EM503 2-phase Digital Stepper Drive

20-50V, 0.21-3A, Sensorless Stall Detection, Pre-Matching Motor

- **Sensorless stall detection** eliminates cost of feedback devices and time of cable connection
- **Super-low** motor noise offers excellent quietness
- **User password protection** prevents others from copying your drive configurations
- **Anti-Resonance** optimizes torque and nulls mid-range instability
- Self-test and Auto-configuration technology offers optimum performance for different motors
- Multi-stepping allows a low resolution input to produce a higher microstep output for smoother system performance
- Options to set output current and microstep resolutions via DIP switch or software
- Command input of PUL/DIR or CW/CCW, microstep from 1 to 512
- Automatic idle-current reduction and reduction rate is software configurable
- Over-current, over-voltage, short-circuit protections besides sensorless stall detection
- Fault out prevents damages to your machines or the materials

Descriptions

By implementing the latest motion control technologies, Leadshine's EM series DSP-based stepper drives deliver excellent performance not available before. Unique features of sensorless stall detection, extra smoothness and excellent high speed performance make EM stepper drives deliver servo-like performance at the cost of stepper drives. They are capable of delivering high performance without damages to your machines or the materials. Leadshine EM series stepper drives are able to drive 2-phase or 3-phase stepper motors from NEMA8 to NEMA42.

Applications

EM503 stepper drives are suitable for driving a wide range of 2-phase stepper motors, from NEMA frame size 14 to 23. Typical applications include CNC routers, laser cutters, laser markers, medical equipments, X-Y tables, measurement equipments, etc.

بلبرینگ اسکوئی

OBC
Oskoyi Ballbearing Company

Specifications

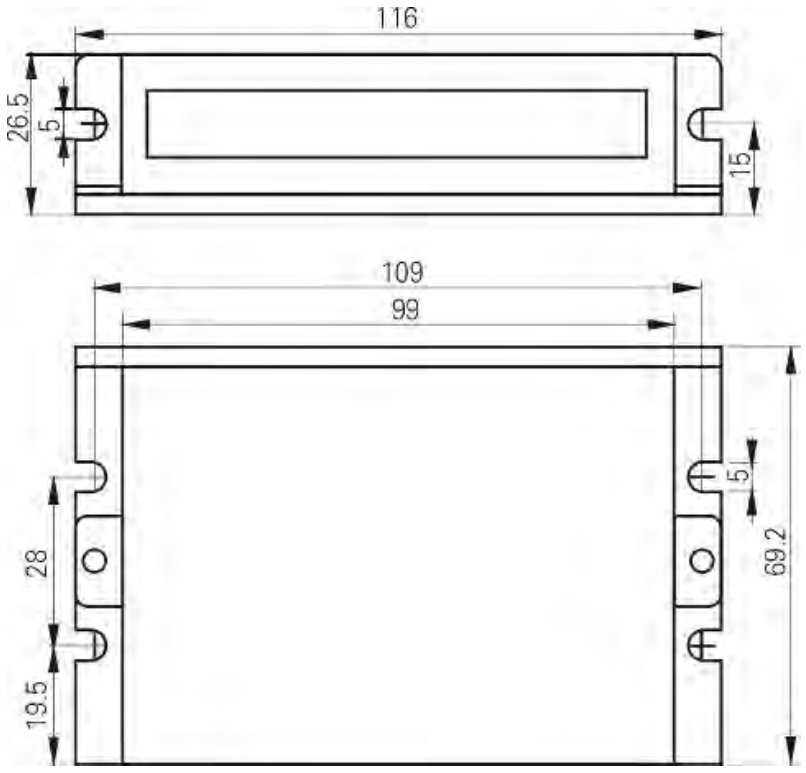
Electrical Specifications

Parameter	Min	Typical	Max	Unit
Input Voltage	20	36	50	VDC
Pulse Input Frequency	0	-	200	kHz
Logic Signal Current	7	10	16	mA
Isolation Resistance	500	-	-	MΩ

Operating Environment

Cooling	Natural Cooling or Forced cooling	
Operating Environment	Environment	Avoid dust, oil fog and corrosive gases
	Storage Temperature	-20°C — 65°C (-4°F — 149°F)
	Ambient Temperature	0°C — 50°C (32°F — 122°F)
	Humidity	40%RH — 90%RH
	Operating Temperature (Heat Sink)	70°C (158°F) Max
	Vibration	10-55Hz, 0.15mm/s
Storage Temperature	-20°C — 65°C (-4°F — 149°F)	
Weight	209 g (7.37 oz)	

Mechanical Specifications



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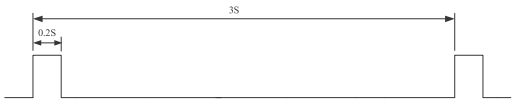
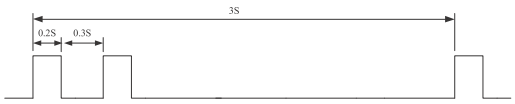
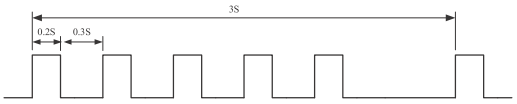
فکس : (021) 33985603

Protection Indications

The green indicator turns on when power-up. When drive protection is activated, the red LED blinks periodicity to indicate the error type

Priority	Time(s) of Blink	Sequence wave of RED LED	Description
1st	1		Over-current protection
2nd	2		Over-voltage protection
3rd	5		Motor Stall Protection

Connectors and Pin Assignment

The EM503 has two connectors, connector for control signals connections, and connector for power and motor connections.

Control Signal Connector			
Pin	**Name**	**I/O**	**Description**
1	PUL+	I	Pulse signal: In single pulse (pulse/direction) mode, this input represents pulse signal, each rising or falling edge active (software configurable, see EM drives software operational manual for more detail); In double pulse mode (software configurable), this input represents clockwise (CW) pulse, active both at high level and low level. 4-5V when PUL-HIGH, 0-0.5V when PUL-LOW. For reliable response, pulse width should be longer than 10μs. Series connect resistors for current-limiting when +12V or +24V used. The same as DIR and ENA signal.
2	PUL-	I	
3	DIR+	I	Direction Signal: In single-pulse mode, this signal has low/high voltage levels, representing two directions of motor rotation. In double-pulse mode (software configurable), this signal is counter-clock (CCW) pulse, active both at high level and low level. For reliable motion response, DIR signal should be ahead of PUL signal by 5μs at least. 4-5V when DIR-HIGH, 0-0.5V when DIR-LOW. Please note that rotation direction is also related to motor-driver wiring match. Exchanging the connection of two wires for a coil to the driver will reverse motion direction. The direction signal's polarity is software configurable.
4	DIR-	I	
5	ENA+	I	Enable signal: This signal is used for enabling/disabling the driver. In default, high level (NPN control signal) for enabling the driver and low level for disabling the driver. Usually left **UNCONNECTED (ENABLED)**. Please note that PNP and Differential control signals are on the contrary, namely Low level for enabling. The active level of ENA signal is software configurable.
6	ENA-	I	
7	FLT+	O	Fault/Alarm Signal: OC output signal, active when one of the following protection is activated: over-voltage, over current, short circuit and stall-error. This port can sink or source 20mA current at 24V. By default, the resistance between FLT+ and FLT- is high impedance in normal operation and become low when EM503 goes into error. **It can not be configured by software.**
8	FLT-	O	

Power and Motor Connector			
Pin	**Name**	**I/O**	**Description**
1	**A+**	O	Motor Phase A+
2	**A-**	O	Motor Phase A-
3	**B+**	O	Motor Phase B+
4	**B-**	O	Motor Phase B-
5	**+Vdc**	I	Power Supply Input (Positive), 20-45VDC recommended, leaving rooms for voltage fluctuation and back-EMF.
6	**GND**	GND	Power Ground (Negative)

RS232 Communication Port

It is used to configure the peak current, microstep, active level, current loop parameters and anti-resonance parameters. See EM drivers' software operational manual for more information.

RS232 Communication Port			
Pin	**Name**	**I/O**	**Description**
1	**NC**	-	Not connected.
2	**+5V**	O	+5V power only for STU (Simple Tuning Unit).
3	**TxD**	O	RS232 transmit.
4	**GND**	GND	Ground.
5	**RxD**	I	RS232 receive.
6	**NC**	-	Not connected.

DIP Switch Settings

Dynamic Current

Peak	RMS	SW1	SW2	SW3
Default	**Default**	on	on	on
1.46A	**1.04A**	of	on	on
1.91A	**1.36A**	on	off	on
2.37A	**1.69A**	off	off	on
2.84A	**2.03A**	on	on	off
331A	**2.36A**	of	on	off
3.76A	**2.69A**	on	off	off
4.20A	**3.00A**	off	off	off

Note: Due to motor inductance, the actual current in the coil may be smaller than the dynamic current setting, particularly under high speed condition.

Idle-Current

SW3 determines whether the idle current is reduced automatic or remains the same as the dynamic current setting.

	ON	OFF
SW4	The motor idle current reduces automatically when there is no pulse applied to EM503.	The motor idle current is the same as the dynamic current when there is no pulse applied to EM503.

Auto-Configuration

Switch SW4 two times in two seconds to auto-configure the drive's current loop parameter. That is, OFF-ON-OFF or ON-OFF-ON. During Auto-configuration, motor parameters are identified and the EM drive's current loop parameters are calculated automatically. The motor shaft will vibrate a little during the process of Auto-configuration which takes about 1 to 3 seconds.

Microstep Resolution

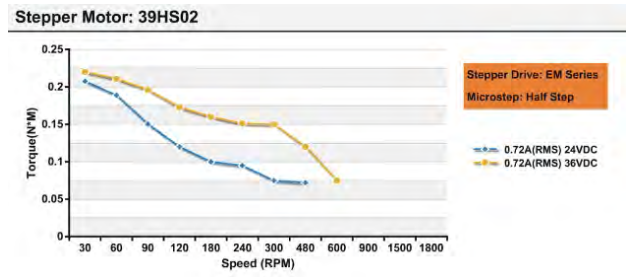
Steps/Revolution	SW5	SW6	SW7	SW8
Software Configured (Default 200)	on	on	on	on
400	off	on	on	on
800	on	off	on	on
1600	off	off	on	on
3200	on	on	off	on
6400	off	on	off	on
12800	on	off	off	on
25600	off	off	off	on
1000	on	on	on	off
2000	off	on	on	off
4000	on	off	on	off
5000	off	off	on	off
8000	on	on	off	off
10000	off	on	off	off
20000	on	off	off	off
25000	off	off	off	off

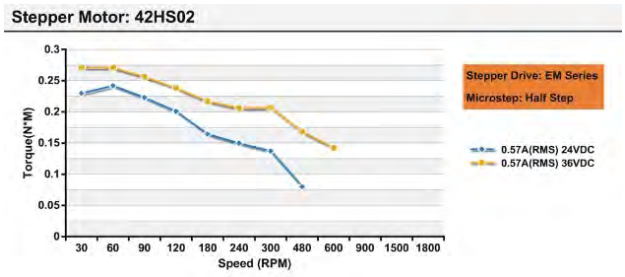
Motor Selection and Pre-matching Leadshine Motor

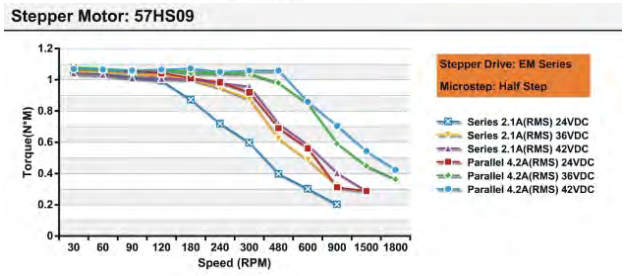
There is a rotation switch used for the motor selection.

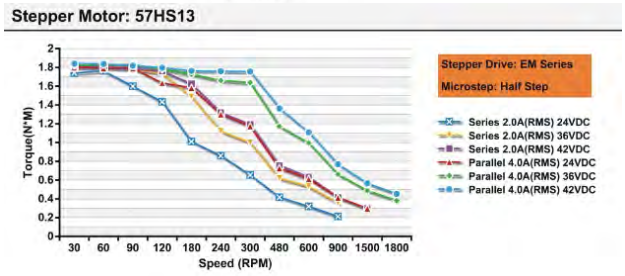
Matching Motor	Connection	Code	Description
39HS02	-	0	Select pre-matching Leadshine stepper motor. EM503 has been tuned for these motors.
42HS03	Parallel	1	
57HS09	Parallel	2	
57HS13	Parallel	3	
57HS22	Parallel -	4	
86HS35	Parallel	5	
42HS03	Serial	6	
57HS04	Serial	7	
57HS09	Serial	8	
86HS13	Serial	9	
86HS22	Serial	A	
86HS35	Serial	B	
Custom1	-	C	Select non-Leadshine motor. EM503 needs tuning either by Auto-configuration or the PC software. There are up to four custom positions for customer selection.
Custom2	-	D	
Custom3	-	E	
Custom4	-	F	

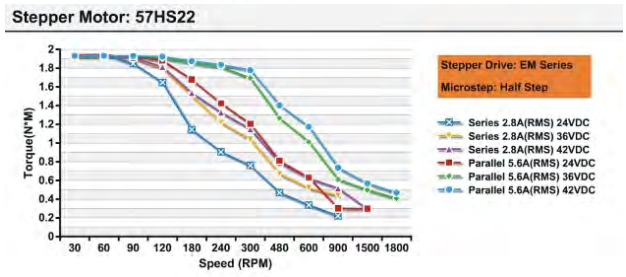
Speed Torque Curve for Pre-matching Leadshine Motor

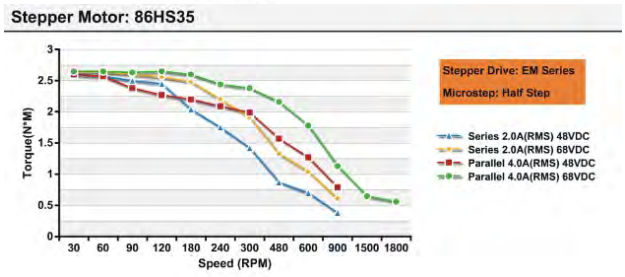






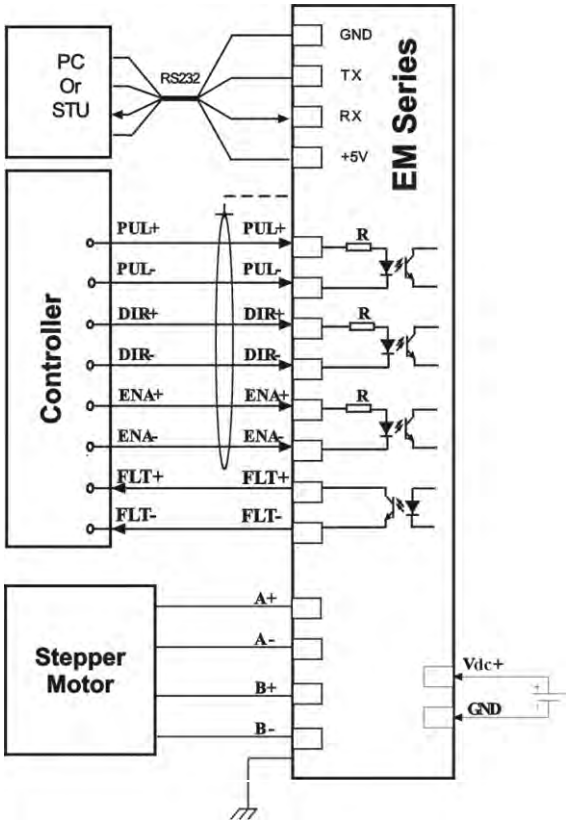




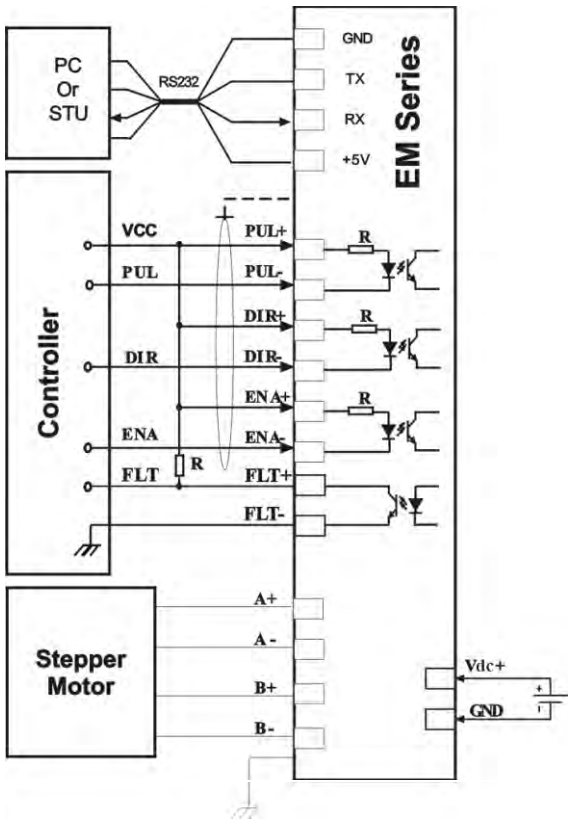


Typical Connections

Differential Control Signal

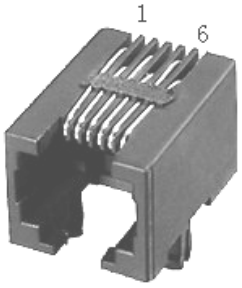


NPN Control Signal



RJ11 Connector for RS232 Communication

RJ11 Connector



Applied To:

Stepper Drive:

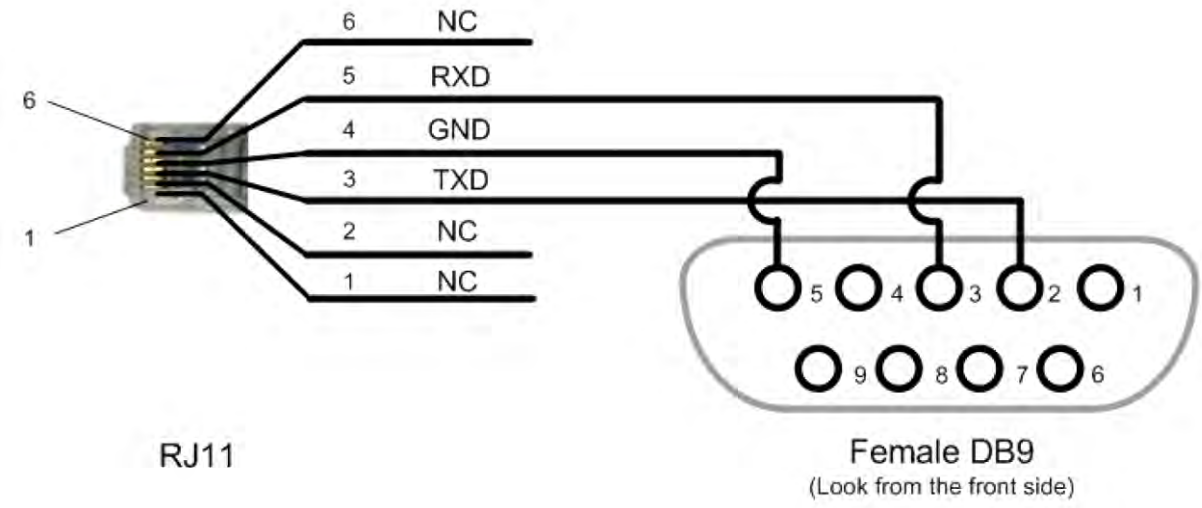
DM432C, DM442, DM556, DM856, 3DM683, AM882, DM1182, DM2282

Servo Drive:

DCS810, DCS810S, ACS306, ACS606, ACS806

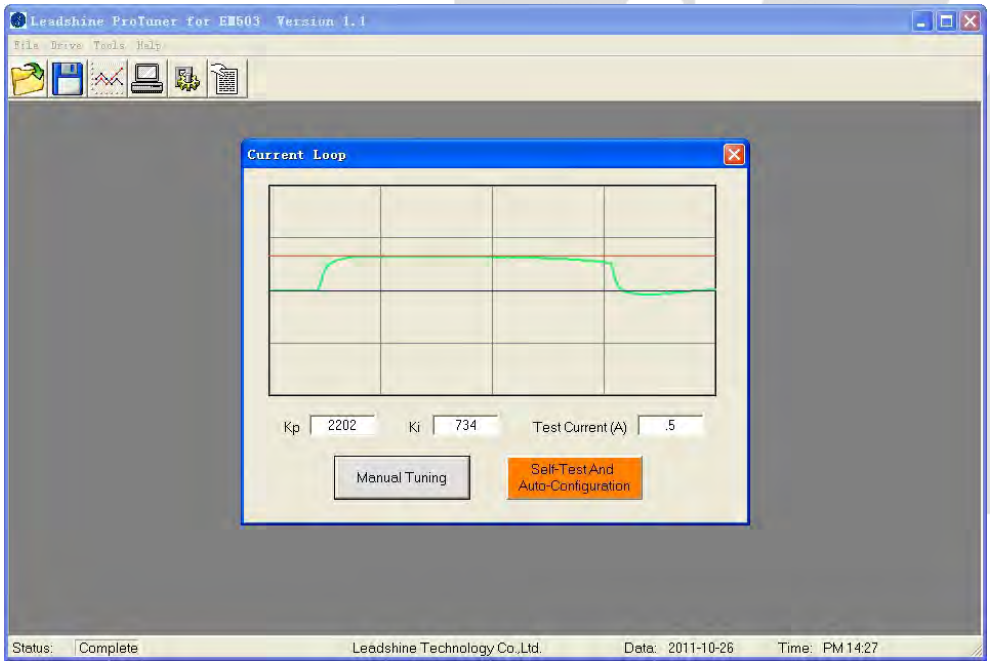
Pin	Signal	Description	I/O
1	NC	-	-
2	+5V	+5V power only for STU,left it unconnected when connect to a PC serial port	O
3	TxD	RS232 transmit.	O
4	GND	Ground.	GND
5	RxD	RS232 receive.	I
6	NC	-	-

2. Cable connections to a PC serial port (Male DB9)



Software Operational Manual

for EM Series Stepper Drives



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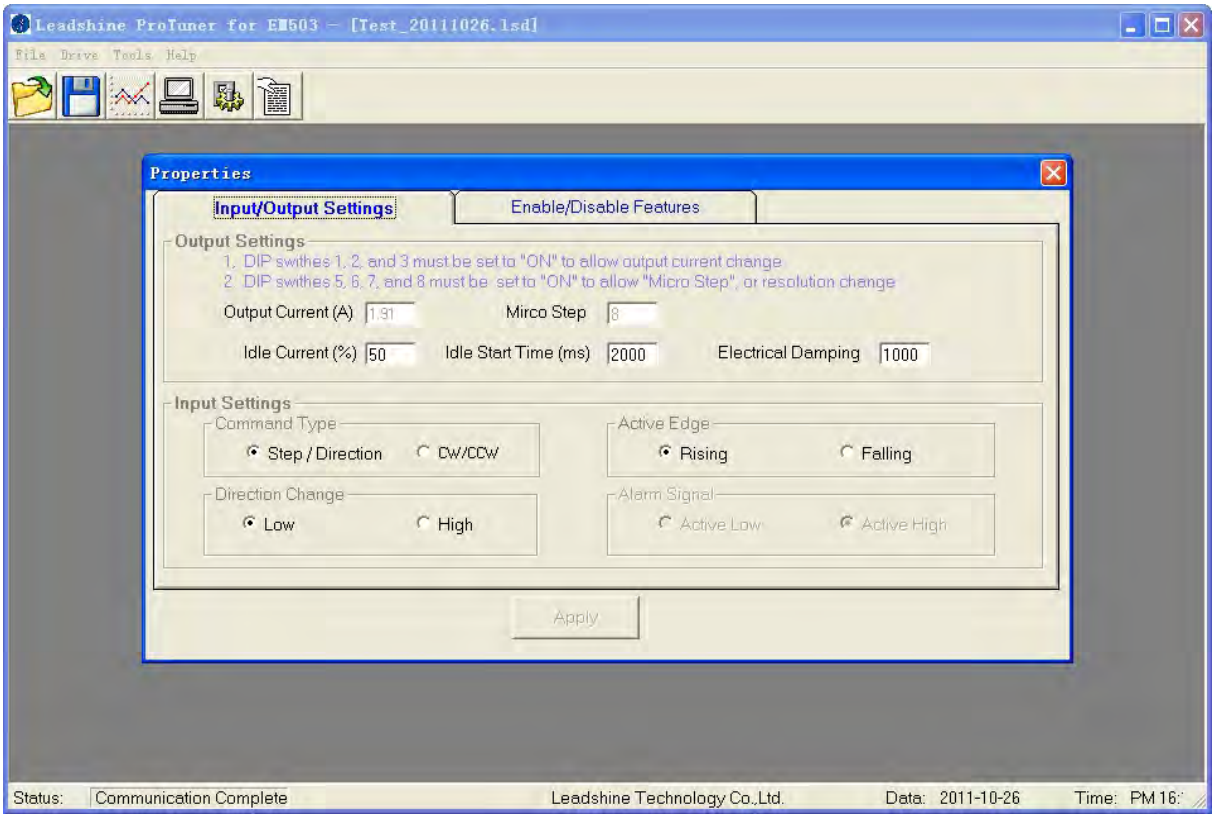
Introduction

The ProTuner is a software tool designed to configure and tune the Leadshine EM series digital stepper drives include EM402, EM503, EM705 and EM806. The user can configure the drive's output current, micro step, electronic damping, command type, tune the current loop and adjust the anti-resonance parameters in this software.

Workspace



Menu

Toolbar

Properties Window

Menus and Toolbar

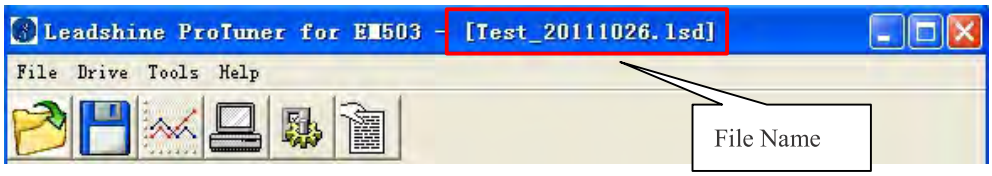
Menus and toolbars are at the top of the workspace. You can click menu bar to view pull-down menu. The toolbar below offers the most frequency used commands.

Menu	Pull Down	Toolbar	Function
File ->	Open		Open a file
	Save		Save a file
	Save As	-	Save as a file
	Close	-	Close the current file
	Exit	-	Exit from the software
Drive ->	Connect To Drive	-	Connect to drive
	Current Loop		Configure current loop parameters Kp and Ki.
	Properties		Set drive properties like output current, Micro Step, command type, electronic damping and active edge.
	Build-in Generator		Configure the built-in pulse generator which is used for anti-resonance tuning and self-test.
	Download to Drive	-	Download data to drive
	Reset Drive	-	Reset drive to factory setting
Tools->	Error Log		Check the drive error log.
	PIN Management	-	Change the drive's PIN
Help->	Hardware Manual on Web	-	Click to view EM drives hardware installation manual.
	Software Manual on Web	-	Click to view EM drives software operational manual.
	Leadshine Home Page	-	Click to visit Leadshine Home Page
	About Leadshine ProTuner	-	Software Information

Using the Software

Opening a file

If you want to load the configuration data from a file in the PC, click on the File->Open. The parameters in the software's workspace will be updated. The file name will appear in the tile bar.



Save a file

Click **Drive->Save** to save the data of current workspace to the open file. If there is no file opened, the Save Dialog appears and you can type in the file name then save it.

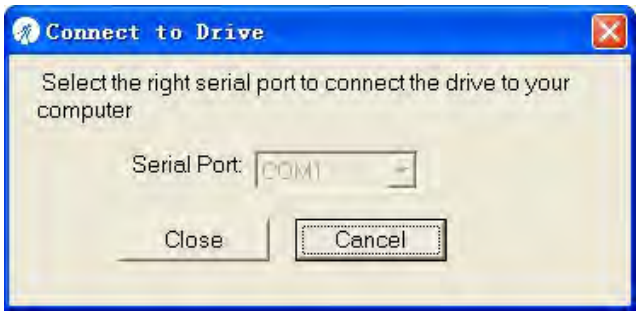
Save as a file

Click **Drive->Save As** to save the data in current workspace to a file and rename it.

Close

Click **Drive->Close** to close the current file.

Connecting Drive



Connect to Drive window appears every time you open ProTuner. You can also open it by clicking **Drive->Connect** any time. Select the serial port and click on the **Connect** button. The software will try to connect to the drive and read the settings. It may take several minutes. Please wait.

Notice

Before connecting the drive, please make sure:

1) The RS232 cable .has been connected between the drive and PC serial port.

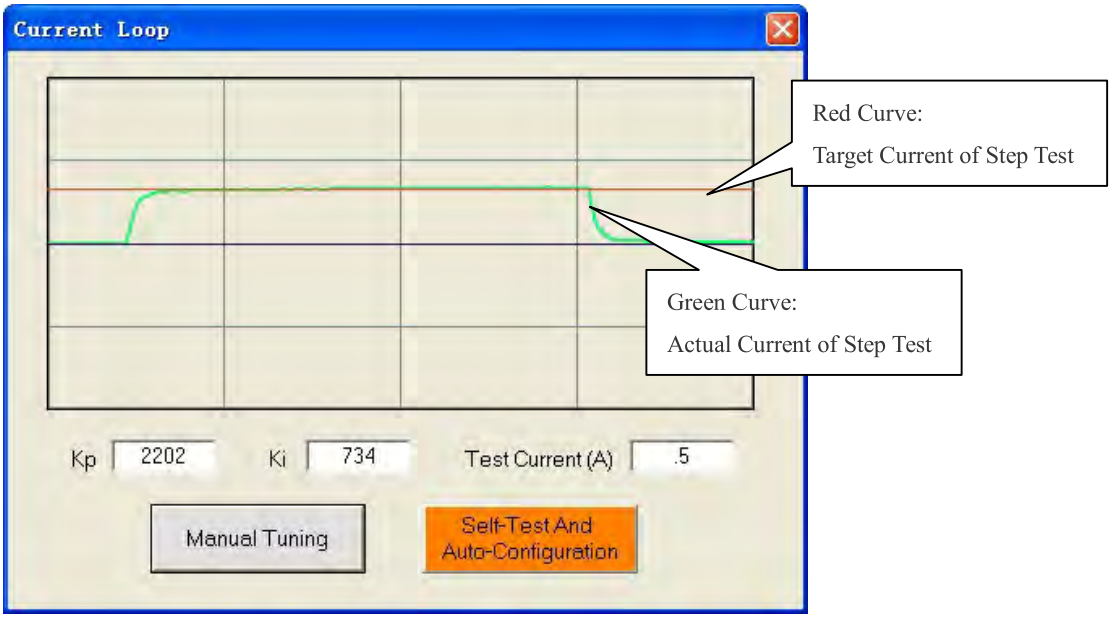
2) Power has been applied to the drive and the green LED is turned on.

The motor is no need to connect to the drive if you just want to change the parameters but not tuning.

Caution

Do not connect or disconnect serial cable when drive is powered on. The drive's communication circuit may be damaged.

Current Loop Tuning Window

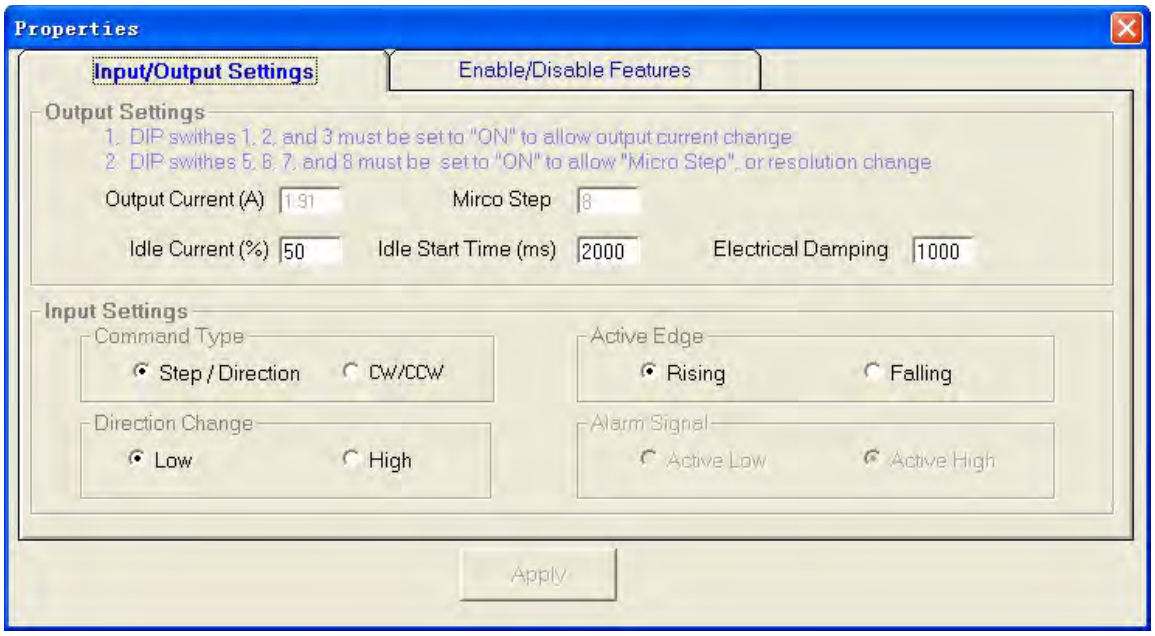


Click **Drive->Current Loop** to open the current loop tuning window. You can adjust the Kp (proportional gain) and Ki (integral gain) in this window. These parameters should be tuned before normal operation.

Item	Description	Range
Kp (Proportional Gain)	Increase Kp to make current rise fast. Proportional Gain determines the response of the drive to current setting command. Low Proportional Gain provides a stable system (doesn't oscillate), has low stiffness, and large current error, causing poor performances in tracking current setting command in each step. Too large Proportional Gain values will cause oscillations and unstable systems.	1 – 65535

Ki (Integral Gain)	Adjust Ki to reduce the steady error. Integral Gain helps the drive to overcome static current errors. A low or zero value for the Integral Gain may have current errors at rest. Increasing the Integral Gain can reduce the error. If the Integral Gain is too large, the systems may "hunt" (oscillate) about the desired position.	1 – 65535
Test Current	The current amplitude for the step response. Let this value not exceed the maximum output current of the drive.	EM402: 0.5 – 2.2A EM503: 0.5 – 4.2A EM705:: 0.5 – 7.0A EM806:: 0.5 – 8.2A
Manual Tuning	Enter Kp and Ki and click this button to activate the test. A target curve (red) and an actual curve (green) will be displayed on the screen for user analysis.	-
Self-test and Auto-configuration	Click this button to activate self-test and auto-configuration. The Kp and Ki will be tuned automatically.	-

Properties - Input/Output Settings



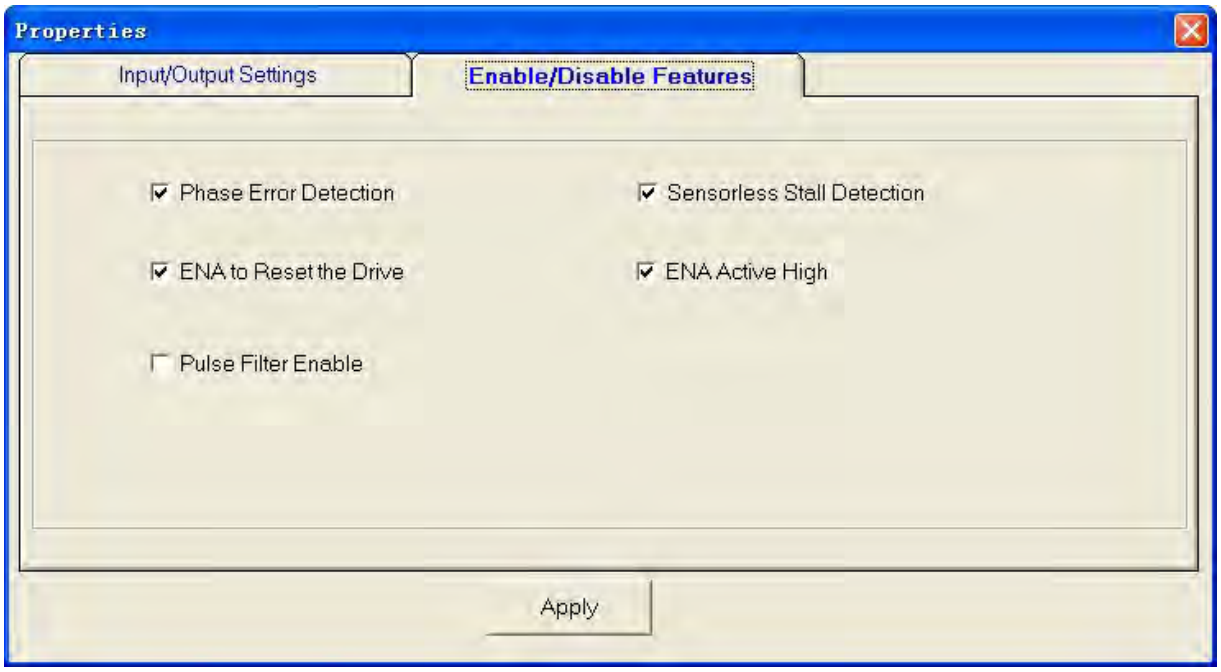
Click **Drive->Properties** to open the **Properties** window. In the **Input/Output Settings** Tab, the user can set Output Current, Micro Step, Idle Current, Electronic Damping, Pulse Active Edge and Command Type.

Notice

1. DIP switch must be in Default mode (SW1, 2 for EM402 and SW1, 2, 3 for the others) to allow current change.
2. DIP switch must be in Default mode (SW4, 5 for EM402, SW5, 6, 7, 8 for EM503 and EM705, SW5, 6, 7 for EM806) to allow Micro Step change.

Item	Description	Range
Output Current	Drive's output current for the motor. It should be less than 1.4 times of the motor's RMS current/phase. **Note**: The DIP switch setting must be in default mode as follows to be configured by software. EM402: SW1 = on, SW2 = on EM503, EM705, EM806: SW1 = on, SW2 = on, SW3 = on	EM402: 0.07-2.2A EM503: 0.21-4.2A EM705: 0.35-7.0A EM806: 0.35-8.2A
Micro Step	Drive's Micro Step setting for the motor. **Note**: The DIP switch setting must be in **Default** mode as follows to be configured by software. EM402: SW4= on, SW5 = on EM503, EM705: SW5 = on, SW6 = on, SW7 = on, SW8=on EM806: SW5 = on, SW6 = on, SW7 = on	1-512
Idle Current	Idle current at motor stop. The drive goes into idle state when there is no pulse applied to it and the DIP SW3 (EM402), SW4 (The others) is set to OFF.	10%-100%
Idle Start Time	The time when there is no pulse applied to the drive. The drive goes into idle state after this time.	1-5S
Electronic Damping	Adjust this parameter to improve the drive's high speed performance. The optimal value depends on the system.	1-6000
Command Type	Command Type or pulse mode of control signal. Select PUL/DIR or CW/CCW according to command type of motion controller. PUL/DIR means pulse and direction mode; CW/CCW means double pulses mode. (Note: The EM402 and EM806 only support step & direction command.)	PUL/DIR CW/CCW
Active Edge	Pulse active edge. The motor shaft moves one micro step every active edge.	Rising /Following
Direction Change	Change the motor direction. It is only active in PUL/DIR command mode. Please note that the actual direction is also related to the motor coil connection.	(High)Positive /(Low)Negative
Alarm Signal	Set active impedance for the alarm (fault) signal. Active High means high output impedance for drive error and Active Low means low output impedance for driver error. (Note: The Alarm Signal of the EM503 and EM705 can not be configured, fixed at Active Low.)	Active Low /Active High
Apply	Apply Button. Click this button to apply all the changes.	-

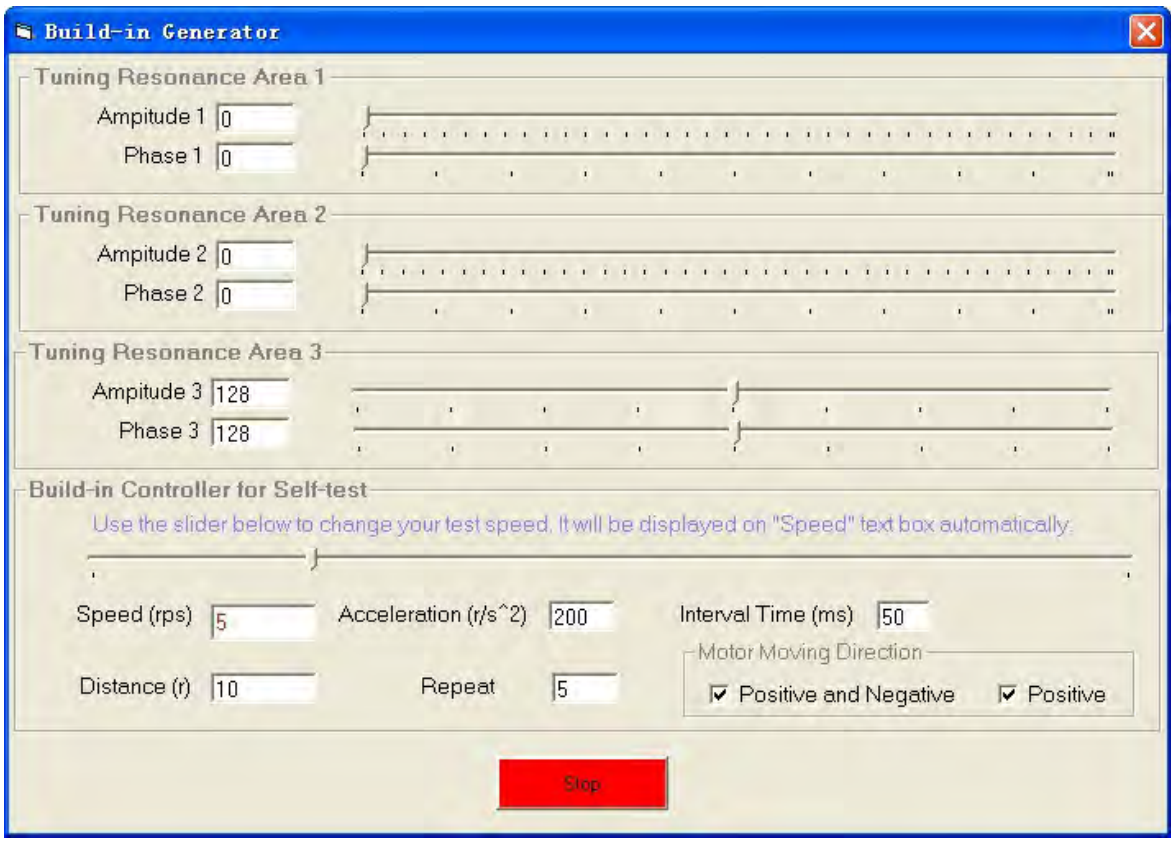
Properties - Enable/Disable Features



This window offers options of enabling phase error detection, motor stall detection and pulse filter. You can also set the active signal of the enable signal and use it for drive reset to clear the error.

Item	Description
Phase Error Detection	Check it to enable phase error detection which is activated when motor connection is wrong or one of the motor lead is disconnected. The alarm/fault output will be active if it is enabled.
Sensorless Stall Detection	Check it to enable motor stall detection without sensor. The alarm/fault output will be active if it is enabled.
ENA to Reset the Drive	Check it to let the enable signal to reset the drive which is in error state. The drive will restart and all the error will be clear.
ENA Active High	Check it to set the active high for ENABLE signal.
Pulse Filter Enable	Check it to enable the pulse filter which smooth the command input.

Built-in Controller for Self-test



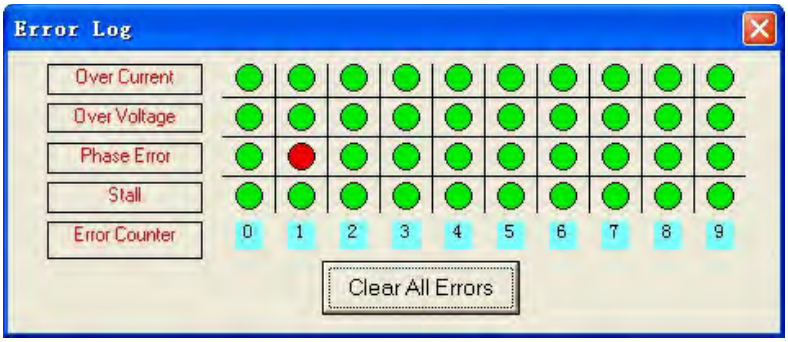
You can adjust the anti-resonance parameters in this window. The built-in controller can be used for anti-resonance tuning and self test.

Item	Description	Range
The 1st Resonance Area	It is usually between 0.6 to 1.2 RPS.	-
Amplitude 1	Amplitude adjustment for the 1st anti-resonance area. The user can enter a value directly in the text box or move the slider bar back and forth to get an optimum value.	0 – 3500
Phase 1	Phase adjustment for the 1st anti-resonance area. The user can enter a value directly in the text box or move the slider bar back and forth to get an optimum value.	0 – 1608
The 2nd Resonance Area	It is usually between 1.2 to 2.4 RPS.	-
Amplitude 2	Amplitude adjustment for the 2nd anti-resonance area. The user can enter a value directly in the text box or move the slider bar back and forth to get an optimum value.	0 – 3500

Phase 2	Phase adjustment for the 2nd anti-resonance area. The user can enter a value directly in the text box or move the slider bar back and forth to get an optimum value.	0 – 1608
The 3rd Resonance Area	It is usually between 2.4 to 4.8 RPS.	-
Amplitude 3	Amplitude adjustment for the 3rd anti-resonance area. The user can enter a value directly in the text box or move the slider bar back and forth to get an optimum value.	0 – 256
Phase 3	Phase adjustment for the 3rd anti-resonance area. The user can enter a value directly in the text box or move the slider bar back and forth to get an optimum value.	0 – 256
Speed	Display the current speed when you move the slider.	0-20 RPS
Acceleration	Acceleration of Built-in Controller.	1-65535
Interval Time	Interval between the positive and negative move.	1-65535
Repeat	Repeat times.	1-65535
Motor Moving Direction	If it is positive, the motor moves only in positive direction. If it is positive and negative, the motor moves in both positive and negative direction.	-
Start	Click to start the motion.	

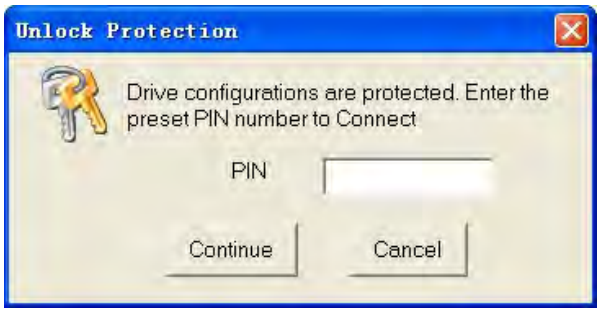
Error Log Window

Click **Tool->Error Log** to open the error log window. This window shows both the present status of each error event and their history.



Item	Description
Over Current	The motor coil current exceeds the output limit of the drive.
Over Voltage	The input voltage exceeds the input limit of the drive.
Phase Error	Wrong motor coil connection or one of the motor lead is disconnected.
Stall	The motor has been stalled.
Clear All Errors	Clear the error log.

PIN Management Window



Every EM drive has a 4-digit PIN (Personal Identification Number). The default PIN is 0000. If you don't want the drive's configuration from read by others, set or change the PIN number in this window. Next time the software communicates with the drive, it requires the operator to enter the PIN number. If you forget the PIN, the only way to communicate with the drive again is resetting the drive by clicking Drive->**Rreset Drive**. The PIN will be 0000 again and all the data is reset to factory setting.

Configuring the Drive

If it is the first time setup, you can follow the steps below to configure the drive.

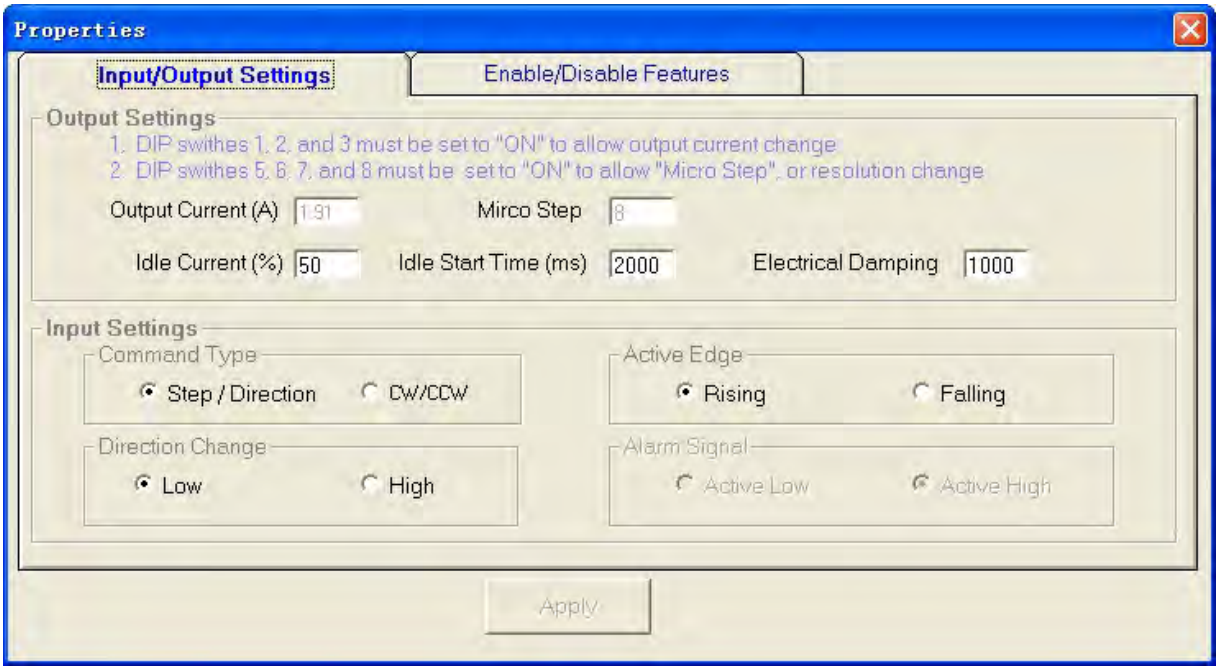
1) Set Input/Output parameters like output current, Micro Step and command type according to the motor and application.
2) Tune the current loop parameters with the connected motor.
3) Tune the anti-resonance parameters if necessary.
4) Adjust the electronic damping when the high speed performance is not good.

Notice

The motor must be connected to the drive before trying to configure the drive.

Set Input/Output Parameters

Click Drive->Properties to open the Property window. You can set the Output Current, Micro Step and Command Type.



In most of the application, it is required to set only the output current, Micro Step and Command. Usually, the motor manufacturer states the RMS (root mean square) current in datasheet. Please refer to the hardware installation manual for how to set the output current.

Notice

1. DIP switch must be in Default mode (SW1, 2, for EM402 and SW1, 2, 3 for the others) to allow current change.
2. DIP switch must be in Default mode (SW4, 5 for EM402, SW5, 6, 7, 8 for EM503 and EM705, SW5, 6, 7 for EM806) to allow Micro Step change.
3. The EM402 and EM806 only support step & direction command.

High resolution Micro Step makes the motor move more smoothly. Low Micro Step resolution reduces the high frequency requirement to the controller. See the EM drives hardware installation manual for more information for how to select the Micro Step.

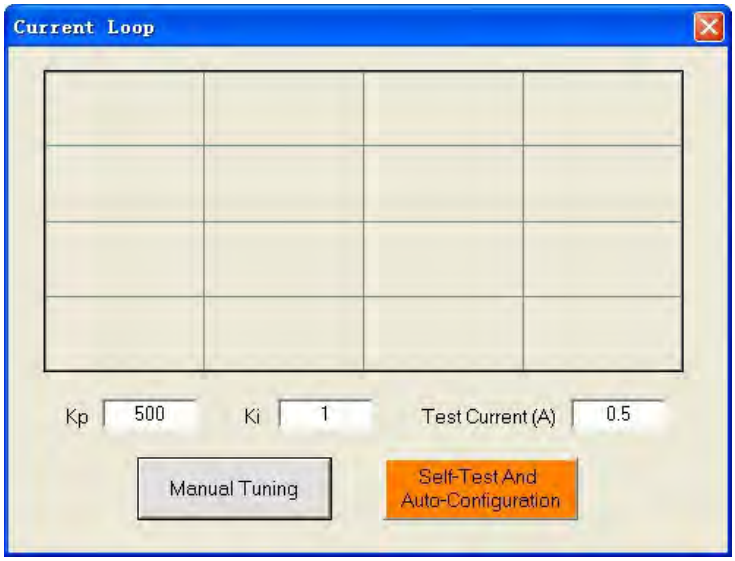
Current Loop Tuning

The current loop parameter needs to be tuned before normal for optimize responses with different motors. Otherwise motor will be easily stalled or howls at power-up. Below is the tuning process of EM705 for a NEMA 23 motor with 24VDC supply voltage.

Notice

Before trying to tune the current loop parameters, select “custom” in the motor selection table for the rotation switch. Please note that change of motor requires re-power of drive.

Step 1: Set **Test Current** 0.5 and start the tuning with small **Kp** and “zero” **Ki**. Here we set **Kp**=500 and **Ki**=1.



Initial Value

Kp = 500

Ki =1

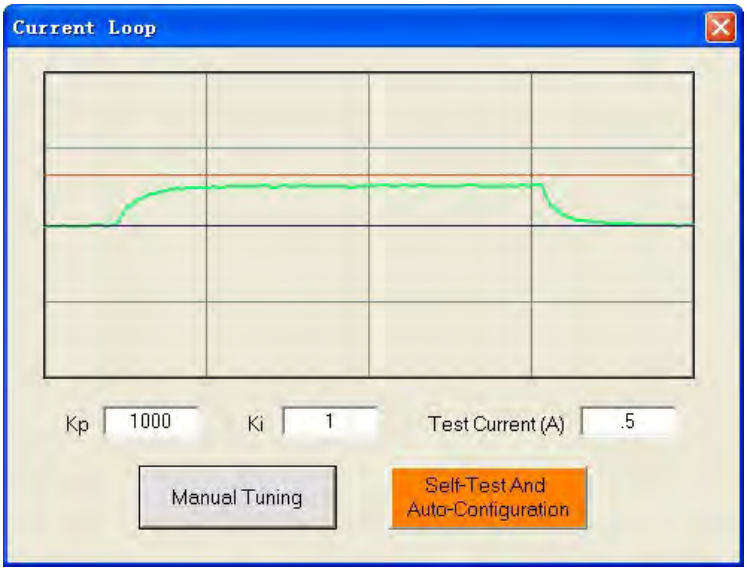
Step 2: Click the **Test** button and the plot window will show two curves. The red curve is target current and the green curve is actual current. There is large gap between them in the scope. It indicates that a large **Kp** needs to be introduced.

Start Test:

Kp = 500

Ki = 1

Step 3: Increase **Kp** to 1000 and click **Start**. The gap between target value and actual value is smaller but a higher **Kp** is still needed.

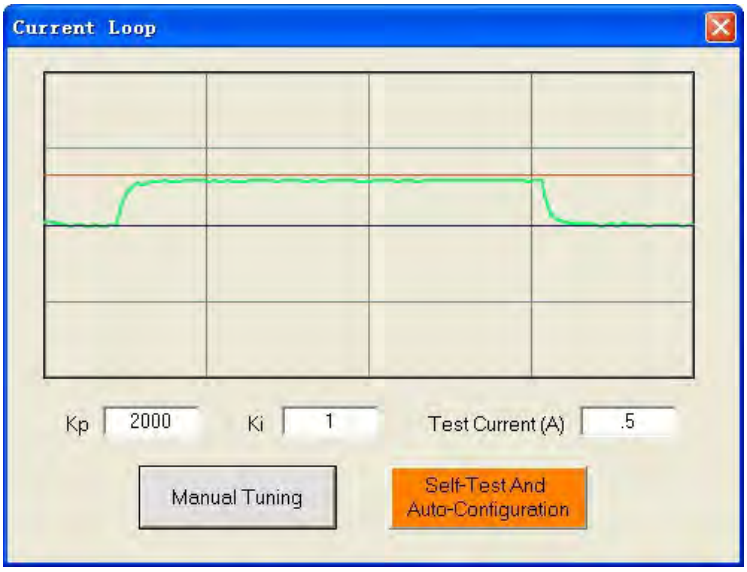


↑ Proportional Gain:

Kp = 1000

Ki = 1

Step 3: Give **Kp** 2000, 3000, 4000 and click **Manual Tuning,** respectively. The green curve is getting more and more close to the red curve. Over-shoot is obvious when we increase **Kp** to 4000. It indicates that you need to stop increasing Kp and back off. Our purpose is to make the green curve (the actual current) a little higher than the red curve (the target). So we decrease Kp to 3700 until the actual value is exactly over the target value.



↑ Proportional Gain:

Kp =2000

Ki = 1

↑ Proportional Gain:

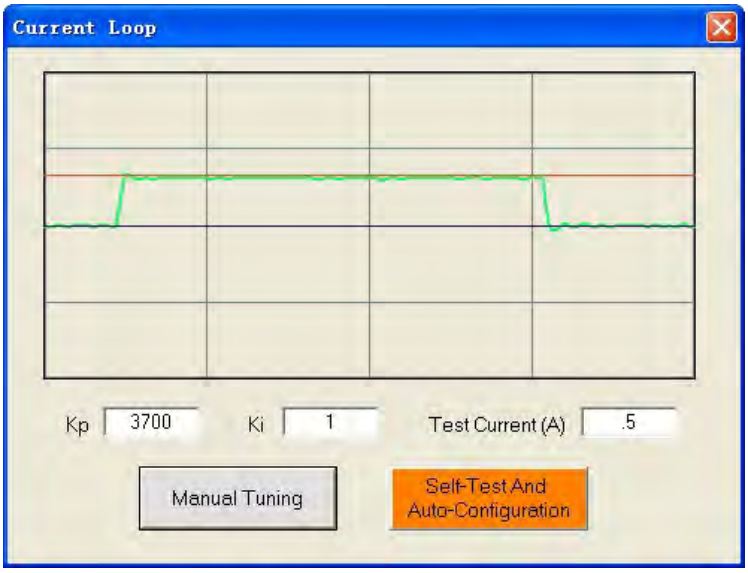
Kp = 3000

Ki = 1

↑ Proportional Gain:

Kp =4000

Ki = 1

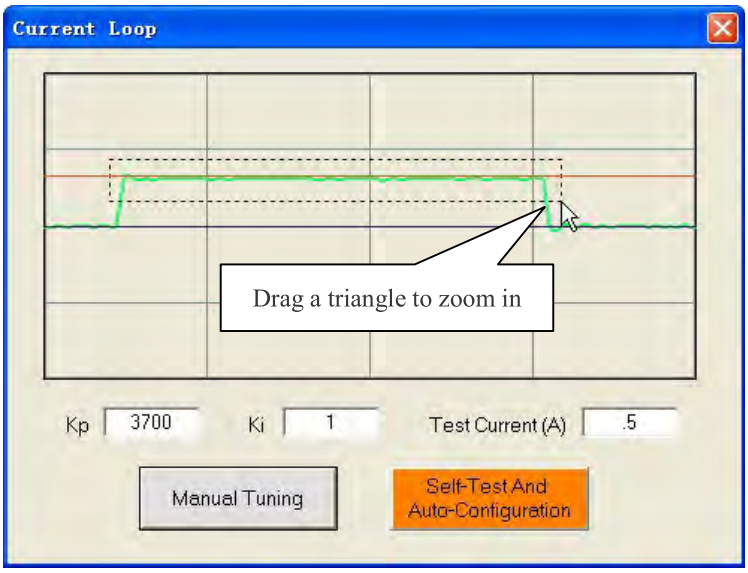


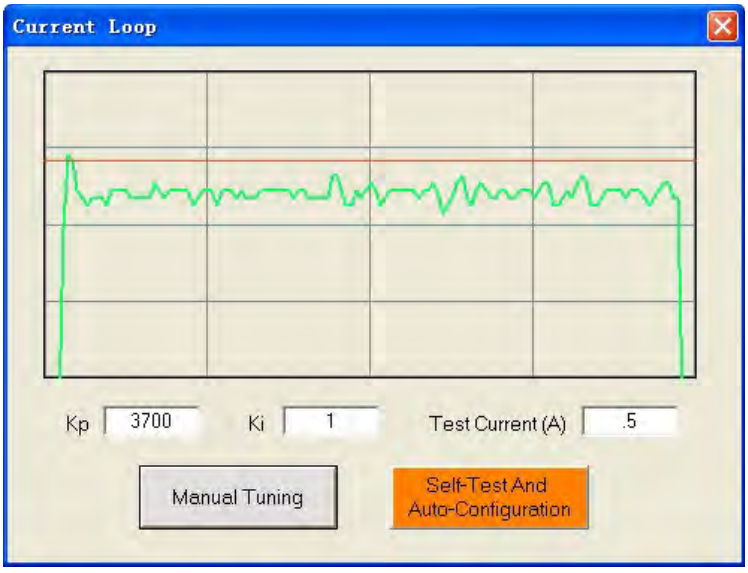
↓ Proportional Gain:

Kp =3700

Ki = 1

Step 4: Now the **Kp** is relatively good enough. But there is still gap between the green curve and the red curve when we use the mouse to zoom in the green curve. So we need to introduce **Ki** to reduce the "gap" or steady error at the constant part. It follows the same procedure as **Kp**. High **Ki** causes big vibration, system lag and makes the performance worse. The following figures show how to tune the integral gain.

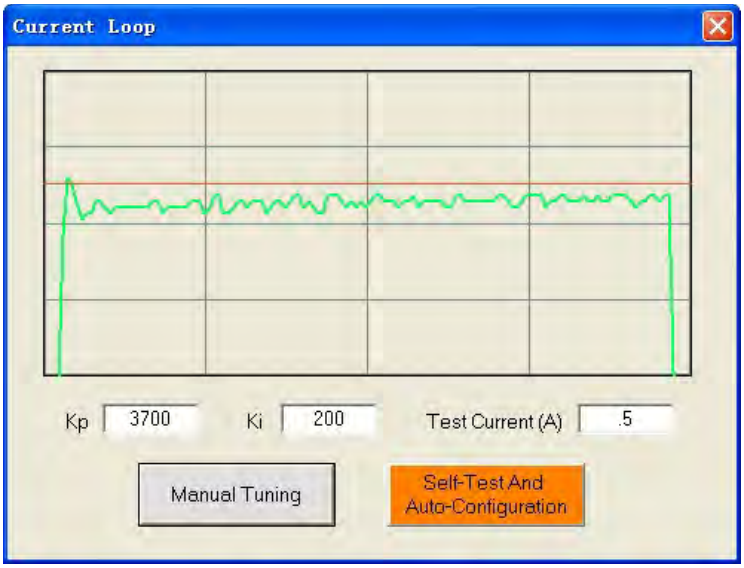




Zero Integral Gain:

Kp =3700

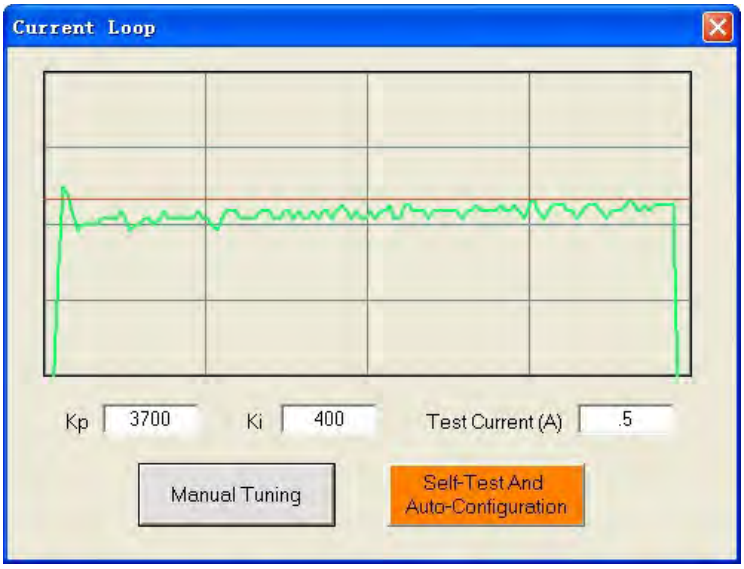
Ki = 1



↑ Integral Gain:

Kp =3700

Ki = 200

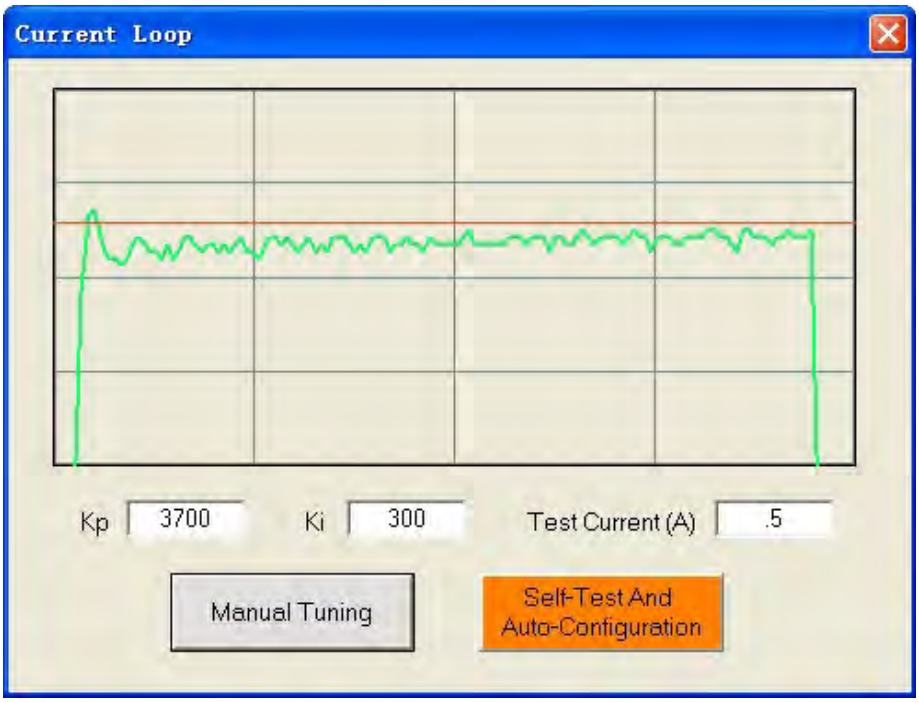


↑ Integral Gain:

Kp =3700

Ki = 400

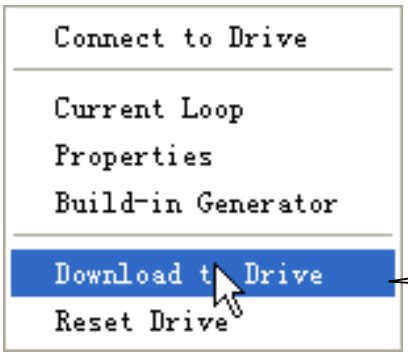
Step 5: The current loop tuning is basically finished. You can continue to adjust Kp and Ki for better performance. Now the updated Kp and Ki is just stored in the driver's RAM. They will be lost when we power off the driver. **Don't forget to click Drive->Download To Drive to store the changed value to the drive's EEPROM.**



Further Adjustment:

Kp =3500

Ki = 300



Save all the changes to the drive's non-violated nonvolatile memory. You need to close the current tuning window firstly.

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Anti-resonance Tuning

Stepper motors are highly resonant, which results in vibration and ringing. The ringing utilizes a large fraction of the motor's available torque – thereby wasting performance. Furthermore, at mid-range velocities, the resonance can become so severe that the motor looses synchronization and stalls. The EM drive provides robust anti-resonance control to stop the vibrations and maintain equilibrium. This feature requires that the drive be configured with respect to the total inertia in the system. If set improperly, the effectiveness of the feature may be diminished.

1. For most of the application, it is not needed to tune EM drive anti-resonance parameters. We only recommend the advance user to use this function as it is a boring process.
2. In most of the case, only the tuning of the 1st and 2nd anti-resonance area has obvious effect.

Step 1: Start the motion test by clicking **Start/Stop** button. Find a resonance speed by slightly moving the slider bar of internal pulse generator back and forth. You can also use the arrow keys to adjust the speed precisely.

Step 2: Run the motor at the resonance speed and verify the motor smoothness. You may find a better smoothing value by slightly moving the slider bars of **Amplitude** and **Phase** back and forth.
It is very important to make the **Amplitude** and **Phase** adjustments at the proper test speeds with an unloaded motor. Running at an incorrect test speed will not excite the motor at its peak resonance, making it more difficult to find proper adjustment values. Optimum **Amplitude** and **Phase** values may be a little different between running the tests with an unloaded motor and a load motor.

Step 3: Keep the motor running at the resonance speed and verify the motor smoothness. You may find a better smoothing value by slightly moving the slider bars of **Amplitude** and **Phase** back and forth. If the motor speed is 0.6-1.2RPS, you should tune the Amplitude and Phase at the 1st resonance area. The 2nd resonance area is 1.2-2.4 RPS and the 3rd resonance area is 2.4 4.8 RPS.

For example, we find a resonance speed at 0.98 rps. We begin to move the Amp1 slider forth and the motor vibration and noise became lower and lower. Finally we find the move is the smoothest when **Amplitude 1** is 3300. The motor vibration and noise increase if **Amplitude 1** exceeds 3300. Then we follow the same procedure to search the best point for **Phase 1**. See Figure 26. Anti-resonance tuning is done.

Step 4: Click **Drive->Download To Drive** to save all the parameters to EM drive's nonvolatile memory.

Adjusting Electronic Damping

The factory setting for the electronic damping is 1000. If the motor is easily stalled and generates odd noise at middle speed, you can try other values such as 500, 1500, 2000, 2500.