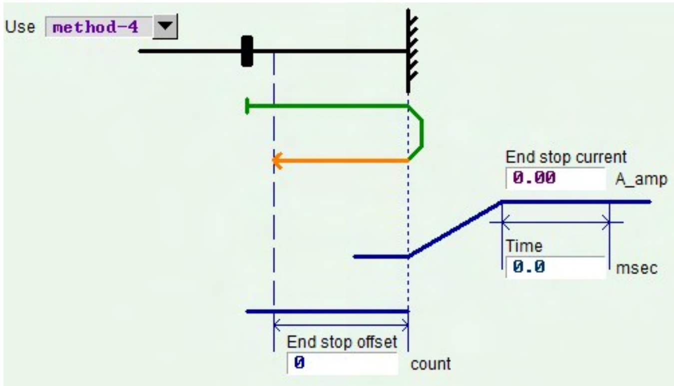
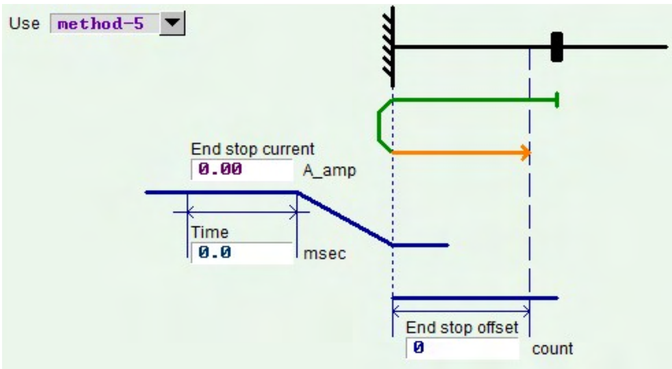
Table 5.6.3.1

No.	Description	Explanation
1	**Homing on negative limit switch and index pulse:** The motor searches the negative limit switch along the negative direction with the faster speed. After finding it, the motor searches the index along the positive direction with the slower speed.	
2	**Homing on positive limit switch and index pulse:** The motor searches the positive limit switch along the positive direction with the faster speed. After finding it, the motor searches the index along the negative direction with the slower speed.	

No.	Description	Explanation
7	**Homing on home switch and index pulse – positive initial motion, left edge of home switch, left-side index:** (1) Outside home switch: The motor searches the left edge of home switch along the positive direction with the faster speed. After finding it, the motor searches the left-side index of this signal along the negative direction with the slower speed. (2) Inside home switch: The motor searches the left edge of home switch along the negative direction with the faster speed. After finding it, the motor searches the left-side index of this signal in the negative direction with the slower speed.	
8	**Homing on home switch and index pulse – positive initial motion, left edge of home switch, right-side index:** (1) Outside home switch: The motor searches the left edge of home switch along the positive direction with the faster speed. After finding it, the motor searches the right-side index of this signal along the positive direction with the slower speed. (2) Inside home switch: The motor searches the left edge of home switch along the negative direction with the faster speed. After finding it, the motor searches the right-side index of this signal along the positive direction with the slower speed.	
9	**Homing on home switch and index pulse – positive initial motion, right edge of home switch, left-side index:** The motor searches the right edge of home switch along the positive direction with the faster speed. After finding it, the motor searches the left-side index of this signal along the negative direction with the slower speed.	
10	**Homing on home switch and index pulse – positive initial motion, right edge of home switch, right-side index:** The motor searches the right edge of home switch along the positive direction with the faster speed. After finding it, the motor searches the right-side index of this signal along the positive direction with the slower speed.	

No.	Description	Explanation
11	**Homing on home switch and index pulse – negative initial motion, right edge of home switch, right-side index:** (1) Outside home switch: The motor searches the right edge of home switch along the negative direction with the faster speed. After finding it, the motor searches the right-side index of this signal along the positive direction with the slower speed. (2) Inside home switch: The motor searches the right edge of home switch along the positive direction with the faster speed. After finding it, the motor searches the right-side index of this signal along the positive direction with the slower speed.	
12	**Homing on home switch and index pulse – negative initial motion, right edge of home switch, left-side index:** (1) Outside home switch: The motor searches the right edge of home switch along the negative direction with the faster speed. After finding it, the motor searches the left-side index of this signal along the negative direction with the slower speed. (2) Inside home switch: The motor searches the right edge of home switch along the positive direction with the faster speed. After finding it, the motor searches the left-side index of this signal along the negative direction with the slower speed.	
13	**Homing on home switch and index pulse – negative initial motion, left edge of home switch, right-side index:** The motor searches the left edge of home switch along the negative direction with the faster speed. After finding it, the motor searches the right-side index of this signal along the positive direction with the slower speed.	
14	**Homing on home switch and index pulse – negative initial motion, left edge of home switch, left-side index:** The motor searches the left edge of home switch along the negative direction with the faster speed. After finding it, the motor searches the left-side index of this signal along the negative direction with the slower speed.	

No.	Description	Explanation
33	**Homing on index pulse – negative initial motion:** The motor searches the index pulse along the negative direction with the slower speed.	
34	**Homing on index pulse – positive initial motion:** The motor searches the index pulse along the positive direction with the slower speed.	
37	**Homing on current position:** Take the current position of the motor as the home position.	
-1	**Homing on hard stop and index pulse – negative initial motion:** The motor searches the hard stop along the negative direction with the faster speed. After finding it, the motor searches the index pulse along the positive direction with the slower speed. (For the setting of searching the hard stop, please refer to Section 5.6.1.)	
-2	**Homing on hard stop and index pulse – positive initial motion:** The motor searches the hard stop along the positive direction with the faster speed. After finding it, the motor searches the index pulse along the negative direction with the slower speed. (For the setting of searching the hard stop, please refer to Section 5.6.1.)	

<table>
<tr><th>No.</th><th>Description</th><th>Explanation</th></tr>
<tr><td>-3</td><td>Homing on absolute encoder:
This method is only available for the motor with the absolute encoder (the 9th bit of the motor model name being 4). Take the current position of the motor as the absolute target position. The motor does not move in this method.</td><td>
</td></tr>
<tr><td>-4</td><td>Homing on hard stop and home offset – positive initial motion:
The motor searches the hard stop along the positive direction with the faster speed. After finding it, the motor moves to the home offset (End stop offset) along the negative direction with the slower speed. (Note)</td><td>
</td></tr>
<tr><td>-5</td><td>Homing on hard stop and home offset – negative initial motion:
The motor searches the hard stop along the negative direction with the faster speed. After finding it, the motor moves to the home offset (End stop offset) along the positive direction with the slower speed. (Note)</td><td>
</td></tr>
</table>

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

5.7 Save parameters to Flash & Recover to factory default

5.7.1 Save parameters to Flash

Click  ("Save parameters from amplifier RAM to Flash") in HMI main window to save the current parameters to the memory. Parameters will not disappear even if the drive is power off. However, users should pay attention to the following two items.

(1) The emulated encoder output will be temporarily disabled during saving. Therefore, if the host controller is connected to the emulated encoder output signal, the received position information may be lost.

(2) Compensation values of "Error map" will not be saved via this function. Users need to perform the "Save" procedure in the "Error map" window to save compensation values.

5.7.2 Recover to factory default

Select "Set amplifier to factory default" on the "Tools" menu of HMI main window. The window of Figure 5.7.2.1 will appear and ask if users want to set the amplifier to factory default. Lightening will not only restore drive parameters to factory settings but also close other windows except the main window. To simultaneously clear the error table, check the "Clear error table in flash and reset drive" option. To simultaneously clear the contents of "user.pdl", check the "Clear user PDL" option. If users check the "Clear user PDL" option, the "Notice" window of Figure 5.7.2.2 will appear to inform users that "user.pdl" will be cleared. If users click the "Yes (Y)" button, the program executes the chosen function in the "Set amplifier to factory default" window. However, if users click the "No (N)" button, it will go back to the "Set amplifier to factory default" window for users to reselect the functions needed to be executed. After parameters are restored to factory settings, the drive will automatically execute the reset function.

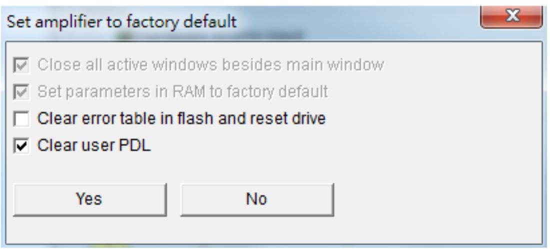


Figure 5.7.2.1

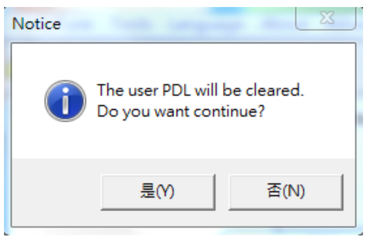


Figure 5.7.2.2

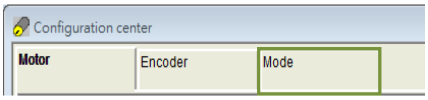
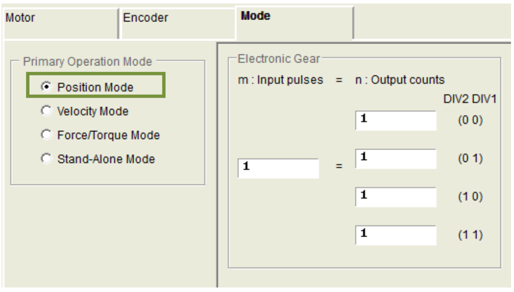
5.8 Parameter setting examples via HMI

5.8.1 Position mode

On position mode, the drive moves a specified distance based on the pulse command it receives. Please refer to Section 3.1.1 for more information.

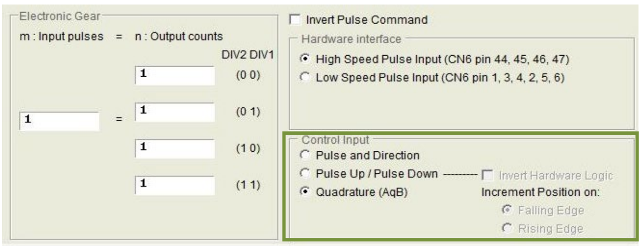
The position mode configuration includes mode selection, pulse format selection, electronic gear ratio setting, and smooth factor setting. After all parameters are set, refer to Section 5.7.1 for saving parameters to Flash.

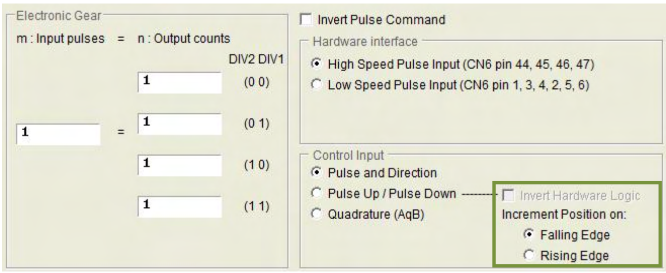
■ **Mode selection**

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

■ **Pulse format selection**

D2T-LM series drive supports three types of pulse signal, please refer to Section 3.1.1.

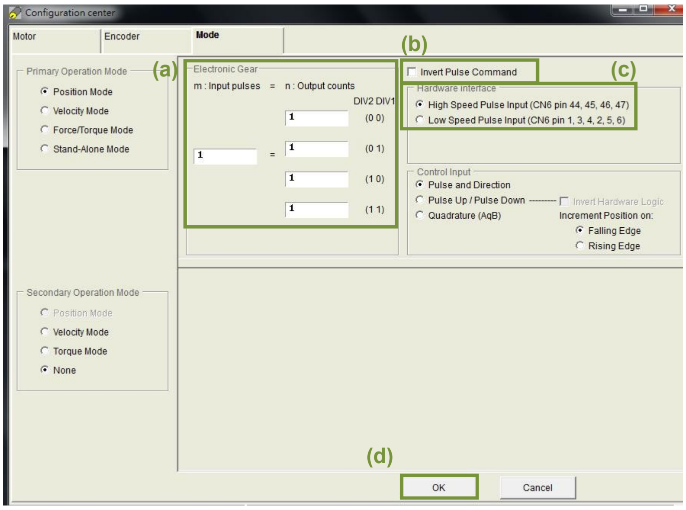
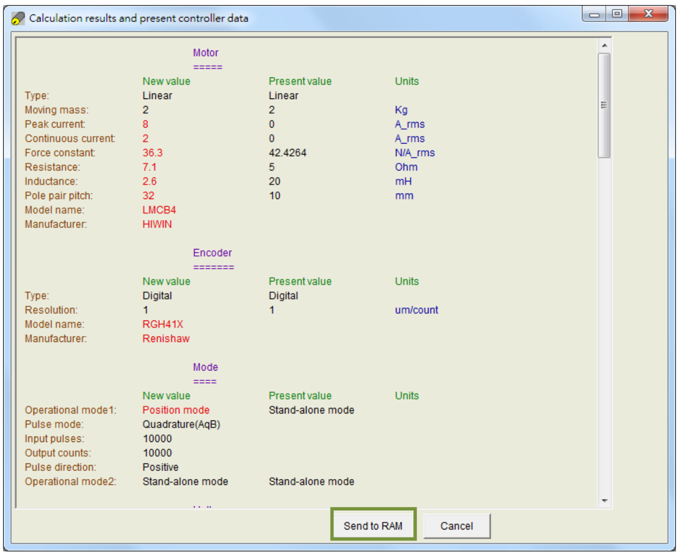
Step	Graphical (HMI) description	Operation
1		Select pulse format in the “Control Input” area of the “Mode” tab based on the requirement.

<table>
<tr><td>2</td><td>
</td><td>Select the trigger method of pulse command in the “Increment Position On” area based on the requirement.

Note: This setting is only for choosing “Pulse and Direction” or “Pulse Up/Pulse Down”.</td></tr>
</table>

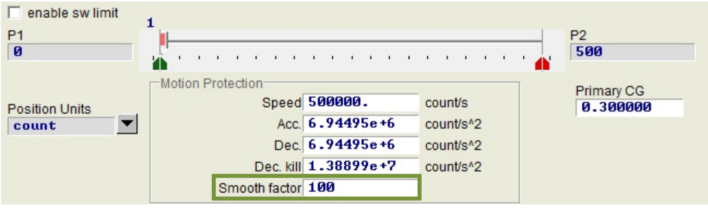
■ **Electronic gear ratio setting**

D2T-LM series drive supports four sets of electronic gear ratio, please refer to Section 5.4.1.

<table>
<tr><th>Step</th><th>Graphical (HMI) description</th><th>Operation</th></tr>
<tr><td>1</td><td rowspan="4">
</td><td>Set electronic gear ratio in the “Electronic Gear” area based on the requirement, as (a) in the left figure shows.</td></tr>
<tr><td>2</td><td>Make the pulse command invert in the “Invert Pulse Command” area based on the requirement, as (b) in the left figure shows.</td></tr>
<tr><td>3</td><td>Set high-speed/low-speed pulse command input in the “Hardware Interface” area based on the requirement, as (c) in the left figure shows.</td></tr>
<tr><td>4</td><td>Click the “OK” button after all settings are completed, as (d) in the left figure shows.</td></tr>
<tr><td>5</td><td>
</td><td>Click the “Send to RAM” button to save parameters to drive RAM after the window of parameters confirmation appears.</td></tr>
</table>

■ Smooth factor setting

D2T-LM series drive provides the function of “Smooth factor”, please refer to Section 3.4.

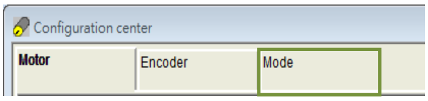
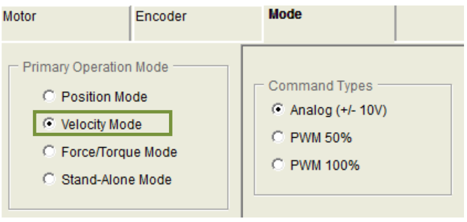
Step	Graphical (HMI) description	Operation
1		Click the “Performance center” icon in HMI main toolbar (as the left figure shows), or select the “Performance center” option in “Conf/Tune”.
2		Set “Smooth factor” in Performance center based on the requirement, as the green box in the left figure shows.

5.8.2 Velocity mode

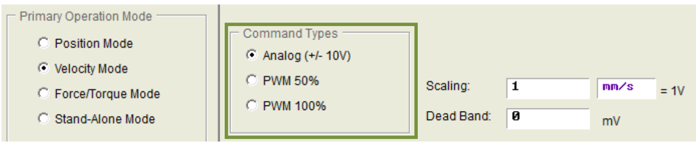
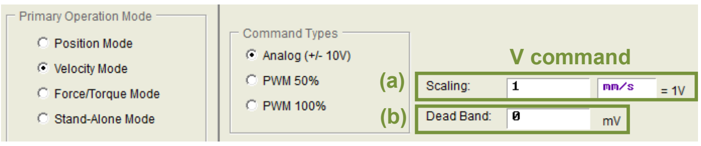
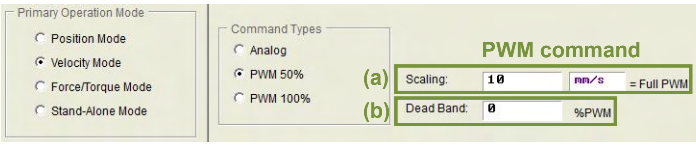
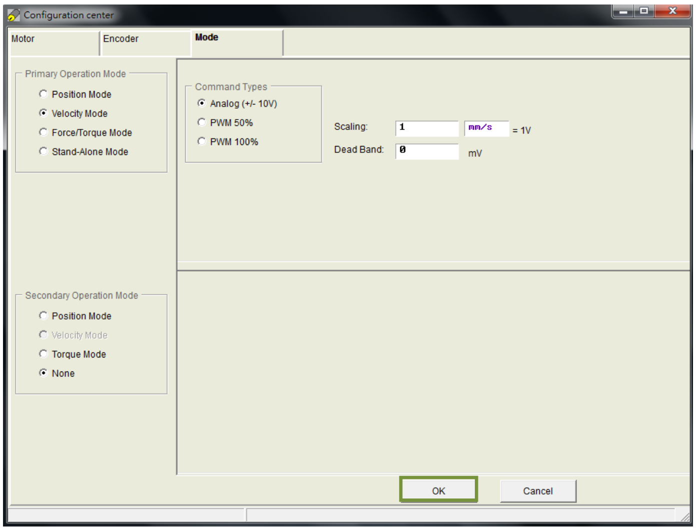
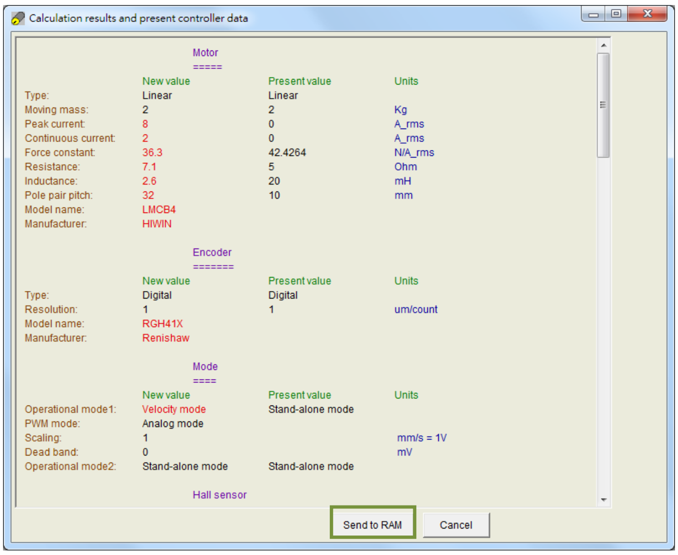
D2T-LM series drive can transfer voltage command and PWM command to velocity command. Please refer to Section 3.1.2 for more information.

The velocity mode configuration includes mode selection and input command format setting. After all parameters are set, refer to Section 5.7.1 for saving parameters to Flash.

■ Mode selection

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

■ Input command format setting

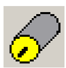
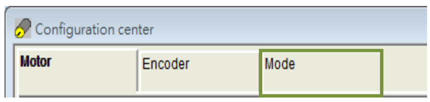
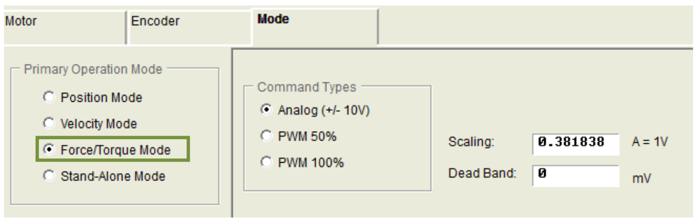
<table>
<tr><th>Step</th><th>Graphical (HMI) description</th><th>Operation</th></tr>
<tr><td>1</td><td>
</td><td>Select input command format in the “Command Types” area of the “Mode” tab based on the requirement.</td></tr>
<tr><td>2</td><td>
</td><td>Set the ratio (Scaling) of external command to speed based on the requirement. The unit is that 1V equals how many mm/s or rpm, or Full PWM equals the maximum speed, as (a) in the left figure shows.</td></tr>
<tr><td>3</td><td>
</td><td>Set “Dead Band” for velocity command, as (b) in the left figure shows. Please refer to Figure 5.2.3.3 for the definition of “Dead Band”.</td></tr>
<tr><td>4</td><td>
</td><td>Click the “OK” button after all settings are completed, as the left figure shows.</td></tr>
<tr><td>5</td><td>
</td><td>Click the “Send to RAM” button to save parameters to drive RAM after the window of parameters confirmation appears.</td></tr>
</table>

5.8.3 Force / Torque mode

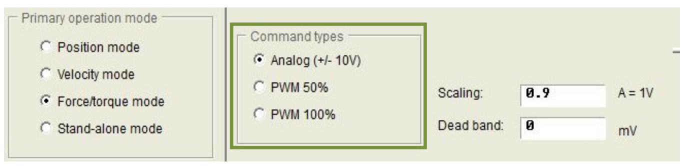
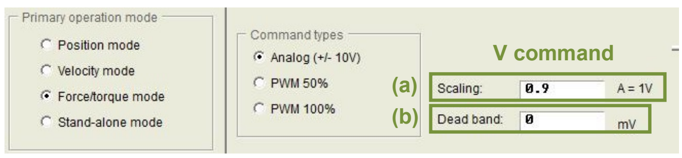
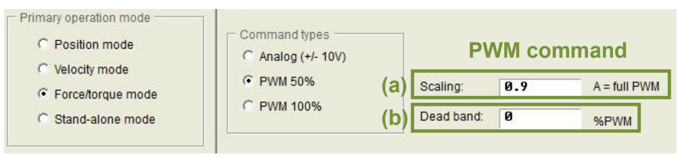
D2T-LM series drive can transfer voltage command and PWM command to current command. Please refer to Section 3.1.3 for more information.

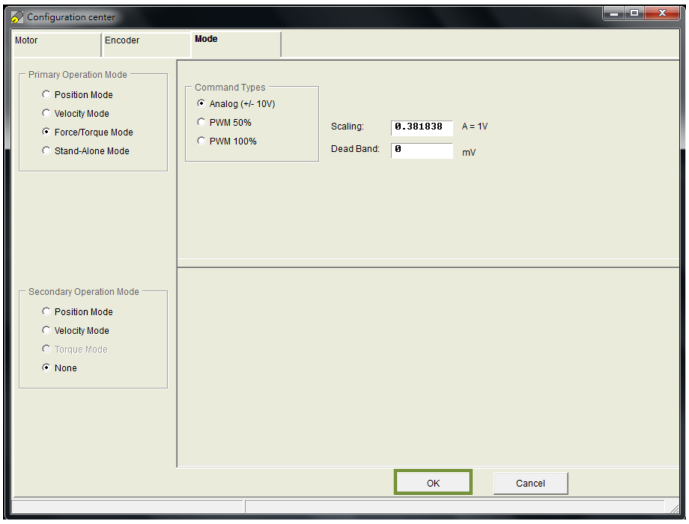
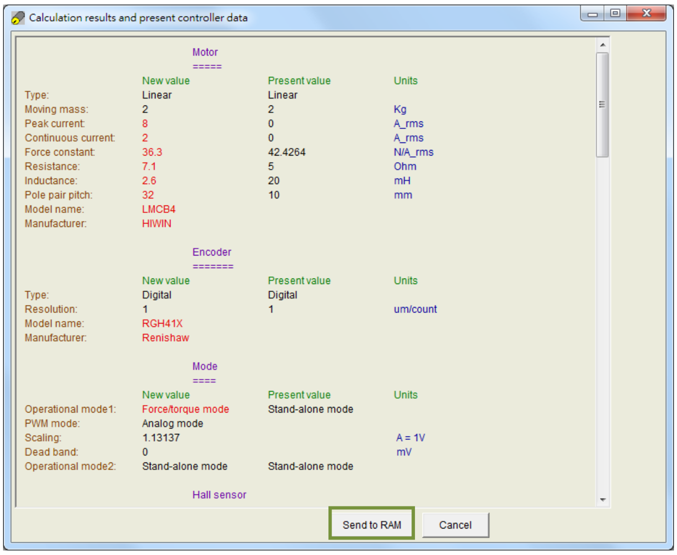
The force / torque mode configuration includes mode selection and input command format setting. After all parameters are set, refer to Section 5.7.1 for saving parameters to Flash.

■ **Mode selection**

Step	Graphical (HMI) description	Operation
1		After executing Lightening, click the “Configuration center” icon in HMI main toolbar (as the left figure shows), or select the “Configuration center” option in “Conf/Tune”.
2		Select the “Mode” tab in Configuration center.
3		Select the “Force / Torque Mode” option in the “Mode” tab.

■ **Input command format setting**

Step	Graphical (HMI) description	Operation
1		Select input command format in the “Command Types” area of the “Mode” tab based on the requirement.
2		Set the ratio (Scaling) of external command to current based on the requirement. The unit is that 1V equals how many amperes, or Full PWM equals the maximum ampere, as (a) in the left figure shows.
3		Set “Dead Band” for current command, as (b) in the left figure shows. Please refer to Figure 5.2.3.3 for the definition of “Dead Band”.

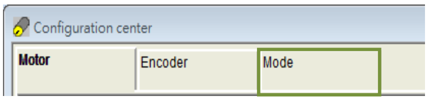
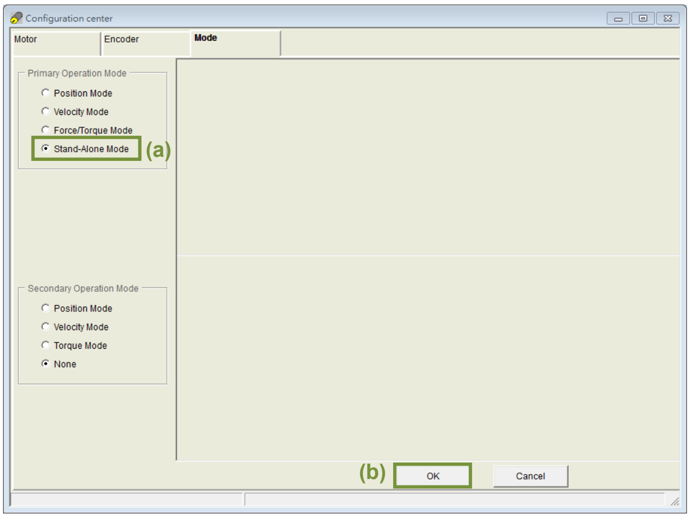
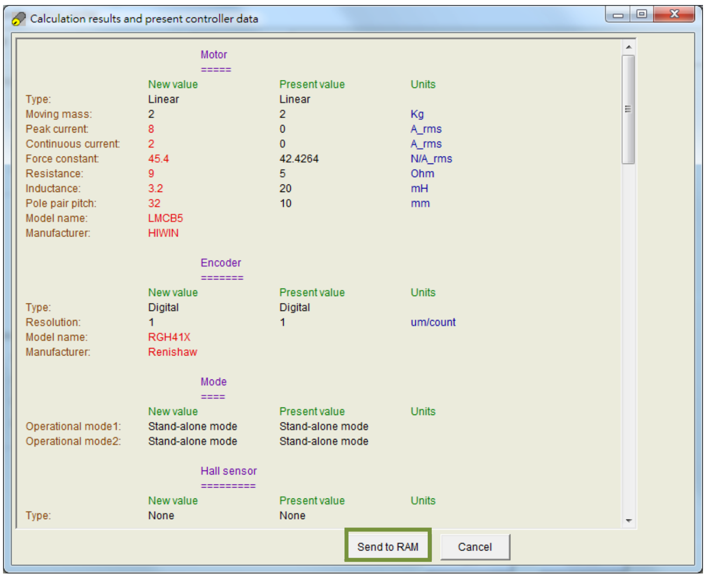
<table>
<tr><td>4</td><td>
</td><td>Click the “OK” button after all settings are completed, as the left figure shows.</td></tr>
<tr><td>5</td><td>
</td><td>Click the “Send to RAM” button to save parameters to drive RAM after the window of parameters confirmation appears.</td></tr>
</table>

5.8.4 Stand-alone mode

On stand-alone mode, the drive will execute the internal path planning to drive the motor. Please refer to Section 3.1.4 for more information.

The stand-alone mode configuration includes the mode selection. After all parameters are set, refer to Section 5.7.1 for saving parameters to Flash.

■ Mode selection

<table>
<tr><th>Step</th><th>Graphical (HMI) description</th><th>Operation</th></tr>
<tr><td>1</td><td></td><td>After executing Lightening, click the “Configuration center” icon in HMI main toolbar (as the left figure shows), or select the “Configuration center” option in “Conf/Tune”.</td></tr>
<tr><td>2</td><td>
</td><td>Select the “Mode” tab in Configuration center.</td></tr>
<tr><td>3</td><td rowspan="2">
</td><td>Select the “Stand-Alone Mode” option in the “Mode” tab, as (a) in the left figure shows.</td></tr>
<tr><td>4</td><td>Click the “OK” button after all settings are completed, as (b) in the left figure shows.</td></tr>
<tr><td>5</td><td>
</td><td>Click the “Send to RAM” button to save parameters to drive RAM after the window of parameters confirmation appears.</td></tr>
</table>

6. Drive Tuning

6.1 Status display & Quick view

In Lightening HMI, “Status display” and “Quick view” are two indispensable auxiliary tools in the tuning process. They not only help users keep track of the drive’s status but also present many important parameter values in motion control.

6.1.1 Status display

There are two status display tools, as Figure 6.1.1.1 shows. The left one shows the “Status” area in HMI main window, while the right one shows the “Status” area in Performance center. Status display provides the status and error / warning message for users to keep track of the system status.

■ **Status**

- Hardware Enable Input: It indicates whether the hardware enable signal is activated or not.
- Software Enabled: It indicates whether the software enable is activated or not.
- Servo ready: It indicates whether the motor is enabled or not.
- Phase Initialized: It indicates whether the motor completes phase initialization or not.
- Moving: It indicates whether the motor is in motion or not.
- Homed: It indicates whether the motor completes the homing procedure or not.
- SM mode: It indicates that the motor is enabled on SM mode.

■ **Errors and warnings**

- Last error: It displays the latest error message.
- Last warning: It displays the latest warning message.

Refer to Chapter 9 for more information.

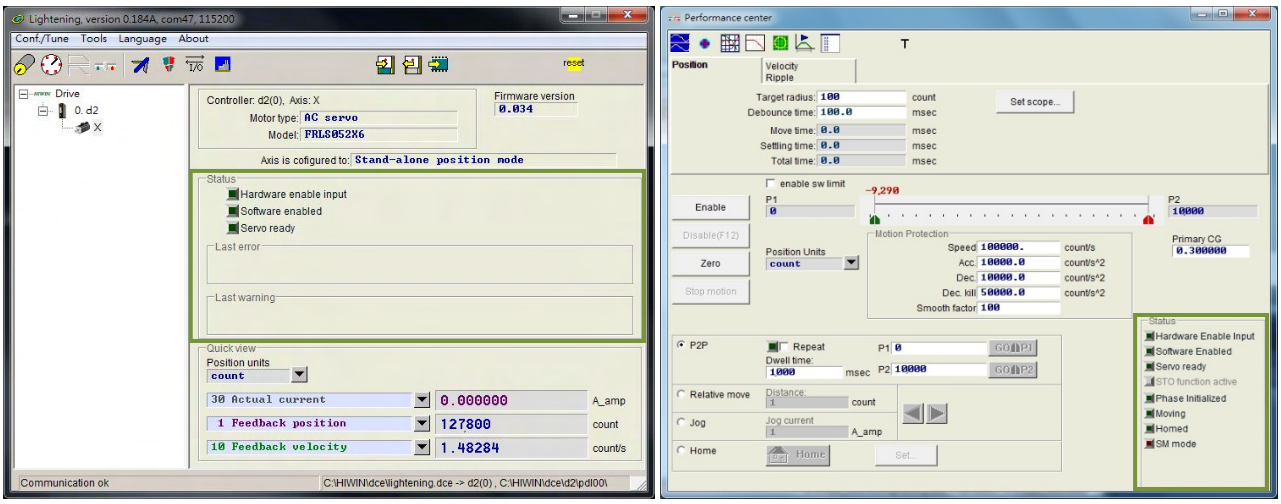


Figure 6.1.1.1 Status display

6.1.2 Quick view

The "Quick view" area is at the bottom of HMI main screen, and it is used to help users know more about the details of the drive's current status. The interface provides the display of three physical quantities. Users are free to select the physical quantity needed to be observed. These three physical quantities update their display values at any time for users to observe and analyze the system status, as Figure 6.1.2.1 shows. Refer to Section 3.11 for selectable physical quantities.

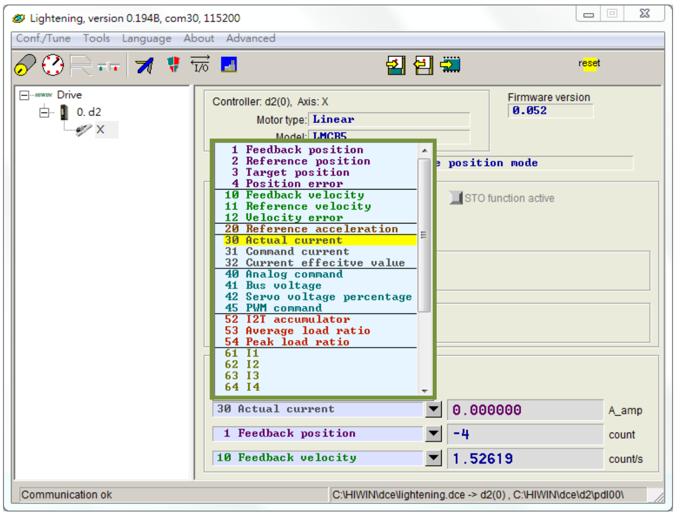


Figure 6.1.2.1 Physical quantity menu in "Quick view"

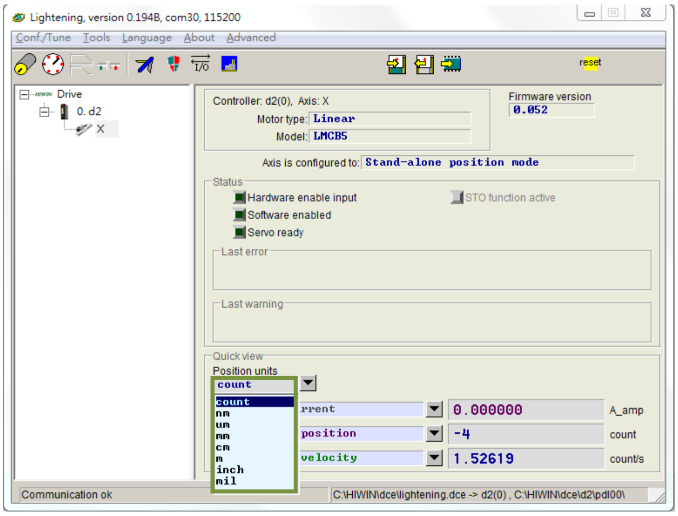


Figure 6.1.2.2 Unit setting menu

Position Units:

For each display of physical quantity, if it is related to distance, users can select the preferred unit to display (or set) the relevant physical quantity (position, velocity, etc.), as Figure 6.1.2.2 shows.

6.1.3 Software shortcuts

There are two function shortcuts, **F6** and **F12**, in HMI for D2T-LM series drive. They are only available when Lightening HMI is active for Windows operation system.

F6: Move the Lightening main window to the top level.

F12: This function is an emergency stop action. For example, if users click **F12** during the motion, it will perform the emergency stop action (refer to Section 3.4). The motor will be disabled after the action.

6.2 Performance center

Most of the tuning procedures are around the operation of Performance center. After users complete the setting in Section 5.3 Auto phase center , the motor is ready for test run. Through Performance center, users can do motion testing and tuning, and observe the motion performance with the help of auxiliary tools. It provides three modes of motion, point-to-point ("P2P") motion, relative motion ("Relative move"), and continuous motion ("Jog"). Parameters related to these motions, such as speed, acceleration, deceleration, emergency stop deceleration and smooth factor, are also set in this interface.

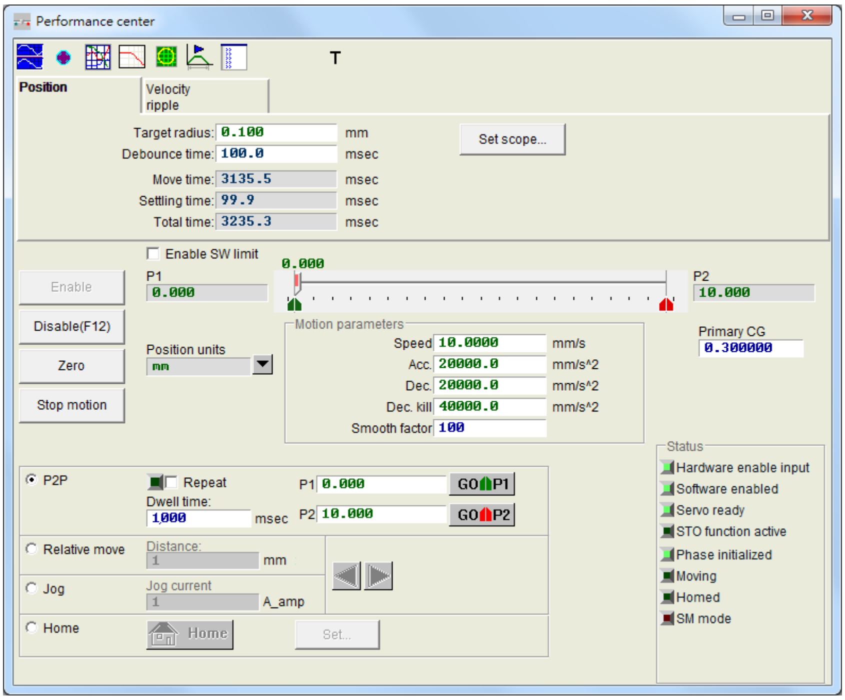
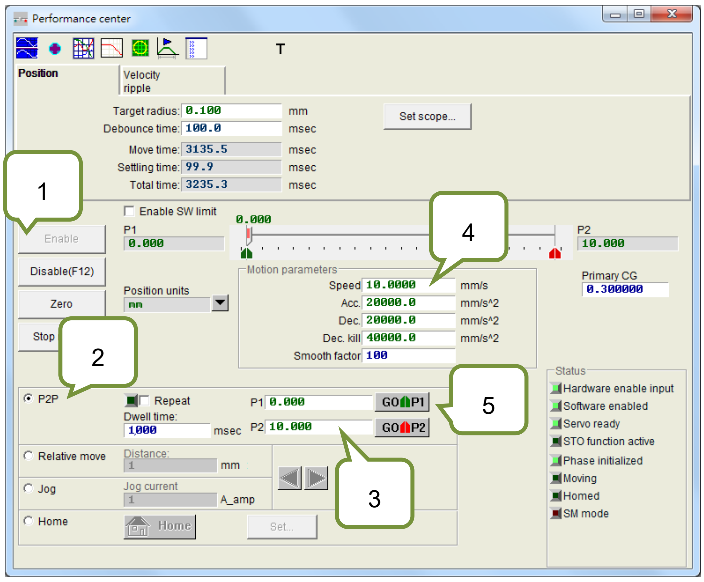


Figure 6.2.1 Performance center

Take point-to-point (P2P) motion as an operational example.

Step	Graphical (HM) description	Operation
1		Click Enable to enable the motor.
2		Select P2P .
3		Set the positions of **P1** and **P2**. (If software limits are used, set the positions between “Lower SW limit” and “Upper SW limit”.)
4		Set speed, acceleration, deceleration, and smooth factor based on the requirement (refer to Section 3.4). If there is no special requirement, simply use default values.
5		Click GO P1 to move toward **P1** and click GO P2 to move toward **P2**. To perform a point-to-point back-and-forth motion, select the “Repeat” option and enter the break time (“Dwell time”). Then, click the button of GO P1 or GO P2 to perform it.

Performance center comes with the function of measuring the settling time. The target radius of position error and debounce time for settling time can be set via “Target radius” (refer to Section 5.5 In-position signal setting). During motion, the servo gain (“Primary CG”) can be tuned to meet the requirement of settling time. The higher the servo gain is, the faster the response is, and the shorter the settling time is. The required time from moving to in-position can be observed via “Move time”, “Settling time”, and “Total time” (refer to Section 3.7). Click “Set scope…” button to make the graphical oscilloscope (“Scope”) appear. This tool can be used to observe the motion waveform related to the settling time.

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

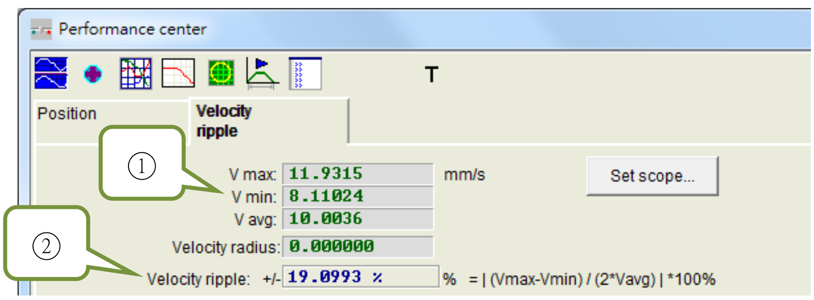


Figure 6.2.2 Performance center – “Velocity Ripple” tab

① V max: the maximum of velocity ripple

V min: the minimum of velocity ripple

V avg: the average of velocity ripple

② Velocity ripple: velocity ripple

Besides P2P function, relative motion ("Relative move") can be set to move a distance, while continuous motion ("Jog") can keep moving along the positive or negative direction by clicking the button of or . The speed, acceleration, deceleration, and smooth factor in the "Motion parameters" area are also used as the function of motion protection. Therefore, if users forget to set these values as the value of motion protection after test run, it may not reach the expected speed or acceleration when receiving the motion command sent from the host controller. Please pay more attention to this.

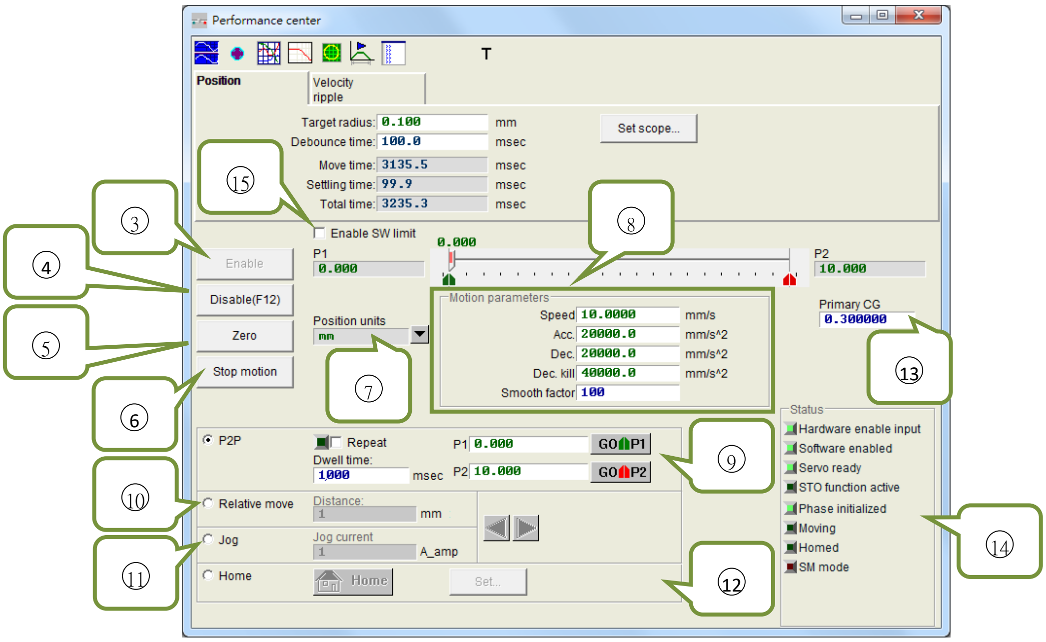


Figure 6.2.3 Performance center – "Position" tab

③ Enable: Enable the motor.

④ Disable: Disable the motor.

⑤ Zero: Set the current position as the zero position.

⑥ Stop motion: Stop the motor.

⑦ Position units: Unit setting; set the preferred unit. This is the same as the unit setting in "Quick View" of the main window.

⑧ Motion parameters: Protection parameters for motor motion, including speed, acceleration, deceleration, emergency stop deceleration, and smooth factor in test run. Users can plan the path trajectory as S-type curve or T-type curve via smooth factor. The adjustment ranges from 1 to 500. The larger the value, the closer to the S-type curve; the smaller the value, the closer to the T-type curve. Refer to Section 3.4 for more information.

⑨ P2P: Execute point-to-point motion.

⑩ Relative move: Execute relative motion.

⑪ Jog: Execute continuous movement. Set the current value for the continuous movement with the constant current.

⑫ Home: Execute homing procedure.

⑬ Primary CG: Servo gain. The greater the gain, the greater the servo stiffness. Users can adjust the servo stiffness via this parameter. If the servo stiffness is too big, it will make the system become instable, and cause the vibration and electrical noise. At this time, users should decrease the value.

⑭ Status: Display the status.

⑮ Enable SW limit: Start the software limit protection, which restricts the travel of the motor.

6.3 Scope

D2T-LM series drive provides a “Scope” graphic oscilloscope, which help users observe all significant physical quantities during the tuning process to judge the tuning result. This feature can also be used to find the error clue when the drive cannot be operated. Click or the “Set scope…” button in Performance center to open “Scope”. Click the “Set scope…” button in the “Position” tab and “Velocity Ripple” tab to display their respective physical quantities. As Figure 6.3.1 shows, users can observe the real-time waveform of the selected physical quantity after selecting parameters.

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

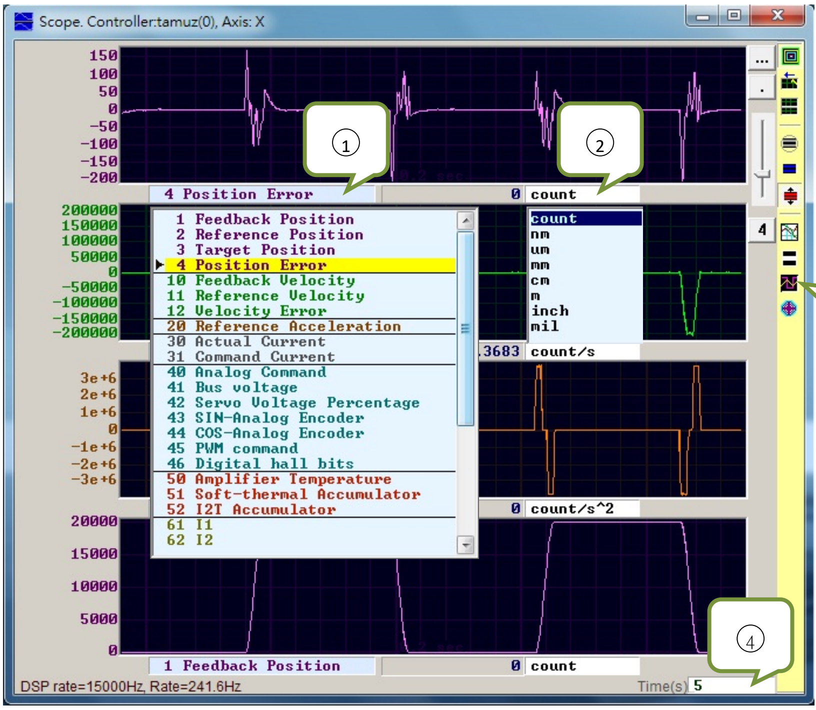


Figure 6.3.1 Scope

① Physical quantity: Select the physical quantity needed to be observed. Refer to Section 3.11 Common physical quantities.

② Unit: Select the unit of physical quantity.

③ Number of channel: Select the number of channels to be displayed simultaneously (1~8).

④ Time range of “Scope”: Set the time length for one screen on the horizontal axis. Unit: second

Table 6.3.1

Symbol	Name	Description
	Scope On/Off (Page Down)	The switch of “Scope”. When users turn the switch off and turn it on again, the scope will re-capture the data.
	View in paper mode (Ctrl + T)	Change the mode (“Normal” and “Paper”) of the display waveform.
	Toggle scopes window (Page Up)	Display all selected physical quantities on one single screen. Switch a physical quantity by each click.
	Fit graph to window	Adjust all physical quantities to the appropriate scale.
	Fit graph to window dynamically	Dynamically adjust all physical quantities to the appropriate scale.
	Fit graph to window dynamically + clip	Same as above, the range of the vertical axis will increase but never decrease.
	Show last data with plot view tool	Use the “Plot view” tool to draw the data of “Scope”.
	Reset scope	“Scope” will re-capture the data.
	Show all plots in same window	All physical quantities are drawn in the same screen and share one vertical axis.
	Open record window	Connect current physical quantities set by “Scope” to the “Data collection” function.

6.4 Data collection

Besides observing physical quantities of each drive via “Scope”, there is a tool that provides not only more setting options for data capture, but also more advanced graphical display and processing functions. The “Data collection” function allows users to set the sampling time, as well as conditional triggers to start and stop the data capture.

6.4.1 Function description

Opened by the “Scope” function of “Open record window” shown in Figure 6.3.1, the program will automatically set the selected physical quantity for the follow-up data capture. The main functions are as follows.

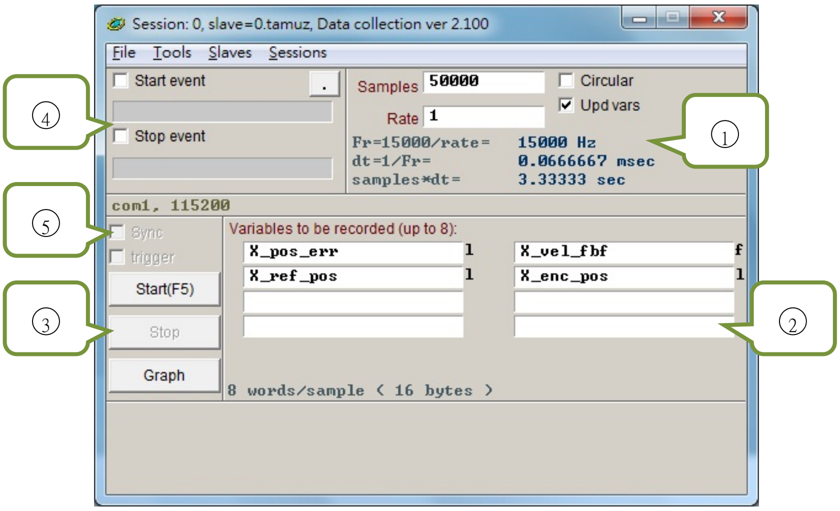


Figure 6.4.1.1 Data collection

① Sampling frequency (“Rate”) and the number of samples (“Samples”):
- Samples: The number of samples.
- Rate: Determine the sampling frequency. If “Rate” is set as 1, the sampling frequency is 15,000 Hz; when it is set as 2, the sampling frequency is 7,500 Hz. The sampling frequency can only be up to 15,000 Hz. If users collect too much data, the data collection may be completed earlier due to the limit of communication bandwidth. To solve the problem, decrease the number of the collected physical quantities.
- dt: Sampling time.
- Samples*dt: Total time of data collection. If users want to increase total time of data collection, simply increase “Samples”.

② It is the internal variable name of the physical quantity of collected data.

③ Manual collection button. Click the “Start” button to start the collection and click the “Stop” button to stop the collection. Click the “Graph” button to draw the collected data via “Plot view”.

④ Conditional auto collection. Set the start event and the stop event for data collection.

⑤ The auto collection option is triggered instantaneously. Refer to Section 6.4.2.

Example 1: To capture the graph of one motion cycle

Check “Start event” and set it as “X_run”. Also, check “Stop event” and set it as “X_stop”. After the setting is done, click the “Start” button. Now, “Data collection” is put on standby. When the motor moves, it starts to collect the data; when the motor stops, it stops collecting the data. After the data collection is done, click the “Graph” button to draw the graph of one motion cycle.

Example 2: To capture the graph of one speed period

Check “Start event” and set it as “X_vel_fb>0”. Also, check “Stop event” and set it as “X_vel_fb<0”. After the setting is done, click the “Start” button. Now, “Data collection” is put on standby. When the motor speed is greater than 0, it starts to collect the data; when the motor speed is less than 0, it stops collecting the data. After the data collection is done, click the “Graph” button to draw the graph of one speed period.

Example 3: To capture the graph from enabled drive to disabled drive

Check “Start event” and set it as “I3”. Also, check “Stop event” and set it as “~I3”. After the setting is done, click the “Start” button. Now, this function will recognize the status of I3. When the drive is enabled (I3 = 1), it starts to collect the data; when the drive is disabled (I3 = 0), it stops collecting the data.

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

6.4.2 Data collection via PDL

To improve the accuracy of data collection, "Sync" (trigger the auto collection instantaneously) in Figure 6.4.1.1 ⑤ provides more flexible and more real-time data capture than the conditional auto collection. Users can add the program fragment with the title labeled "_RecordSync" to PDL program, and set the start event of data collection. Once this event is triggered, "Data collection" starts to collect the data. Operational steps are given as follows.

Step 1. An empty task is required to execute "_RecordSync".

Step 2. Add the following content in PDL program:

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

Step 3. Add the interrupted condition or status in the parentheses of "till( )" on the "_RecordSync" function. For example, it could be I9 (default for the right limit state) in I/O center.

Step 4. Check "Sync" in Figure 6.4.1.1 ⑤.

Step 5. Click the "Start" button in ③. The program starts to execute the "_RecordSync" function and waits for the trigger event being established. For example, when the status of I9 is changed from False to True, the data collection starts to capture the data. If I9 is repeatedly triggered, it collects the record data of last trigger.

【Example】

```
#task/1;
_RecordSync:
      till(I9);         //  Wait for the status of I9 changing from False to True.
      rtrs_act=1;   //  Start to record.
ret;
```

6.5 Plot view

The “Plot view” function is built on the “Data collection” function. It draws the data collected by “Data collection” into graphs. “Plot view” has a powerful analysis function, which provides measurement and calculation. It is divided into five areas, function menu area, main toolbar area, physical quantity display area, graph display area, and timeline scroll bar area (as Figure 6.5.1 shows).

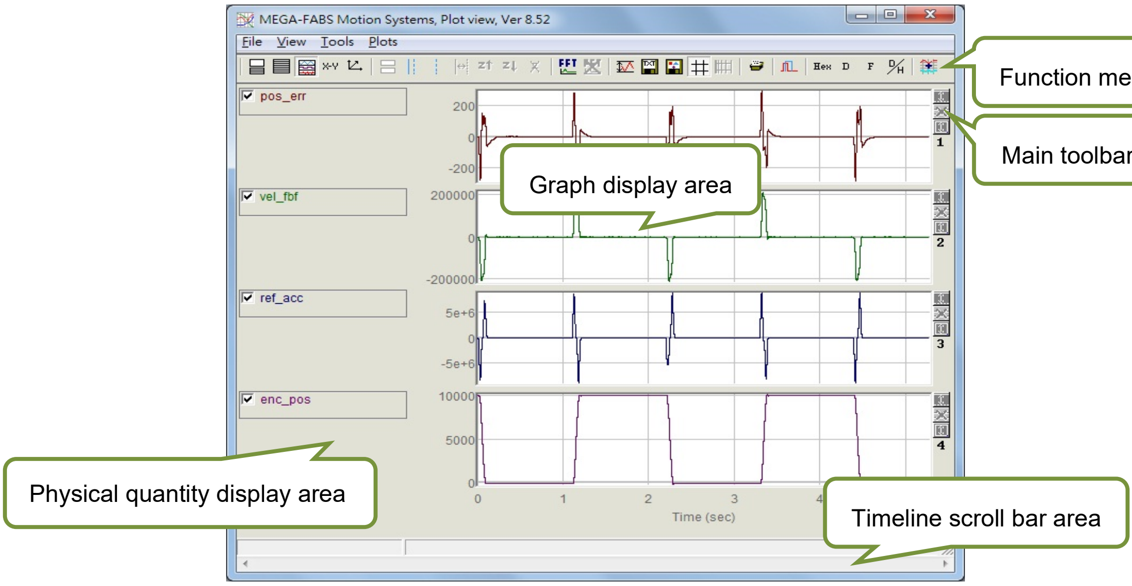


Figure 6.5.1 Plot view

6.5.1 Graph display mode

- **Number of display channels**

  Graphic display area mainly displays the graph of physical quantity. When the graph of physical quantity is captured from “Scope” or “Data collection”, “Plot view” will display all physical quantities selected by “Scope”. “Plot view” can also change the number of channels shown in graph display area, but the maximum limit is eight. The related icons in main toolbar area are described as follows.

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

  To observe the graph of two physical quantities, click and select “Only graph 2” to change the number of channels into two. To observe the graph of one physical quantity, click and select “Only graph 1” to change the number of channels into one. Figure 6.5.1.1 gives an example that “Scope” or “Data collection” only collects two physical quantities.

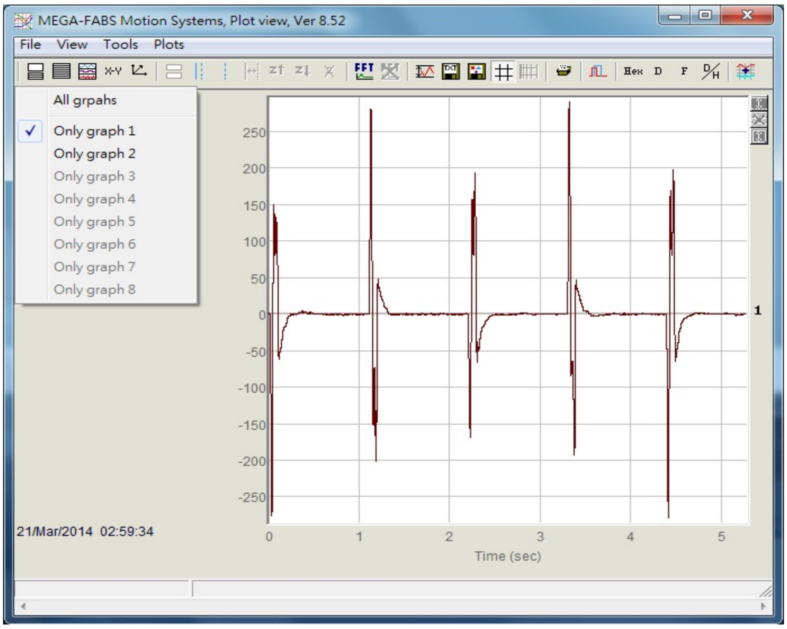


Figure 6.5.1.1

■ Show or hide physical quantities

If the physical quantity is unchecked, graph display area will hide the graph of this physical quantity. Figure 6.5.1.2 is the example of two physical quantities being unchecked. Users can uncheck all physical quantities by clicking the following related icon in main toolbar area.

- : Uncheck all physical quantities (or press the "Delete" key).

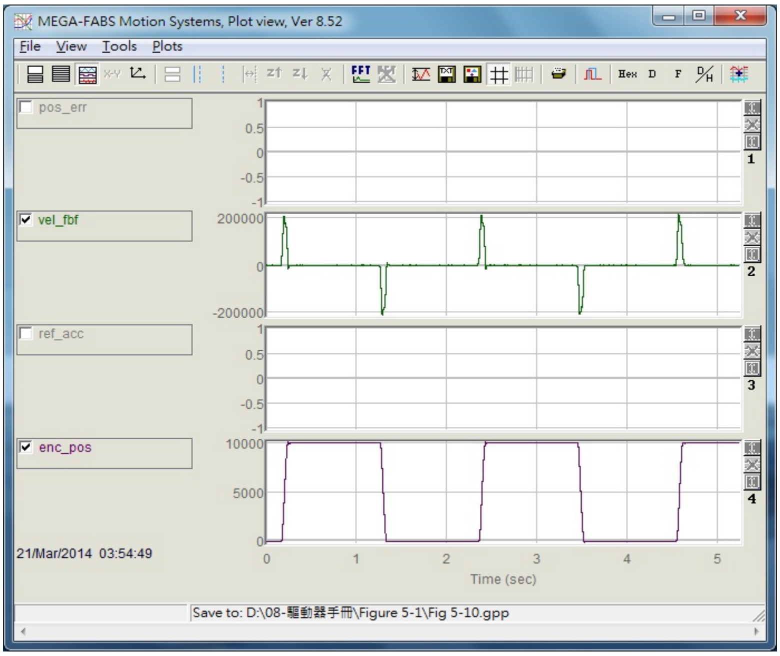


Figure 6.5.1.2

- **Zoom in/out**

  To observe a more subtle change in a certain interval, select it by the solid-line and dotted-line cursors. "Plot vies" provides the function of zoom in/out on the X and Y axes. The related icons and operational methods in main toolbar area are described as follows.

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

- **Zoom in/out on the X axis**

  To zoom in on the graph of physical quantities ranging from 2 to 4 seconds and frame this interval, move the blue solid-line cursor by the left mouse button, or move the dotted-line cursor by the right mouse button (as Figure 6.5.1.3 shows). Then, click to zoom in on this interval, as Figure 6.5.1.4 shows. To zoom in on a more subtle interval, such as 2 to 3 seconds, simply repeat steps above. To go back to the zoom-in interval between 2 and 4 seconds, click . If is clicked, the zoom-in interval between 2 and 3 seconds will be displayed again. No matter how many times users zoom in, click to get the original graph, as Figure 6.5.1.3 shows.

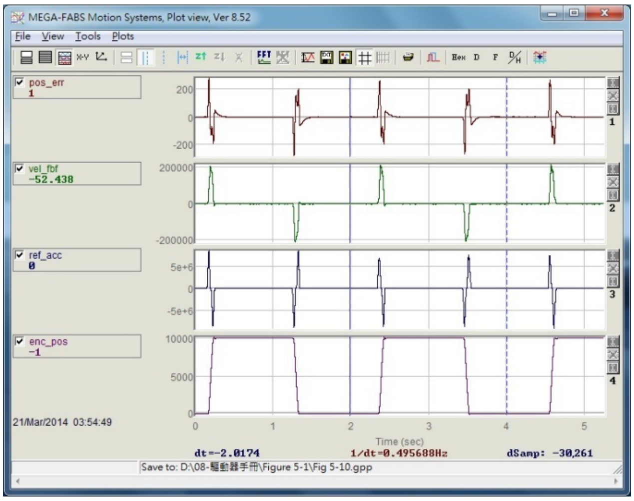


Figure 6.5.1.3

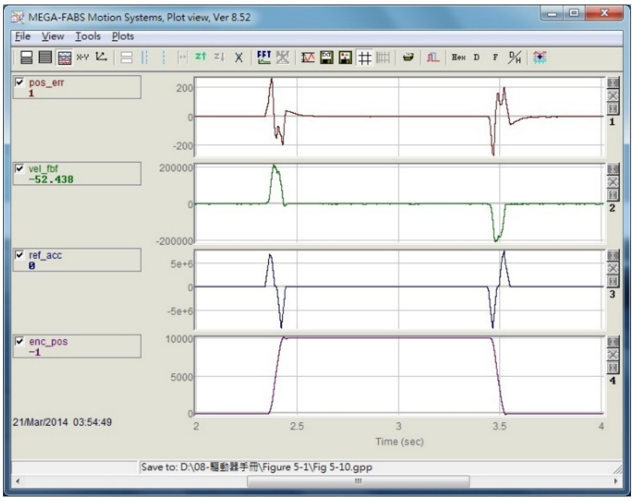


Figure 6.5.1.4

■ **Zoom in/out on the Y axis**

To zoom in on the Y axis and frame a suitable interval, move the red solid-line cursor by pressing and holding the “Ctrl” button and the left mouse button, or move the dotted-line cursor by pressing and holding the “Ctrl” button and the right mouse button (as Figure 6.5.1.5 shows). Then, click at the top-right corner of the screen to zoom in on the graph within the selected interval, as Figure 6.5.1.6 shows. At this time, the Y-axis value of the graph is locked and shown in red. Dragging the horizontal scroll bar will not dynamically adjust the vertical display range, as Figure 6.5.1.7 shows. Finally, users can click to get the original graph of Y axis, as Figure 6.5.1.5 shows.

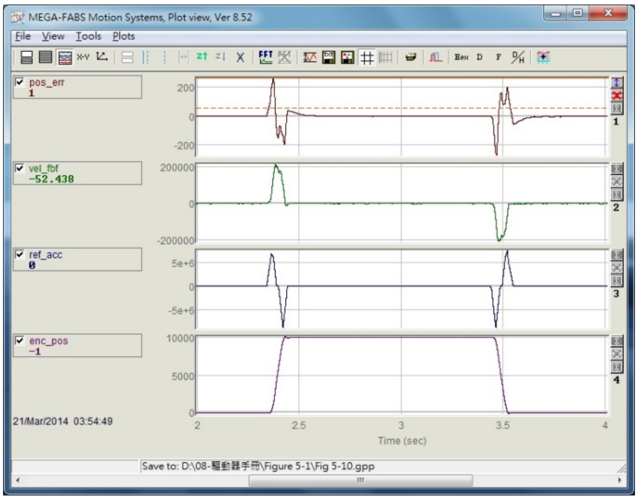


Figure 6.5.1.5

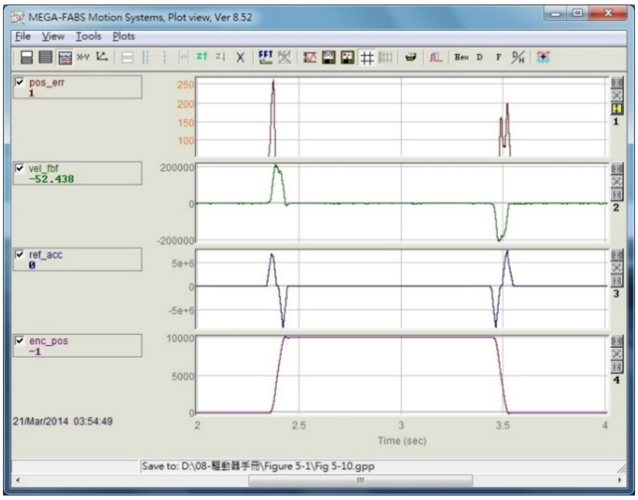


Figure 6.5.1.6

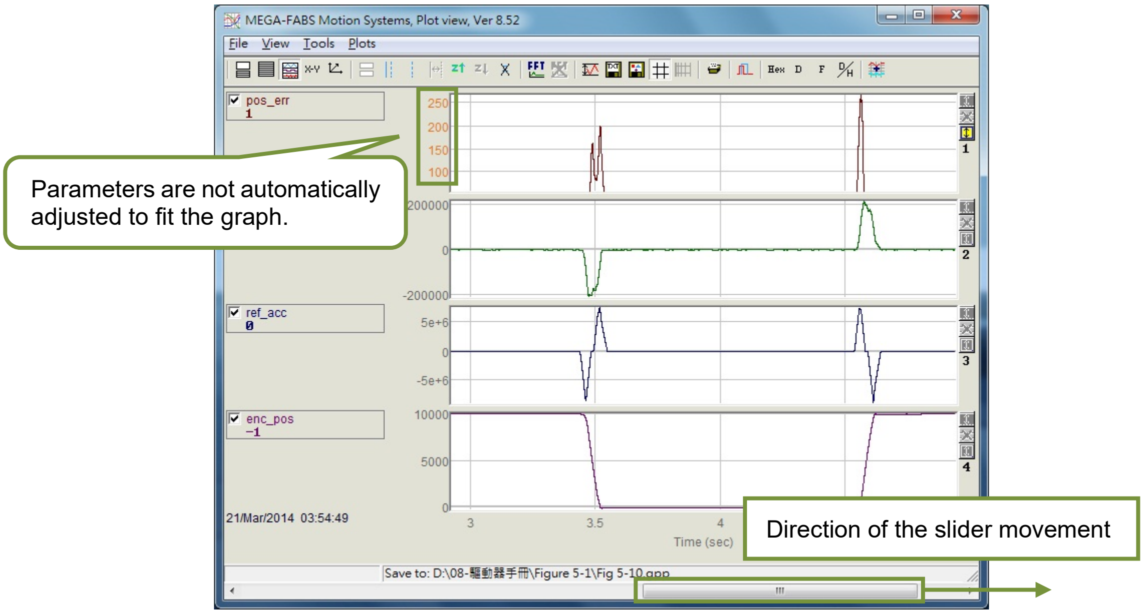


Figure 6.5.1.7

- **dt, 1/dt, dSamp**

  When the interval is framed by the blue solid-line and dotted-line cursors, values of “dt”, “1/dt”, and “dSamp” will appear at the bottom of graph display area. “dt” is the time in the interval, and “dSamp” is the sampling number in the interval, as Figure 6.5.1.3 shows.

- **Display a physical quantity on different channels**

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

- **Display the value of physical quantity**

  When the blue solid-line cursor is moved to a specific time point, the value of physical quantity at this time will be displayed at the bottom of this physical quantity. The value is displayed in decimal or hexadecimal, as Figure 6.5.1.3 shows. The related icons in main toolbar area are described as follows.

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

6.5.2 Save / open file

In “Plot view”, there are three saved-file types, text file (.txt), picture file (.bmp), and “Plot view” special file (.gpp). The .txt file is for saving the value of each physical quantity within the collection time. The .bmp file is for saving the graph of all physical quantities as a figure. The .gpp file is the only one allowed to be opened in “Plot view”. Therefore, if users need to re-open the file via “Plot view” someday, remember to save it as a .gpp file. The related icons in main toolbar area are described as follows.

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

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

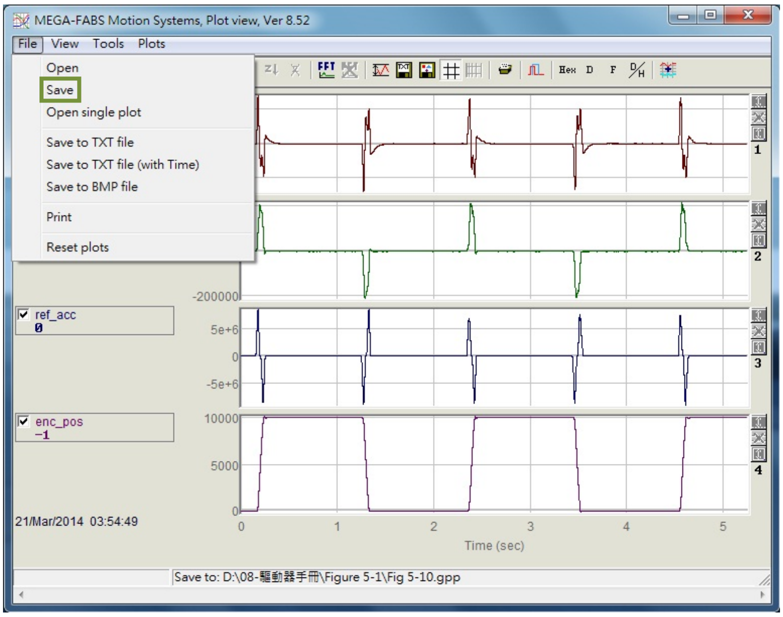


Figure 6.5.2.1 Save as a .gpp file

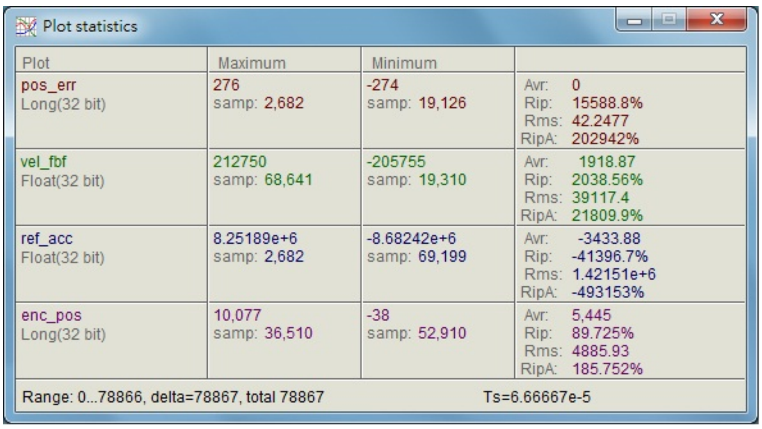
6.5.3 Mathematical operation

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

- **Statistics table**

  Click to display the table of Figure 6.5.3.1, which shows the maximum, minimum, average, root mean square (Rms), Rip, and RipA of each physical quantity within the interval selected by cursors. Rip = standard deviation/average, and RipA = (maximum - minimum) /average. The related icon in main toolbar area is described as follows.

  - : the maximum, minimum, root mean square (Rms), and ripple calculation of physical quantity



Plot statistics

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

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

Figure 6.5.3.1

■ Operational method

Select "Math operation" of "Tools" on the function menu, or click to open the window of Figure 6.5.3.2 for a suitable mathematical operation. Take the addition as an operational example. After clicking the "Linear" option, choose "pos_err" and "vel_fbf" via the drop-down menu. Then, name new physical quantity in the "New plot name" column and set its color. Finally, click the "Create" button to generate the physical quantity ("lin_1") of "pos_err" plus "vel_fbf", as Figure 6.5.3.3 shows. Other mathematical operations are the same as that of addition. The related icon in main toolbar area is described as follows.

- : mathematical operation

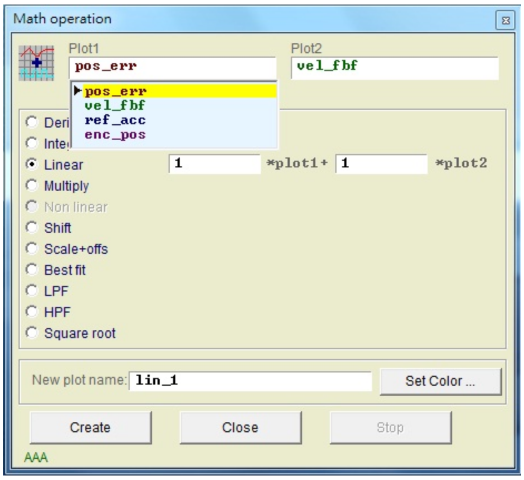


Figure 6.5.3.2

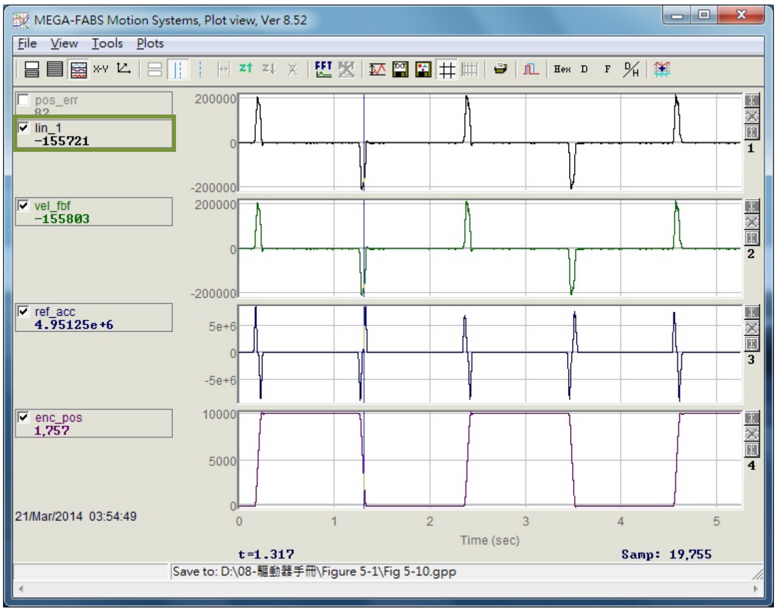


Figure 6.5.3.3

■ **Fast Fourier transform (FFT)**

Click in main toolbar area to open the window of Figure 6.5.3.4, and choose the required physical quantity to do fast Fourier transform (here takes “pos_err” as an example). Then, click the “Run FFT” button to generate the transformed graph, as Figure 6.5.3.5 shows. To cancel the result of fast Fourier transform, click . The related icons in main toolbar area are described as follows.

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

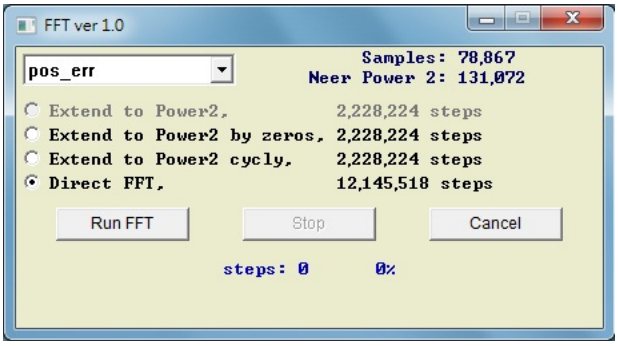


Figure 6.5.3.4

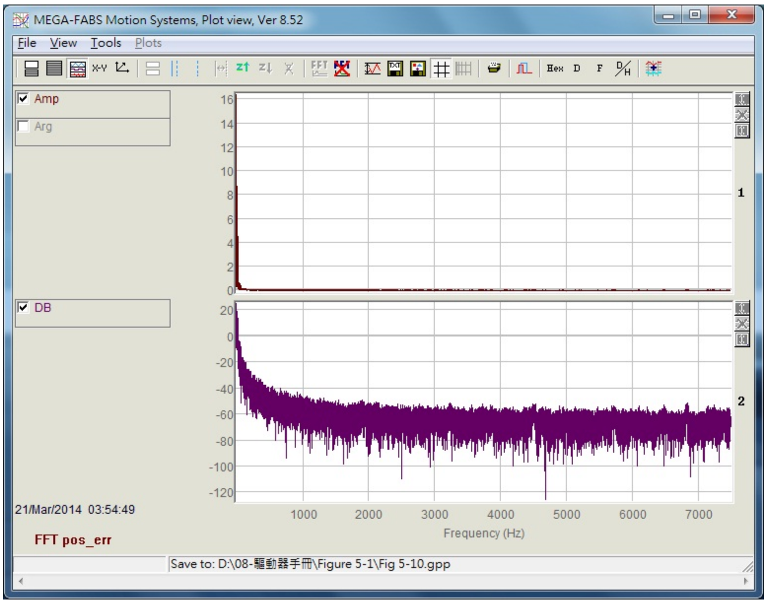


Figure 6.5.3.5

■ **Natural logarithm**

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

- : Express the X axis as the logarithmic form. It is only available after fast Fourier transform is completed.

6.6 Advanced gains

There are several important tasks for a servo drive to achieve, such as the performance of move and settling (refer to Section 3.7), whether the position error is very small during motion, and whether the velocity is smooth during motion. The performance can be improved by tuning gains and parameters. Tuning common gain ("Primary CG") is the easiest way for D2T-LM series drive to adjust the performance of motor motion. The greater the common gain is, the greater the servo stiffness is. However, the servo stiffness cannot be too big, or it may cause system vibration or electrical noise. These phenomena change based on the status of the mechanism.

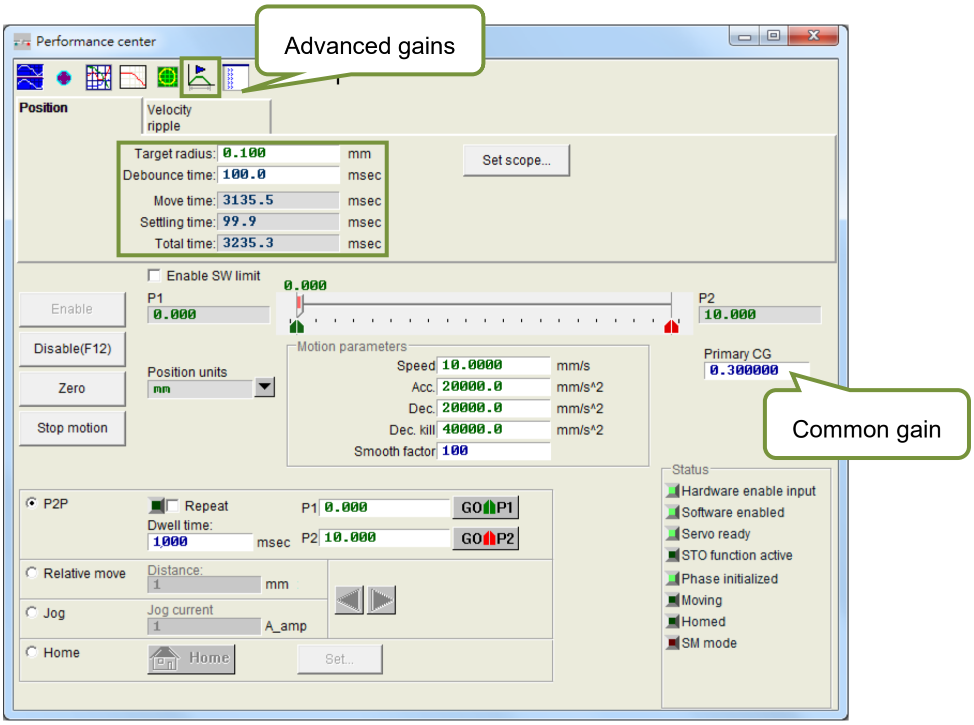


Figure 6.6.1

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

6.6.1 Filter

The filter is located on the servo control loop inside the drive. It is used to eliminate the control problem caused by the high-frequency vibration of the system, and to deal with the inappropriate resonant frequency of overall mechanical system. The performance of system control can be enhanced via the filter. D2T-LM series drive provides two filters that can be used simultaneously, and the form can be set as low pass filter or notch filter. When it comes to designing a filter, the frequency analyzer is often used to analyze the characteristic of the system. By clicking the “Bode…” button given in Figure 6.6.1.1, the simulative interface of “Bode plot” will appear for the filter design. Two common settings are described as follows.

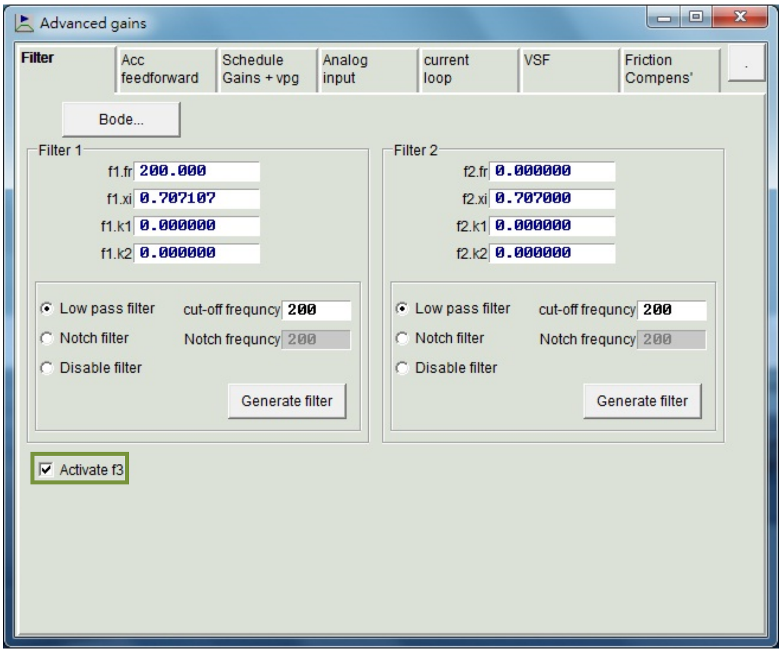


Figure 6.6.1.1 Filter

- **Low pass filter**

  The setting of a typical low pass filter is given as follows.

  ① fr: The cutoff frequency of the filter. (Unit: Hz) For general applications, it can achieve a good effect at the setting of 500Hz. For other cases, it can be considered to decrease the value. However, the control performance will be reduced if the cutoff frequency is too small.

  ② xi: The damping ratio of the filter. Its value ranges from 0 to 1.

  ③ k1: 0

  ④ k2: 0

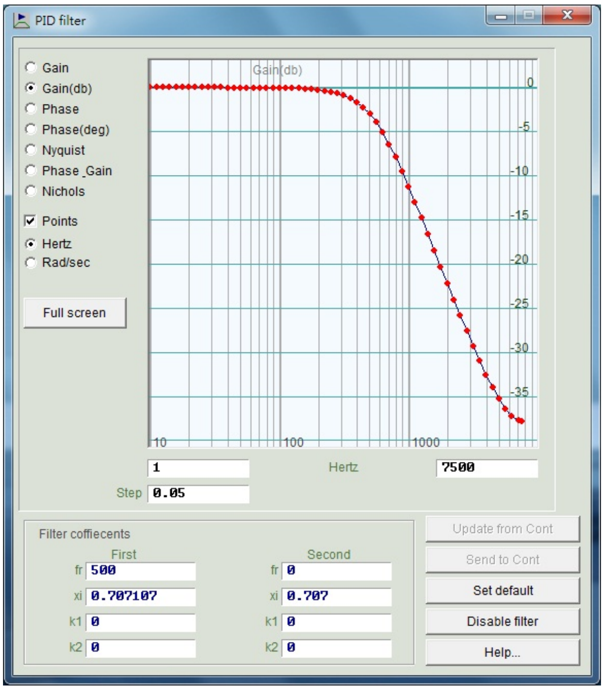


Figure 6.6.1.2 Low pass filter

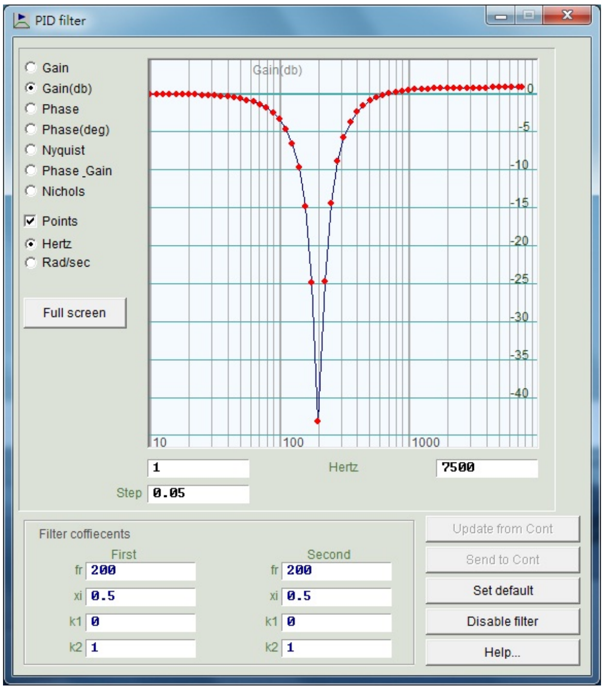


Figure 6.6.1.3 Notch filter

- **Notch Filter**

When the system has an inappropriate resonance frequency (for example, between 10 and 250 Hz) that cannot be eliminated by mechanism correction or design enhancement, notch filter can be used to improve this problem. Generally, notch filter should be set according to the result of frequency analysis. Refer to Section 6.7.3 for more information.

The setting of a typical notch filter is given as follows.

① fr: The cutoff frequency of the filter. (Unit: Hz)

② xi: The damping ratio of the filter. Its value ranges from 0 to 1. The closer to 0 the value is, the narrower the filtering frequency band is. The closer to 1 the value is, the wider the filtering frequency band is.

③ k1: 0

④ k2: 1

- **Automatic resonance suppression filter**

Automatic resonance suppression filter (f3) will be set and started automatically after auto tune is done by pressing the “Freq analyzer” button during phase initialization. However, if the system cannot effectively suppress the vibration via f3 filter when users drive the motor, cancel the check of “Activate f3” in the “Filter” tab of “Advanced gains” window (as the green box in Figure 6.6.1.1 shows). Then, modify “Filter 1” and “Filter 2” by manual operation to achieve an effective vibration suppression.

6.6.2 Acceleration feedforward

The position error of servo control is usually larger in acceleration or deceleration phase, especially for the application with a larger moving mass or moment of inertial. By setting the parameter of acceleration feedforward, the position error can be effectively reduced.

To adjust the acceleration feedforward, follow the following steps.

Step 1. Click the "Set scope…" button to display the "Scope" window.

Step 2. Set "Acc feedforward gain" in Figure 6.6.2.1 as 0.

Step 3. Set the pre-planned maximum acceleration, and make the motor do point-to-point motion.

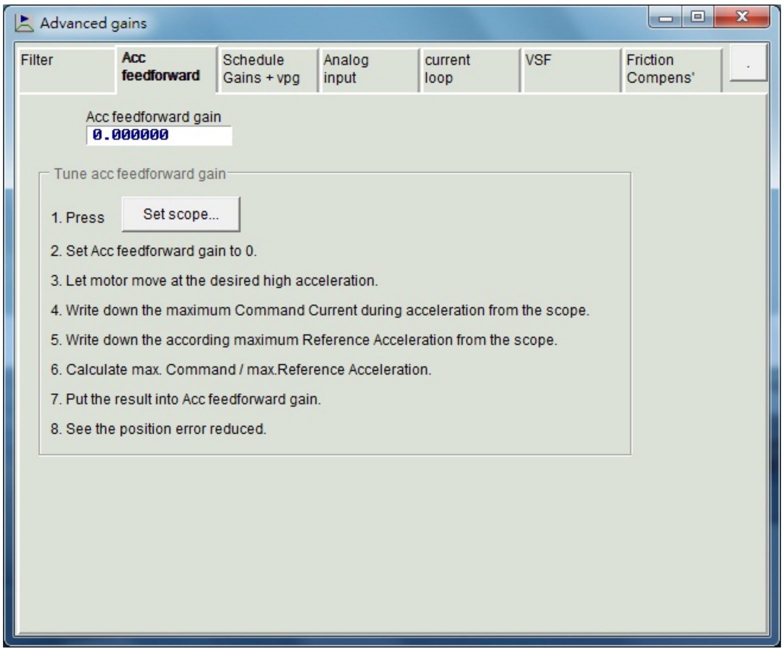


Figure 6.6.2.1 Acceleration feedforward

Step 4. Observe and record the maximum value of "Command Current" in acceleration phase. In Figure 6.6.2.2, the value is 16. When the motor starts moving, "Scope" is like Figure 6.6.2.2. Click the "Toggle scopes windows (Page UP)" button to change the graph into a single physical quantity. Repeatedly click this button can sequentially switch to the graph of "Command Current", "Reference Acceleration", and "Position Error" to facilitate observing the value of the graph.

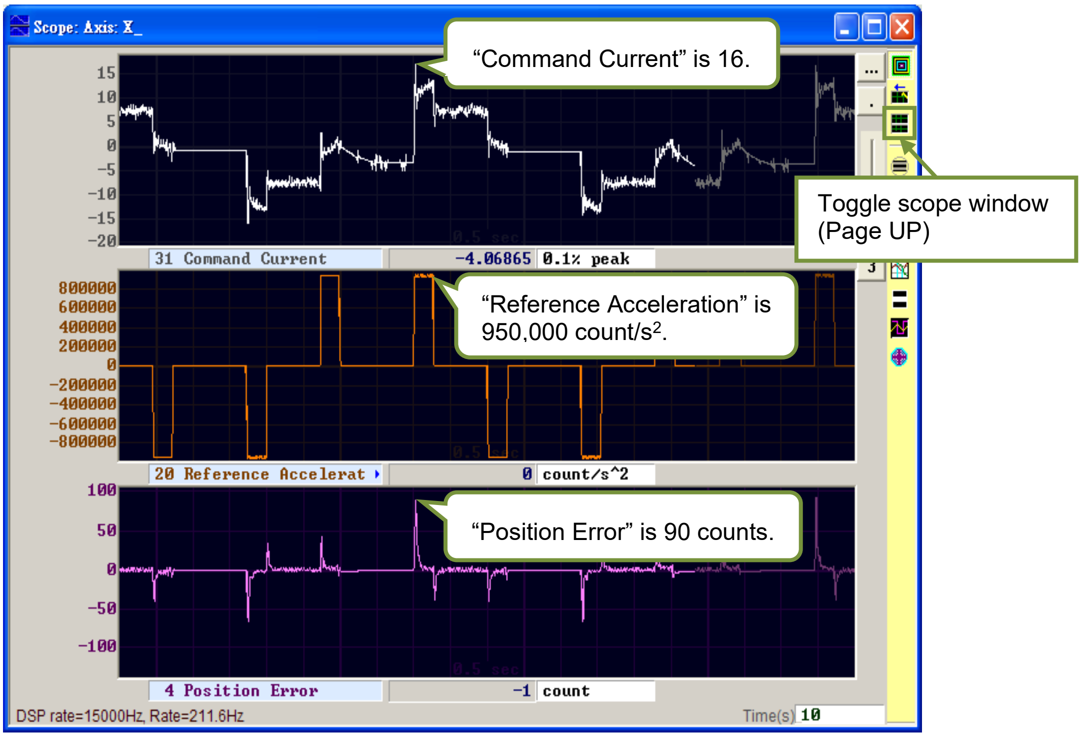


Figure 6.6.2.2 Trajectory result of motor movement

Step 5. Observe and record the maximum value of "Reference Acceleration" in acceleration phase. In Figure 6.6.2.2, the value is 950,000 count/s^2.

Step 6. The value obtained in Step 4 is divided by the value obtained in Step 5. Acc feedforward gain = Command Current/Reference Acceleration = 16/950,000 =1.68421e-5.

Step 7. Enter the result obtained in Step 6 to the "Acc feedforward gain" column, as Figure 6.6.2.3 shows.

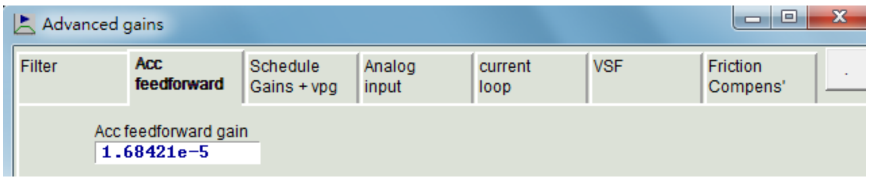


Figure 6.6.2.3 Acceleration feedforward gain

Step 8. Observe whether "Position Error" is reduced. As Figure 6.6.2.4 shows, the position error in acceleration phase is decreased from 90 counts in Figure 6.6.2.2 to 65 counts.

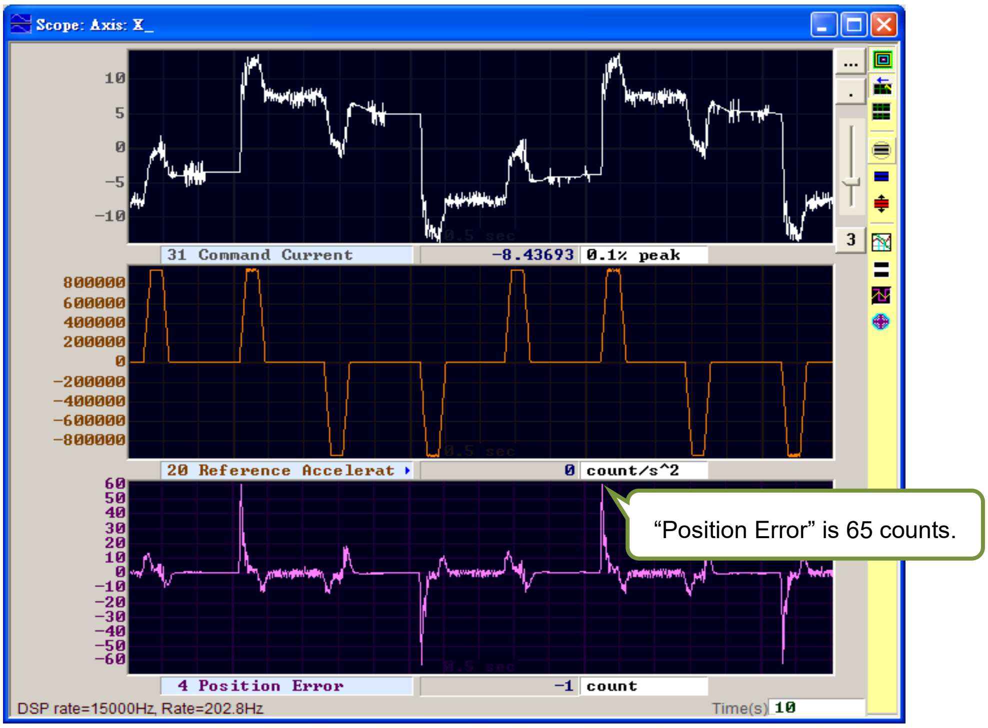


Figure 6.6.2.4 Result of adding acceleration feedforward

6.6.3 Schedule gains & Velocity loop gain

■ **Schedule gains**

A complete motion can be roughly divided into three phases (refer to Section 3.7).

a. Move: From the start to the end of path planning.

b. Settling: From the end of path planning to in-position phase.

c. In-position: Output an in-position signal.

The main purpose of "Schedule gains" is to adjust the output servo stiffness of each motion phase ("Move", "Settling", "In-position") by changing the servo gain. The adjustment of the gain in each phase is implemented in a proportional manner. When it is set as 1, the original servo gain is used. When it is less than 1, the gain in this phase is reduced. The corresponding parameters of each phase are given as follows.

a. Move: sg_run

b. Settling: sg_stop

c. In-position: sg_idle

If "CG" = 0.5 and "sg_run" = 1.2, it means that the actual servo gain in "Move" phase is changed into 0.5 x 1.2 = 0.6. Through "Schedule gains", "Settling" and "In-position" phases adopt the same setting method to change the originally fixed servo gain into the gain which meets the different requirement in each motion phase.

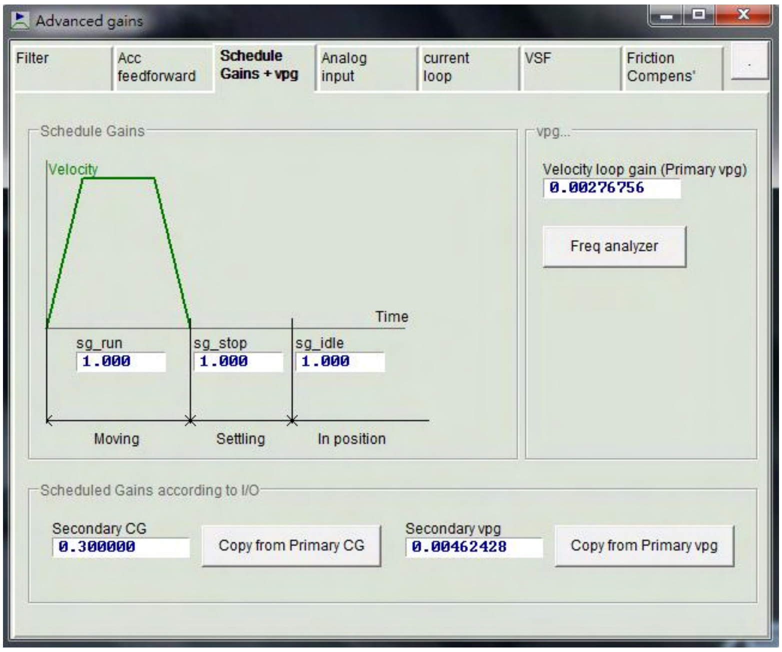


Figure 6.6.3.1 Schedule gains

■ **Velocity loop gain (vpg)**

Velocity loop gain (vpg) is an internal control parameter of D2T-LM series drive. Generally, the initial value is calculated by parameters set in Configuration center. There is no need to modify the value under normal circumstances. However, users still can re-adjust it via “Freq analyzer”.

Step 1. Click the “Freq analyzer” button to display the window of Figure 6.6.3.2.

Step 2. Click the “Enable” button.

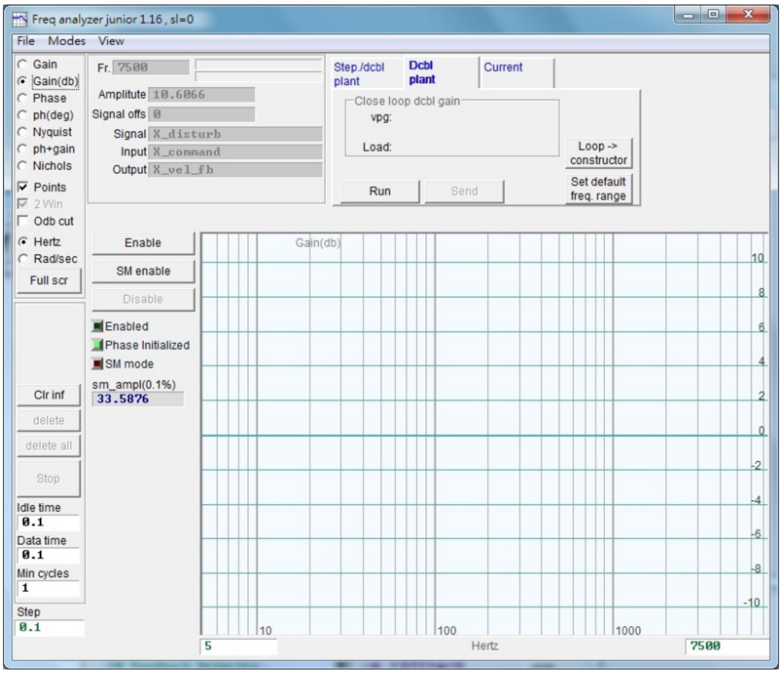


Figure 6.6.3.2

Step 3. Click the “Run” button to start the frequency analyzer. The motor starts from low-frequency vibrations and gradually produces high-frequency sounds. After it is done, a frequency response will be drawn on the screen, as Figure 6.6.3.3 shows.

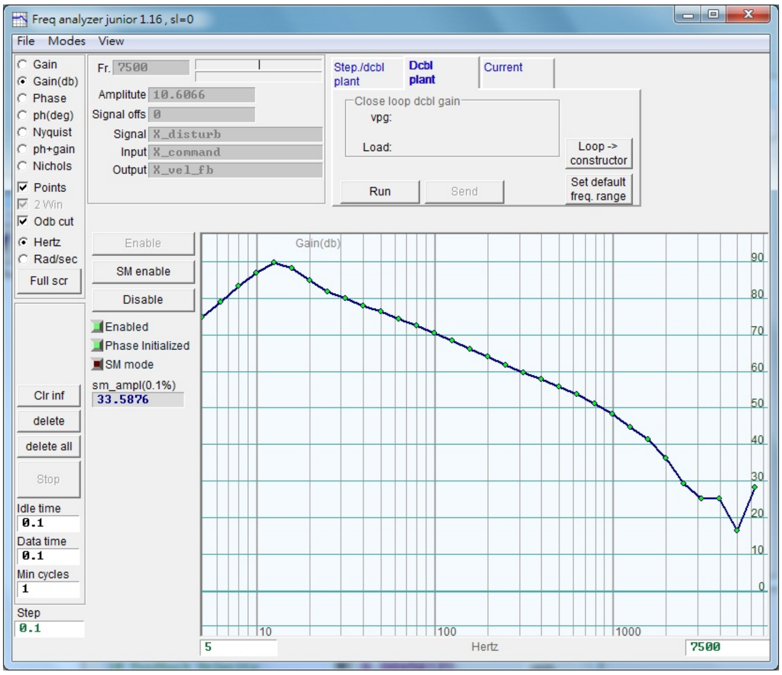


Figure 6.6.3.3

Step 4. Left click the frequency response graph to display the cursor line of -20dB. Drag the cursor line by pressing the left mouse button to make it get closer to the frequency response line, as Figure 6.6.3.4 shows. During the process, the gain will be re-calculated and the vpg value will be displayed. When the cursor line is dragged downward, the gain increases. When the cursor line is dragged upward, the gain decreases.

Step 5. Click the “Send” button to send velocity loop gain to the drive. To keep the setting, do not forget to save it to the drive’s Flash.

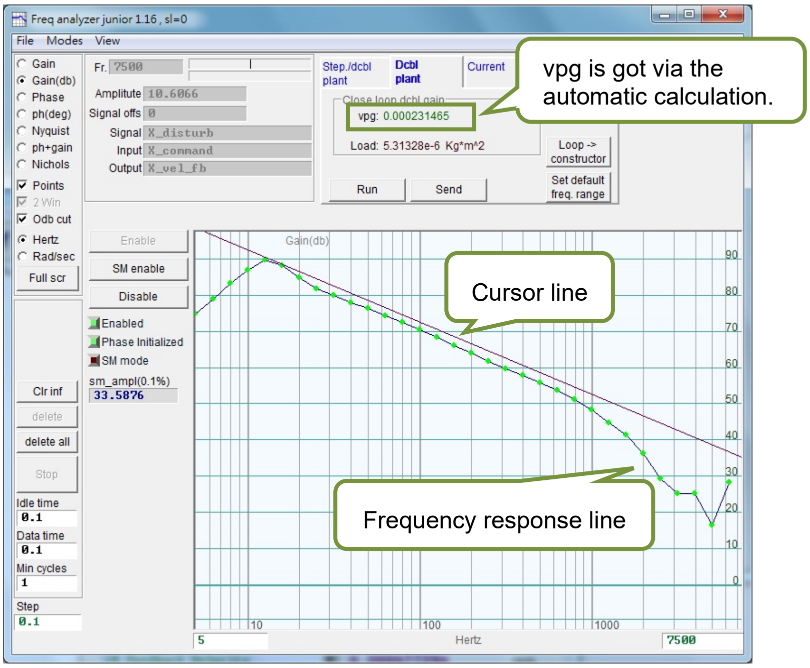


Figure 6.6.3.4

6.6.4 Analog input

When voltage mode is used, the voltage command sent by the host controller may contain the DC bias due to various factors, which distorts the command and affects the performance. In this case, analog input can be used to compensate and correct the voltage. As long as users click the “Set Offset” button in Figure 6.6.4.1, the measurement and the offset correction will be executed automatically.

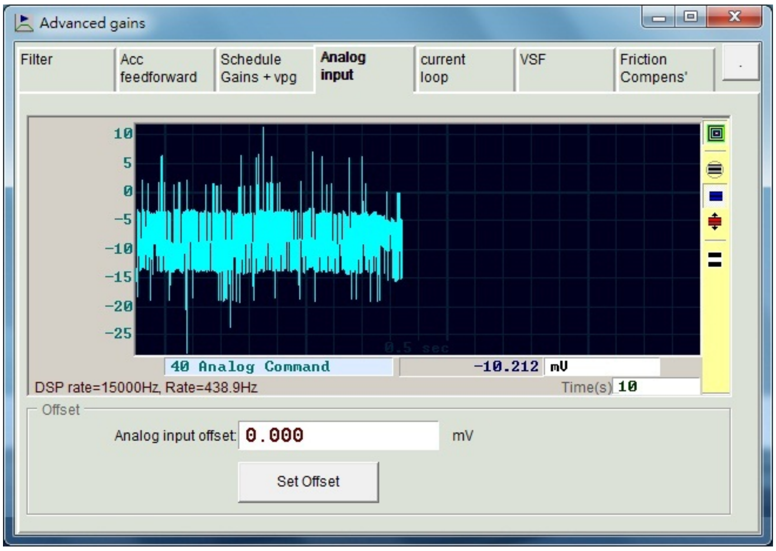


Figure 6.6.4.1 Analog input

6.6.5 Current loop

Gain values of current loop, “Ki” and “Kp”, are basically calculated based on the motor parameters in Configuration center when the motor model is chosen. Generally, there is no need to adjust them. However, if motor parameters are not correctly set, users can adjust the values with this function.

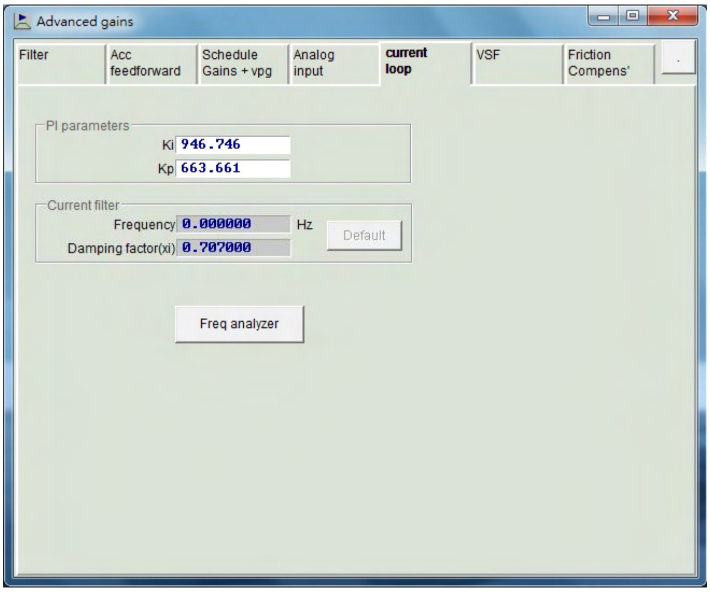


Figure 6.6.5.1 Current loop

6.6.6 Vibration suppression feature

Vibration suppression feature (VSF) is for suppressing the vibration generated by the motor during the movement. Especially when the load of the mechanism is cantilever, the vibration is particularly evident. Through the “VSF” tab in the “Advanced gains” window, the effect of vibration suppression can be achieved by setting “Frequency” and “VSF factor”, and checking the “enable VSF” option. The setting range of “Frequency” is from 0.1 to 200Hz, and the range of “VSF factor” is from 0.7 to 1.5. Generally, it is recommended to set the value of “VSF factor” as 1.0, which is same as the default value. When the motor is moving, users cannot check or uncheck the “enable VSF” option. Otherwise, the motor will generate an unexpected vibration and error.

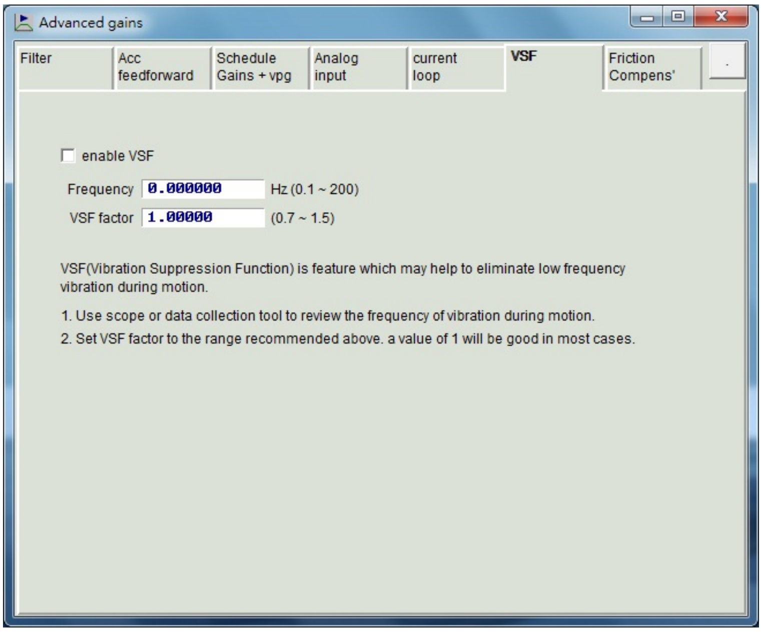


Figure 6.6.6.1 Vibration suppression feature (VSF)

The operational method for finding vibration frequency and starting vibration suppression feature is shown as follows.

Step 1. Set the pre-planned acceleration, deceleration, speed, and travel. Then, make the motor do point-to-point motion.

Step 2. Open “Scope” to observe “Position Error” and “Reference Velocity”, as Figure 6.6.6.2 shows.

Step 3. Click  (“Plot view”) on the right side of the “Scope” window to analyze the captured graphs.

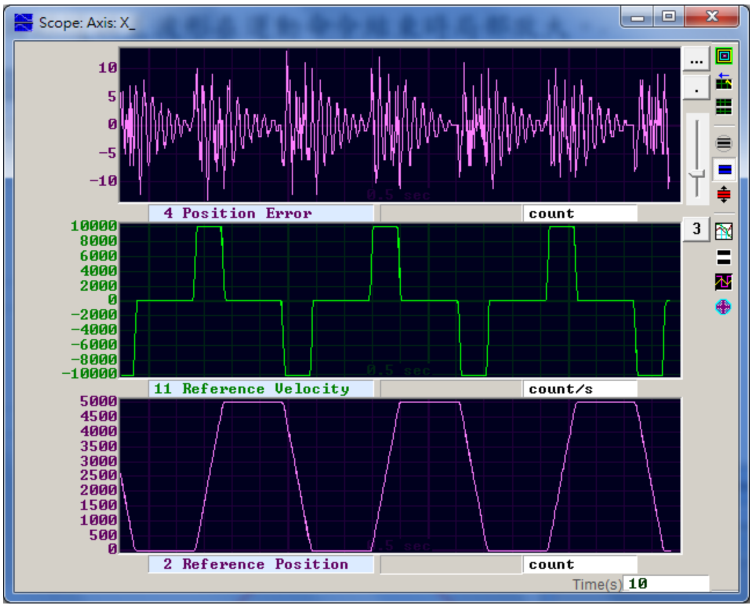


Figure 6.6.6.2

Step 4. Enlarge the graph of "Position Error" at the end of the motion command. Select the range in the window (as Figure 6.6.6.3 shows), and click to enlarge the set range. Refer to Section 6.5 for related operations.

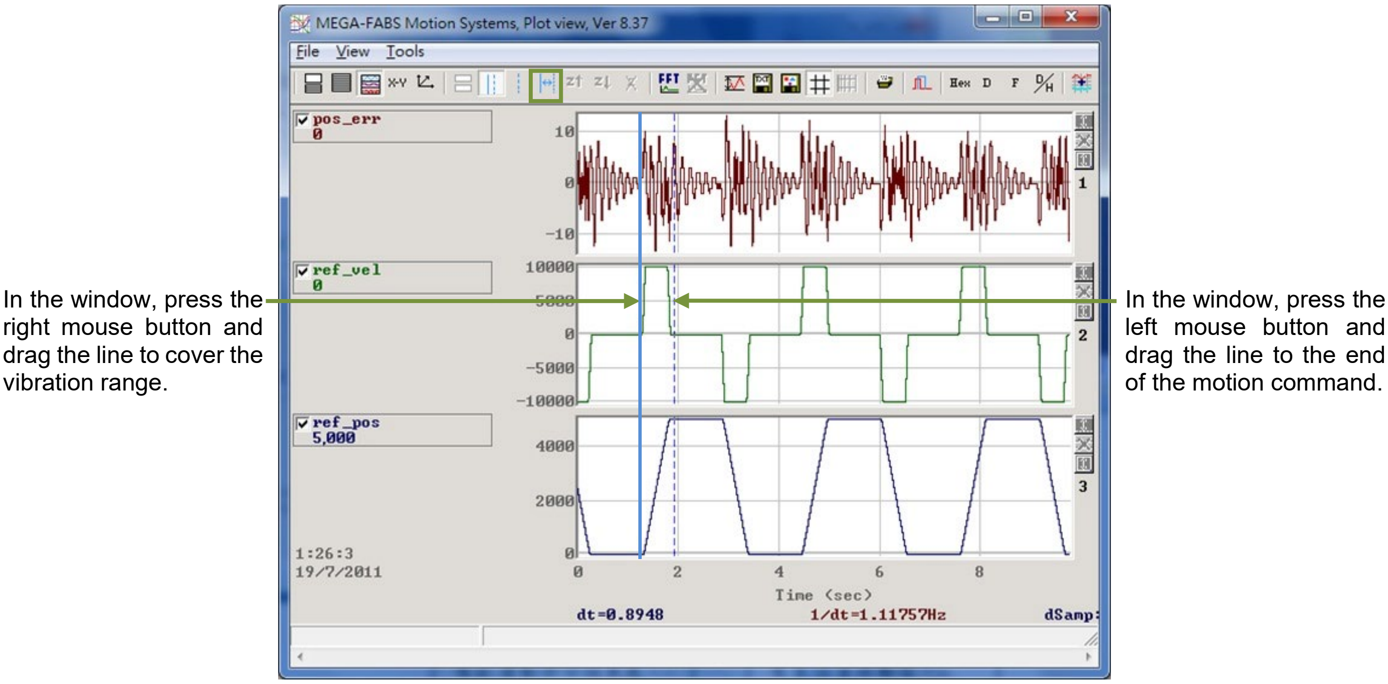


Figure 6.6.6.3

Step 5. Click at the toolbar of "Plot view" window to open the operational window for fast Fourier transform (FFT). Execute FFT to pos_err, as Figure 6.6.6.4 shows.

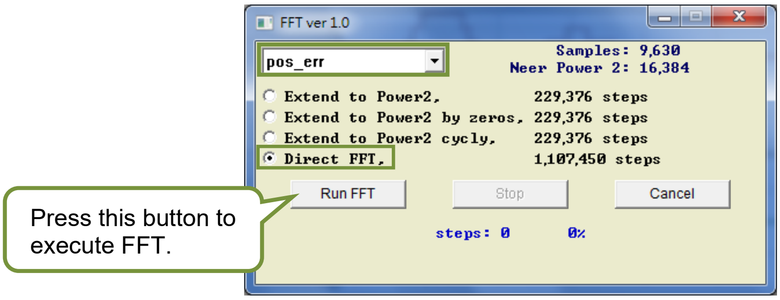


Figure 6.6.6.4

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

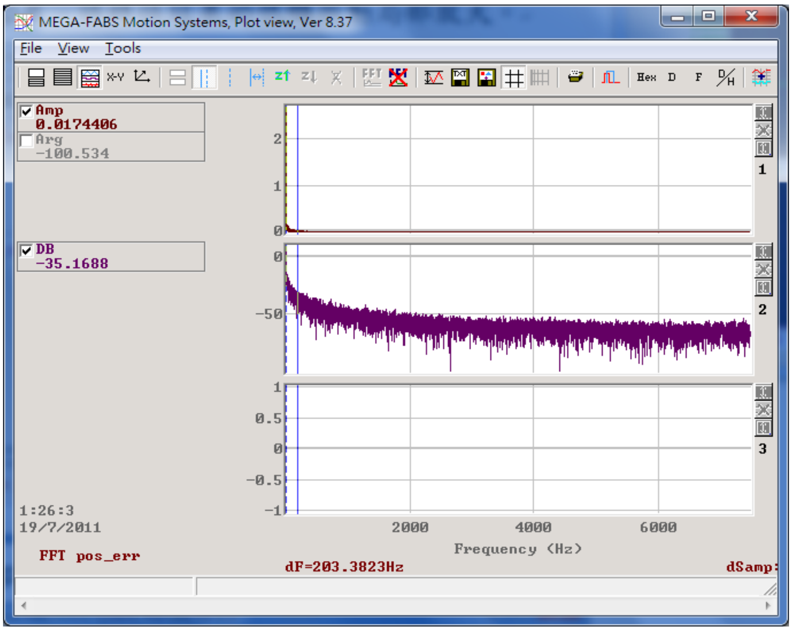


Figure 6.6.6.5

Step 7. Enlarge the low-frequency region and observe the maximum amplitude of vibration frequency, as Figure 6.6.6.6 shows.

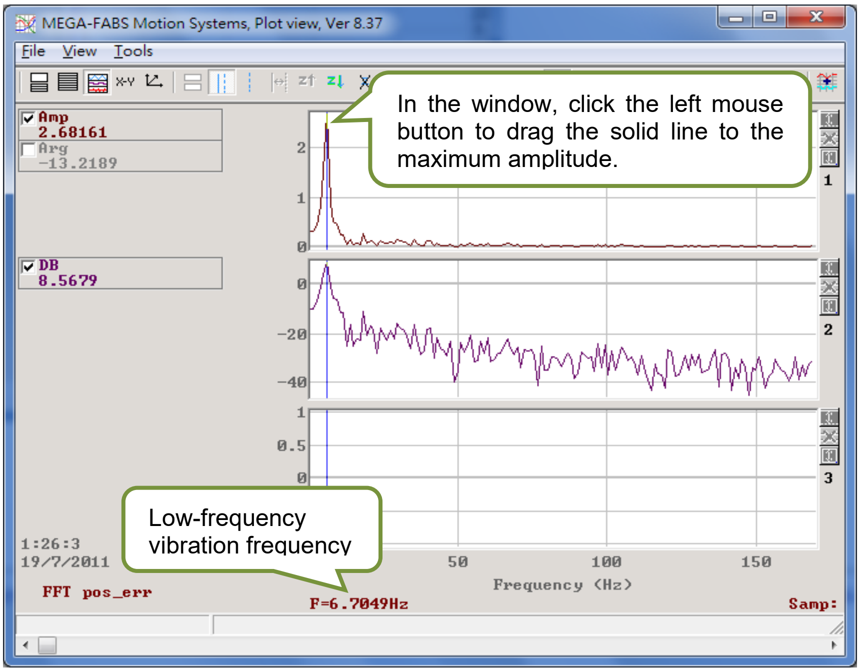


Figure 6.6.6.6

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

Step 9. Check the “enable VSF” option to enable vibration suppression feature, as Figure 6.6.6.7 shows.

Note: Do not check or uncheck the “enable VSF” option during motor motion.

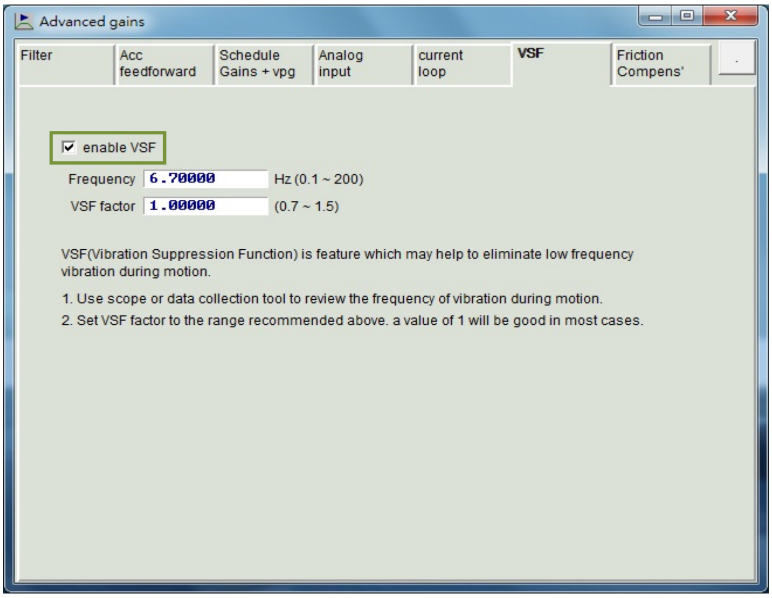


Figure 6.6.6.7

Step 10. After vibration suppression feature is enabled, it is found from the “Scope” that “Position Error” has become smaller when the motor stops moving (as Figure 6.6.6.8 shows).

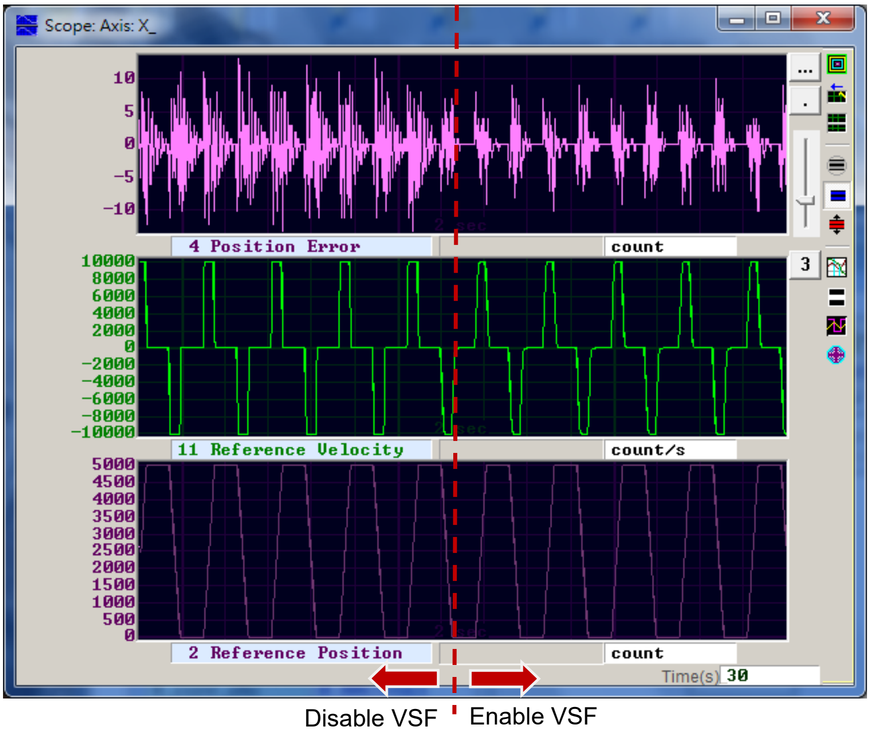


Figure 6.6.6.8

6.6.7 Friction compensation

When operating the drive component, there is always a mechanical friction which affects the efficiency and the function of movement. D2T-LM series drive provides a friction compensation method which reduces the effect of friction, as Figure 6.6.7.1 shows.

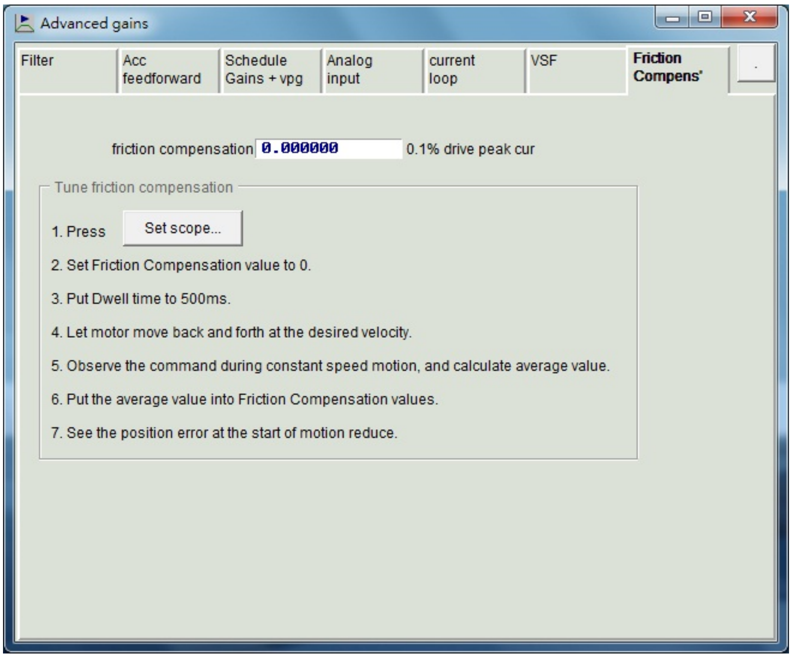


Figure 6.6.7.1

After users complete a convenient set of steps provided by Lightening HMI, friction compensation can be successfully added.

Step 1. Click the “Set scope” button to display the “Scope” window.

Step 2. Set “friction compensation” in Figure 6.6.7.1 as 0.

Step 3. Set “Dwell time” as 500ms.

Step 4. Set the pre-planned speed and make the motor do point-to-point motion. By observing “Position Error” in “Scope”, users can determine whether it is necessary to add friction compensation or not. If the motor has a large position error when it starts, as the left side of Figure 6.6.7.2 shows, friction compensation can be added to improve position error.

Step 5. Observe “Command Current” at the constant speed, and calculate the average value. In Figure 6.6.7.2, the average value of “Command Current” is 20.

Step 6. Enter the average value obtained from Step 5 to the “friction compensation” column.

Step 7. Observe whether “Position Error” is reduced when the motor starts moving. As the right side of Figure 6.6.7.2 shows, friction compensation does reduce position error.

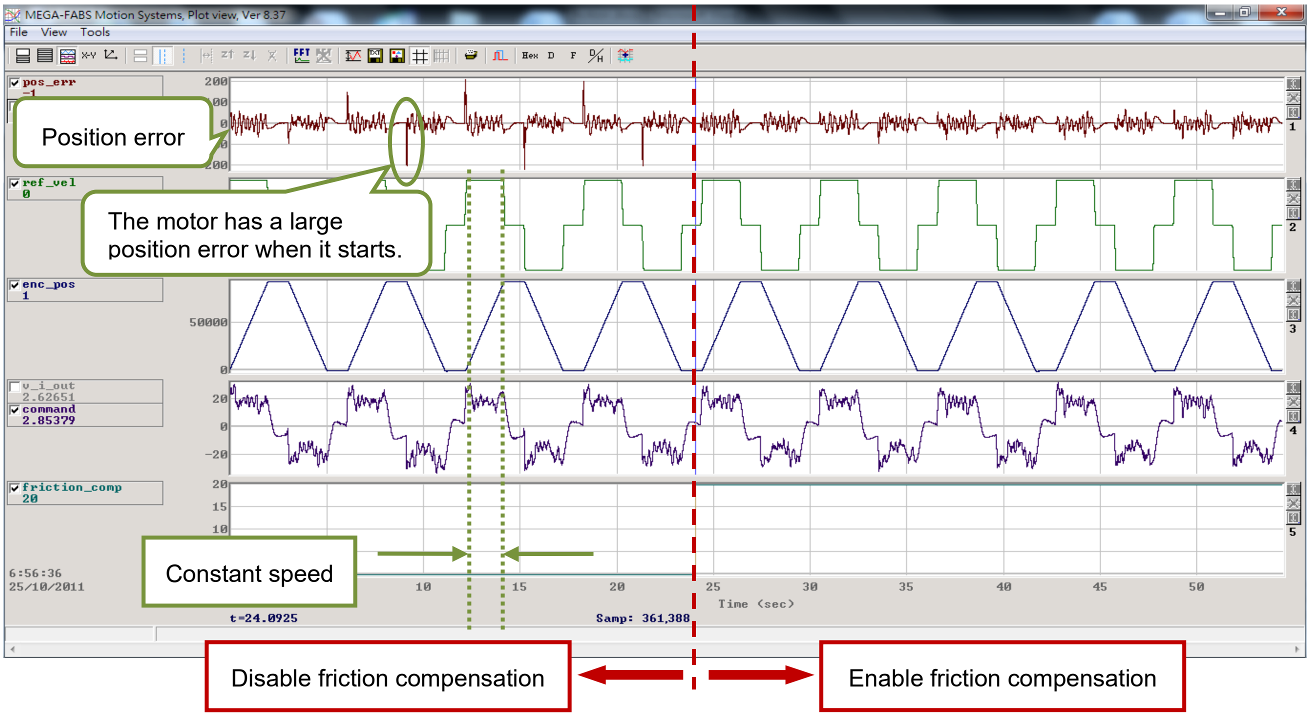

MEGA-FABS Motion Systems, Plot view, Ver 8.37
File View Tools
pos_err
ref_vel
enc_pos
command
friction_comp
Position error
The motor has a large position error when it starts.
Constant speed
6:56:36
25/10/2011
t=24.0925
Samp: 361,388
Time (sec)
Disable friction compensation
Enable friction compensation

Figure 6.6.7.2

6.7 Loop constructor

“Loop constructor” allows users to confirm the stability of the control system. “Loop constructor” comes with spectrum analysis tools, such as Nyquist, Nichols, and Bode. It also provides users the way to adjust filters and gain values (vpg, vig, ppg, and CG). Through this function, users can directly adjust parameters to observe the frequency response of the control system. Click the “Loop constructor” option on the “Tools” menu of Lightening, as Figure 6.7.1 shows. The “Loop constructor” window is given in Figure 6.7.2.

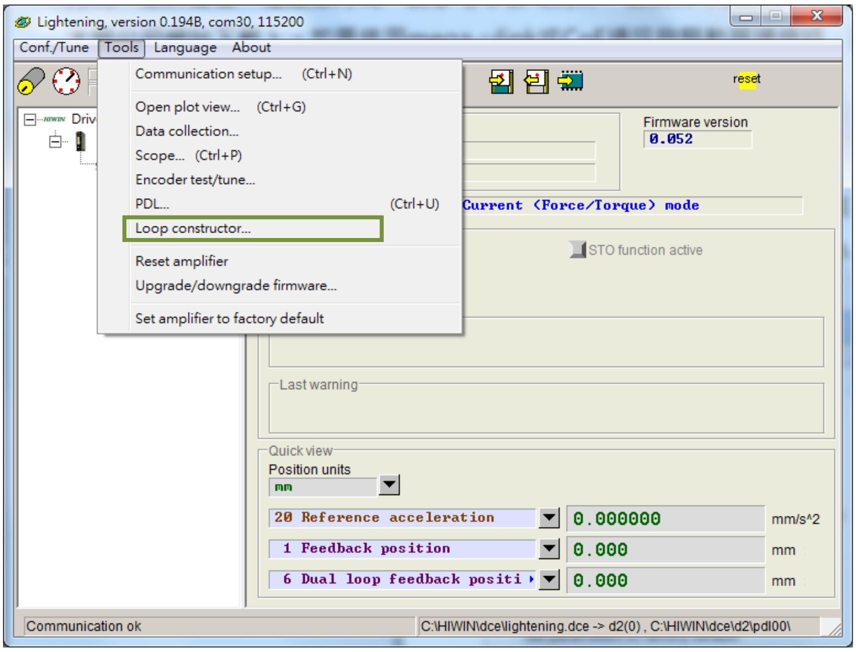


Figure 6.7.1 Open “Loop constructor” from “Tools”

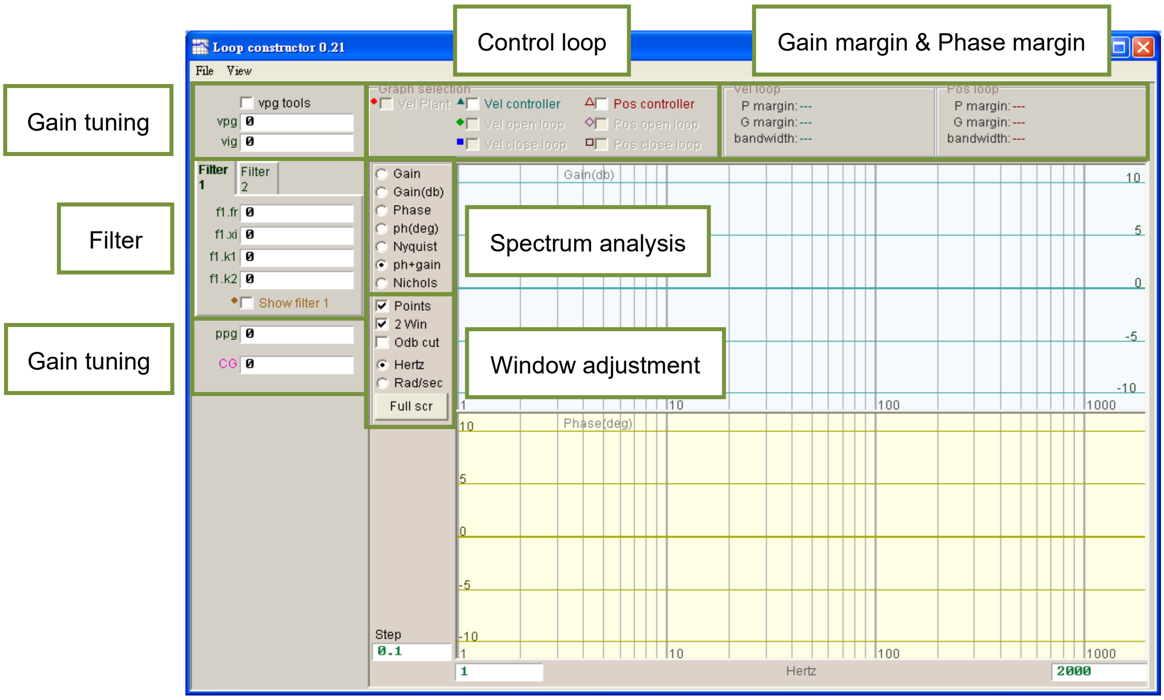


Figure 6.7.2 Loop constructor

6.7.1 Load / save file

Before analyzing the control system via “Loop constructor”, users must load the control system and gain parameters by selecting the “Load” option on the “File” menu of “Loop constructor” window. There are three methods of loading file, “Load plant+gains from file...”, “Load plant from file…”, and “Load gains from file…”, as Figure 6.7.1.1 shows.

(1) “Load plant+gains from file…” : Load the .lop file, which contains the control system and gain parameters.
(2) “Load plant from file…” : Load the .fgr file, which contains the control system.
(3) “Load gains from file…” : Load the .gns file, which contains the gain parameters.

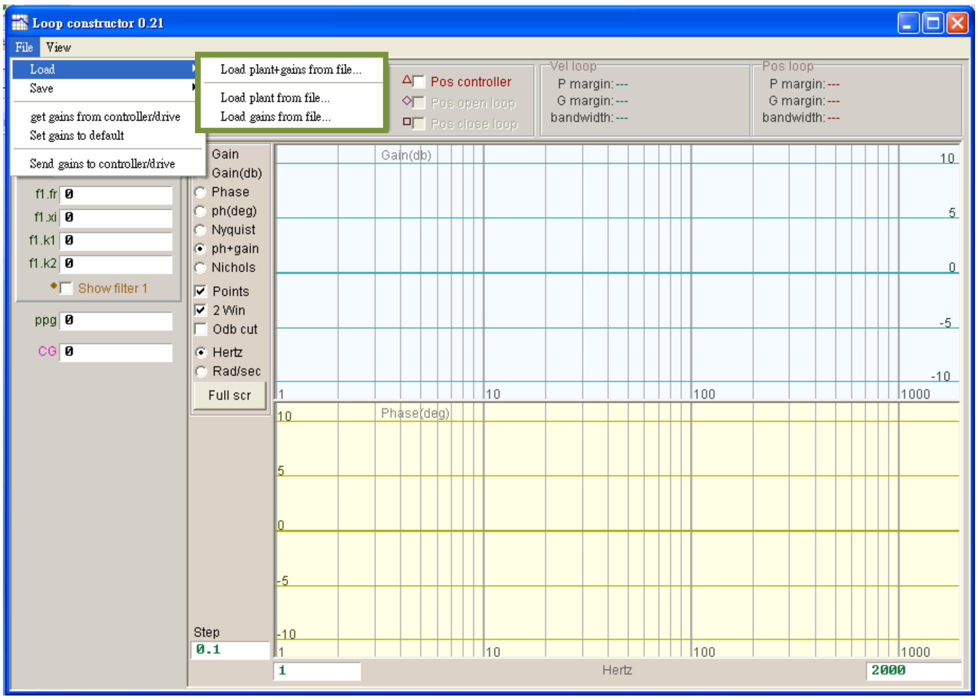


Figure 6.7.1.1 Loop constructor – load data from file

After analyzing the control system via “Loop constructor”, users can select the “Save” option on the “File” menu of “Loop constructor” window if it is needed to save the control system and gain parameters. There are three methods of saving file, “Save plant+gains to file...”, “Save plant to file…”, and “Save gains to file...”, as Figure 6.7.1.2 shows.

(1) “Save plant+gains to file…” : Save the control system and gain parameters as the .lop file.
(2) “Save plant to file…” : Save the control system as the .fgr file.
(3) “Save gains to file…” : Save the gain parameters as the .gns file.

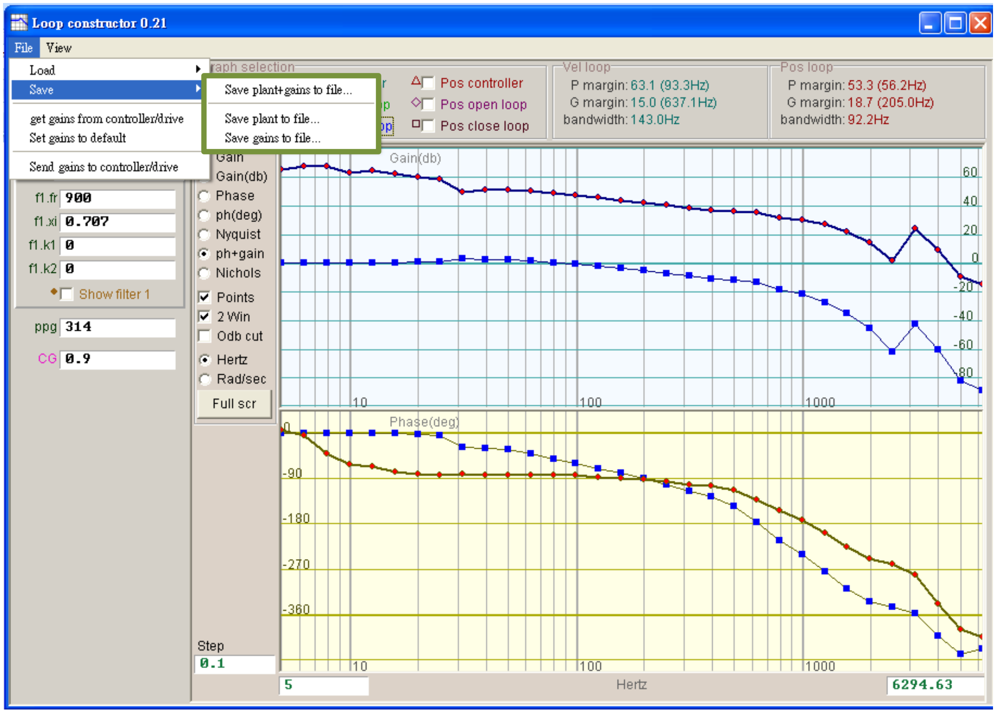


Figure 6.7.1.2 Loop constructor – save data to file

6.7.2 Tool

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

6.7.2.1 Frequency response function

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

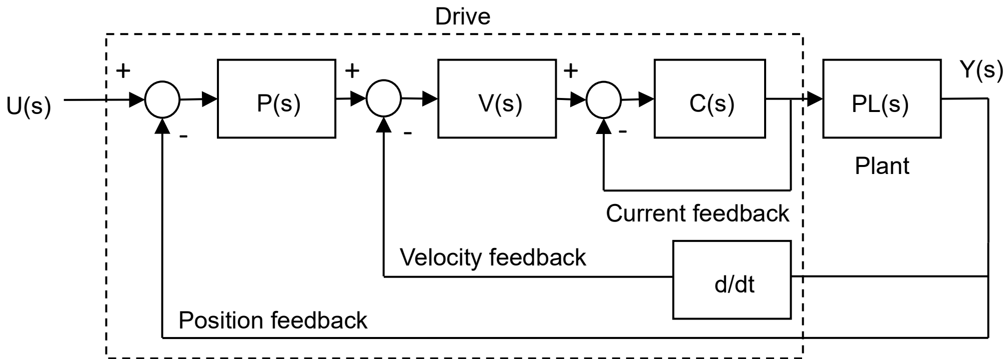


Figure 6.7.2.1.1 Control architecture of the drive

- U (s): system input; the drive command
- Y (s): system output; the feedback position of the encoder
- Plant: PL(s) is the relationship between the drive command and the feedback position. The plant includes the mechanical platform, motor, and the feedback system.
- Controller: P(s) is the position loop controller. V(s) is the velocity loop controller. C(s) is the current loop controller.
- Open loop: The transfer function of the open loop system is "$G(s) = P(s) \times V(s) \times C(s) \times PL(s)$", that is, ignoring all feedback signals.
- Close loop: The transfer function of the close loop system is shown as below.

$$T(s) = \frac{P(s) \times V(s) \times C(s) \times PL(s)}{\left(\left(\frac{d}{dt}\right) \times P(s) \times V(s) \times C(s) \times PL(s)\right) + P(s) \times V(s) \times C(s) \times PL(s)}$$

6.7.2.2 Nyquist

The "Nyquist" option of "Loop constructor" can analyze and simulate frequency responses of "Vel open loop" and "Pos open loop" of control system. Users can select either of them, or both of them at the same time. The Nyquist plot of "Pos open loop" is given in Figure 6.7.2.2.1. Move the mouse cursor to the curve on the Nyquist plot to display the value of the frequency response.

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

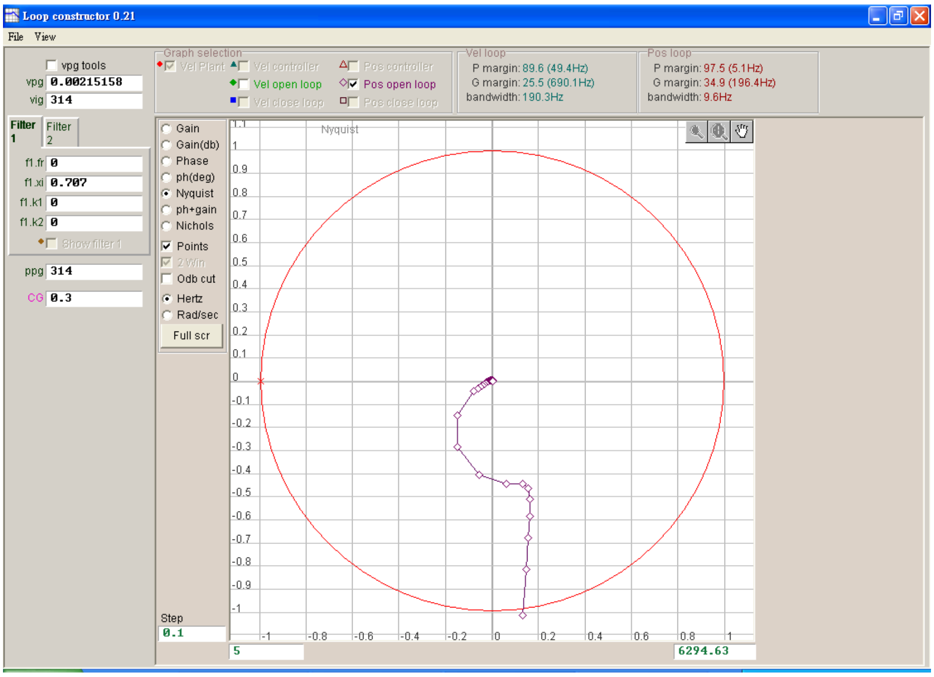


Figure 6.7.2.2.1 Nyquist plot of Pos open loop

6.7.2.3 Bode

The “ph+gain” option of “Loop constructor” can analyze and simulate frequency responses of “Vel controller”, “Vel open loop”, “Vel close loop”, “Pos controller”, “Pos open loop”, and “Pos close loop” of control system. Users can select either velocity loop or position loop, or six loops at the same time. Bode plots of “Vel close loop” and “Pos close loop” are given in Figure 6.7.2.3.1. Move the mouse cursor to the curve on the Bode plot to display the value of the frequency response.

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

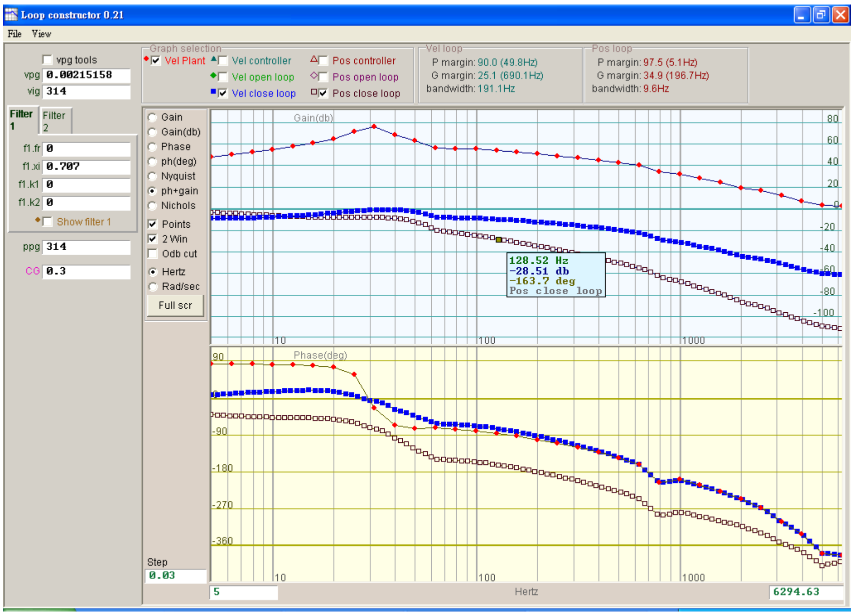


Figure 6.7.2.3.1 Bode plots of Vel close loop and Pos close loop

6.7.2.4 Nichols

The “Nichols” option of “Loop constructor” can analyze and simulate frequency responses of “Vel open loop” and “Pos open loop” of control system. Users can select either of them, or both of them at the same time. Nichols plots of “Vel open loop” and “Pos open loop” are given in Figure 6.7.2.4.1. Move the mouse cursor to the curve on the Nichols plot to display the value of the frequency response.

(1) Vel open loop: the frequency response of the velocity open loop of control system

(2) Pos open loop: the frequency response of the position open loop of control system

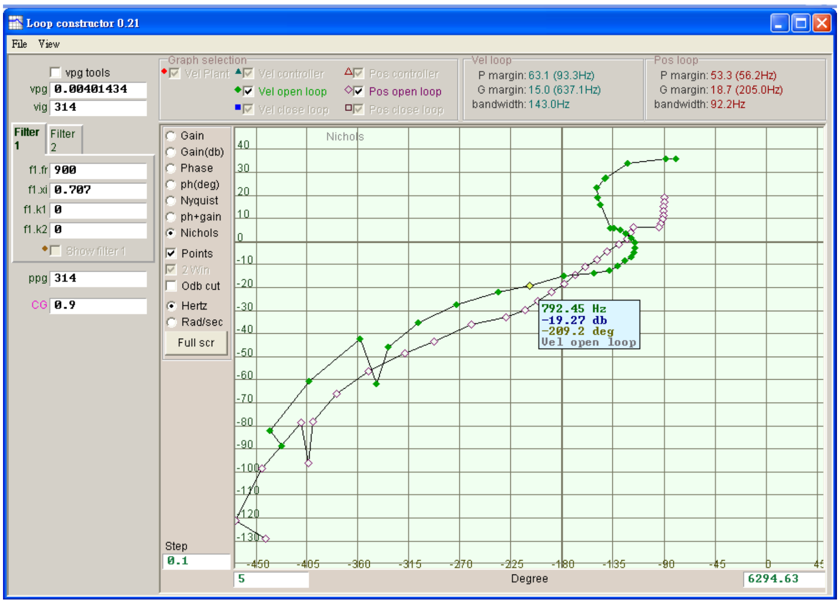


Figure 6.7.2.4.1 Nichols plots of Vel open loop and Pos open loop

6.7.3 Filter

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

6.7.3.1 Low pass filter

Low pass filter in control system can suppress the high-frequency noise or machine vibration. The Bode plot of low pass filter is given in Figure 6.7.3.1.1. Modifying the filter parameters (fr, xi) will affect the frequency response of various control loop analysis.

(1) fr: The cutoff frequency of the filter. (Unit: Hz) For general applications, it can achieve a good effect at the setting of 500Hz. For other cases, it can be considered to decrease the value. However, the control performance will be reduced if the cutoff frequency is too small.

(2) xi: The damping ratio of the filter. Its value ranges from 0 to 1.

(3) k1: Low pass filter = 0

(4) k2: Low pass filter = 0

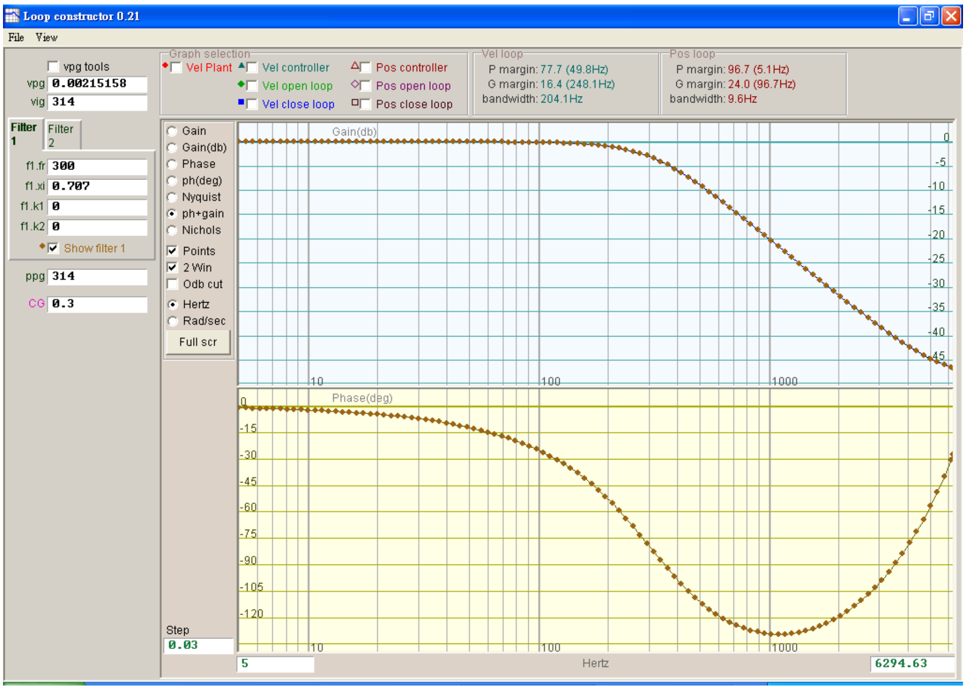


Figure 6.7.3.1.1 Low pass filter

6.7.3.2 Notch filter

When the system has an inappropriate resonance frequency that cannot be eliminated by mechanism correction or design enhancement, notch filter can be used to improve this problem. The Bode plot of notch filter is given in Figure 6.7.3.2.1. Modifying the filter parameters (fr, xi) will affect the frequency response of various control loop analysis.

(1) fr: The cutoff frequency of the filter. (Unit: Hz)

(2) xi: The damping ratio of the filter. Its value ranges from 0 to 1. The closer to 0 the value is, the narrower the filtering frequency band is. The closer to 1 the value is, the wider the filtering frequency band is.

(3) Notch filter = 0

(4) Notch filter = 1

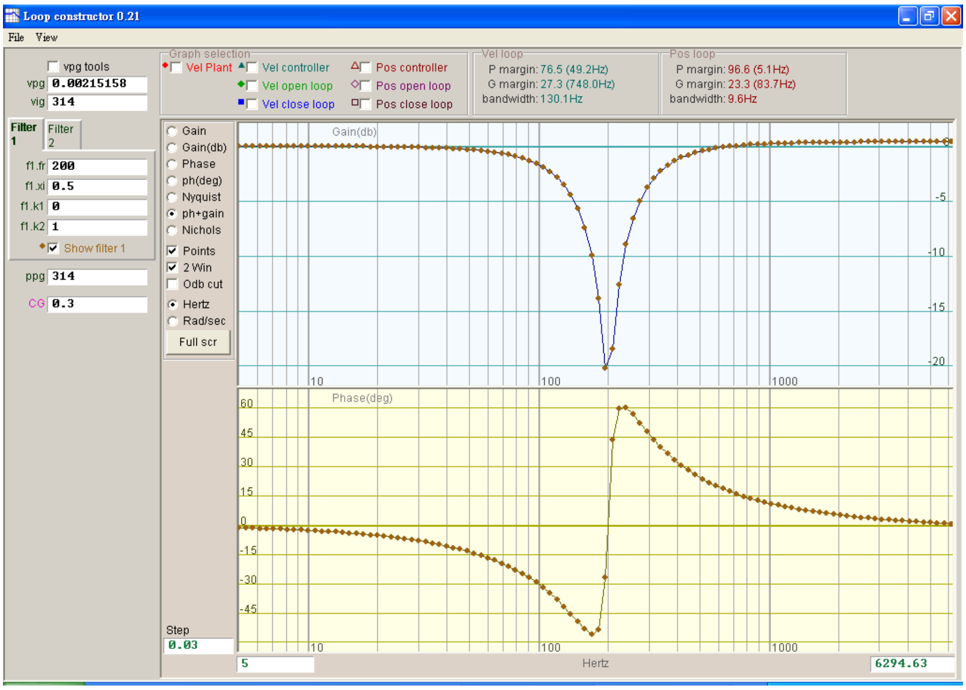


Figure 6.7.3.2.1 Notch filter

6.7.4 Gain tuning

“Loop constructor” provides not only gain values of velocity loop (vpg, vig) and position loop (ppg) but also common gains (CG, refer to Section 6.6), as Figure 6.7.4.1 shows. Gain tuning can be performed by these parameters to simulate the stability of control system.

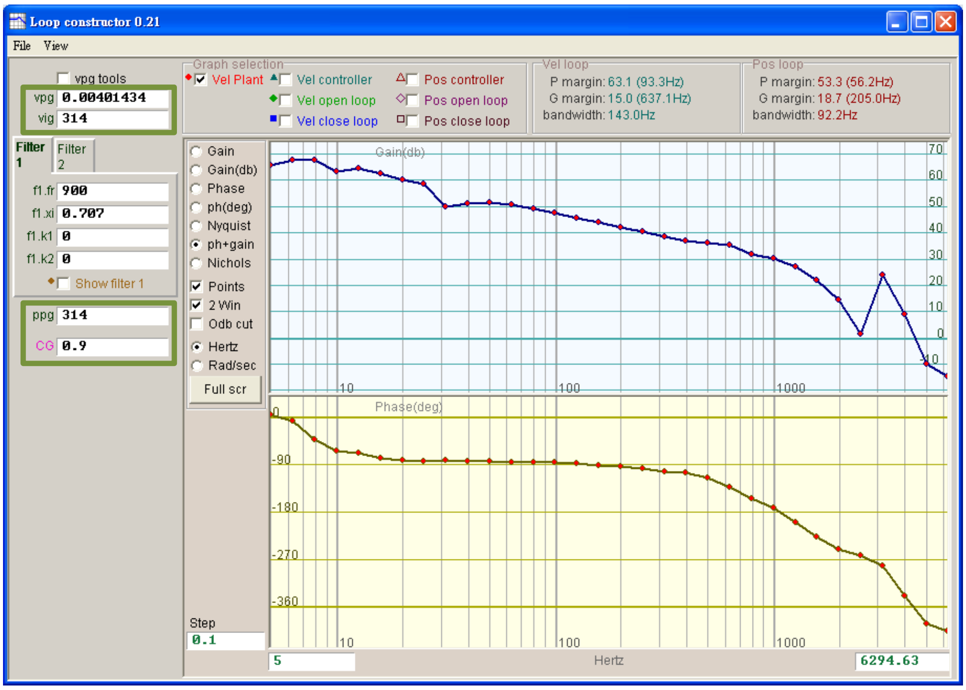


Figure 6.7.4.1 Loop constructor – gains

- **Velocity loop**

  Gains of velocity loop includes vpg and vig. The proportional gain of velocity loop is vpg, and the integral gain of velocity loop is vig.

  - vpg: Tuning vpg affects the transient response of velocity loop and increases the bandwidth of velocity loop.

  - vig: Tuning vig affects the steady-state error of velocity loop, but the excessive adjustment may cause instability of the system.

- **Position loop**

  The proportional gain value of position loop is ppg.

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

6.7.5 Spectrum analysis

"Loop constructor" provides phase margin (P margin), gain margin (G margin), and the bandwidth of velocity loop and position loop, as Figure 6.7.5.1 shows. This function can be performed to simulate the stability of control system. Refer to Section 3.6 for more information.

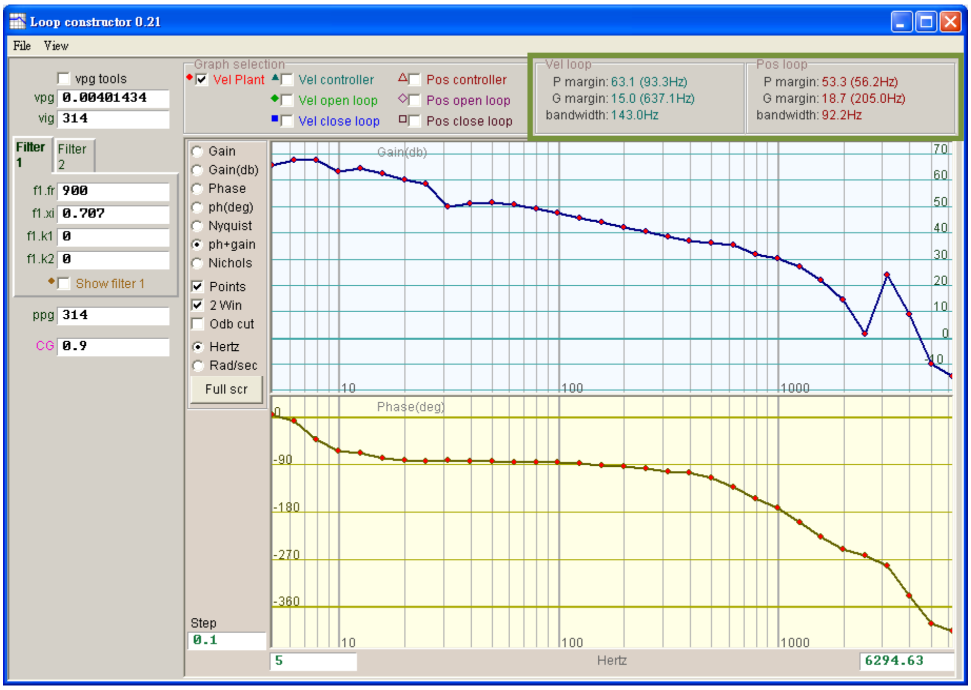


Figure 6.7.5.1 Loop constructor – P margin and G margin

6.8 Encoder signal confirmation

An encoder usually plays an important role in servo motor control. It provides the information of positions or angles for the drive to control servo loop. For D2T-LM series drive, the encoder output signal can be ensured via HMI.

- **Encoder signal confirmation function**

  Click  in the window of Performance center, or select the “Encoder test/tune” option on the function menu of “Tools”. The function window will appear for users to observe whether encoder value or signal is normal, as Figure 6.8.1 shows.

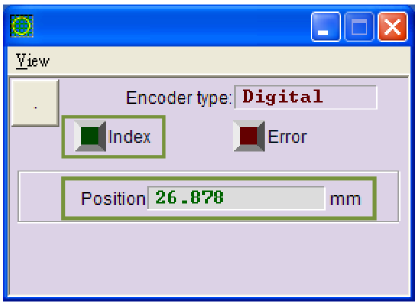


Figure 6.8.1 Digital encoder

- **Encoder value confirmation**

  Digital encoder signal is mainly comprised of two digital pulses with 90°-phase difference. For D2T-LM series drive, users can check whether the encoder value is correct through this function. For example, move the motor with a known distance in manual operation to check whether the read “Position” is the same as the moved distance.

- **Index signal confirmation**

  Through the “Index” light in Figure 6.8.1, the Z-phase signal of the encoder can be used to ensure whether the signal is normally received. When the drive gets a Z-phase signal, the “Index” light in the window flashes green.

6.9 Error map function

Generally, the accuracy of the motor is determined by the linear encoder used on the positioning platform. The positioning accuracy is usually measured and corrected by the laser interferometer to get the error table. D2T-LM series drive comes with an error map function, which inputs and saves the error table to the drive via HMI. To enhance the positioning accuracy, the drive calculates the value of error compensation by adopting linear interpolation between fixed distances.

After measuring the positioning accuracy and obtaining the error table, set compensation interval ("Interval") and total compensation points ("Total points") first, and then enter the error compensation values to the table one by one.

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

6.9.1 Set error map

The steps of enabling the error map function are described as follows.

Step 1. Go to Application center and select the "Error Map" tab to open the window of error map function, as Figure 6.9.1.1 shows.

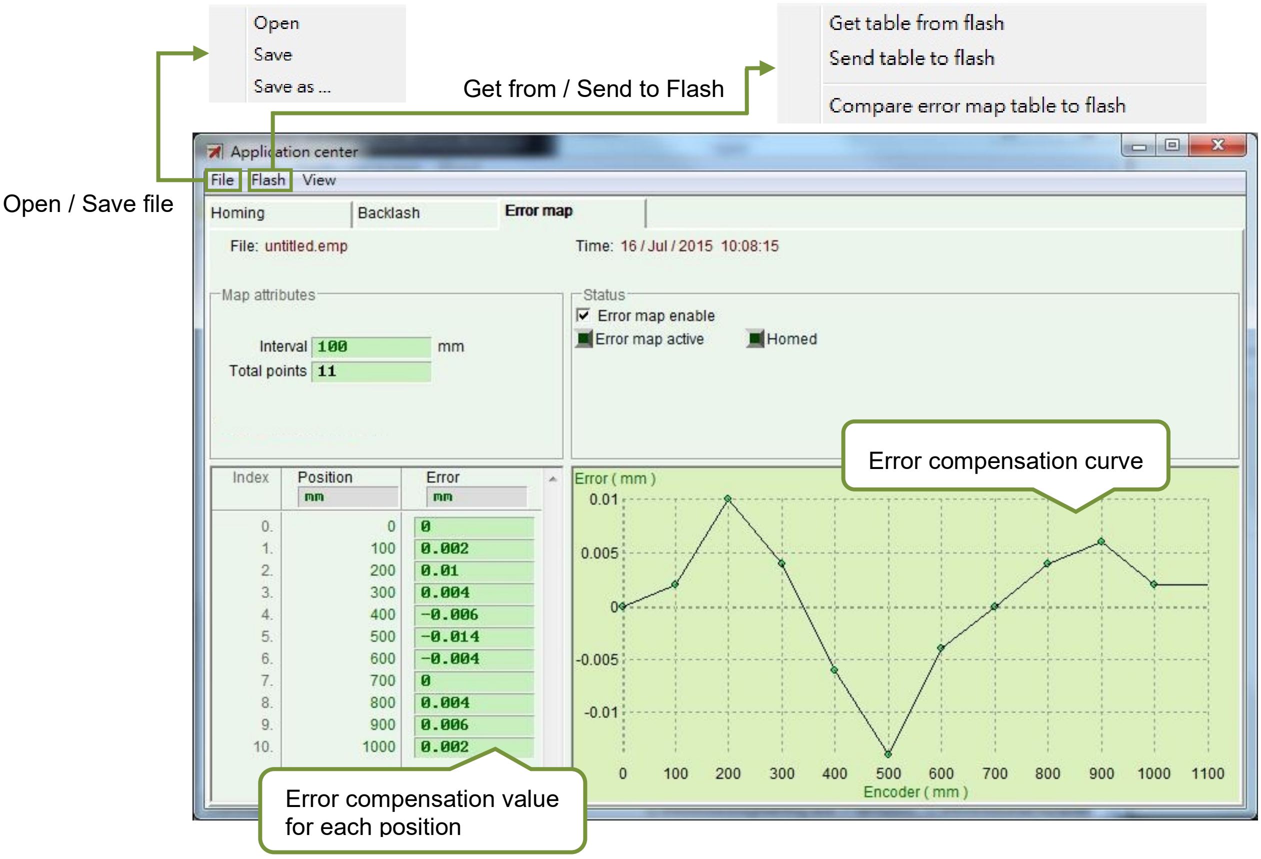


Figure 6.9.1.1 Error map window

Step 2. Set compensation interval ("Interval") and total compensation points ("Total points"), and enter the error compensation values to the "Error" column. Click the unit column to set the preferred unit. Take Figure 6.9.1.2 as an example, the compensation range is from 0 to 1,000 mm, the compensation interval is 100 mm, and the total compensation points are 11 points. The values in the "Error" column are obtained from the error measurement of the laser interferometer. For example, when the target position is 100 mm, the laser measurement reports 100.002 mm.

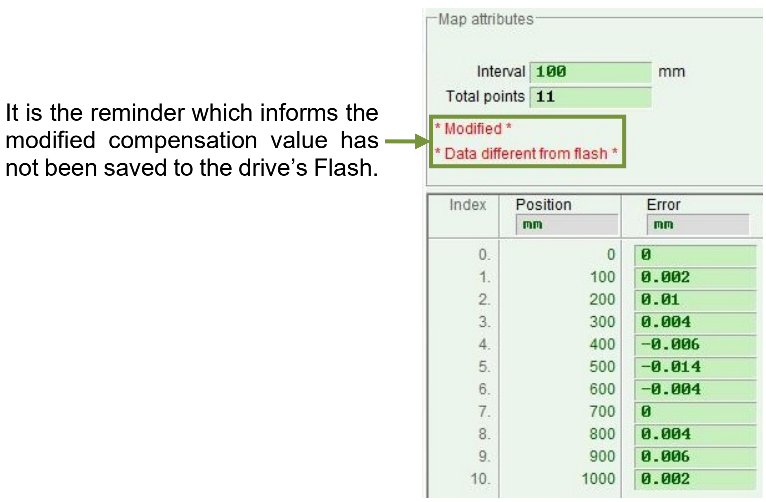


Figure 6.9.1.2 Parameter setting of error map

Note 1: After users enter the error compensation value to the table, the entered value is rounded to an integer multiple of the encoder resolution. For example, if the encoder resolution is 2 um and the entered compensation value is 1 um, the program will forcibly convert it to 2 um. If the input value is 0.5 um, it will be converted to 0 um.

Note 2: Select appropriate unit for “Position” and “Error” because the displayed accuracy is only to the third decimal place.

Step 3. Check the “Error map enable” option (☑ Error map enable).

Step 4. Choose the “Send table to flash” option of “Flash” on the function menu. If other parameters (except error map parameters) still need to be modified and saved to Flash, the following window will appear. If all parameters are saved except for error map parameters, go to Step 6.

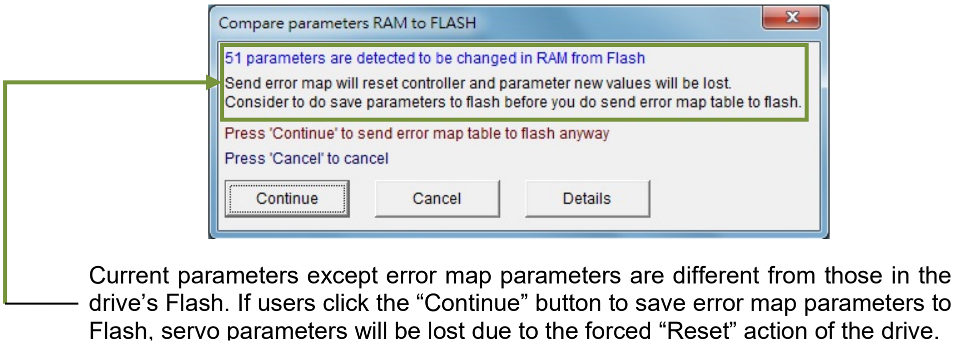


Figure 6.9.1.3

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

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

Figure 6.9.1.4

6.9.2 Enable error map

After setting the related error map parameters described above, the drive can do error compensation. As soon as the motor completes homing procedure, the drive will start the error map. There are two ways for D2T-LM series drive to complete the homing procedure, users can choose either of them for the operation.

- **Homing with the host controller**

  First, set the input function of “Home Ok, start err. map” in the I/O center (refer to Section 5.4). As Figure 6.9.2.1 shows, assume that the function is set at I2. To make the motor move to the home position, the host controller sends the motion command to the drive via pulse command or voltage command. After the motor moves to the home position, the host controller stops sending the motion command and sends a signal to I2 through its digital control output. If the drive receives this signal, it is considered that the homing procedure is completed. Then, the drive starts the error map function.

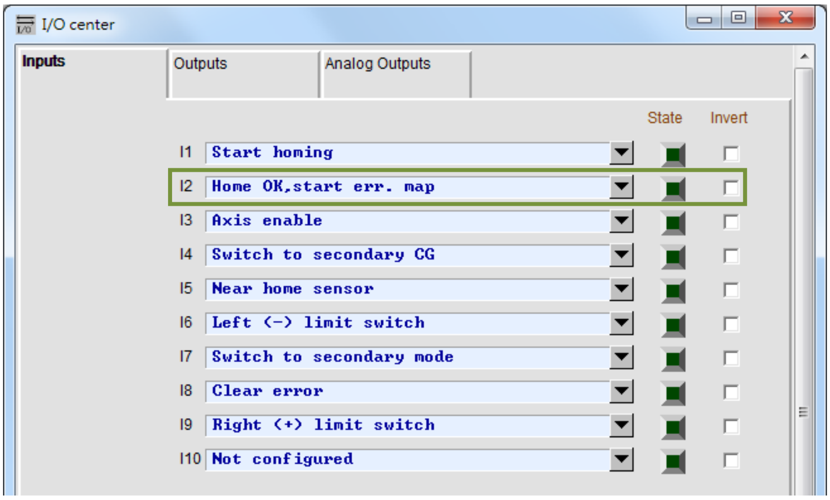


Figure 6.9.2.1

- **Stand-alone homing**

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

How to ensure whether the error map function is enabled

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

6.9.3 Save / open error map

The established error compensation values can be directly saved to the disk, and can also be directly read from the disk. As the following figure shows, click “File” on the function menu for the operation. As Section 6.9.1 mentions, the “Send table to flash” option of “Files” on the function menu can save the error map table to the drive’s Flash. Note that the “Save to Flash” button () in the main window cannot automatically save the error map table to the drive’s Flash (refer to Section 5.7.1).

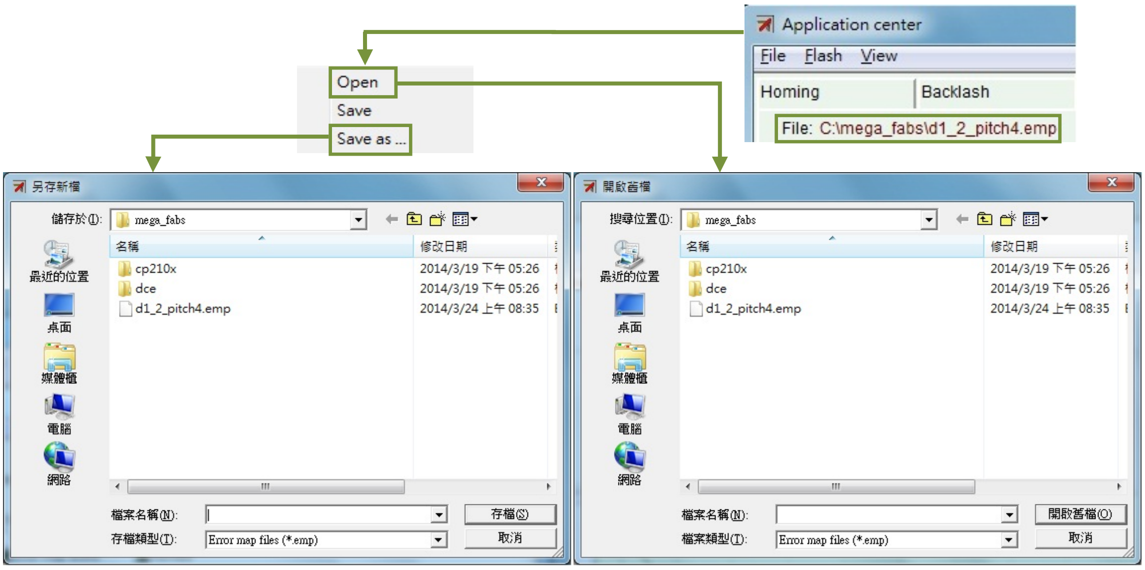


Figure 6.9.3.1

6.9.4 Change start position

To change the start position of error map, select the “Advanced” option of “View” on the function menu to display the window of Figure 6.9.4.1. Enter the required start position of compensation in the “Start position” column. If users press the “Next” button on the right side of the window, the motor will move forward the distance of one “Interval”. If users press the “Previous” button, the motor will move backward the distance of one “Interval”. The “Error” value in the “Status” area is updated as the error compensation value corresponding to the current position. The red dot on the “Error Map” graph is the “Encoder” value, and the “Feedback position” value equals the “Encoder” value plus the “Error” value.

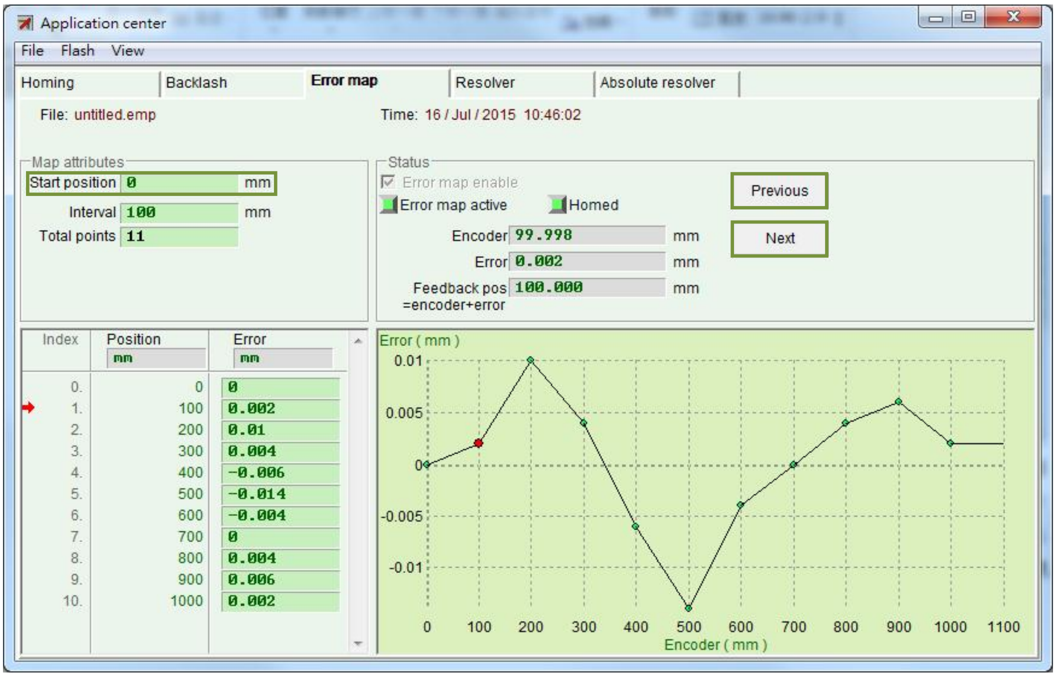
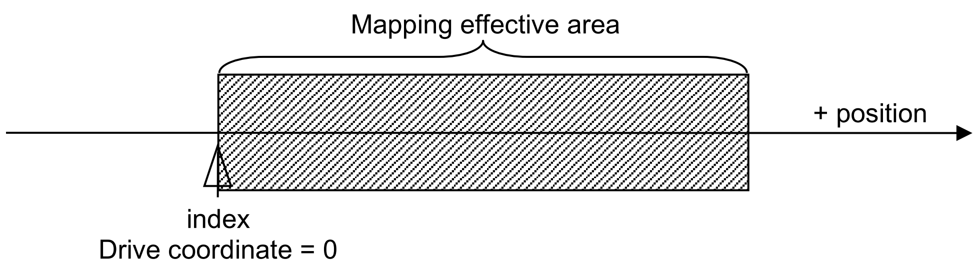


Figure 6.9.4.1

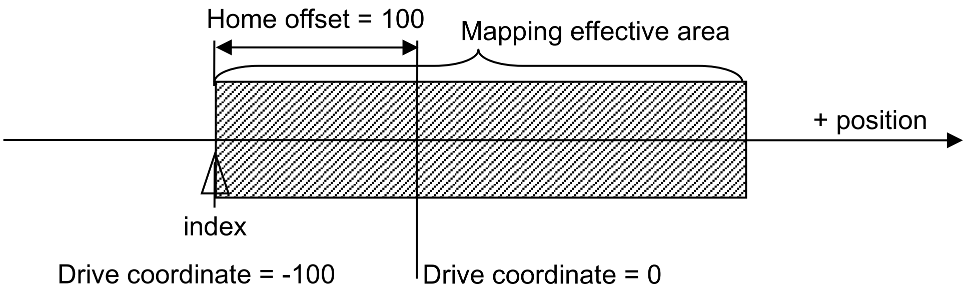
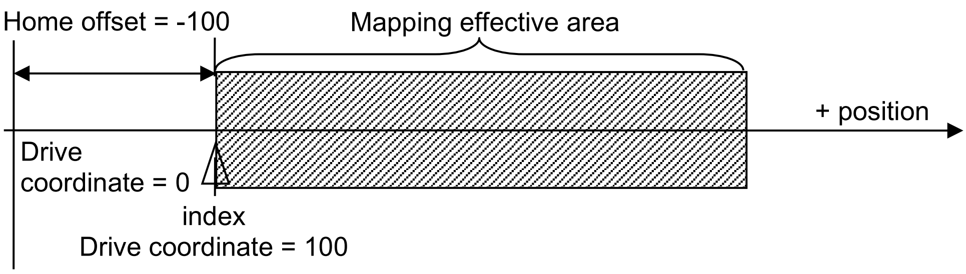
■ "Home offset" = 0 and "Start position" = 0

For the setting of both "Home offset" and " Start position" being zero, the effective range of error map takes the index as the boundary. The area from index toward positive direction is the mapping effective area, while the area from index toward negative direction is not.

Home offset	Start position	Mapping effective area
0 mm	0 mm	

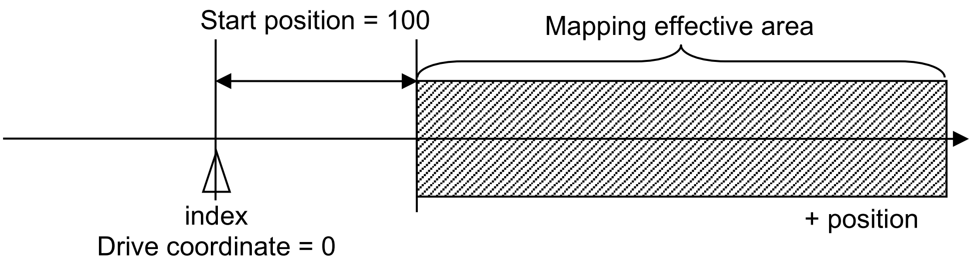
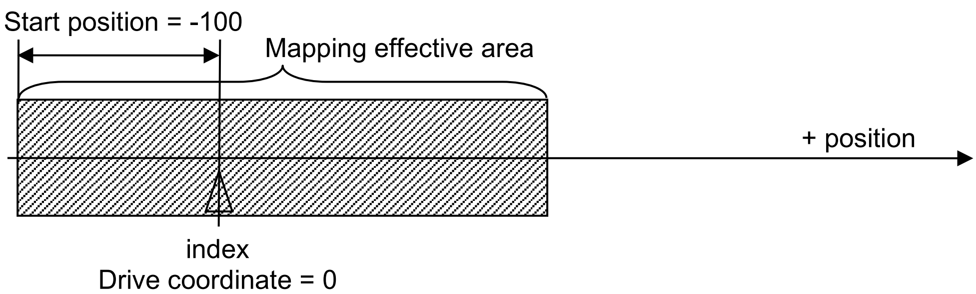
■ "Home offset" ≠ 0 and "Start position" = 0

For the setting of "Home offset" being non-zero and "Start position" being zero, the mapping effective area is the same as that for the setting of both "Home offset" and " Start position" being zero.

<table>
<tr><th>Home offset</th><th>Start position</th><th>Mapping effective area</th></tr>
<tr><td>100 mm</td><td>0 mm</td><td>
</td></tr>
<tr><td>-100 mm</td><td>0 mm</td><td>
</td></tr>
</table>

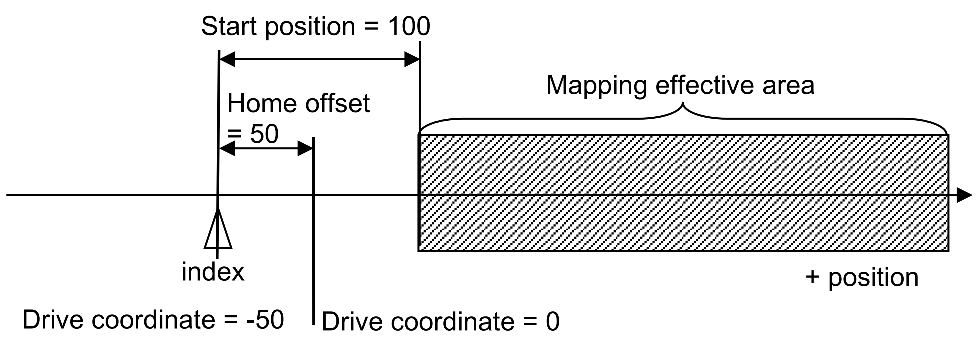
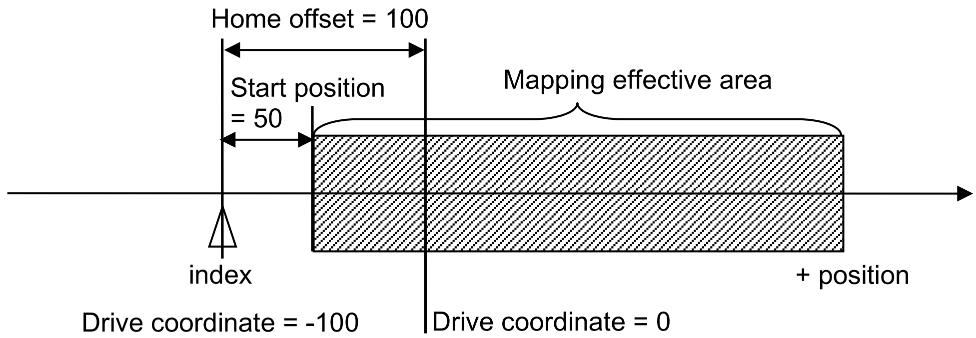
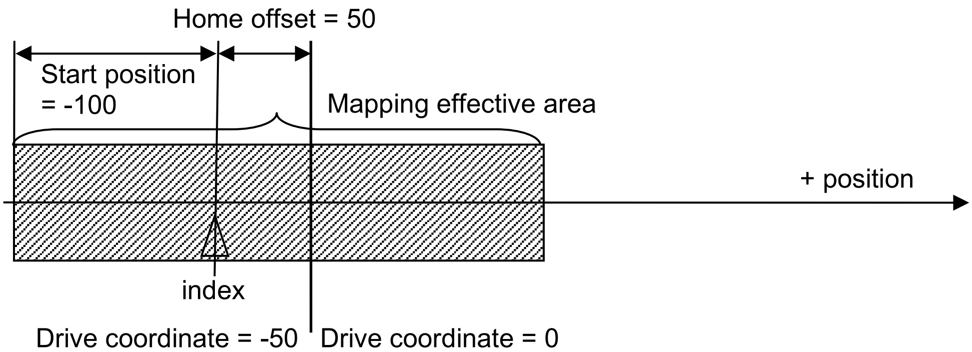
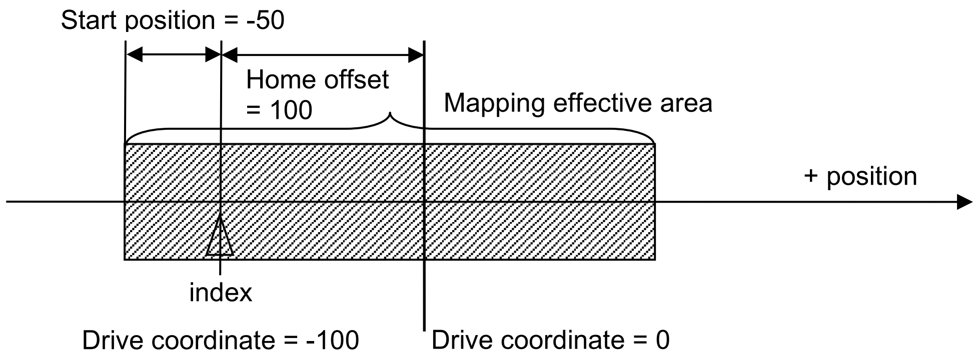
- "Home offset" = 0 and "Start position" ≠ 0

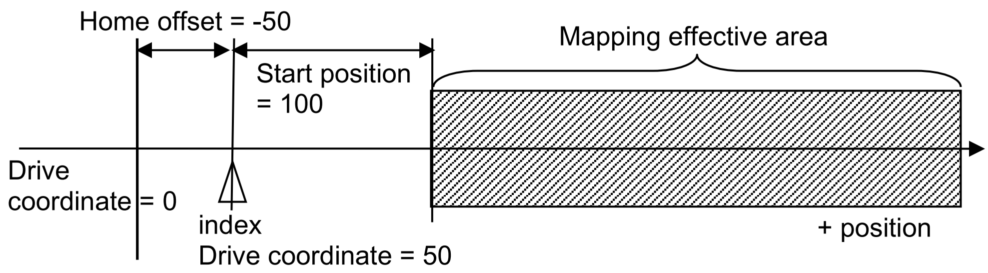
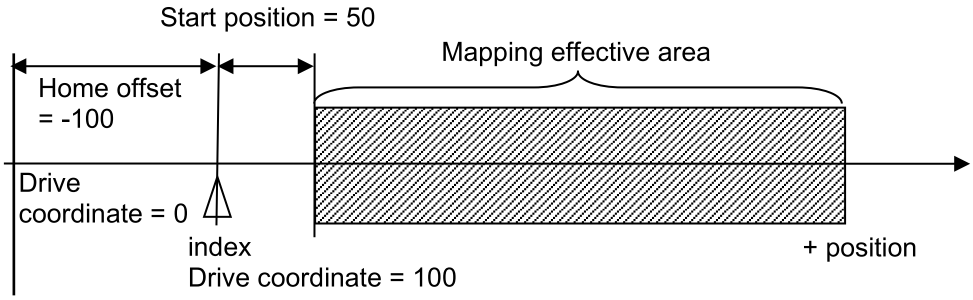
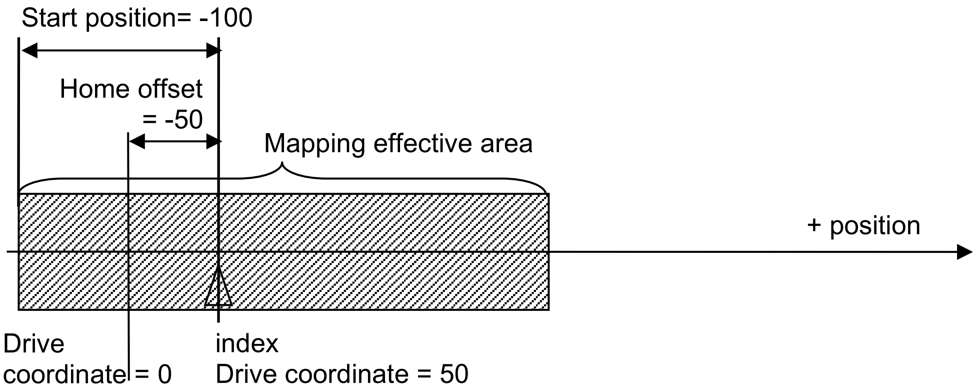
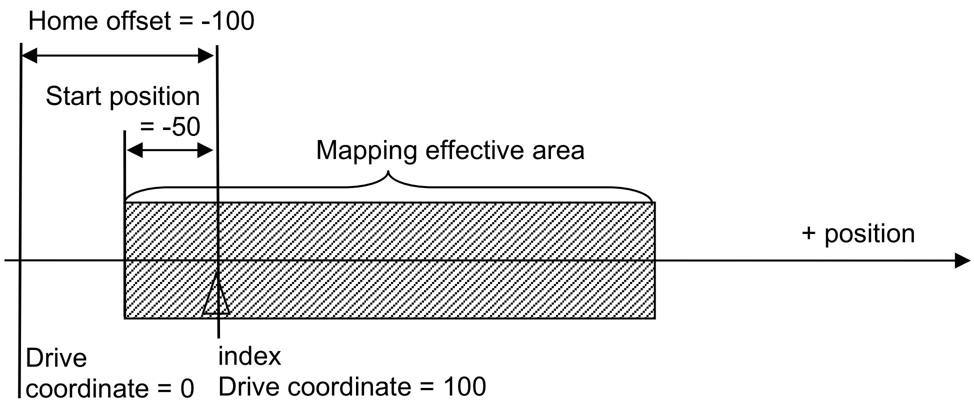
  For the setting of "Home offset" being zero and "Start position" being non-zero, the mapping effective area takes the index as the reference and moves corresponding to "Start position".

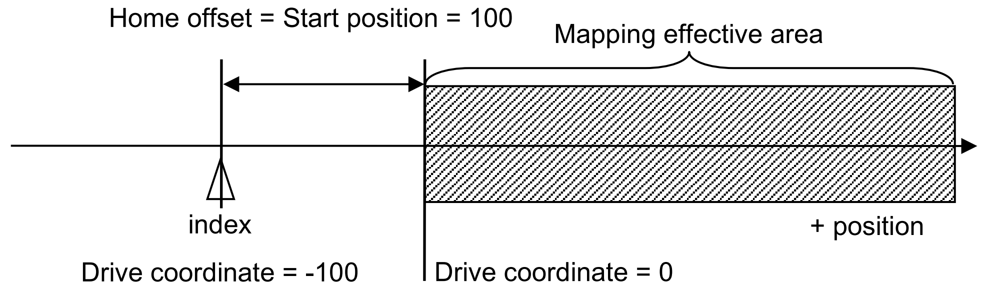
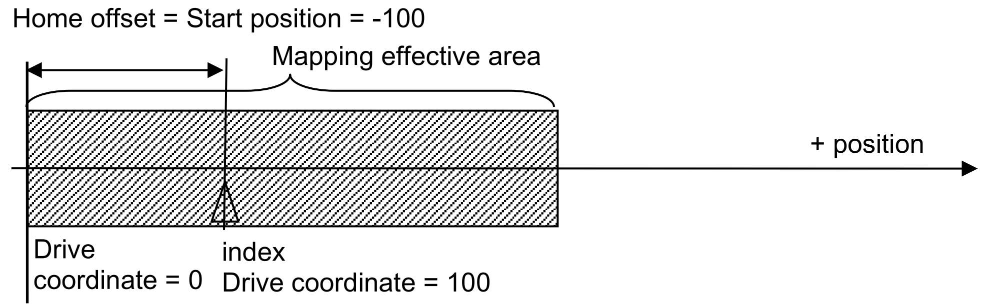
<table>
<tr><th>Home offset</th><th>Start position</th><th>Mapping effective area</th></tr>
<tr><td>0 mm</td><td>100 mm</td><td>
</td></tr>
<tr><td>0 mm</td><td>-100 mm</td><td>
</td></tr>
</table>

■ "Home offset" ≠ 0 and "Start position" ≠ 0

For the setting of both "Home offset" and " Start position" being non-zero, the mapping effective area does not change with "Home offset", but moves with "Start position".

Home offset	Start position	Mapping effective area
50 mm	100 mm	
100 mm	50 mm	
50 mm	-100 mm	
100 mm	-50 mm	

Home offset	Start position	Mapping effective area
-50 mm	100 mm	
-100 mm	50 mm	
-50 mm	-100 mm	
-100 mm	-50 mm	

Home offset	Start position	Mapping effective area
100 mm	100 mm	
-100 mm	-100 mm	

7. LCD

7.1 Panel description

LCD panel mainly displays the status of servo ready, error or warning message, and axis name.

Note: D2T-LM model does not support parameter editing function.

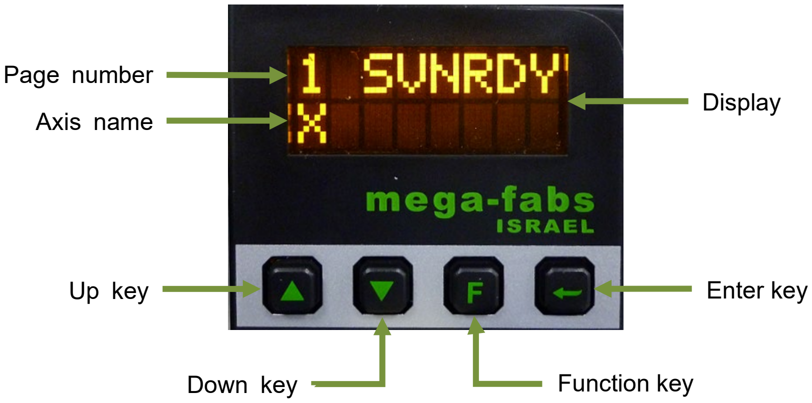


Figure 7.1.1 LCD panel

Table 7.1.1 Description of panel function

Name	Function
Display	Display the change of parameter value, status, parameter, action, etc.
Page number	LCD display is divided into four pages. The current page number is shown at the top-left corner.
Axis name	The axis name is displayed on the first page (home page) and can be modified in HMI main window. (Refer to Section 5.1.3.) Messages will also be displayed if there are errors or warnings.
Up key	Unavailable in D2T-LM model.
Down key	Unavailable in D2T-LM model.
Function key (F key)	Unavailable in D2T-LM model.
Enter key	Unavailable in D2T-LM model.

7.2 Display description

When the drive is power-on, display will show the status of servo ready first. The LCD display symbols are given in the following table.

Table 7.2.1 LCD display symbol of the status of servo ready

LCD display symbol	Description
SV RDY	Servo is ready.
SVNRDY	Servo is not ready.

When the drive detects the occurrence of error or warning, its message will be displayed on the second line of the screen, as Figure 7.2.1 shows. The LCD display symbols of error and warning message are respectively described in Table 7.2.2 and Table 7.2.3.

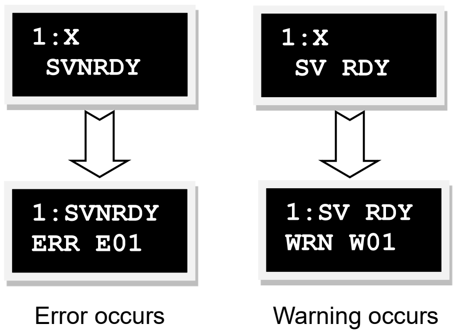


Figure 7.2.1

Table 7.2.2 LCD display symbol of error message

No.	LCD display symbol	Error message displayed on Lightening
1	ERR E01	Motor short (over current) detected
2	ERR E02	Over voltage detected
3	ERR E03	Position error too big
4	ERR E04	Encoder error
6	ERR E06	Motor maybe disconnected
7	ERR E07	Amplifier over temperature
9	ERR E09	Under voltage detected
10	ERR E10	5V for encoder card fail
11	ERR E11	Phase initialization error
12	ERR E12	Serial encoder communication error
13	ERR E13	Hall Sensor Error
15	ERR E15	Current Control Error
17	ERR E17	Hybrid deviation too big

18	ERR E18	STO active
19	ERR E19	HFLT inconsistent error
21	ERR E21	Incompatible motor model and drive
22	ERR E22	DC bus voltage abnormal
23	ERR E23	EtherCAT interface is not detected
24	ERR E24	CiA-402 homing error
25	ERR E25	Fan fault error
26	ERR E26	Drive overload error

Table 7.2.3 LCD display symbol of warning message

No.	LCD display symbol	Warning message displayed on Lightening
1	WRN W01	Left SW limit
2	WRN W02	Right SW limit
3	WRN W03	Left HW limit
4	WRN W04	Right HW limit
5	WRN W05	Servo voltage big
6	WRN W06	Position error warning
7	WRN W07	Velocity error warning
8	WRN W08	Current Limited
9	WRN W09	Acceleration Limited
10	WRN W10	Velocity Limited
11	WRN W11	Both HW limits are active
12	WRN W12	I2T Warning
13	WRN W13	Homing Fail
14	WRN W14	Pulse command and homing conflict
15	WRN W15	Absolute encoder battery warning
16	WRN W16	Wrong absolute position

8. Protection Function

8.1 Motion protection

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

Table 8.1.1

Limit parameter / Operation mode	Velocity	Acceleration	Deceleration	Emergency stop deceleration
Position mode	O	O	O	O
Velocity mode	O	O	O	O
Force / Torque mode	O	X	X	X
Stand-alone mode	O	O	O	O

Note: "O" indicates active, while "X" indicates inactive.

■ **Speed, acceleration, and deceleration limits**

Click  to enter Performance center to display motion protection configuration page, as Figure 8.1.1 shows. To observe the same setting of motion protection, click  to enter Performance center and get it from the "Motion parameters" area in the "Protection" tab. However, this area cannot be modified, it can only be displayed.

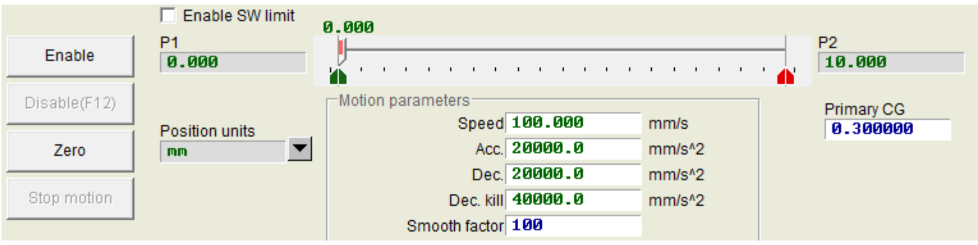


Figure 8.1.1

Table 8.1.2

Parameter	Description	Default value
Speed	Set maximum velocity of the motor during motion	100 mm/s
Acc.	Set maximum acceleration of the motor during motion	20,000 mm/s^2
Dec.	Set maximum deceleration of the motor during motion	20,000 mm/s^2
Dec. kill	Set deceleration of the motor for emergency stop	2 * Acc
Smooth factor	Smooth factor	100

As Figure 8.1.1 shows, the "Motion parameters" area displays maximum speed, maximum acceleration, and maximum deceleration of movement. Users can set the preferred unit by clicking "Position units". These settings are not only for motion protection, but they also can be the parameters for test run. Therefore, when the motion function ("P2P", "Relative move", or "Jog") in Performance center is used, it is important for users to check whether the data in the "Motion parameters" area is the users' motion protection setting (as Figure 8.1.2 shows). On the position mode or velocity mode, make sure to multiply the required value of "Acc." and "Dec." by 10 times to avoid being limited by the motion protection function. If this action is ignored, the desired speed or acceleration / deceleration may not be achieved when the motion command is sent from the host controller.

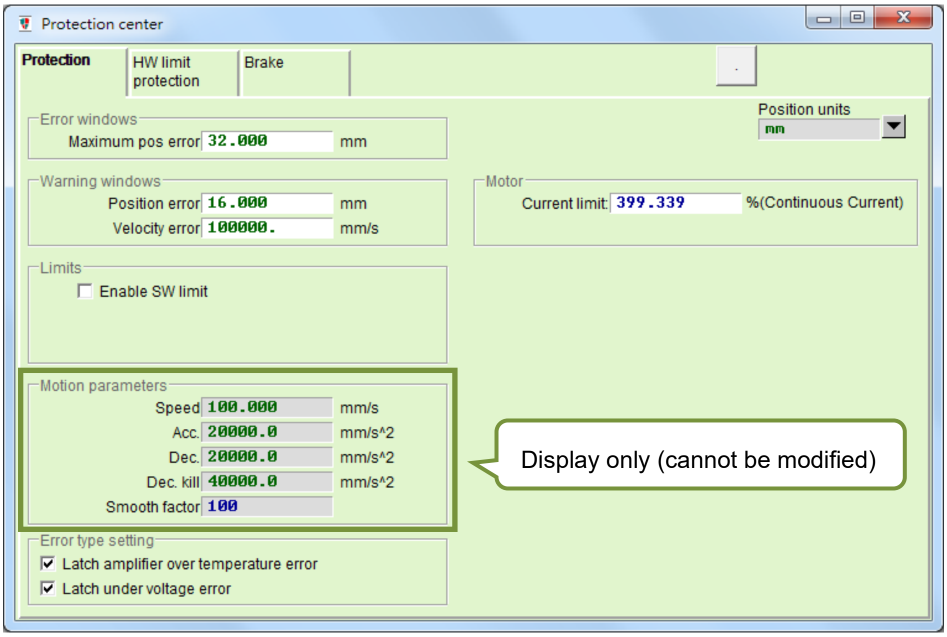


Figure 8.1.2

- **Cancel speed, acceleration, and deceleration limits**

  On the position mode, when "Smooth factor" is set as 0, it indicates that the drive's limit functions of speed, acceleration and deceleration are cancelled. The motor movement completely follows the path planning based on the pulse commend sent from the host controller. Users can decide whether to cancel the drive's limit function based on the requirement.

- **Applicable scope of emergency stop deceleration**

  The emergency stop deceleration ("Dec. kill") will be activated in the following cases.

  A. On the position and velocity modes, it is the deceleration when the motor in motion is disabled to the emergency stop condition.

  B. When executing "P2P" or "Relative move" in Performance center, it is the deceleration after the "Stop motion" button is pressed.

C. When executing the homing procedure, it is the deceleration after the home position is found.

D. Under “Jog” mode, it is the deceleration when the “Jog” motion is stopped.

“Dec. kill” is used for the case which requires a high deceleration. Thus, it is recommended to set “Dec. kill” based on the maximum capacity of the motor. The formulas are described as follows.

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

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

- **Smooth motion**

The function of smooth motion is to reduce the impact of motor force to the load in the acceleration / deceleration phase of the motion process. This purpose is achieved by setting “Smooth factor”, a parameter designed according to the number of samples in the moving average filter (as Figure 8.1.3 shows). The relationship between filter time constant and “Smooth factor” is described as follows.

Not CoE model filter time constant = “Smooth factor” × 0.5333 ms

CoE model filter time constant = “Smooth factor” × 0.5 ms

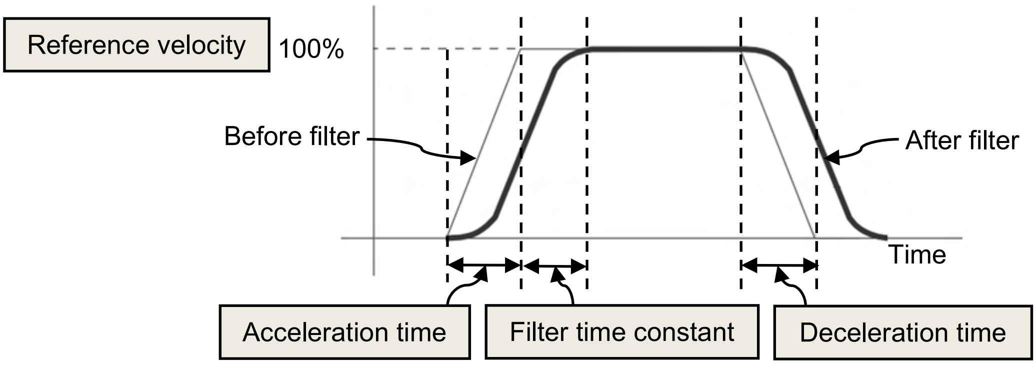


Figure 8.1.3

The value of “Smooth factor” ranges from 1 to 500. The higher the value is, the smaller the impact is. When the value is 1, there is no effect on smooth function. Increasing the value of “Smooth factor” reduces the influence on motor force. In some cases, it enhances the settling performance during the process of positioning. However, the Move time of path planning will unavoidably increase when the motion becomes smoother (refer to Section 3.7). Users have to test on the machine to find the balance between them.

8.2 Position and velocity error protection

8.2.1 Position error limit

The position error exists in servo control. It usually becomes bigger when the motor moves. Some external factors may also make the position error becomes abnormally big. For example, bearings or linear guideways on the mechanism have a high friction due to the lack of lubrication, the winding or cable tray is too tight, foreign objects invades the motor travel, the motor hits the foreign object or the hard stop, and the position encoder is abnormal or interfered, etc. To avoid all kinds of abnormalities causing the position error being too big, D2T-LM series drive comes with an “Error windows”. When the position error exceeds this “Error windows”, the drive will generate an error message of “Position error too big”. Then, it will start the emergency stop procedure, send the brake signal, and disable the motor. Refer to “maximum pos error” in Figure 8.2.1.1 for the setting.

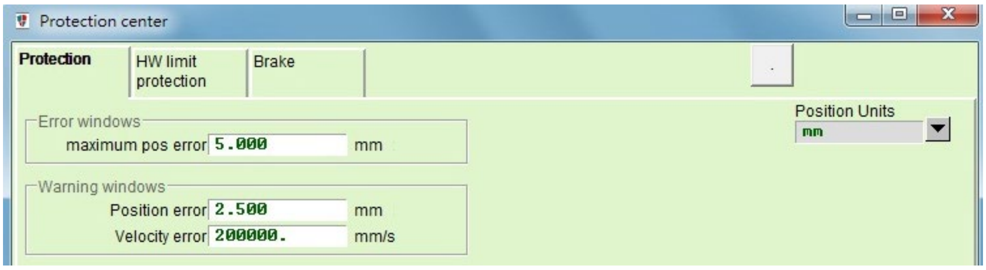


Figure 8.2.1.1

Table 8.2.1.1

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

8.2.2 Position error and velocity error warnings

Besides the setting of position error limit described above, D2T-LM series drive also provides an early warning function. When the position error or velocity error exceeds the set value in “Warning windows”, the warning message will be displayed in the “Status” area of the main window. Users are warned in advance that an abnormality has occurred.

8.3 Brake output

To protect the motor and the system structure, D2T-LM series drive provides a brake signal output for actuating an external electromagnetic brake, which is often used for motor actuation in the Z direction. In this application, there are some issues of timing motion. For example, when the motor moves in the Z direction and the drive receives a disable command, if the brake is directly activated at the high speed, the great shock will be generated to damage the mechanism. In addition, if the motor is disabled too early, the mechanism and the motor may slide down. D2T-LM series drive comes with proprietary brake parameters to reduce these risks.

Click to enter Protection center, and select the "Brake" tab to open the brake timing configuration page. The output pin of the brake can be set by clicking the "Set…" button on this page. The default pin is CN2_BRK. Click the "Set…" button to display the configuration page of I/O center. Refer to Section 5.4.2 for the setting method.

Brake configuration page

The brake configuration page is shown in Figure 8.3.1. After the drive receives the hardware input signal or the software disable operation, the following actions begin.

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

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

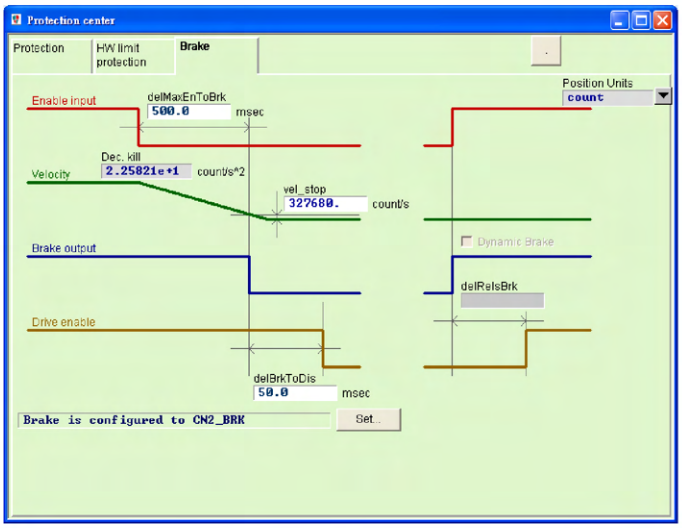


Figure 8.3.1

Table 8.3.1

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

8.4 Limit protection

8.4.1 Hardware limit protection

D2T-LM series drive comes with hardware limit protection. The hardware limit is usually a photoelectric switch or a micro switch installed on the positioning platform. It is used to identify the stroke of the mechanical movement. When the motor hits the hardware limit, emergency brake protection will be activated. Generally, the hardware limit switch is a normally closed sensor. When the hardware limit switch is touched, the drive stops the motor by emergency stop deceleration (“Dec. kill”). At this moment, the drive can only accept the motion command in the opposite direction.

After clicking  to enter Protection center, select the “HW limit protection” tab to open the hardware limits configuration page. To enable the hardware limit protection, the “enable HW limit” option (
) must be checked. The digital input pin of the hardware limit can be set by clicking the “Set…” button on this page. Click the “Set…” button to display the configuration page of I/O center. Refer to Section 5.4.1 for the setting method.

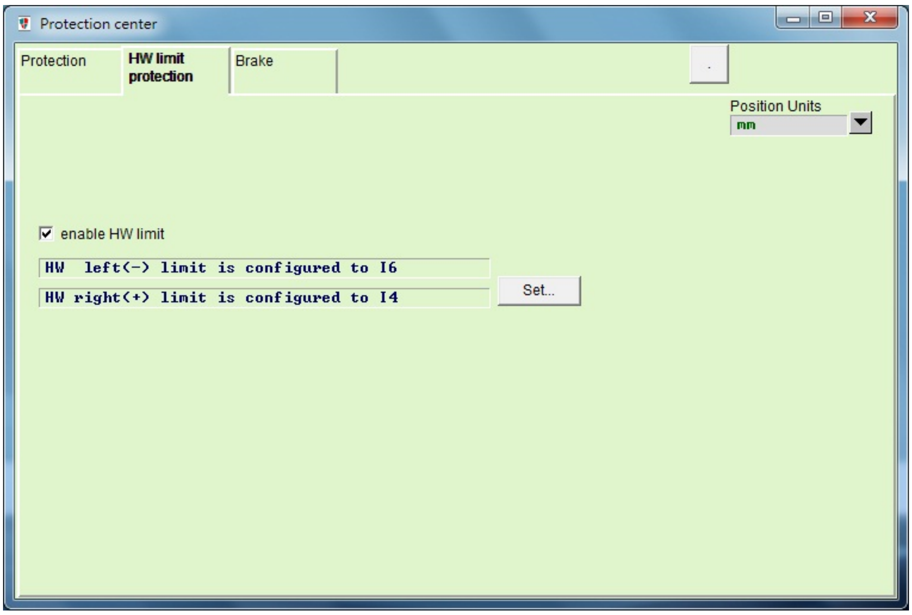


Figure 8.4.1.1

8.4.2 Software limit protection

Besides hardware limit protection, D2T-LM series drive also comes with software limit protection. When the motor reaches the coordinate position of the software limit, the drive can only accept the motion command in the opposite direction.

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

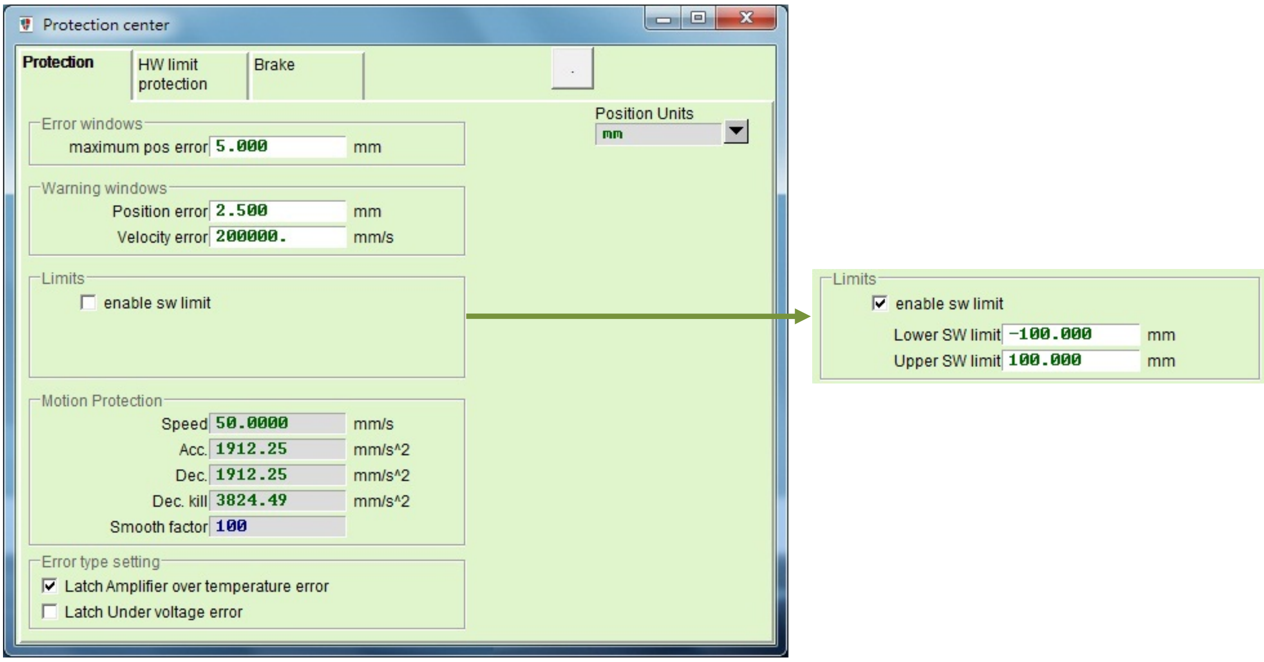


Figure 8.4.2.1

Table 8.4.2.1

Parameter name	Description
enable sw limit	Check it to activate the software limit protection.
Lower SW limit	Negative software limit position
Upper SW limit	Positive software limit position

8.5 Over temperature protection

8.5.1 Soft-thermal protection

D2T-LM series drive can estimate the motor temperature through software. D2T-LM series drive estimates the motor power by current output first, and then it estimates the motor temperature. If the motor current exceeds peak current for a long time and the linear motor's output has exceeded the software over-temperature protection limit threshold, the drive will issue a warning message of "I2T warning" and limit the motor current to continuous current to protect the motor. Select "I2T accumulator" in "Quick view" to observe the current estimation of the motor temperature.

8.5.2 Drive over temperature protection

D2T-LM series drive comes with the protection of drive over temperature. When the drive temperature reaches 80°C, the error message of "Amplifier over temperature" is displayed, and the motor is stopped.

8.6 Over voltage protection

When the motor is decelerating, the kinetic energy is converted into the thermal energy for the consumption, and the remaining energy charges the drive's capacitor. However, when the energy exceeds the capacity of the drive's capacitor, the energy must be consumed on the regenerative resistor in the regenerative circuit to protect the drive. The cut-in voltage of D2T-LM series drive's regenerative resistor is 370Vdc, and the drop-out voltage of that is 360Vdc.

HIWIN standard regenerative resistor models are given in Table 8.6.1. Users can use them in series or in parallel based on the requirement. The appearances and sizes are given in Table 8.6.2 and Figure 8.6.1.

Table 8.6.1

Regenerative resistor model	HIWIN Part No.	Resistance value	Rated power / Peak power
RG1	050100700001	68Ω	100W / 500W
RG2	050100700009	120Ω	300W / 1500W
RG3	050100700008	50Ω	150W / 750W
RG4	050100700019	50Ω	600W / 3000W

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

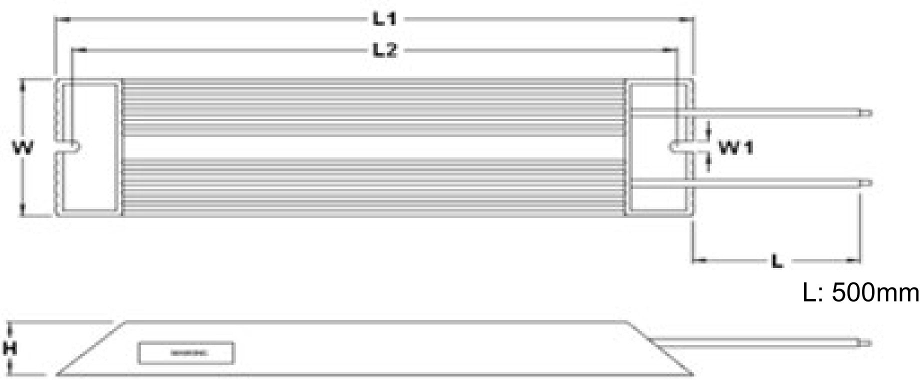


Figure 8.6.1

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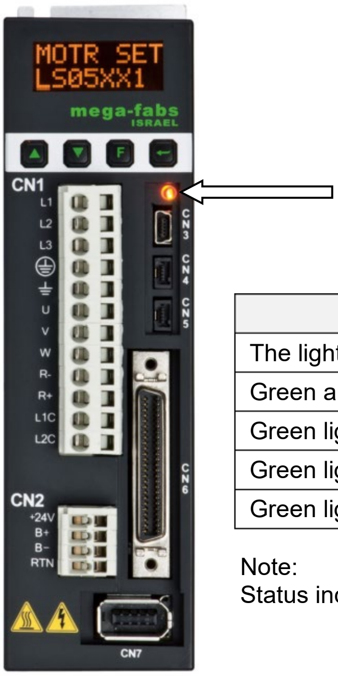
9. Troubleshooting

9.1 Drive's status indicator

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



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

Note:
Status indicator will look like orange when red and green lights are activated at the same time.

Figure 9.1.1

9.2 Drive's errors and warnings

9.2.1 Status display area in Lightening HMI main window

When D2T-LM series drive detects an error, it not only starts the protection mechanism but also displays the last error message in the error message display area ("Last error"), as Figure 9.2.1.1 shows. Users can judge the error condition of the drive based on the message. On the other hand, when the event needed to be warned occurs during the operation, the warning message will be shown in the warning message display area ("Last warning").

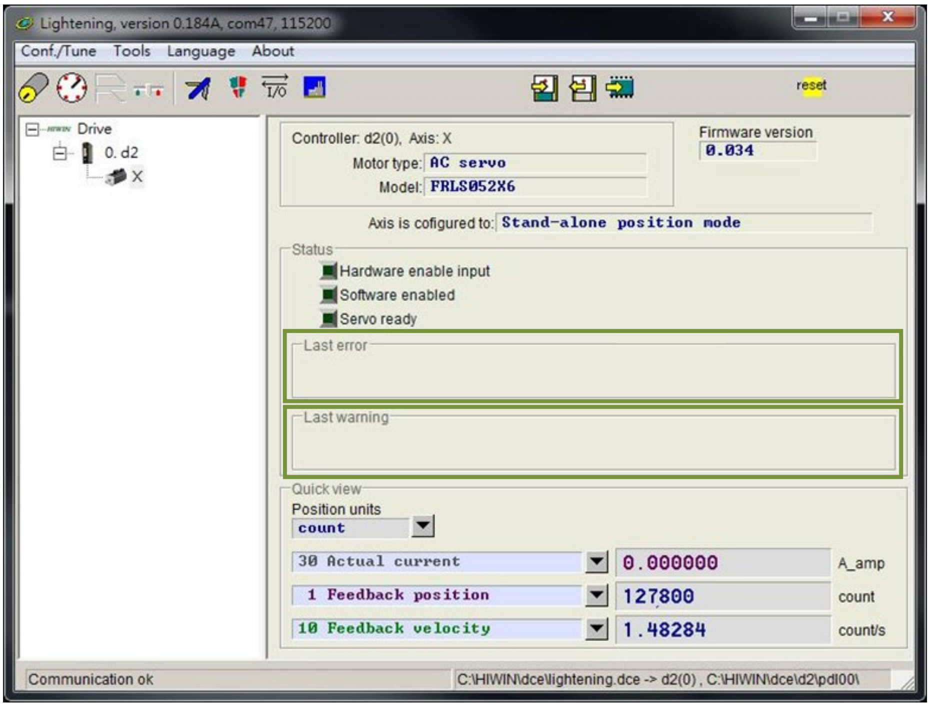


Figure 9.2.1.1 Status display area

9.2.2 Errors and warnings log

When an error or a warning event is detected by D2T-LM series drive, it is not only shown in the error message display area or the warning message display area (as Figure 9.2.1.1 shows) but also recorded in "Errors and warnings log". The method to open "Errors and warnings log" is given in Figure 9.2.2.1.

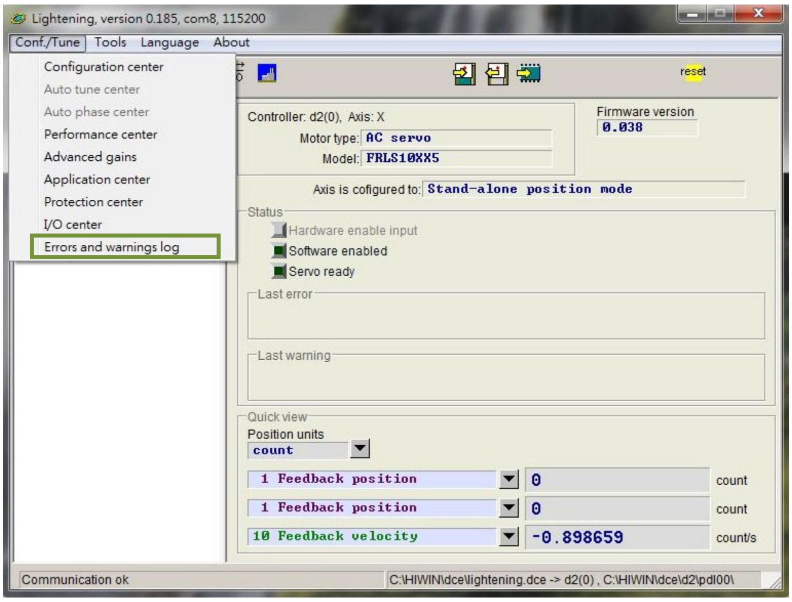


Figure 9.2.2.1 Open “Errors and warnings log”

To prevent users from losing the error and warning messages reported by the drive, Lightening provides this function. The occurred error and warning messages, also the number of times, are recorded in “Errors and warnings log” after the drive is powered on. Refer to Figure 9.2.2.2 for the “Time log” tab in “Errors and warnings log”. All the occurred error and warning messages are chronologically recorded in the “Type of error/warning” column, and the occurrence time is recorded in the “Time (seconds)” column.

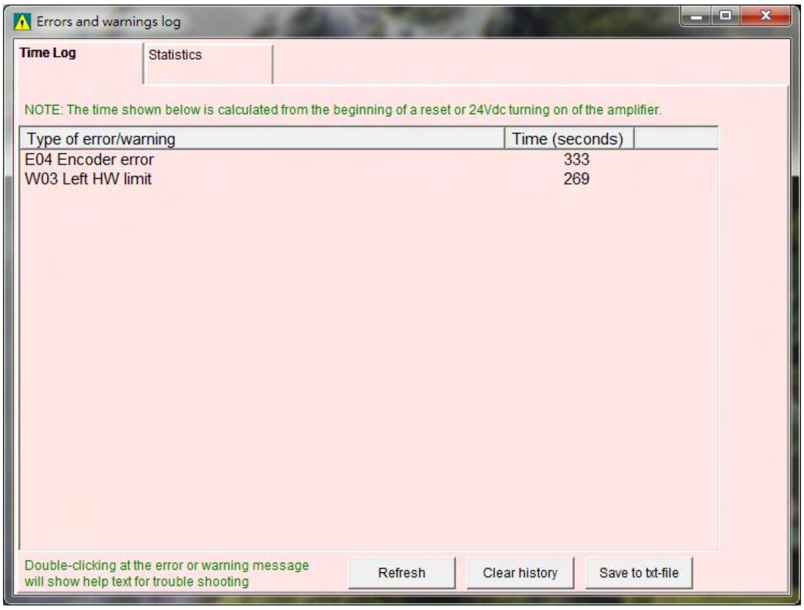


Figure 9.2.2.2 Time Log in “Errors and warnings log”

Refer to Figure 9.2.2.3 for the “Statistics” tab in “Errors and warnings log”. The number of times that errors or warnings occurring in the drive (“Frequency”) is recorded in this window. Users can realize which event occurs most frequently and find a way to debug it.

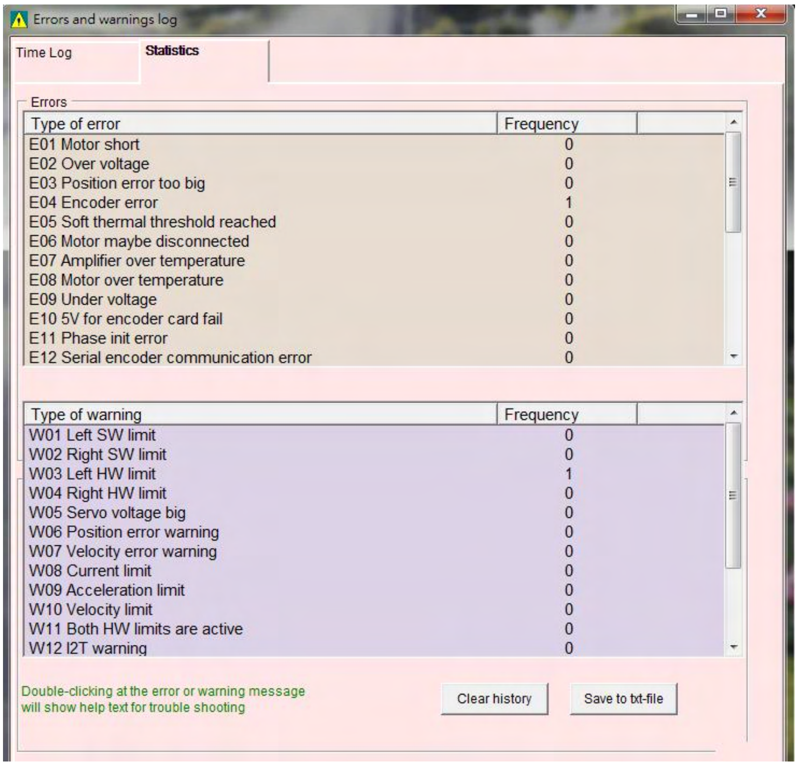


Figure 9.2.2.3 Statistics in “Errors and warnings log”

To know more about the content of errors and warnings, double click the name of the error or warning event to display the “Help tips” window. For example, as Figure 9.2.2.4 shows, if the error event of “E04 Encoder error” is clicked, the possible cause and solution can be obtained from this window.

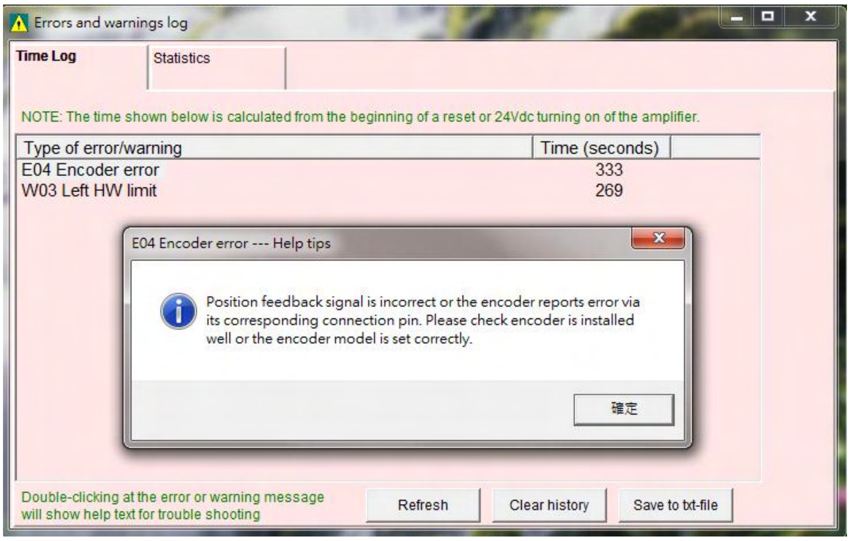


Figure 9.2.2.4 “Help tips” window in “Errors and warnings log”

9.2.3 Error at loading PRM file

To ensure the compatibility between the loaded PRM parameter file and the drive's firmware, Lightening will check if the PRM file is suitable for the current firmware version. When the error message in the following figure appears, it means that the PRM file is unsuitable. Users need to reset the parameters or get another appropriate firmware version. The number in the brackets indicates the PRM error situation. Refer to Table 9.2.3.1 for details.

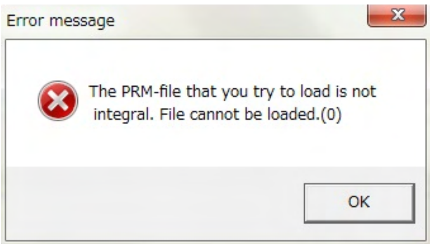


Figure 9.2.3.1

Table 9.2.3.1

Number	Description of PRM error situation
0	The MDP version of the loaded PRM file is greater than the drive's MDP version.

9.3 Error codes and troubleshooting

No.	Error	LCD error code	Description / Troubleshooting
1	Motor short (over current) detected	ERR E01	A three-phase short circuit of the motor is detected.
			(1) After power off, unplug the UVW-phase connector at the drive-side. Measure the resistance between each phase of UVW and Ground to check if there is a short circuit. If there is, the motor may be burned down. (2) Measure the line-to-line resistance between UVW phases of the motor to check if it is close to the specification. If it is lower than the specification a lot, the motor may be burned down. (3) Separate the motor from the motor power cable. Use a multimeter to check if the motor power cable is short.
2	Over voltage detected	ERR E02	The DC bus voltage in the drive exceeds the limit.
			When the motor has a heavy load and is operated at high speed, the back EMF exceeding the voltage limit will cause this error. Consider installing a regenerative resistor which is selected according to the load and the motion specification.
3	Position error too big	ERR E03	The position error is greater than “maximum pos error” set in the “Motion Protection” area.
			(1) Check if the gain tuning is improper. (2) Ensure that the maximum position error is properly set. (“Application center” → “Protection” → “maximum pos error”). (3) Check if the motor movement is obstructed. (4) Check if the load is too heavy. (5) Check if the guideway is out of maintenance for a long time. (6) Check if the cable tray is installed too tight. (7) “WRN W05” continues occurring before “E03”. Use 220V power.
4	Encoder error	ERR E04	The encoder signal is incorrect or the alarm pin reports an error.
			(1) Ensure that all encoder connectors are firmly connected. (2) Ensure that the encoder wiring is correct. (3) If it is a digital-type encoder, the cause of the error may be the external interference. Ensure that there is an anti-interference twisted wire and shield on the encoder cable, or the encoder cable is equipped with an iron core.
5	Soft-thermal threshold reached	ERR E05	Motor overload. (It is not supported by D2T-LM series drive.)
			(1) Ensure that the continuous current and the peak current during motor movement meet the motor’s specifications. (2) Check if the motor movement is obstructed. (3) The error can be eliminated by resetting and re-enabling the drive. However, if the current exceeds the motor’s specifications due to the load and the motor parameters, it may occur again. (4) Reduce the speed, acceleration, and deceleration. (5) Check if the motor model name or the motor current parameter is incorrectly set.
6	Motor maybe disconnected	ERR E06	The motor power cable is not physically connected to the drive.
			(1) Check if the connector of UVW cable is loose. (2) Check if the motor model name is incorrectly set.

No.	Error	LCD error code	Description / Troubleshooting
7	Amplifier over temperature	ERR E07	The drive is over temperature.
			(1) Ensure that the drive is placed in a well-ventilated location. (2) Check if the ambient temperature is too high. (3) Wait for the internal temperature of the drive to decrease. (4) To drive a large load or operate at a high duty cycle, install the heat sink if needed.
9	Under voltage detected	ERR E09	The DC bus in the drive is too small.
			Ensure that L1 and L2 of the drive are connected to 220Vac power source. Use a multimeter to check whether the input is 220 Vac.
10	5V for encoder card fail	ERR E10	The 5V power supply of encoder interface is abnormal.
			(1) Unplug CN6, CN7, and motor power cable of D2T-LM series drive to check whether there is still the error “ERR E10”. If yes, contact the manufacturer for maintenance. Otherwise, check if there is a short circuit and then modify the wiring. (2) Do not hot plug CN6 and CN7 of D2T-LM series drive.
11	Phase initialization error	ERR E11	Phase initialization of the motor fails.
			(1) Check if the encoder is abnormal and if the motor parameters are incorrectly set. (2) Check if the load is too high, if the friction is abnormally high, and if there is any obstacle in the stroke.
12	Serial Encoder Communication Error	ERR E12	There is an error in serial encoder communication.
			(1) Check if the encoder cable is connected to the drive. (2) Check if the encoder cable meets the motor’s specifications.
13	Hall sensor error	ERR E13	The less-wire encoder detects a hall signal error.
			Check if the encoder cable is correctly connected to the drive.
15	Current control error	ERR E15	There is an error in the current control.
			(1) Ensure that the motor model name is correctly set. (2) Ensure that the current-loop gain (“Kp”) and the servo gain (CG) are properly set. (3) Ensure that the encoder cable is correctly connected.
17	Hybrid deviation too big	ERR E17	Under the dual-loop control architecture, the hybrid control deviation exceeds the allowable maximum of hybrid control deviation. (Linear motor does not use dual-loop.)
			(1) Ensure that the linear encoder parameters are correctly set. (2) Check if the direction of the linear encoder is consistent with that of the rotary encoder, or if there is a signal interference in the linear encoder. (3) Check if the coupling is loose, if the gear is not tightly engaged, or if the pitch tolerance or the backlash of screw is too large.
18	STO active	ERR E18	The STO safety function is triggered.
			Reconnect STO to 24V after the risk has been removed, and then contact “DSF+” and “DSF-” for one second to release the error condition.
19	HFLT inconsistent error	ERR E19	Drive hardware’s signals conflict abnormally.
			Check the grounding of each cable.

No.	Error	LCD error code	Description / Troubleshooting
21	Incompatible motor model and drive	ERR E21	The motor model name is not compatible with the drive. Ensure that the motor model name is correct.
22	DC bus voltage abnormal	ERR E22	The DC bus voltage is abnormal. Ensure that the input voltage is correct.
23	EtherCAT interface is not detected	ERR E23	EtherCAT interface is not detected by the drive, or there is no EtherCAT interface. (1) Power cycle the drive to re-detect it. (2) The drive does not support EtherCAT. Ensure that the drive model is correct.
24	CiA-402 homing error	ERR E24	An error occurs while performing CiA-402 homing. This causes the failure of homing. (1) Ensure that the left and right limits, near home sensor, and index signals are normal. (2) Ensure that the homing method in use is appropriate.
25	Fan fault error	ERR E25	The fan system is abnormal. Check if the foreign objects are stuck in the fan.
26	Drive overload error	ERR E26	The motor operates over the rated current longer than the sustainable duration. Ensure that the motion condition is appropriate and the load is not too heavy.

Supplement for E03 error correction

(1) Modify the maximum position error through the steps described in Figure 9.3.1.

(2) It is not recommended to set the position error higher than the default value. If “ERR E03” appears at the default value, adjust servo stiffness.

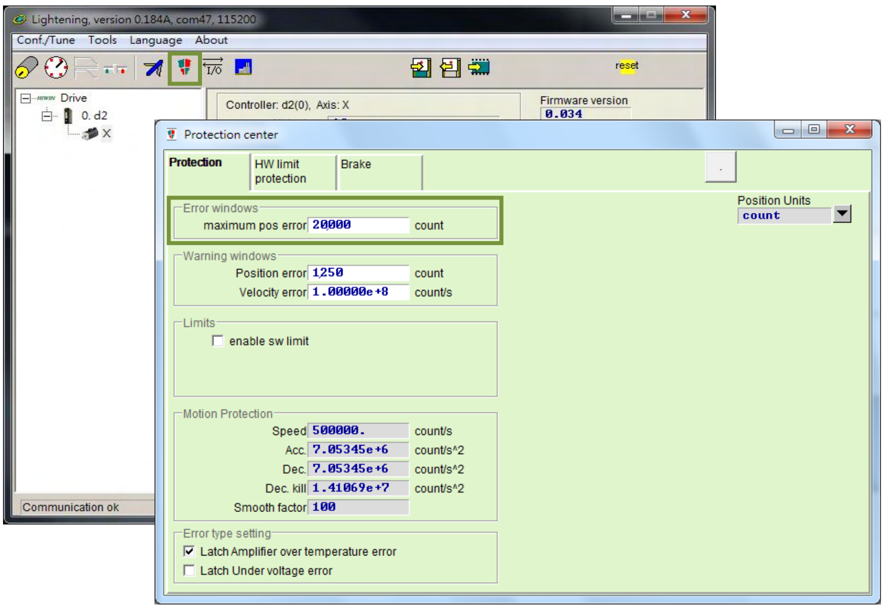


Figure 9.3.1

9.4 Warning codes and troubleshooting

No.	Warning	LCD warning code	Description / Troubleshooting
1	Left SW limit	WRN W01	The set left software limit has been reached. The motor can no longer move to the left.
2	Right SW limit	WRN W02	The set right software limit has been reached. The motor can no longer move to the right.
3	Left HW limit	WRN W03	The hardware limit switch on the left side has been detected. The motor can no longer move to the left.
			(1) If the hardware limit is not connected to the drive but is falsely triggered, cancel the enabling of the hardware limit. (2) If it is confirmed that the limit switch is not actually triggered, make sure that the wiring or actuation logic is correct.
4	Right HW limit	WRN W04	The hardware limit switch on the right side has been detected. The motor can no longer move to the right.
			(1) If the hardware limit is not connected to the drive but is falsely triggered, cancel the enabling of the hardware limit. (2) If it is confirmed that the limit switch is not actually triggered, make sure that the wiring or actuation logic is correct.
5	Servo voltage big	WRN W05	The drive's PWM output switch is greater than the limit value, and the current output cannot be increased. If this warning continues occurring in the position control, the error "ERR E03" will happen.
			(1) Change the power source to 220V. (2) Reduce the speed, acceleration, or deceleration.
6	Position error warning	WRN W06	The position error exceeds the set warning window for position error.
			(1) Ensure that the servo gain is properly tuned. (2) Check if the warning threshold is set too small. (3) Sometimes, this phenomenon may occur since the maintenance period is over but the lubrication is not implemented.
7	Velocity error warning	WRN W07	The velocity error exceeds the set warning window for velocity error.
			(1) Ensure that the servo gain is properly tuned. (2) Check if the warning threshold is set too small. (3) Sometimes, this phenomenon may occur since the maintenance period is over but the lubrication is not implemented.
8	Current Limited	WRN W08	The current reaches the specification of the motor peak current. If this warning keeps occurring, the error of "ERR E05" may happen and the motor may be disabled.
			(1) Reduce the speed, acceleration, or deceleration. (2) Decrease the load.
9	Acceleration Limited	WRN W09	In the position mode or the velocity mode, the acceleration protection setting is reached when the motor is moving.
			To increase the acceleration, increase the acceleration setting in the motion protection.
10	Velocity Limited	WRN W10	In the velocity mode or the torque mode, the velocity protection setting is reached when the motor is moving.

No.	Warning	LCD warning code	Description / Troubleshooting
			To increase the velocity, increase the velocity setting in the motion protection.
11	Both HW limits active	WRN W11	Both left and right hardware limits have been triggered. (1) If the hardware limit is not connected to the drive but is falsely triggered, cancel the enabling of the hardware limit. (2) If it is confirmed that the limit switch is not actually triggered, make sure that the wiring or actuation logic is correct.
12	I2T warning	WRN W12	The output of linear motor or torque motor has exceeded the software over-temperature protection limit threshold. Lower the motion conditions or reduce the load of the motor.
13	Homing fail	WRN W13	The homing procedure fails. (1) Ensure that left and right limits, near home sensor, and index signal are normal. (2) Ensure that “Time out” and “Search end stop current” are properly set.
14	Pulse command and homing conflict	WRN W14	In the position mode, the conflict situation of simultaneously receiving the pulse command and the homing command occurs. Do not send the pulse command and perform the built-in homing function at the same time.
15	Absolute encoder battery warning	WRN W15	The encoder battery has no power. Replace the battery.
16	Wrong absolute position	WRN W16	The absolute encoder sends the wrong absolute position back. Reset the home position.

Supplement for W03 and W04 warning correction

If the hardware limit is not connected to the drive and is falsely triggered, inactivate the hardware limit function.

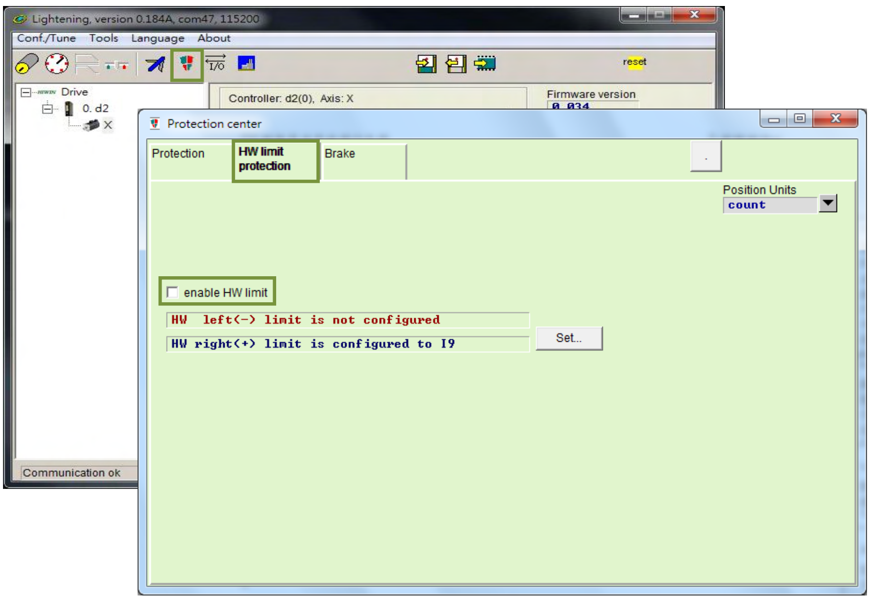


Figure 9.4.1

Supplement for W09 and W10 warning correction

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

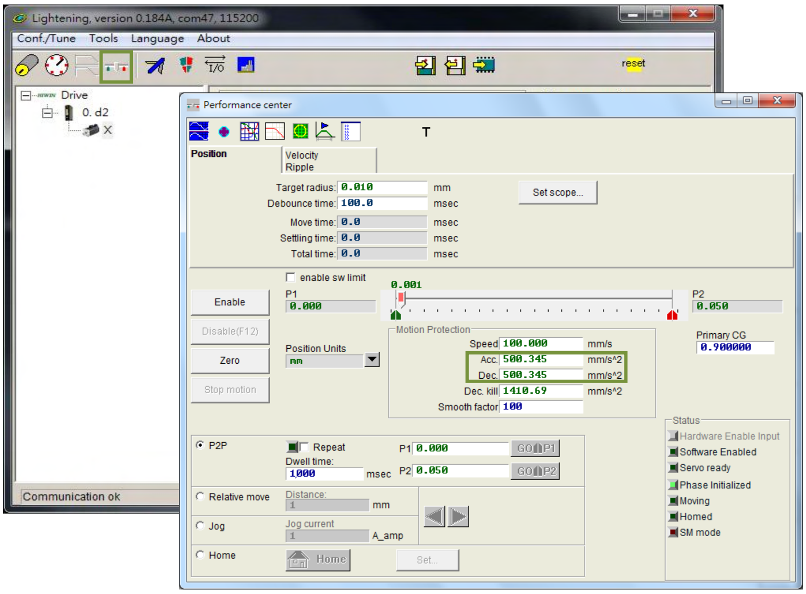


Figure 9.4.2

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

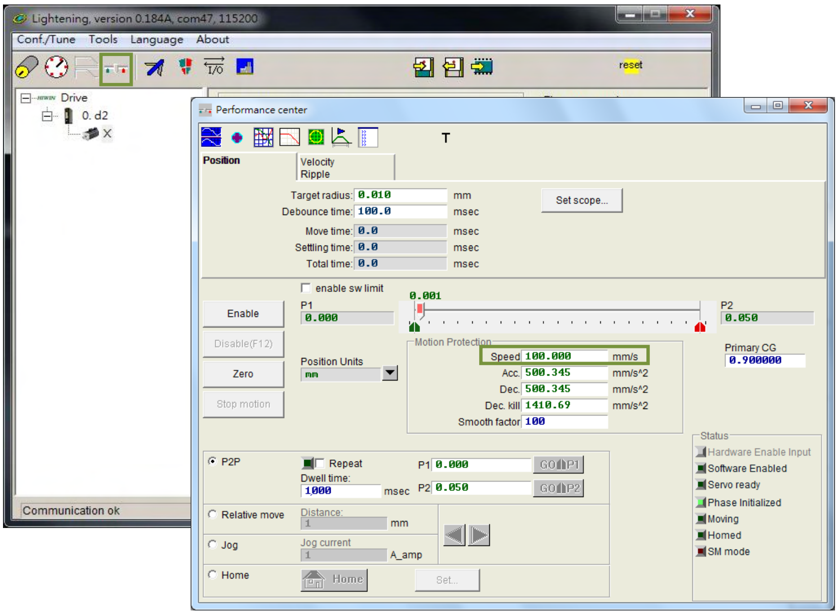


Figure 9.4.3

9.5 Troubleshooting for common issues

No.	Issue	LCD code	Troubleshooting
1	The speed or acceleration is limited when the motion command is sent through pulse or voltage command. Or, the host controller has sent out all pulse commands for movement, but the motor still slowly moves toward the target position.	WRN W10 WRN W09	Check if the speed, acceleration, and deceleration in the “Motion Protection” area of Performance center are set too small.
2	The motor moving direction is opposite to the user-defined direction.	None	(1) On the “Details” menu of Auto phase center, select “Toggle direction” to reset the motor moving direction. (2) Check the “Invert” option in the mode configuration page to invert the command.
3	“Error map” is not activated.	None	Open the “Error Map” tab in Application center to confirm the following items. (1) Ensure that the “Error map enable” option is checked. Refer to Section 6.9.2. (2) Ensure that the homing process is done, or the related homing signals are set in the “Input” tab.
4	After it is enabled, the motor moves without getting any commands.	None	(1) Use “Quick View” or “Scope” to check if “Target Position” has received the input pulse signal. (2) Check if the pulse signal cable is disconnected or poor contact. (3) Ensure that the signal of 0V is connected to the shield or the ground. (4) Ensure that the drive and the machine are grounded. (5) Add a core to the pulse cable for filtering if needed.
5	After it is enabled, the motor does not move when the command is sent out.	None	(1) Ensure that the command unit is correct. (2) Check if the speed or acceleration is set as 0. (3) Check if the “Enable SW Limit” option has been enabled. If yes, check if the value of “Upper limit” or “Lower limit” is correctly set. (4) After it is disabled, turn the motor’s spindle to ensure that the rotation is smooth.
6	The pulse command has been sent out, but the motor does not move.	None	(1) Use “Quick View” or “Scope” to check if “Target Position” has received the input pulse signal. (2) Check if the pulse signal cable is disconnected or poor contact. (3) Check if the electronic gear ratio is set to small.
7	The analog voltage command (V Command) has been sent out, but the motor does not move.	None	(1) Use “Quick View” or “Scope” to check if “Analog Command” has received the input voltage. (2) Set the voltage offset in the “Analog input” tab of the “Advanced gains” window.

No.	Issue	LCD code	Troubleshooting
8	The motor is moving with a loud noise.	None	(1) Decrease the value of the servo gain (common gain). (2) Set the filter in the “Filter” tab of the “Advanced gains” window.
9	The drive’s temperature is too high.	ERR E07	(1) Ensure that the drive is placed in a well-ventilated location. (2) Check if the ambient temperature is too high.
10	The position feedback sensor (reader) sends an incorrect signal.	ERR E04	Ensure that the drive, the machine and the shield are grounded.
11	The DC bus voltage is too small.	ERR E09	(1) Check whether the drive’s main power is connected to 220Vac, or disconnected. (2) Use a multimeter to check that there is a 220Vac power supply.
12	The DC bus voltage is too big.	ERR E02	(1) Ensure that the speed, acceleration, and load meet the specifications. (2) When the motor is operated at high speed, consider installing a regenerative resistor which is selected according to the load and the motion specification. (3) Check if the load is too heavy. (4) Check if the speed is too high.
13	The position error exceeds the set maximum position error.	ERR E03	(1) Check if the servo gain (common gain) is too small and the maximum position error (“maximum pos error”) is set too small. (2) Check if the motor movement is obstructed. (3) Check if the load is too heavy.
14	There is a short circuit in UVW phases of the motor.	ERR E01	(1) Solve the short circuit between UVW phases of the motor and the wiring. (2) Solve the short circuit between UVW phases of the motor and Ground. (3) Measure the line-to-line resistance between UVW phases of the motor and ensure that the resistances are the same. (4) Check if the motor cable is too old.
15	The equivalent current of the drive output exceeds the limit of the motor continuous current.	ERR E05	(1) Ensure that the continuous current and the peak current during motor movement meet the motor’s specifications. (2) Check if the acceleration command in the path planning is higher than the motor rated acceleration. (3) Check if the motor movement is obstructed. (4) Reset and re-enable the drive. (5) Check if the motor model name or the motor current parameter is incorrectly set.
16	The computer cannot communicate with the drive.	None	Ensure that the transmission rate (“BPS”) and the communication port (“Port”) are correctly set.
17	The host controller receives an incorrect position when using the emulated encoder function.	None	When “Use emulated encoder” is set, the motor moves due to various factors during the operation of “Save to flash” () on the main window. The emulated output function has no effect when “Save to flash” is performing.

10. Axis Enable Setting

10.1 Start enable method

■ **Enable via host controller**

To control the motor enable, the host controller usually sends a command to the drive. The process is done through the drive's input pin. Generally, the "Axis Enable" function is set at the digital input I3 (refer to Section 5.4.1), as Figure 10.1.1 shows.

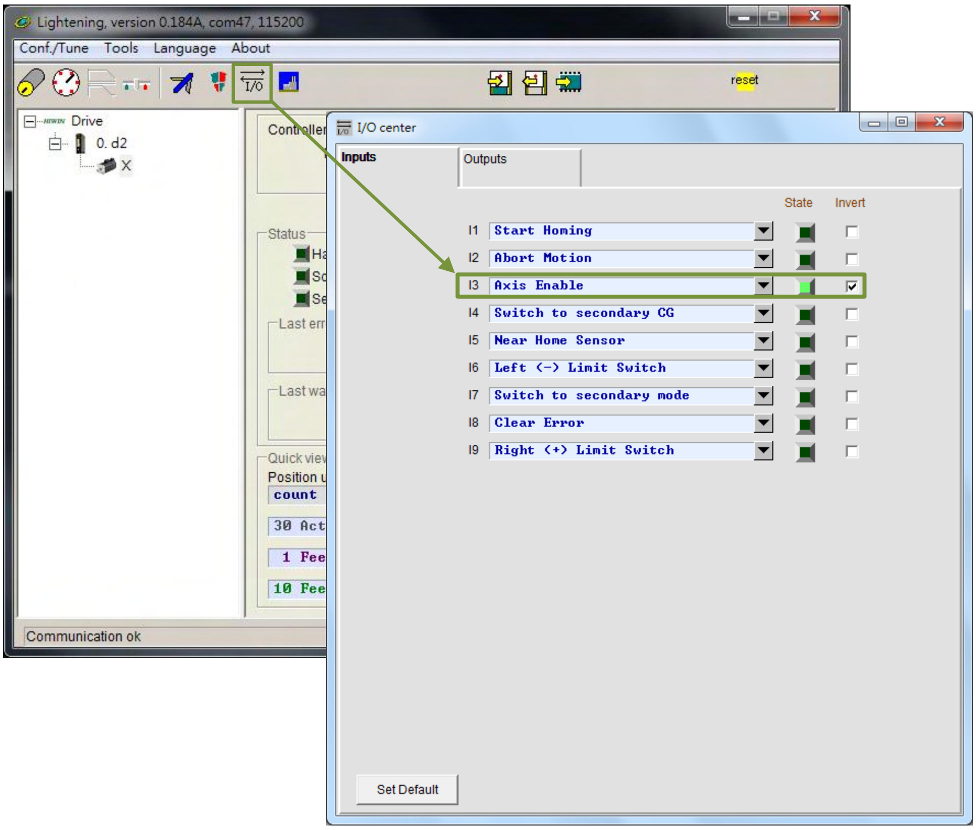


Figure 10.1.1

■ **Temporarily provide hardware enable**

If there is no host controller sending the hardware enable signal to the drive, the following method can be used to temporarily provide hardware enable. First, click  in the main toolbar to open the I/O center, as Figure 10.1.1 shows. Ensure that the status light of "Axis Enable" is green. Generally, I3 is set for the input of hardware enable signal. Since there is an "Invert" function for each input pin, the signal logic can be reversed via this "Invert" option to temporarily provide a simulated hardware enable signal according to the test requirement. When the status light in the "State" column lights up in green, it indicates that the drive has received a hardware enable signal.

10.2 Confirm enable status via HMI

When “Hardware enable input” in the HMI main window lights up in green, it indicates that the drive has received a hardware enable signal from the host controller, as Figure 10.2.1 shows.

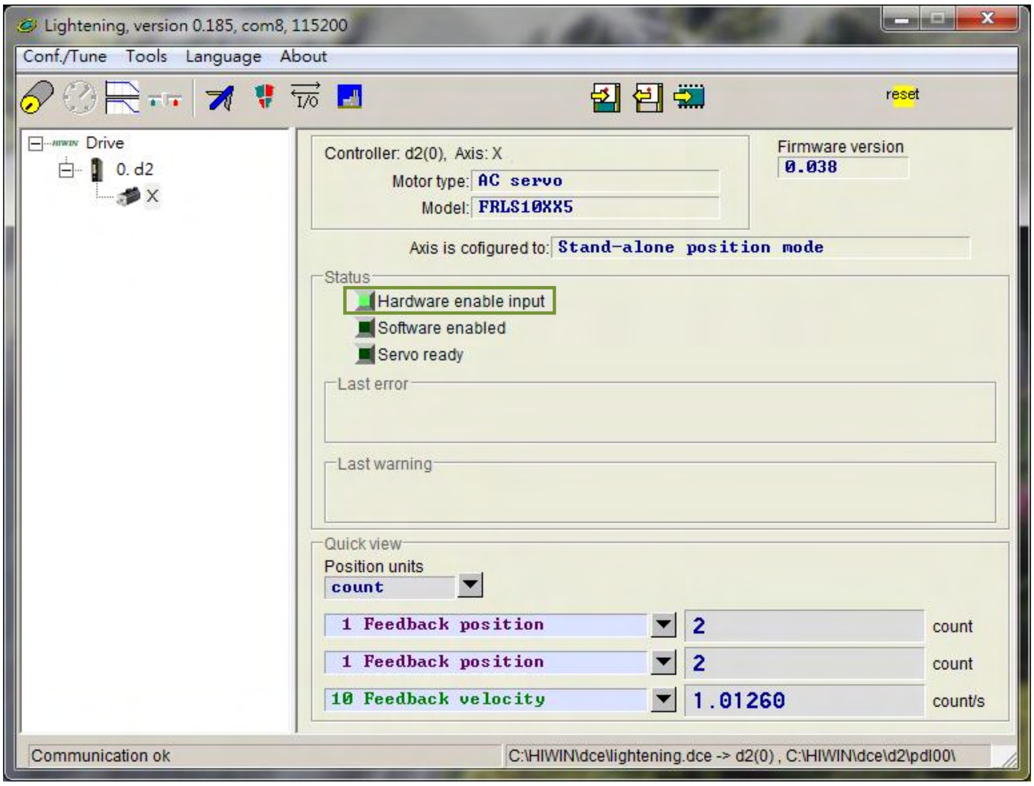


Figure 10.2.1

Generally, the motor enable is controlled by the “Axis Enable” signal sent from the host controller to the drive’s input pin. When HMI is on, pay attention to the following items.

(1) When Lightening is a valid window on the computer, press **F12** to disable the motor at any time. It is always useful in the emergency.

(2) When opening Performance center in Lightening, users can press the “Disable” button (same as **F12**) to disable the motor. When the “Hardware enable input” light is still green, click the “Enable” button on the window to enable the motor again.

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11. Parameter Comparison

11.1 Compare parameters in RAM and Flash

When users modify motor parameters during the operation of Lightening and do not save them in the drive's Flash, the prompt window of "Compare parameters RAM to Flash" appears (as Figure 11.1.1 shows) in the situation of closing Lightening or saving error map parameters to Flash (refer to Section 6.9.1). This window mainly reminds users that parameters have been modified but not yet saved to Flash.

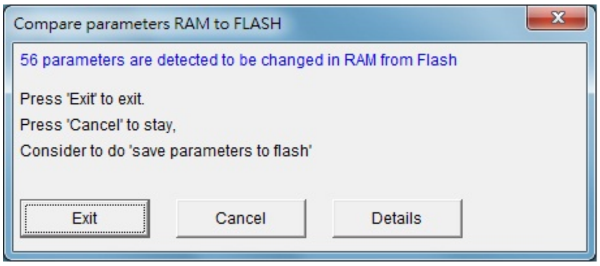

Figure 11.1.1

Click the "Details" option in the window to open the advanced comparison window. Users can further observe which parameters are set differently in RAM and Flash, as Figure 11.1.2 shows. If the data in RAM and Flash are not the same, the parameter's name and value will be listed in blue. In addition, the "Flash value" column will display one of the following two states.

(1) = : The parameter in Flash is the same as that in RAM.

(2) **: The parameter has performed the "Undo" action and the value in RAM has been changed to that in Flash, as Figure 11.1.3 shows.

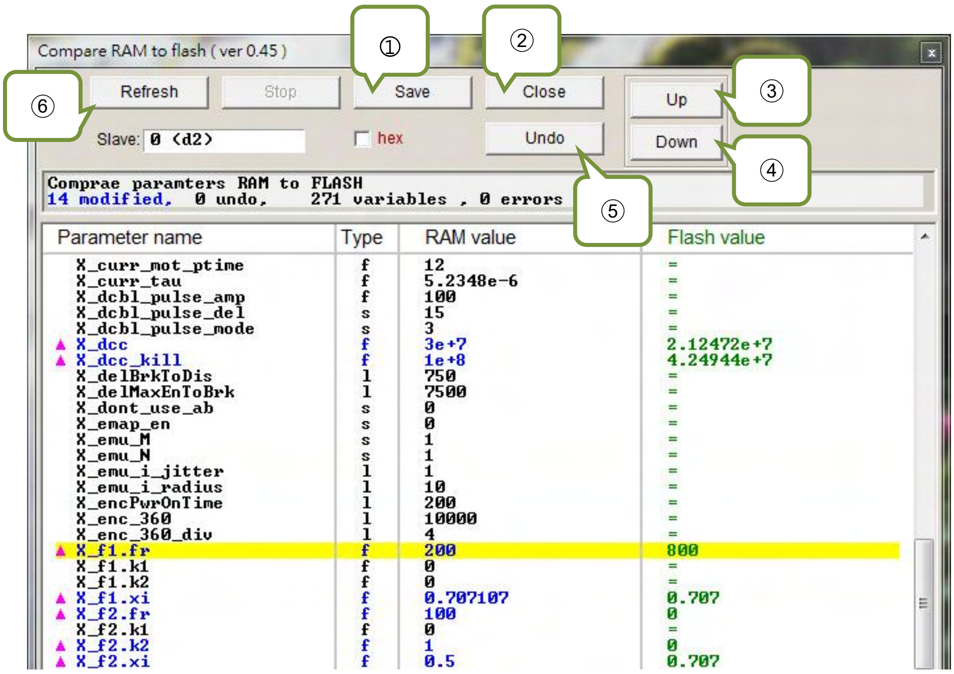

Figure 11.1.2

The function of the main buttons are described as follows.

① Save: Save parameters to Flash.
② Close: Close the window.
③ Up: Go to the previous parameter different in RAM and Flash.
④ Down: Go to the next parameter different in RAM and Flash.
⑤ Undo: Restore the selected parameter saved in RAM to that saved in Flash.
⑥ Refresh: Re-compare parameters saved in RAM and Flash.
⑦ Redo: Cancel the previous "Undo" action for the selected parameter.

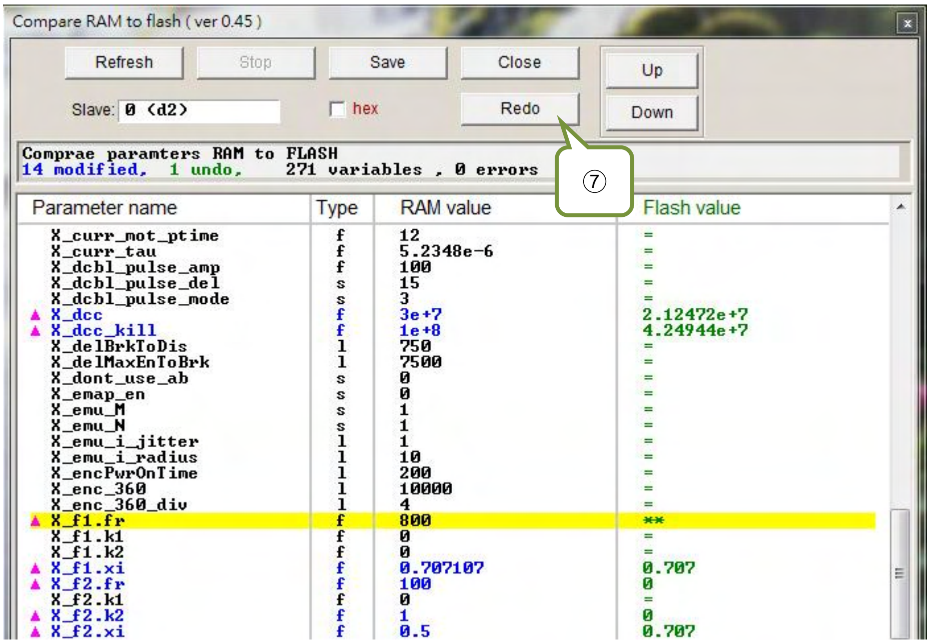

Figure 11.1.3

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12. Update Firmware & Load PDL

12.1 Update drive's firmware

To update the drive's firmware, click the "Tools" option in the main window and select "Upgrade/downgrade firmware...", as Figure 12.1.1 shows. By doing so, the window of Figure 12.1.2 will appear.

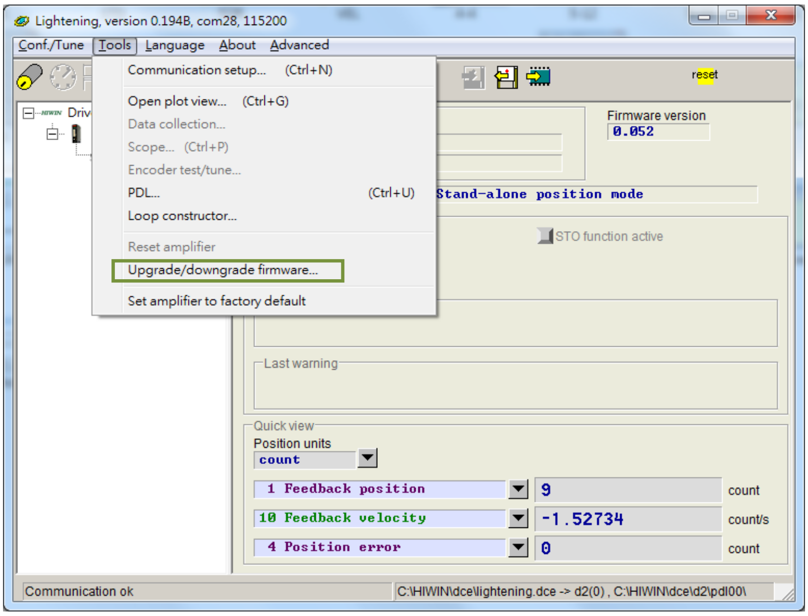

Figure 12.1.1

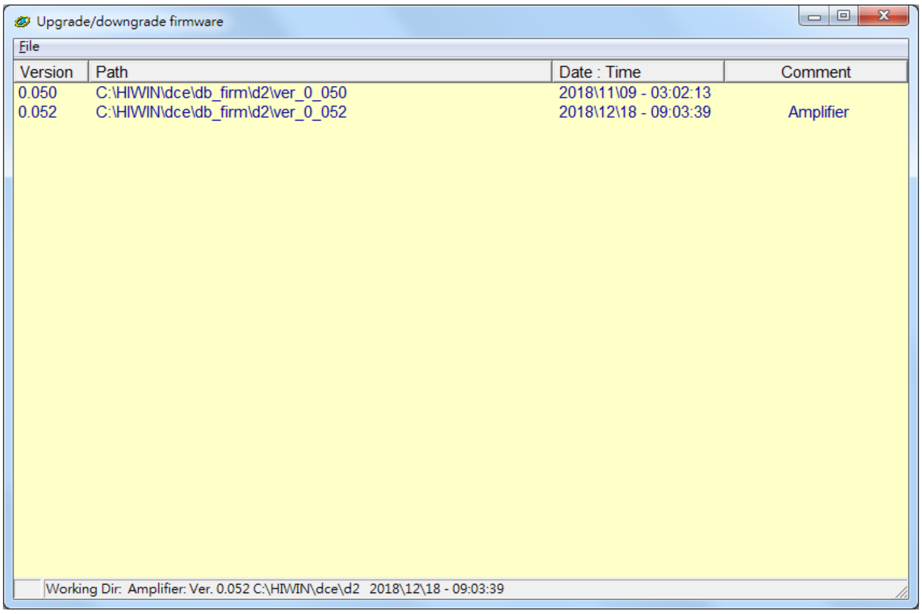

Figure 12.1.2

In the “Upgrade/downgrade firmware” window, follow the following steps to complete the update.

Step 1. Left click the firmware version to be updated. Make it become white letters on a blue background.

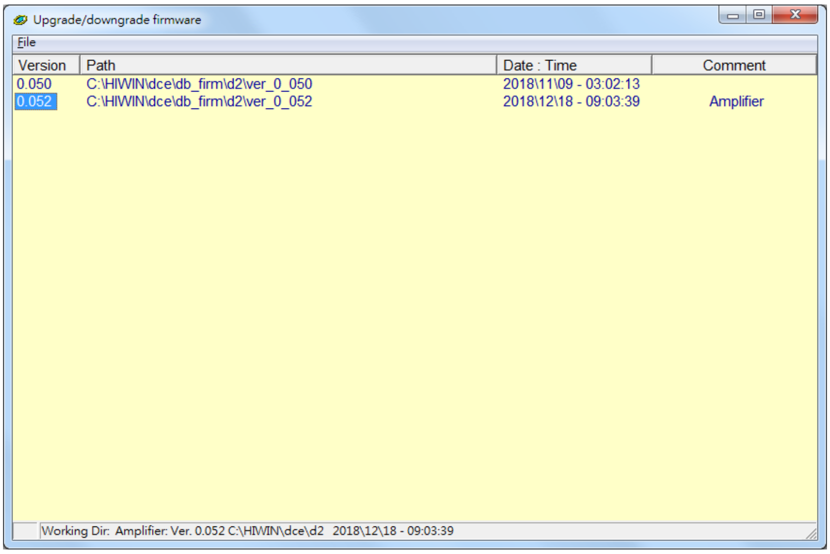

Figure 12.1.3

Step 2. Click the “File” option at the top-left corner of window and select “Update selected firmware to amplifier”. Then, the dialog window of Figure 12.1.5 will show up. If users want to save current parameters as a file, click the “(Y)” button; otherwise, click the “(N)” button.

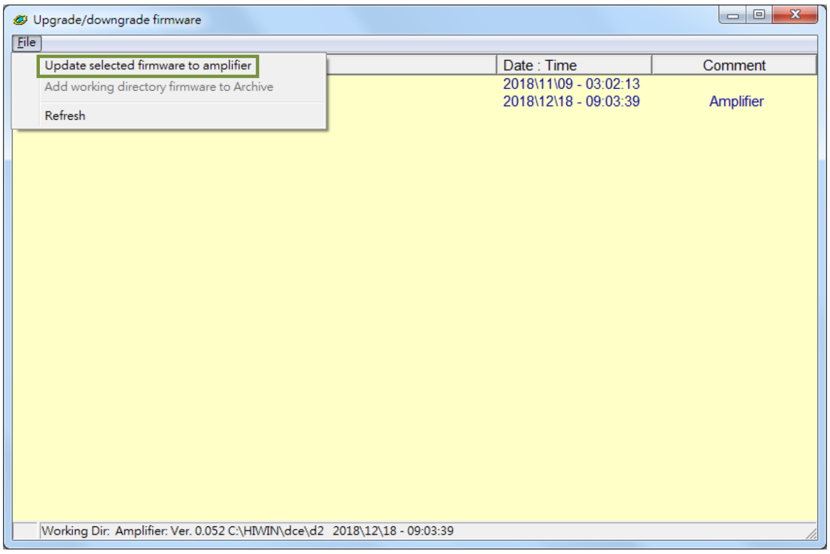

Figure 12.1.4

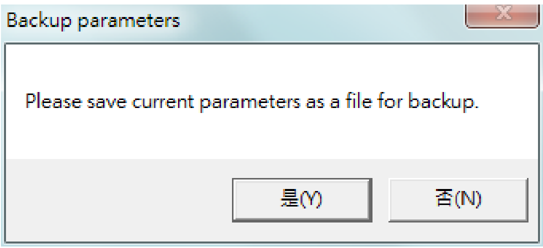

Figure 12.1.5

Step 3. After that, the dialog window of Figure 12.1.6 will show up.

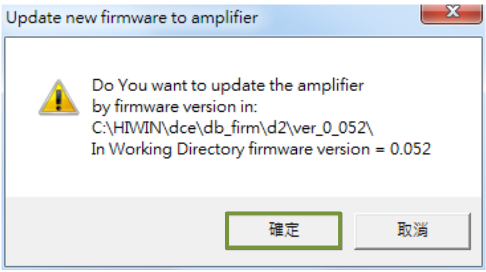

Figure 12.1.6

Step 4. Click the "Confirm" button to display the "Auto load programs" window. The firmware will be automatically loaded to the drive, as Figure 12.1.7 shows.

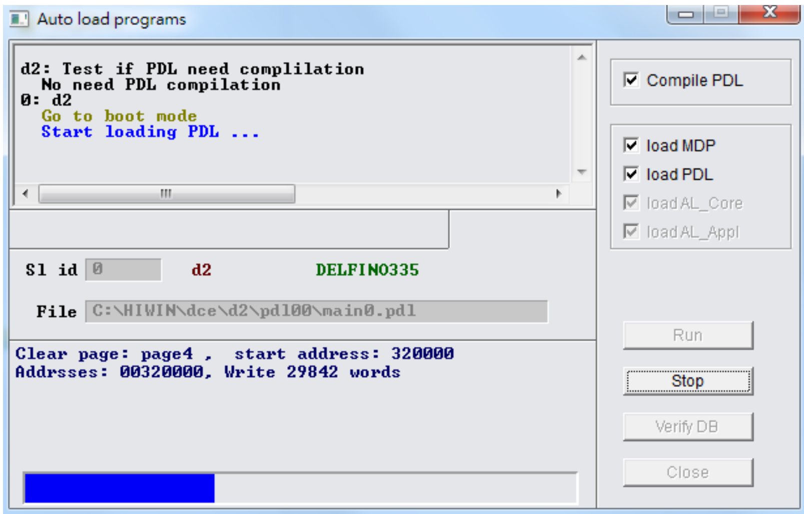

Figure 12.1.7

Step 5. After the update is completed, the message window of Figure 12.1.8 will appear. Click the "Conform" button.

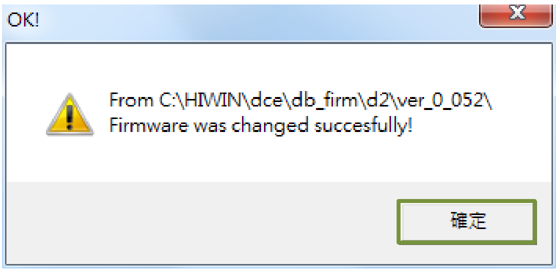

Figure 12.1.8

Note: If a power failure or a communication error occurs during the update, Lightening may be stuck at “Boot mode”. It cannot be changed after the power is restored or the communication cable is connected again, as Figure 12.1.9 shows. When this happens, please contact the dealer for assistance.

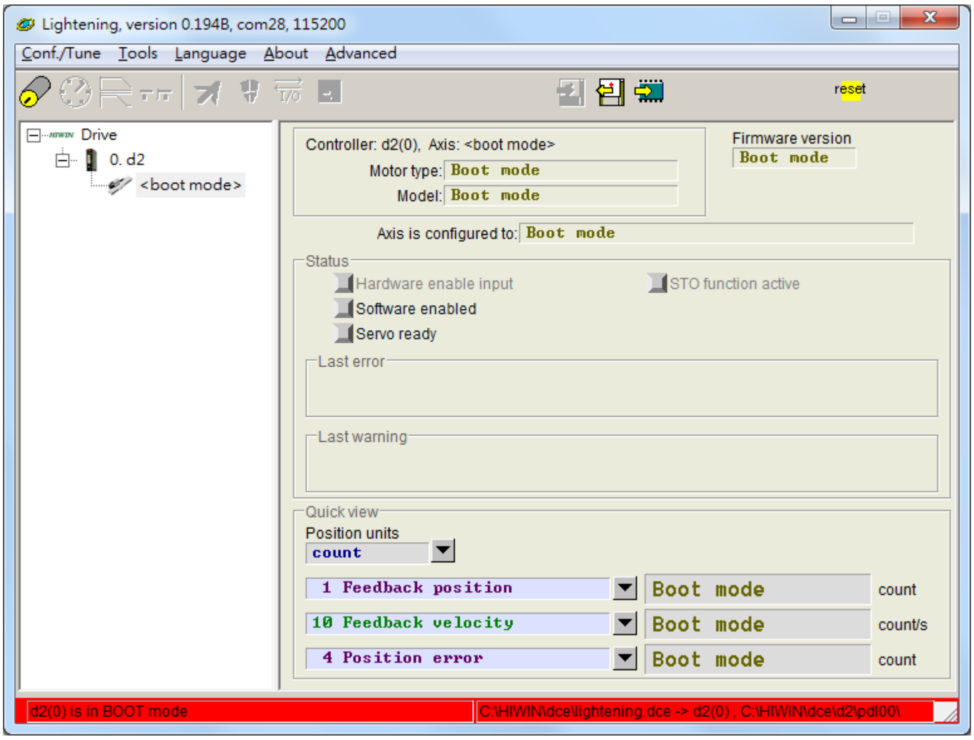

Figure 12.1.9

12.2 Load PDL program to drive

To load PDL program to drive, follow the following steps. To clear PDL program in drive, delete the code in "user.pdl" and follow the same steps to load the codeless "user.pdl" to drive.

Step 1. Click the icon ( ) shown in Figure 12.2.1 to open the "PDL" window.

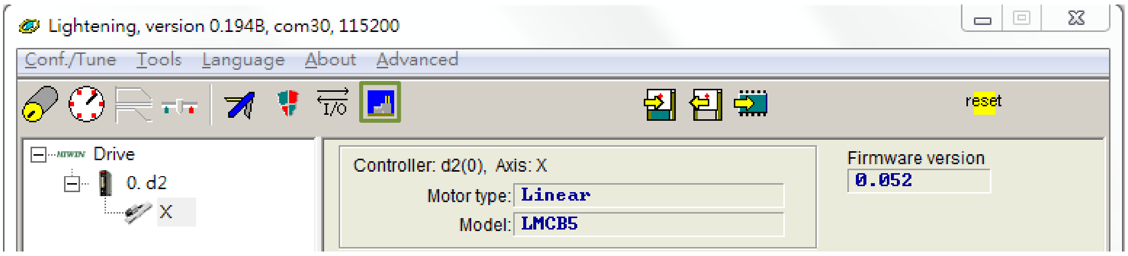

Figure 12.2.1

Step 2. Click the "Edit" button to display the PDL edit interface.

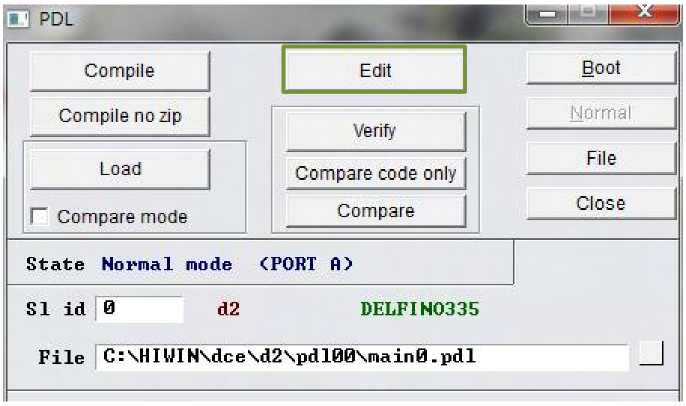

Figure 12.2.2

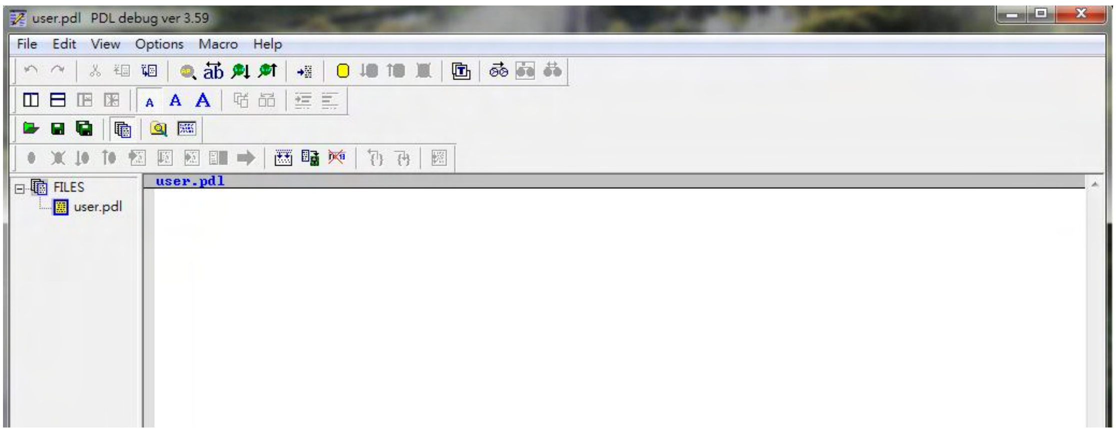

Figure 12.2.3

Step 3. After pasting or writing the PDL program, click the “Compile” icon ( ) to display the “Compile” window, as Figure 12.2.4 shows.

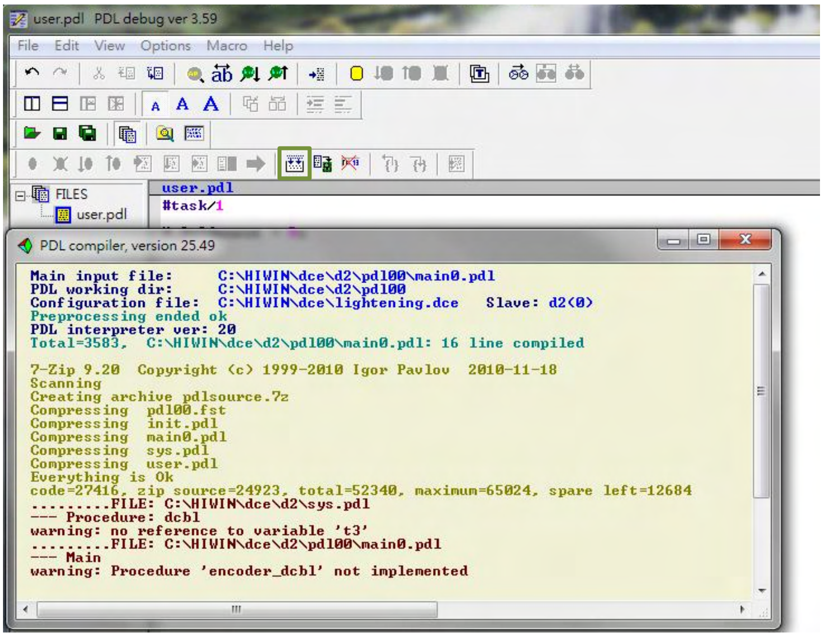

Figure 12.2.4

Step 4. When “Compile” is completed, click the “Send to slave” icon ( ). Then, click the “Confirm” button in the dialog window of Figure 12.2.5 to display the execution window of Figure 12.2.6. After the PDL program loading is done, this window will close automatically.

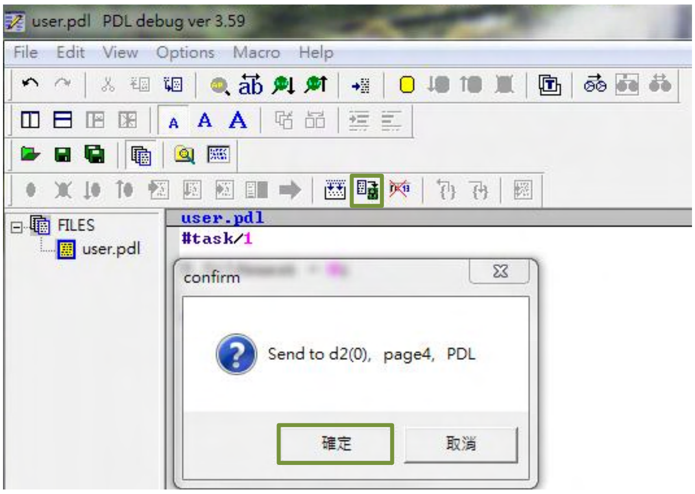

Figure12.2.5

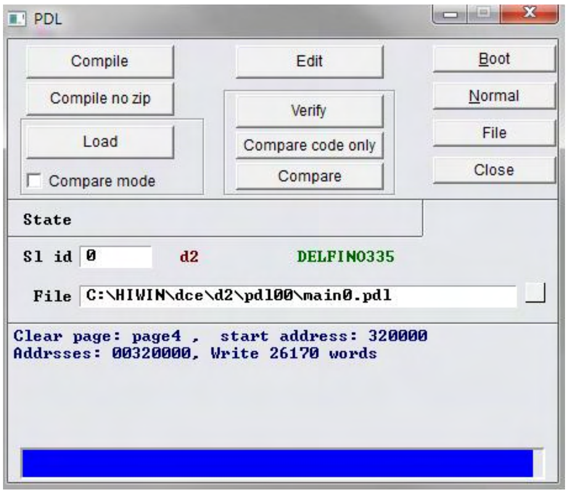

Figure 12.2.6

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13. EMC Solution

13.1 Common mode motor filter

A common mode motor filter can be considered when the following situations occur.

(1) The encoder feedback is disturbed and the error "E04 Encoder error" occurs when the drive is enabled.

(2) Reduce the common mode noise at the drive's output.

MF-CM-S is the part number of HIWIN self-made common mode motor filter. It is suitable for D2T-LM series drive with the power less than 2KW (included). Its specification is given in Table 13.1.1. When a common mode motor filter connects to the drive and the motor, the effects of the common mode inductor should be considered to improve the performance of motor control.

Table 13.1.1

Item		Specification
Input	Maximum voltage	373 Vdc
	Maximum current	11 A_{rms}
Output	Maximum voltage	373 Vdc
	Maximum current	11 A_{rms}
Peak current* / Maximum duration of peak current		33 A_{rms} / 1 second
Ambient operating temperature†		0~50°C
Common mode inductor (line)		1,100μH (nominal)

*The maximum input/output peak current can last 1 second after startup.

†If the drive is operated below the maximum temperature, there is no need to use a cooling fan. However, if the ambient temperature exceeds 50°C, an external fan should be used for cooling. The flow rate of the fan should be at least 110 cubic feet (CFM).

Figure 13.1.1

The dimensions of MF-CM-S are shown as follows.

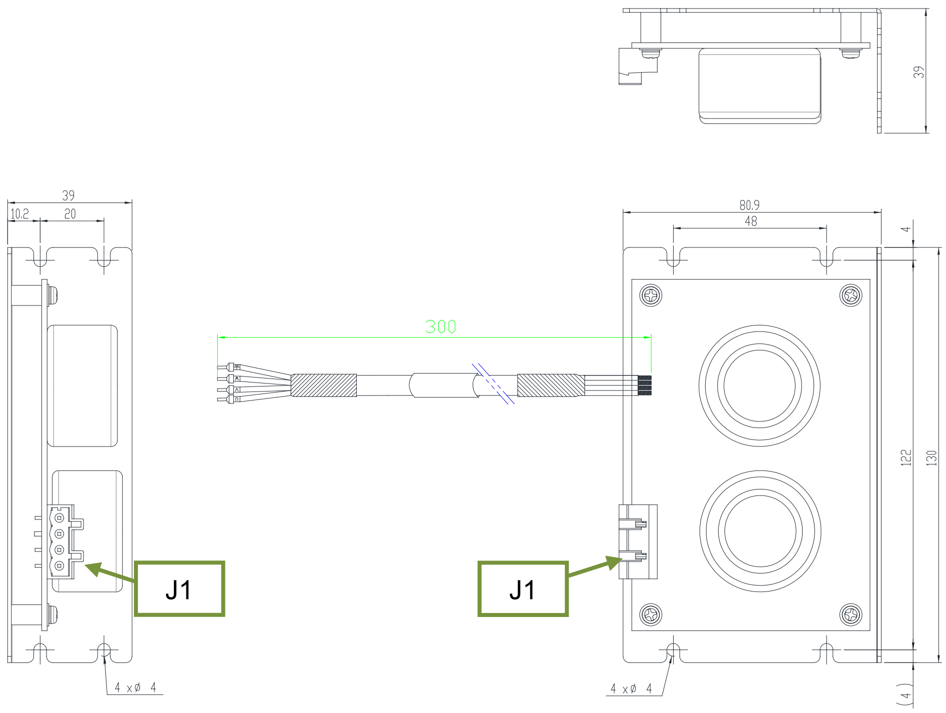

Figure 13.1.2

Figure 13.1.3 is the wiring diagram of the common mode motor filter, the drive and the motor.

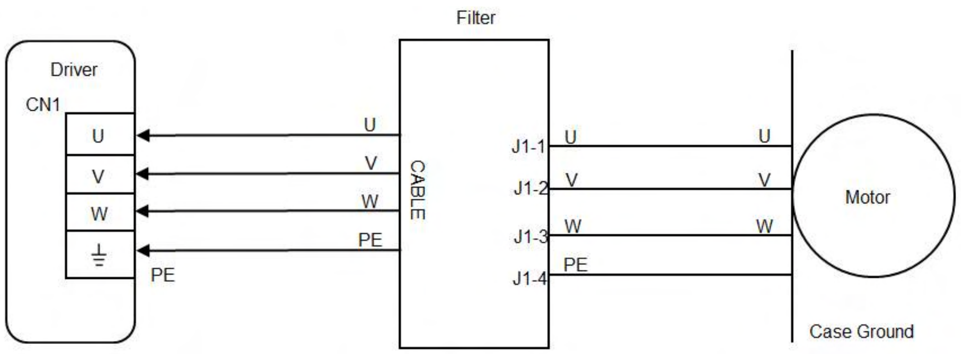

Figure 13.1.3

Instruction:

(1) Insert the terminals of common mode motor filter into the drive's CN1 in sequence based on the labels on the lines.

(2) Insert the motor cables into the connectors of common mode motor filter based on the labels on the connectors.

■ Filter to drive

Table 13.1.2 Filter-to-drive cable specification

Description	E191346 AWM 2586 2mm 2x4C 105°C 600V
Cable size	14 AWG

Table 13.1.3 Filter-to-drive cable pin assignment

Pin (color)	Name	Function
Red	U	Connect to the drive's U-phase (input)
White	V	Connect to the drive's V-phase (input)
Black	W	Connect to the drive's W-phase (input)
Green	PE	Case grounding and cable shielding

■ Filter (J1) to motor

Table 13.1.4 Filter J1 specification

Description	4 position, 7.5mm pluggable female terminal block
Manufacturer PN	Wago 721-864/001-000
Cable size	28~12 AWG
Recommended wire	14 AWG, 600V
Wire insertion / extraction tool	475604 (SUPU) 4PIN, Female, pitch 7.5mm

Table 13.1.5 Connector definition

Pin	Name	Function
1	U	Connect to the motor's U-phase (output)
2	V	Connect to the motor's V-phase (output)
3	W	Connect to the motor's W-phase (output)
4	PE	Case grounding and cable shielding

⚠ DANGER

◆ The cables and J1 connector are high-voltage circuits, and they are connected to the main power. Be careful when installing it, or it may cause damage to equipment or injury to people.

13.2 Motor power cable with magnetic rings

When the motor is at the enable state, consider installing magnetic rings on the motor power cable if the control signals are interfered by the noise.

- Cable with plug-in magnetic rings

Table 13.2.1

Part No.	Specification	Quantity	Description
HE00831RB200	Plug-in CM choke filter	1	Motor filter

Table 13.2.2

Item	Specification
Maximum voltage	240 Vac
Maximum current	7.5 A_{rms}
Peak current / Maximum duration of peak current	15 A_{rms} / 1 second
Ambient operating temperature	0~40°C

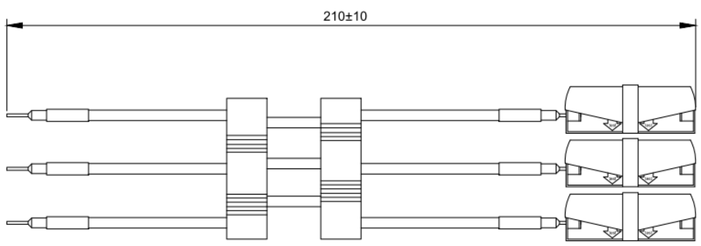

Figure 13.2.1

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