User's Manual

For

MSD_E210V1

Digital Dc Servo Driver

Revision 1.0

Attention: Please read this manual carefully before using the driver!

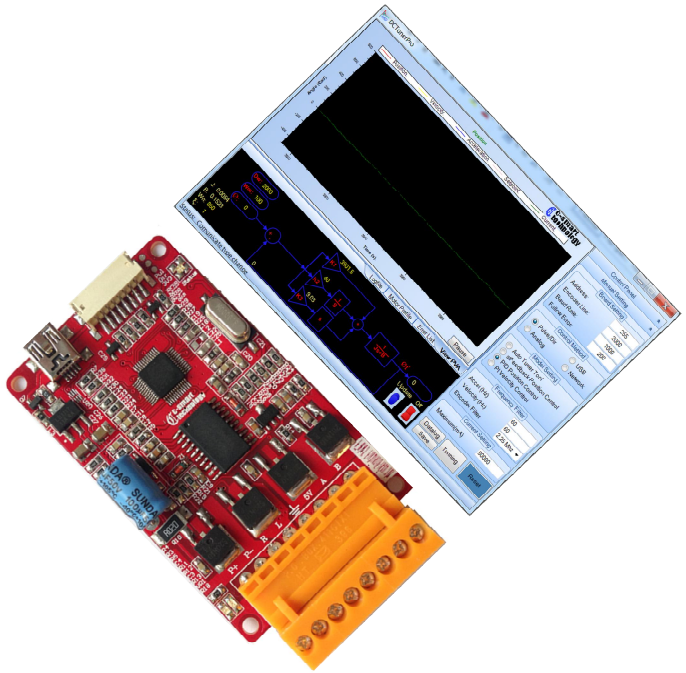

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Table of Contents

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1. Introuduction, Features and Applications

Introduction

The driver is a digital DC servo driver developed with ARM Coretex-M3 and high efficient MOSFET technologies. In position control, it's easy for the end users to change stepping drivers to the MSDE210V1 without changing control systems, because its input command is PUL/DIR signal, which is compatible with that of stepping drivers. In low power motion control applications, performances of DC servo systems using the driver are better than those of digital AC servo systems in velocity, precision, noise, stability, or at least as good as those of digital AC servo systems. However, the cost of the driver stays at the price line of stepping driver, namely far lower than those of AC servo drivers.
Meanwhile the MSD_E210V1 has higher Max Pulse Input Frequency, hence can drive a faster motor or choose a higher accuracy encoder for a given motor.
What's more, broader input voltage range makes the MSD_E210V1 can drive broader range of servo motors. The MSD_E210V1 is very easy to tune and all parameters are visible. Parameter visible tuning tools, including DCTunerPro (Windows based setup software) can meet different tuning environments or requirements.

Features

- ✓ 10-28VDC, 0-10A, 20-200W
- ✓ Based on ARM Coretex-M3 control technology and high smooth servo control algorithm
- ✓ Parameter visible tuning tools, including Tuner Pro
- ✓ Feedback resolution ×4 encoder line count
- ✓ Position Following error lock range adjustable
- ✓ Position error can be eliminated to 1 count, and Velocity error can be eliminated to the Desired Velocity* ±0.3%
- ✓ Electronic gear ratio.
- ✓ Built-in motion controller for self-test with trapezoidal velocity profile
- ✓ Many latest errors self-record function
- ✓ Over-current, over-voltage, under-voltage, phase error, encoder error, position following error protections
- ✓ Small size, surface-mount technology

Applications

Suitable for a wide range of equipments and instruments such as mini type engraving machines, jet-ink machines, etc. It performs better in equipments desired for low noise, high velocity, high precision and high reliability.

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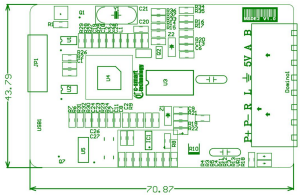
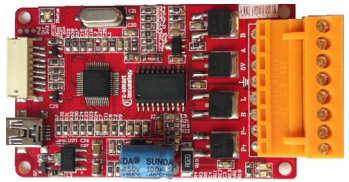
2. Specification and operating Enviroment

Mechaniccal Specification (unit: mm)





Elimination of Heat

- ❖ Driver's reliable working temperature should be <70℃ (158°F), and motor working temperature should be <80℃ (176°F);
- ❖ It is recommended to mount the driver vertically to maximize heat sink area.

Electrical Specifications (Tj = 25℃ /77°F)

Parameters	MSDI			
	Min.	Typical	Max.	Unit
Peak Output Current	0	-	30	A
Supply voltage	+10	-	+28	VDC
Logic signal voltage	+4.7		+5.2	VDC
Logic signal current	7	10	15	mA
Pulse input frequency	0	-	500	KHz
Isolation resistance	500			MΩ
Current Provided to encoder			200	mA

Operating Environment and Parameters

Cooling	**Natural cooling or forced cooling**	
Operating Environment	Environment	Avoid dust, oil fog and corrosive gases
	Ambient Temperature	0℃－50℃ (32°F－ 122°F)
	Humidity	40%RH－ 90%RH
	Vibration	5.9 m/s2 Max
Storage Temperature	-20℃ － 65℃ (-4°F － 149°F)	
Weight	Approx. x grams	

3. Connections

General information

Control Signal 1 Connector			
Pin	Signal	Description	I/O
1	PUL+	Pulse control signal (+). See more information about PULL in “More about PUL/DIR/EN Signals” section	I
2	DIR+	Direction control signal (+).See more information about DIR in “More about PUL/DIR/EN Signals” section	I
3	COM	Ground of control signal	I
4	B	RS485 Network (*)	I/O
5	A		

Control Signal 2 Connector			
Pin	Signal	Description	I/O
1	VEL+	Velocity input control: Analog signal input to control motor at speed mode	I
2	+5VDC	Output 5VDC (200mA(Max))	O
3	GND	Ground of Driver	I

Encoder Signal Connector			
Pin	Signal	Description	I/O
1	E +5V	Positive pole of the auxiliary pow supply (200 mA (Max)).	O
2	E GND	Ground of the auxiliary power supply	GND
3	EA+	Encoder channel A+	I
5	EB+	Encoder channel B+	I

Power Connector			
Pin	Signal	Description	I/O
1	P+	+10 TO 40VDC Power input	I
2	P-	Power ground	GND
3	M+	Motor positive connection	O
4	M-	Motor negative connection	O

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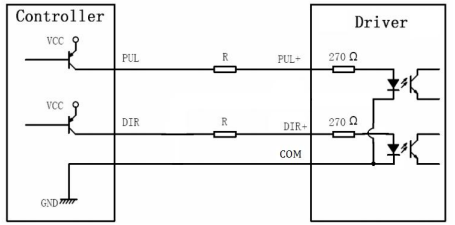
More about PUL/DIR/EN Signals

Pin Function	Details
PUL+	Pulse signal: in single pulse (pulse/direction) mode, this input represents pulse signal; 3-5V when PUL-HIGH, 0-0.5V when PUL-LOW. Series connect resistor for current-limiting when using +12V or +24 control signals.
DIR+	DIR signal: in single pulse mode, this signal has low/high voltage levels, representing two direction of motor rotation (reset in software). DIR signal should be ahead of PUL signal by 5μS at least. 3-5V when DIR-HIGH, 0-0.5 when DIR-LOW. Please note that motion direction is also related to motor-driver wiring and encoder feedback A/B phase signals. Exchanging the connections of two wires of the motor to the driver and A/B phase signal of encoder will reverse motion direction.
COM	Ground signal for PUL/DIR/EN signal

Control Signal Connections

The driver has 2 optically isolated logic inputs to accept line driver control signals. These inputs are isolated to minimize or eliminate electrical noises coupled onto the control signals. Recommend use line driver control signals to increase noise immunity in interference environment.



Note: R=0 if VCC = 3-5V;
R=1K (>0.125W) if VCC=12V;
R=2K (>0.125W) if VCC=24V;

Figure 3.1: control signal connection

USB Interface Connection:

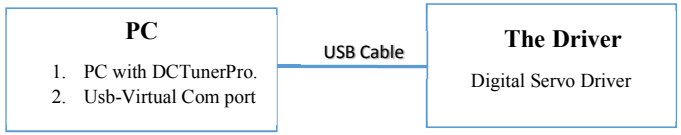


Figure 3.2: USB interface connection.

Encoder Connections:

The driver can accept encoder input from either differential or single-ended encoders. Differential encoders are preferred due to their excellent noise immunity.
The connections for a single-ended encoder are identical to a differential encoder except that no connections should be made to channel A- and channel B-. (The A- and B- lines are pulled

up). Note that twisted-pair shielded cabling provides the best immunity in electrically noisy environments.
If the encoder drains less than 200mA, the driver can supply the encoder directly, and connect it as Figure 3.4**. Figure 3.3 have no support.**

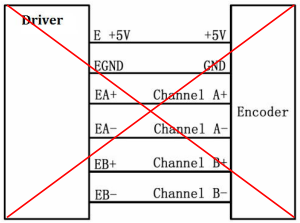


Figure 3.3 differential encoder

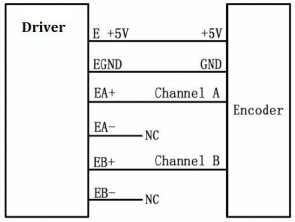


Figure 3.4 single-ended encoder

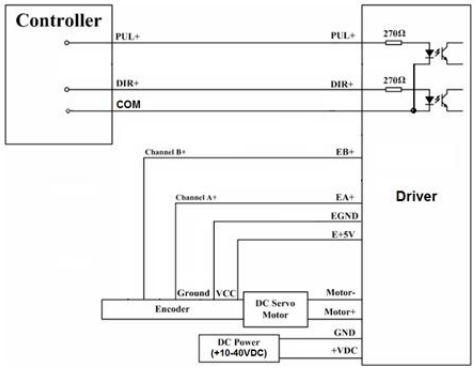


Figure 3.5: Typical connection (Full Connection)

4. Servo Setup

Before you start the servo, you can follow the below steps.

Install Encoder

If your motor have no encoder, you must have encoder properly mounted on the motor before you start. And please assemble the encoder according to its factory manual. If you do have to use a single-ended encoder, please use shielded cables and separate encoder signal cable from interference sources, such as motor wires and power wires at least 5 cm.

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Prepare Power Supply:

Regulated or Unregulated Power Supply

Both regulated and unregulated power supplies can be used to supply the driver. However, unregulated power supplies are preferred due to their ability to withstand current surge. If regulated power supplies (such as most switching supplies.) are indeed used, it is important to have large current output rating to avoid problems like current clamp, for example using 4A supply for 3A motor-driver operation. On the other hand, if unregulated supply is used, one may use a power supply of lower current rating than that of motor (typically 50%～70% of motor current). The reason is that the driver draws current from the power supply capacitor of the unregulated supply only during the ON duration of the PWM cycle, but not during the OFF duration. Therefore, the average current withdrawn from power supply is considerably less than motor current. For example, two 3A motors can be well supplied by one power supply of 4A rating.

Selecting Supply Voltage

The driver can actually operate within +10V to +40VDC, including power input fluctuation and back EMF voltage generated by motor coils during motor shaft deceleration. The rated voltage of the motor is an important parameter when selecting supply voltage. Generally speaking, do not use a power supply voltage more than 5 volts of the rated voltage of the motor. Higher voltage may cause bigger motor vibration at lower speed, and it may also cause over-voltage protection or even driver damage.

Prepare Controller

Prepare a controller with pulse and direction signals. However, the driver has a built-in motion controller for self-test and Servo Tuning. The built-in motion controller can generate control signal with trapezoidal velocity profile.

System Connections and Noise Prevention

After finishing the above steps, you can connect your servo system. Before you start, make sure that the power is off. Connect your system according to connection diagrams before, and pay attention to the following tips when wiring.

Wire Gauge

The smaller wire diameter (lower gauge), the higher impedance. Higher impedance wire will broadcast more noise than lower impedance wire. Therefore, when selecting the wire gauge, it is preferable to select lower gauge (i.e. larger diameter) wire. This recommendation becomes more critical as the cable length increases. Use the following table to select the appropriate wire size to use in your application.

Current (A)	Minimum wire size (AWG)
10	#20
15	#18
20	#16

Cable Routing

All content sensitive signal wires should be routed as far away from motor power wires and driver power wires as possible. Motor power and driver power wires are major sources of noise and can easily corrupt a nearby signal. This issue becomes increasingly important with longer motor power and driver power wires lengths.

Twisted Wires

Twisted wires effectively increasing noise immunity. The successive twists eliminate noise transients along the length of the cable. Both signal cables and power cables should be of the twisted and shielded type. Differential signal wires should be twisted as a pair. The combination of twisted pair wires and a differential signal significantly adds to noise immunity. Power wires should be twisted as a group along with the ground (or chassis) wire, if available.

Cable Shielding

All signal wires should be bundled and shielded separately from driver power and motor power wires. Power wires should also be bundled and shielded. When grounding a shield, the rule-of-thumb is to do so at the 'source' of power while leaving the other shield end open. For example, in the case of motor power wires, this would be the drive side. Ideally, twisted pairs should be individually shielded and isolated from the outer shield, which encompasses all wires within the cable.

However, since this type of stringent shielding practice is often not required, typical cables do not provide isolation between inner and outer shields.

System Grounding

Good grounding practices help reduce the majority of noise present in a system. All common grounds within an isolated system should be tied to PE (protective earth) through a 'SINGLE' low resistance point. Avoiding repetitive links to PE creating ground loops, which are a frequent source of noise. Central point grounding should also be applied to cable shielding; shields should be open on one end and grounded on the other. Close attention should also be given to chassis wires. For example, motors are typically supplied with a chassis wire. If this chassis wire is connected to PE, but the motor chassis itself is attached to the machine frame, which is also connected to PE, a ground loop will be created. Wires used for grounding should be of a heavy gauge and as short as possible. Unused wiring should also be grounded when safe to do so since wires left floating can act as large antennas, which contribute to EMI.

Power Supply Connection

NEVER connect power and ground in the wrong direction, because it will damage the driver. The distance between the DC power supply of the drive and the drive itself should be as short as possible since the cable between the two is a source of noise. When the power supply lines are longer than 50 cm, a **1000μF/100V** electrolytic capacitor should be connected between the terminal "GND" and the terminal "+VDC". This capacitor stabilizes the voltage supplied to the drive as well as filters noise on the power supply line. Please note that the polarity can't be reversed.

It is recommended to have multiple drivers to share one power supply to reduce cost if the supply has enough capacity. To avoid cross interference, **DO NOT** daisy-chain the power supply input pins of the drivers. Instead, please connect them to power supply separately.

Testting the servo

You may wish to secure the motor so it can't jump off the bench. Turn on the power supply, the Red (Power) LED will light first about one second. The driver has default parameters stored in the driver. If the system has no hardware and wirings problem, the motor should be locked and the driver should be ready, the Green Led will light. If the motor jumps slightly and the red LED immediately turns on (flickers), then either the motor or the encoder is wired in reversal. Open the tuning software DCTurnerPro and check driver status by clicking **Error List tab**. If it's **Phase Error**, then reversal motor wires or exchange encoder inputs and try again. If it's **Encoder Error**, please check encoder and its wirings, and then try again. If it still doesn't work after you followed all of the previous steps, please contact us at **ccsmart.net@gmail.com**. If the red LED is off, the green LED is on and the motor is normal, then you can start to tune the servo with selected tool **DCTunerPro**.

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Tuning the Servo

A servo system is error-driven. The "Gain" of the system determines how hard the servo tries to reduce the error. A high-gain system can produce large correcting torques when the error is very small. A high gain is required if the output is required to follow the input faithfully with minimal error. A servo motor and its load both have inertia, which the servo amplifier must accelerate and decelerate while attempting to follow a change at the input. The presence of the inertia will tend to result in over-correction, with the system oscillating beyond either side of its target. It's called UNDER DAMPED status. See Figure 4-1. This oscillation must be damped, but too much damping will cause the response to be sluggish, namely cause the system to get into an OVER DAMPED state. When we tune a servo, we are trying to achieve the fastest response with little or no overshoot, namely get a CRITICALLY DAMPED response.

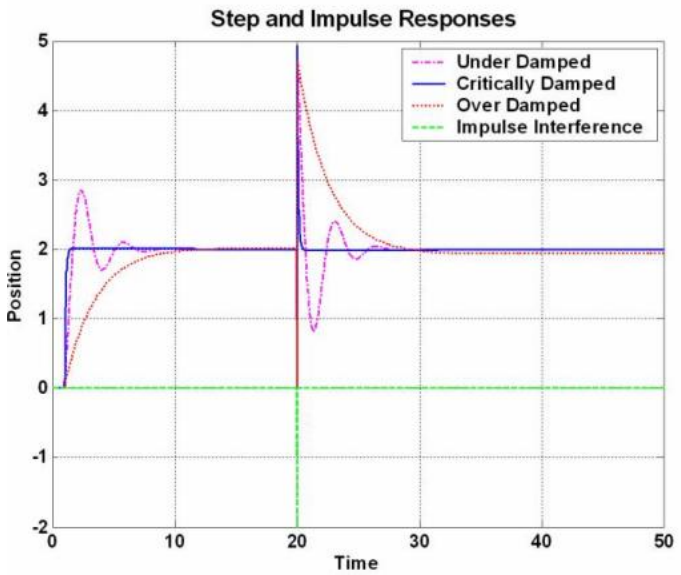

Figure 4-1: Step and impulse responses

As mentioned in previous contents, the driver is a digital servo driver and its input command is PUL/DIR signal. In other words, step response just exists in each step command signal. For each step command signal is a very small movement, so OVER SHOOT and SETTLING

TIME between each step are very small. However, if you try to evaluate performances of the digital servo by investigating its position tracking-error or position following error, you may find it's much easier than investigating its step response. The easiest way to get a tracking-error or position following error response is to induce an impulse load on the motor.

Use Auto Tuning Tool

This tool can auto find your motor information very easy and quickly. After turning finish you can be summarized as the following rules:

- If servo system is UNSTABLE or CRITICALLY DAMPED. You can decrease Wn
- If Servo system is UNDER DAMPED, then increase Wn.

5. PC Window Based Tuning Using DCTunerPro

Introduction

This manual will provide an overview of connection and basic setup instructions for the digital servo driver using the **DCTunerPro** software. The basic setup of a digital driver is designed to be analogous to the setup and tuning of an analog amplifier. These instructions will walk you through the following steps necessary to start up your driver and motor. This document is intended for setting up the driver with the DCTunerPro.

Software Installation

The DCTunerPro is windows based setup software for tuning Cc-Smart's digital drivers. It can run in windows systems, including Win95/Win98/WindowsNT/ Windows 2000/Windows XP/Window **7 and 8**. And the selected PC should have 1 USB port at least for communicating with the driver. Double click "**DCTunerPro_V2.0.exe**" to begin installing the **DCTunerPro**. See Figure 5.1 to 5.4

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Figure 5.1

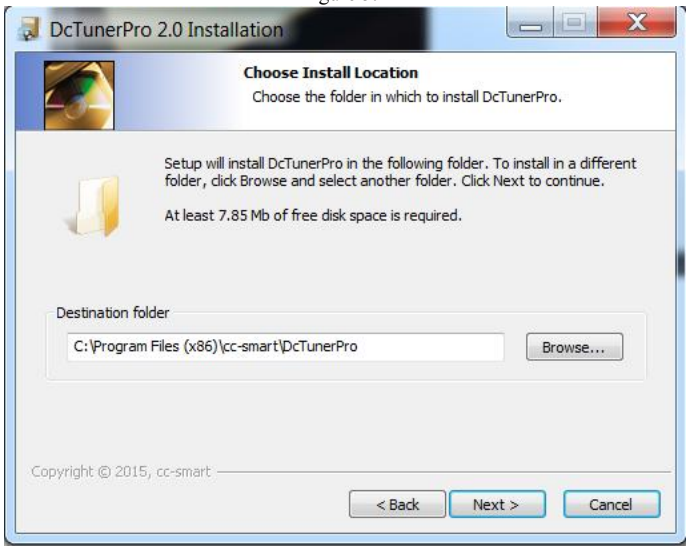


Figure 5.2

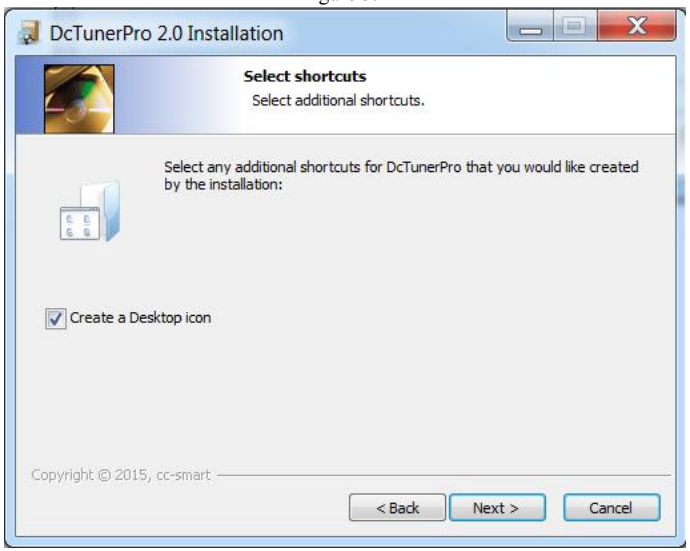


Figure 5.3

Figure 5.4

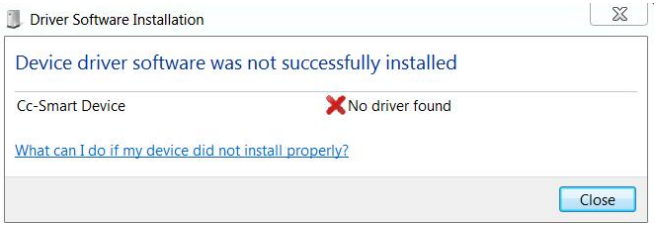
USB Interface Connection:

Connect the servo system according to chapter "**Connections**" and connect the PC to the driver as the following figure.

3. PC with TunerPro. 4. Pc with Usb-_virtual Com port	USB Cable	**The Driver** Digital Servo Driver

Install Usb Driver:

The widow will show a below dialog When you plug USB cable and turn on the driver power in the first time.



Right click "My Computer-> Manage -> Device manage"

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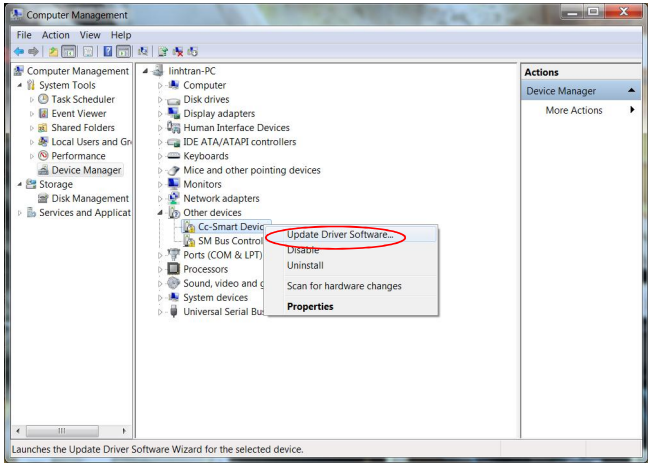
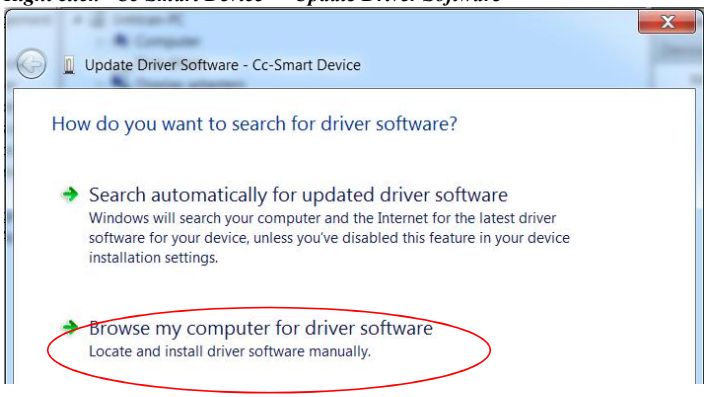
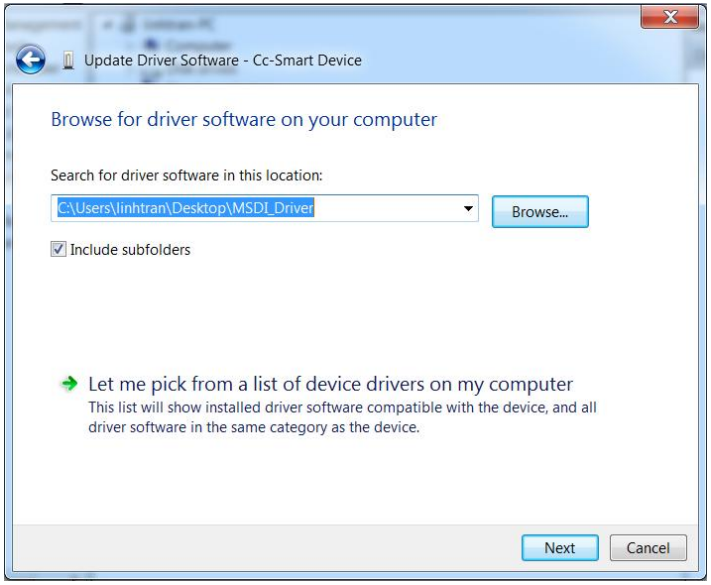


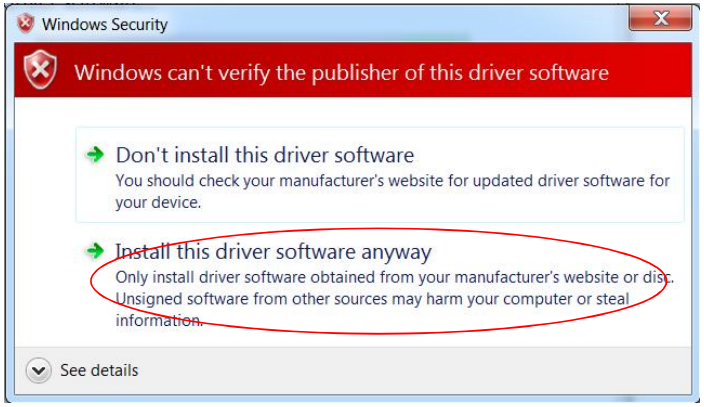
Right click "Cc-Smart Device -> Update Driver Software"



Choose "Browse my computer for driver software"



Choose Browse button to MSDI_Driver folder -> choose Next button



Choose "Install this driver software anyway"

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6. Software Introduction

DCTunerPro Main Window

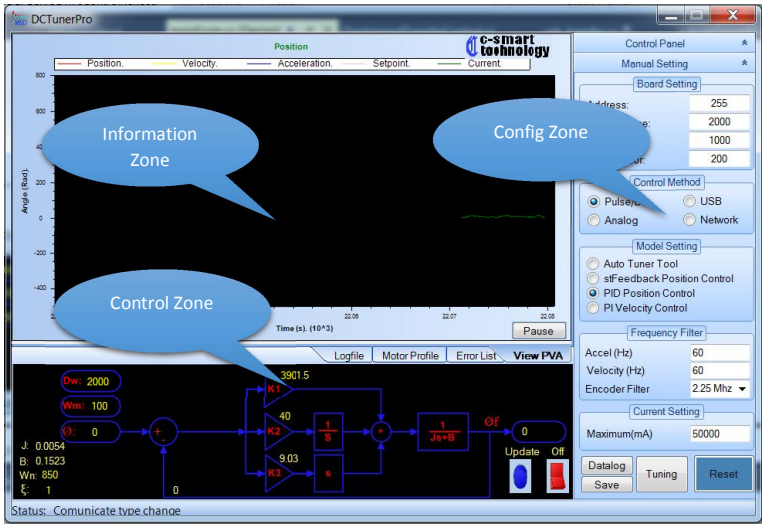


Figure 6-1 main window

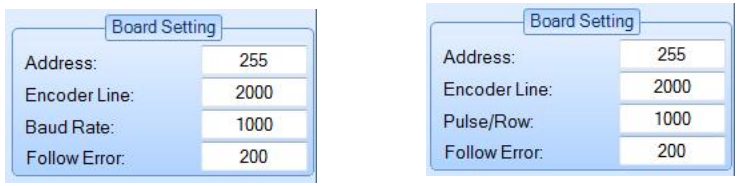


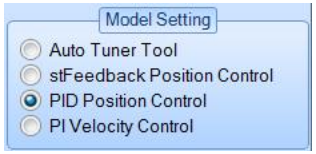
Figure 6-2 configuration encoder and board information.

Address: Don't care
Encoder Line: The resolution of encoder (number pulses encoder per one circle).
*Pulse/Row (Baud Rate)***: Same electronic gear ratio.** This value configures how many external pulses correspond to ONE rotation round of motor. For example, if the value is 300 means the motor needs 300 pulses (from the external source) to rotate exactly one round.
Follow Error: The system will threw a "Follow Error" if the estimates minus the current value greater than Follow _Error

Control method

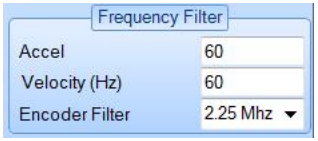
Pulse/Dir: This method the driver is controlled by external signal "Pulse-Direction".
USB: The driver is controlled by software via USB.
Analog: The analog signal input is command for driver. It is only used with Velocity mode.
Network: not using in this type of driver.

Selecting Model Control



Auto Tuner Tool: This tool is used to auto finding a system information.
stFeedback Position Control: The motor is used a position mode and controlled by state feed-back loop.
PID Position Control: The motor is used a position mode and controlled PID loop.
PI Velocity Control: The motor is used a velocity mode and controlled by PI loop**.**

Filter:



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Accel: A frequency of low pass filter for accelerator. This value is usually about 50-60 (Hz)
Velocity: A frequency of low pass filter for velocity loop. This value is usually about 50-60 (Hz)

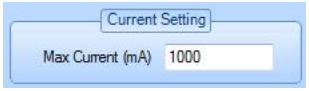
Encoder Filter: **A frequency hardware filter.** The Hardware filter Encoder is calculated as below formula:

F_filter = Encoder Line*4*60*V_max+ 1000

With:

F_filter: filter frequency.
Encoder_Line: the number of encoder pulse per round.
V_max: the maxium velocity of motor.

Current Setting:



Configure maximum current for controlling motor. This function protects overload or short circuit. The Driver automatically cuts off output current in 50ms.

In these cases, the user has to reset system to continue operating.

7. Automatically identify motor specification:

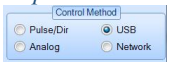
Principles:

The system will run as 80% power in first 4s then inverse rotation in next 4s. While this process is running, the *Auto Tuning* tool collects the response data of system, then analyzed and calculated *J* and *B* parameter of motor.

Operation:

Step 1: Put the button like this 

and choose USB method to command the driver.



Step 2: Click the button "Tuning" 

, the system starts to automatic identification.

Step 3: Wait until the process finished and motor stopped. Observing **J, B**

*Try this step about three times if the difference of **J, B** between identified time is small. We can use apply this values for our system.*

Step 4: Click "Reset" button to reset driver: 

Step 5: Chose one of two controllers: ***State Feedback* or *PID*** *(*recommended) to control position or ***PI*** for velocity control.

Step 6: Modified "Wn" by rule:

If servo system is UNSTABLE or CRITICALLY DAMPED. You can decrease Wn.
If Servo system is UNDER DAMPED, then increase Wn.

Step 7: Set the position, velocity and accelerator witch you want your response system.

∅s: position value (rad)

Wm: velocity (rad/s)

Dm: accelerator (rad/s^2)

Step 8: Click button update 

at *control zone* then look at the system response at *Information zone area in* ***"View_PVA"*** *tab*. If the response signal does not meet the requirement, we can back to step 6 to modify the *Wn*.

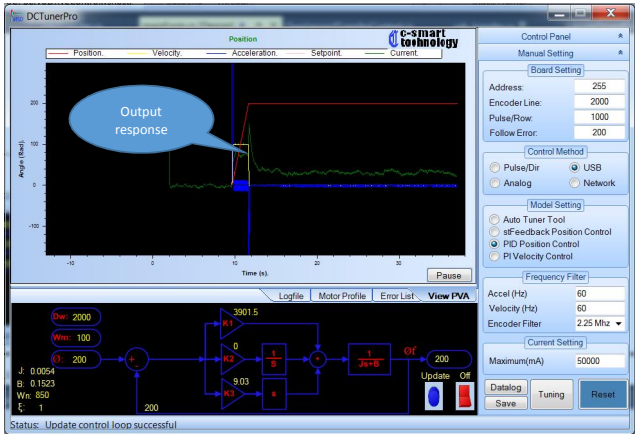


Figure6.1: Ouput respont

Step 9: After output response is ok, choosing a control method witch you want to send a kind of command to driver, example: (Pulse/Dir, Analog or by Network) "Save" button to download and save these parameters to flat of board: 

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8. Diagnostic Error:

Error List: will show history error when the driver running

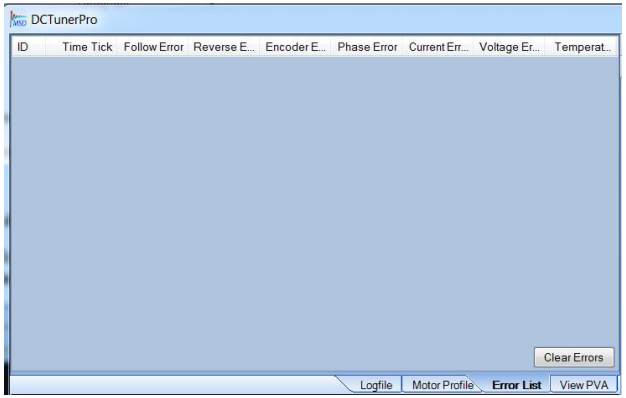

Figure 8.1: Error table

Can't detect J, B or J, B negative value:

Please sure encoder wiring and motor wiring is right. When you click "Tuning" button **the position have to positive first and after that negative**. See picture below:

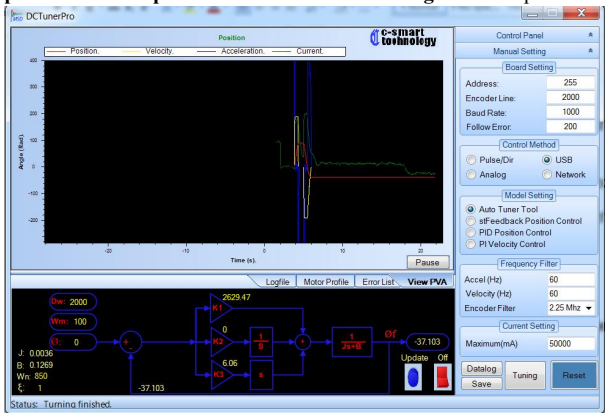

Figure 8.2: Right respond

If have no respond please check wire connection

If the respond different Figurate 8.2, please revert encoder wire **or** motor wire.

9. External Control Pulse mode:

Initial setup:

Step 1: Connect *Pulse* and *Dir* of the driver into controlled board.

Step 2: The generated pulse from controlled board controls motor through the driver.

Position control, monitoring velocity and acceleration (position mode):

The position is decided by the number of pulse from controlled board connect with the driver and *Pulse/Row* parameter.

Position = (I_Pulse/ Pulse_Per_Row)*360º(degree).

With:

I_Pulse: the input controlled pulse.

Pulse_Per_Row: the value is set by user.

Monitoring velocity: Velocity is defined by pulse frequency from controlled board. For example: at the same position at 200 pulses, if pulse frequency is higher than the velocity is higher and the time is shorter.

- ✓ Monitoring acceleration: Acceleration is the rate of change of velocity or in other words, acceleration is the rate of change of input frequency pulse in the driver.
- ✓ Direction: decided by signal in *Dir*: inverse the logical signal ("1" or "0") in *Dir* pin will inverse the direction of motor.

Velocity control (velocity mode)

The analog input is used to input command for the driver.

10. License register:

The license is now being accompanied by hardware, so no additional cost to use. By default, the license has 5 trial days, when expired, the software is blocked. To use trial, click *Trial*.

In order to manage better customer service, we need some information from the customer. To register, customer must complete license information then click on *Register*. The license requirement will appear, copy all the information and send it to us by ccsmart.net@gmail.com. License will be emailed to customer no later than 2 days from the time license submitted.

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Attention:

If the system does not respond, or just start up then immediately turned off, the user must verify that the set current is less than the system current or not. Some cases, the start current is over than maximum value of system, the driver will switch off. To continue, it needs to reset system.

Tips:

Right click on the *Status Monitor 1* to save the current chart, or modify a chart view.