

Hardware Installation Manual for EM Series Stepper Drives



Leadshine reserves the right to make changes without further notice to any products herein to improve reliability, function or design. Leadshine does not assume any liability arising out of the application or use of any product or circuit described herein; neither does it convey any license under its patent rights of others.

Leadshine's general policy does not recommend the use of its products in life support or aircraft applications wherein a failure or malfunction of the product may directly threaten life or injury. According to Leadshine's terms and conditions of sales, the user of Leadshine's products in life support or aircraft applications assumes all risks of such use and indemnifies Leadshine against all damages.

©2016 by Leadshine Technology, All Rights Reserved

Change Log

Revision Date	Changes	Version
2011-10-18	Original Create	MN-EM-R20111018
2016-09-18	Series model, current-limited resistors	V1.1

Safety Items



Read this manual carefully before trying to install the stepper drive into your system. The person setup the stepper drive should have a better understanding on electronics and mechanics. Contact Leadshine technical guys when have questions on this document.



Make sure the power supply voltage dose not exceed the drive's input range. Double check the connections and make sure the power lead polarity is correct.



Do not set high current to small stepper motor. It is possible that the motor will be damaged.



Disconnect the motor from the load if you are not sure the move direction. Adjust the axis in the middle before trying to run the motor.



Never disconnect the motor lead when the power source is energized.

Table of Contents

1. Family Overview.....	1
Introduction.....	1
Product Covered.....	1
2-phase EM Stepper Drives.....	1
Mechanical Specifications.....	1
Elimination of Heat.....	2
3. Connectors and Pin Assignment.....	2
4. Control Signal Requirement.....	3
Signal Mode and Sequence Chart.....	3
5. Connecting Control Signal.....	3
NPN Signal Connections.....	4
PNP Signal Connections.....	4
Differential Signal Connections.....	4
6. Connecting the Motor.....	5
2-phase, 4-lead Motors Connections.....	5
2 phase, 6-lead Motors Connections.....	5
Half Coil Configurations.....	5
Full Coil Configurations.....	5
2 phase, 8-lead Motors Connections.....	6
Series Connections.....	6
Parallel Connections.....	6
Matching Stepper Motors.....	6
7. Power Supply Selection.....	7
Regulated or Unregulated Power Supply.....	7
Multiple Drives.....	7
Selecting Supply Voltage.....	7
Recommended Supply Voltage.....	8
8. Typical Connections.....	8
9. Wiring Notes.....	8
10. Configuring the Drive.....	9
Introduction.....	9
Configuration Procedure.....	10
Selecting Motor.....	10
Auto Configuration.....	10
Microstep Resolution Selection.....	11
Current Settings.....	11
Dynamic Current Setting.....	11
Idle Current Setting.....	11
11. Protection Functions.....	12

Over-current Protection.....	12
Over-voltage Protection.....	12
Sensorless Stall Protection.....	12
Protection Indications.....	12
12. Frequently Asked Questions.....	13
Problem Symptoms and Possible Causes.....	13
Appendix.....	14
Speed Torque Curves for Pre-Matching Leadshine Motors.....	14
Twelve Month Limited Warranty.....	15
Exclusions.....	15
Obtaining Warranty Service.....	15
Warranty Limitations.....	15
Shipping Failed Product.....	15
Contact Us.....	16

1. Family Overview

Introduction

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.

Product Covered

The EM series stepper drives can be cataloged as follows:

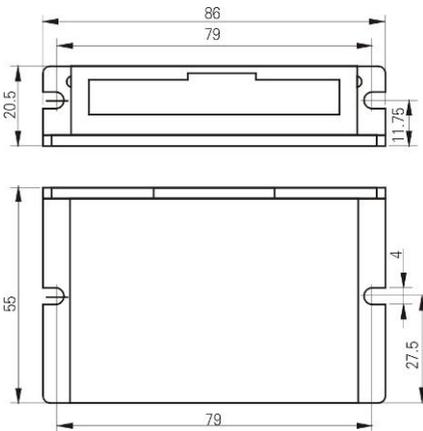
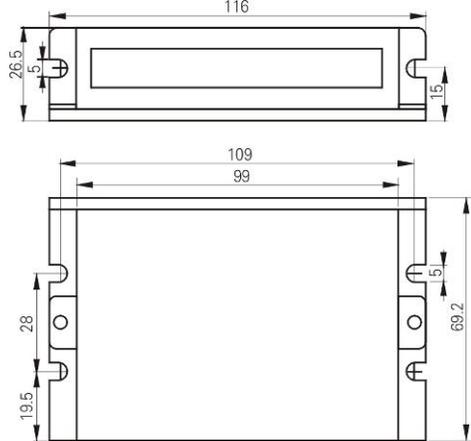
◆ 2-phase EM stepper drives include EM402, EM503, EM705, EM806

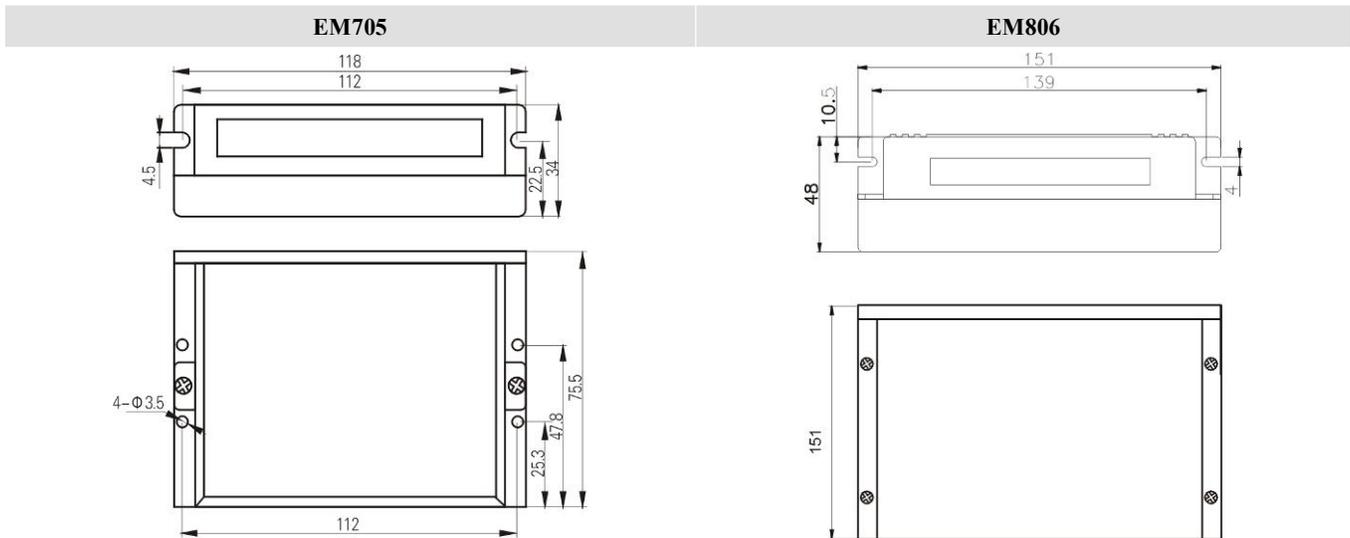
This manual describes how to install and configure the above stepper drives.

2-phase EM Stepper Drives

Part Number	Input Voltage	Typical Supply Voltage	Output Current	Pulse Frequency
EM402	DC (20-40)V	DC 24V	RMS (0.07-2.0)A	50K
EM503	DC (20-50)V	DC 36V	RMS (0.21-3.0)A	200K
EM705	DC (20-70)V	DC 48V	RMS (0.35-5.0)A	200K
EM806	DC (24-80)V	DC 68V	RMS (0.35-6.0)A	200K

Mechanical Specifications

EM402	EM503
	

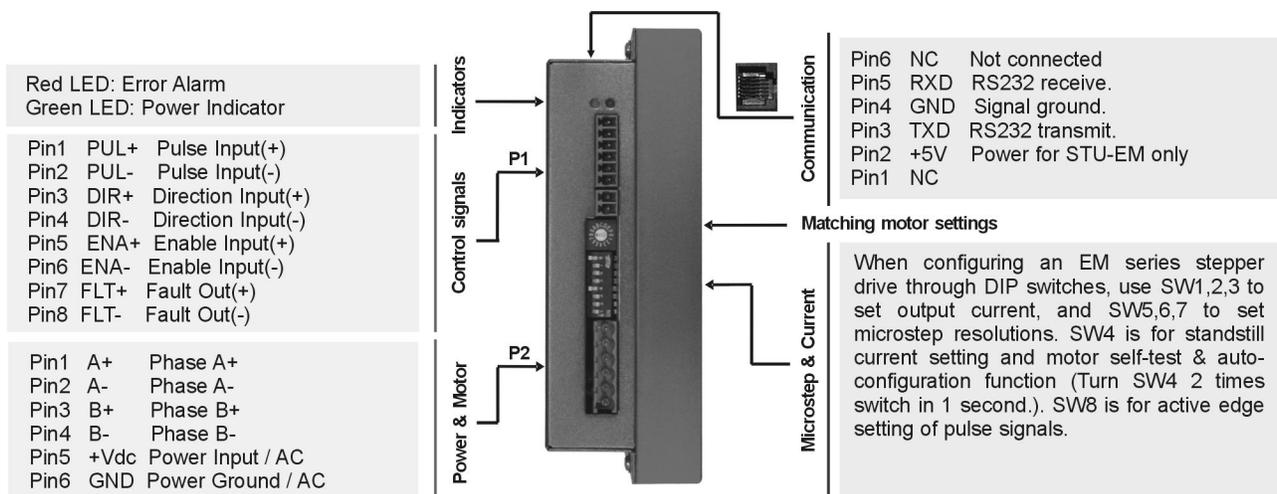


Elimination of Heat

- Drive's reliable working temperature(heat sink) should be $<70^{\circ}\text{C}$ (158°F), and motor working temperature(surface) should be $<80^{\circ}\text{C}$ (176°F);
- It is recommended to use automatic idle-current mode, namely current automatically reduce to 60% when motor stops, so as to reduce driver heating and motor heating;
- It is recommended to mount the driver vertically to maximize heat sink area. Use forced cooling method to cool the system if necessary.

3. Connectors and Pin Assignment

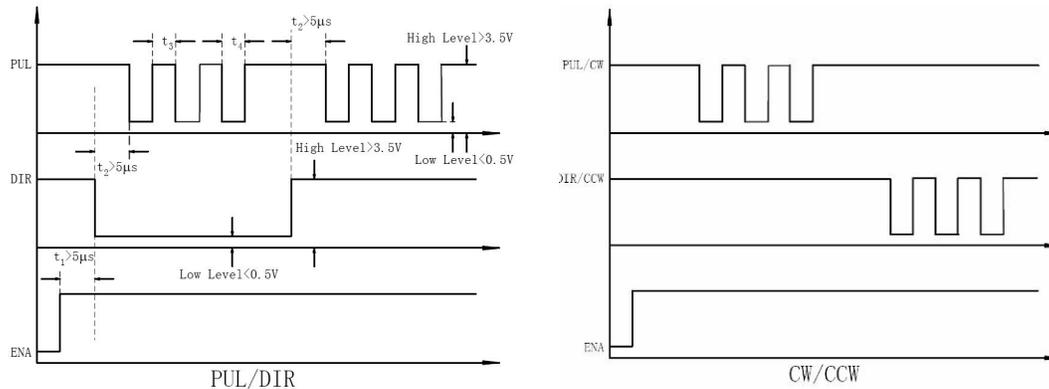
The EM stepper drives have two connectors, connector for control signals connections and connector for power and motor connections. Most EM drives adopt screw terminals for signal and power connections as follows. The following figure is connectors and pin assignment of EM806. The other EM drives have similar interface. Please refer to drive's datasheet for the detail.



4. Control Signal Requirement

Signal Mode and Sequence Chart

Most EM drive can support Pulse/Direction and CW/CCW control signal modes. In order to avoid some fault operations and deviations, PUL, DIR and ENA should abide by some rules, shown as following diagram:



Remark:

- ENA must be ahead of DIR by at least 5us. Usually, ENA+ and ENA- are NC (not connected).
- DIR must be ahead of PUL active edge by 5us to ensure correct direction;
- Pulse width not less than t_3 ;
- Low level width not less than t_4 .

Model	t_3	t_4
EM402	10 us	10 us
EM503	2.5 us	2.5 us
EM705	2.5 us	2.5 us
EM806	2.5 us	2.5 us

5. Connecting Control Signal

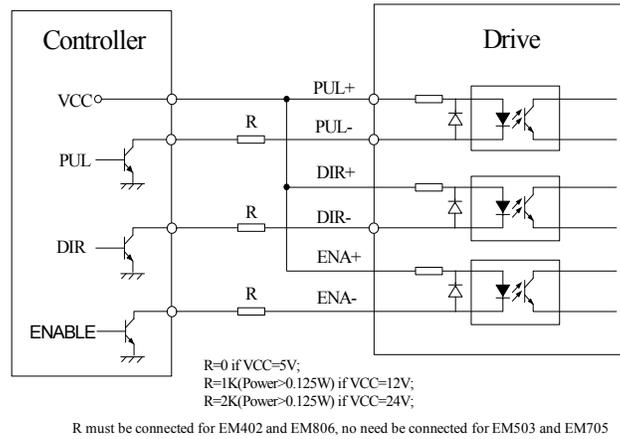
Most of the EM stepper drives can accept both differential and single-ended inputs (including open-collector and PNP output).

※Note: (1) EM402 can EM806 can only support PUL/DIR control mode.

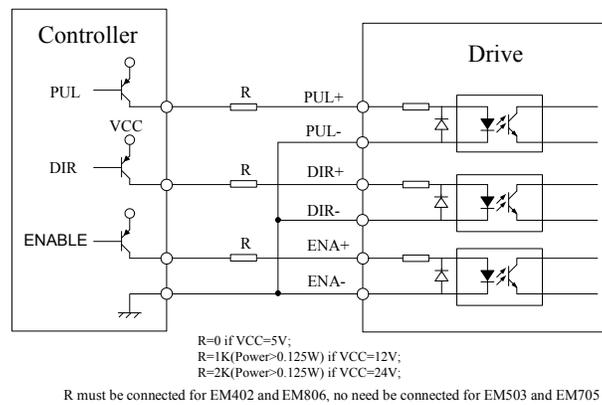
(2) For EM503 and EM705, no need series connect resistors when +12V or +24V used. The same as DIR and ENA signal.

(3) For EM402 and EM806, need series connect resistors when +12V or +24V used. The same as DIR and ENA signal.

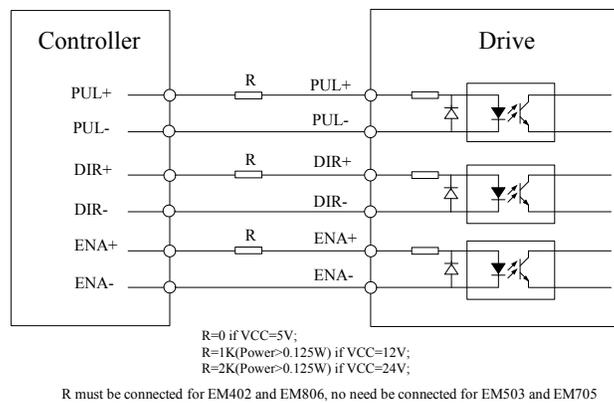
NPN Signal Connections



PNP Signal Connections



Differential Signal Connections

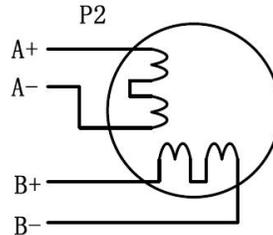


6. Connecting the Motor

The EM drive can drive any 2-phase hybrid stepper motors.

2-phase, 4-lead Motors Connections

4 lead motors are the least flexible but easiest to wire. Speed and torque will depend on winding inductance. In setting the drive output current, multiply the specified phase current by 1.4 to determine the peak output current.

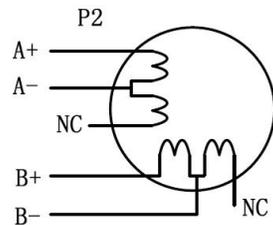


2 phase, 6-lead Motors Connections

Like 8 lead stepping motors, 6 lead motors have two configurations available for high speed or high torque operation. The higher speed configuration, or half coil, is so described because it uses one half of the motor's inductor windings. The higher torque configuration, or full coil, uses the full windings of the phases.

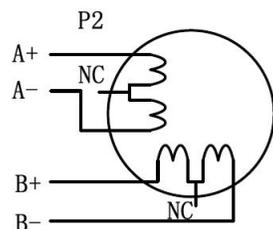
Half Coil Configurations

As previously stated, the half coil configuration uses 50% of the motor phase windings. This gives lower inductance, hence, lower torque output. Like the parallel connection of 8 lead motor, the torque output will be more stable at higher speeds. This configuration is also referred to as half chopper. In setting the drive output current multiply the specified per phase (or unipolar) current rating by 1.4 to determine the peak output current.



Full Coil Configurations

The full coil configuration on a six lead motor should be used in applications where higher torque at lower speeds is desired. This configuration is also referred to as full chopper. In full coil mode, the motors should be run at only 70% of their rated current to prevent over heating.

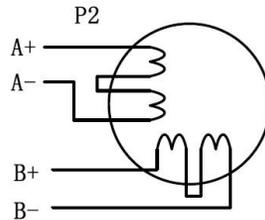


2 phase, 8-lead Motors Connections

8 lead motors offer a high degree of flexibility to the system designer in that they may be connected in series or parallel, thus satisfying a wide range of applications.

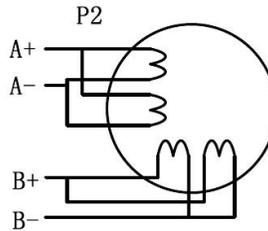
Series Connections

A series motor configuration would typically be used in applications where a higher torque at lower speeds is required. Because this configuration has the most inductance, the performance will start to degrade at higher speeds. In series mode, the motors should also be run at only 70% of their rated current to prevent over heating.



Parallel Connections

An 8 lead motor in a parallel configuration offers a more stable, but lower torque at lower speeds. But because of the lower inductance, there will be higher torque at higher speeds. Multiply the per phase (or unipolar) current rating by 1.96, or the bipolar current rating by 1.4, to determine the peak output current.



Matching Stepper Motors

	Minimum Motor Size	Typical Motor Size	Maximum Motor Size	Leadshine Stepper Motors
EM402	NEMA 8	NEMA 17	NEMA 23	35HS01, 39HS02, 42HS02, , 42HS03
EM503	NEMA 14	NEMA 23	NEMA 23	57HS04, 57HS09, 57HS13, 57HS22
EM705	NEMA 17	NEMA 23	NEMA 34	57HS22, 86HS35, 86HS45
EM806	NEMA 23	NEMA 34	NEMA 34	86HS35, 86HS45, 86HS85

7. Power Supply Selection

The DM drive can match medium and small size stepping motors (from NEMA frame size 8 to 34) made by Leadshine or other motor manufactures around the world. To achieve good driving performances, it is important to select supply voltage and output current properly. Generally speaking, supply voltage determines the high speed performance of the motor, while output current determines the output torque of the driven motor (particularly at lower speed). Higher supply voltage will allow higher motor speed to be achieved, at the price of more noise and heating. If the motion speed requirement is low, it's better to use lower supply voltage to decrease noise, heating and improve reliability.

Regulated or Unregulated Power Supply

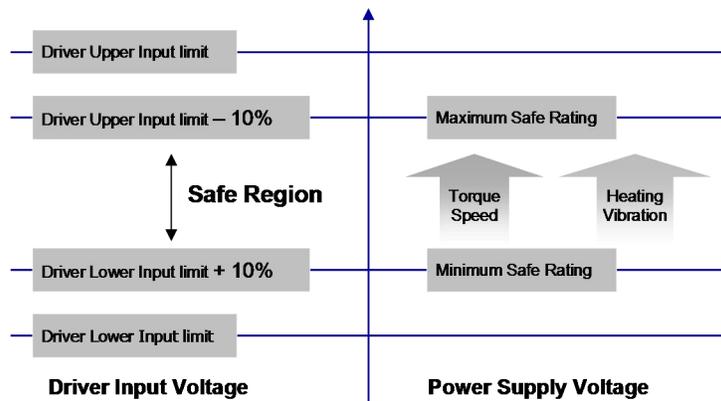
Both regulated and unregulated power supplies can be used to supply the drive. However, unregulated power supplies are preferred due to their ability to withstand current surge. If regulated power supplies (such as most switching supplies.) are indeed used, it is important to have large current output rating to avoid problems like current clamp, for example using 4A supply for 3A motor-drive 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 drive 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.

Multiple Drives

It is recommended to have multiple drives 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 drives. Instead, please connect them to power supply separately.

Selecting Supply Voltage

The power MOSFETS inside the EM drive can actually operate with wider voltage range than the input specification. Higher supply voltage can increase motor torque at higher speeds, thus helpful for avoiding losing steps. However, higher voltage may cause bigger motor vibration at lower speed, and it may also cause over-voltage protection or even drive damage. Therefore, it is suggested to choose only sufficiently high supply voltage for intended applications, and it is suggested to use power supplies with theoretical output voltage of drive's minimum + 10% to drive's maximum - 10%, leaving room for power fluctuation and back-EMF.



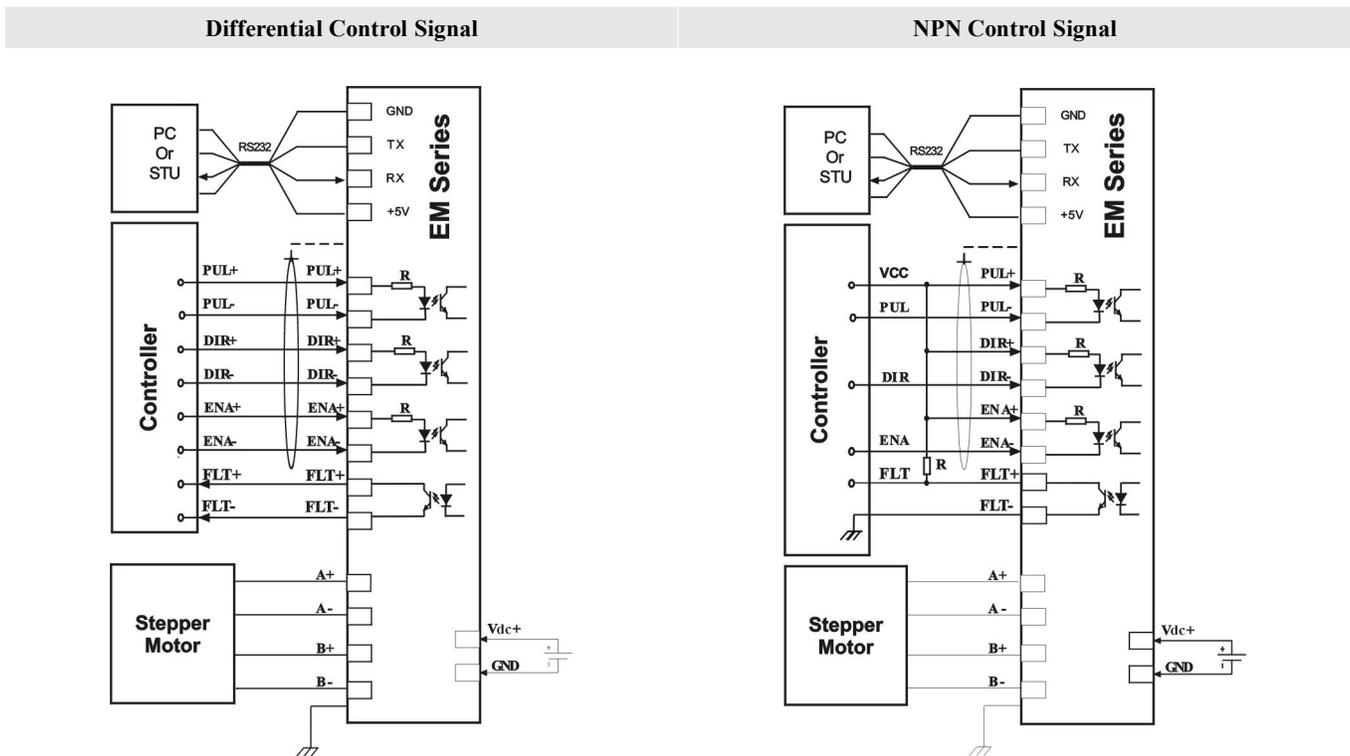
Recommended Supply Voltage

The following table gives the recommended supply voltage for different drives.

Model	Voltage Range	Typical Voltage	Leadshine Power Supply
EM402	DC(20-36)V	DC 24V	RPS2410(-L)
EM503	DC(20-45)V	DC 36V	RPS369
EM705	DC(20-63)V	DC 48V	RPS488
EM806	DC(24-72)V	DC 60V	RPS608

8. Typical Connections

A complete stepping system should include stepping motor, stepping drive, power supply and controller (pulse generator). Typical connections for differential control signal and NPN control signal are as follows.



9. Wiring Notes

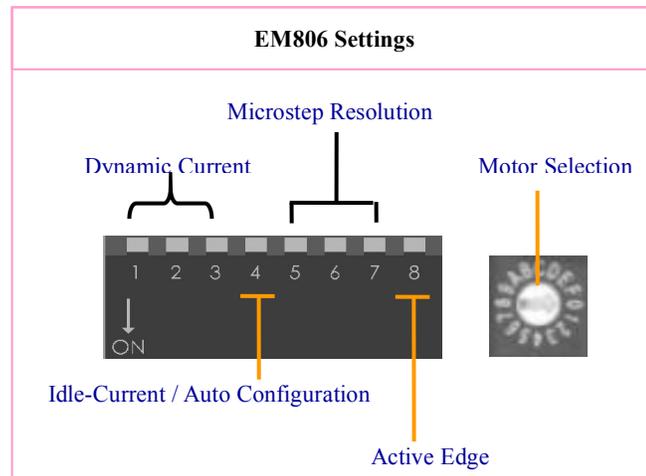
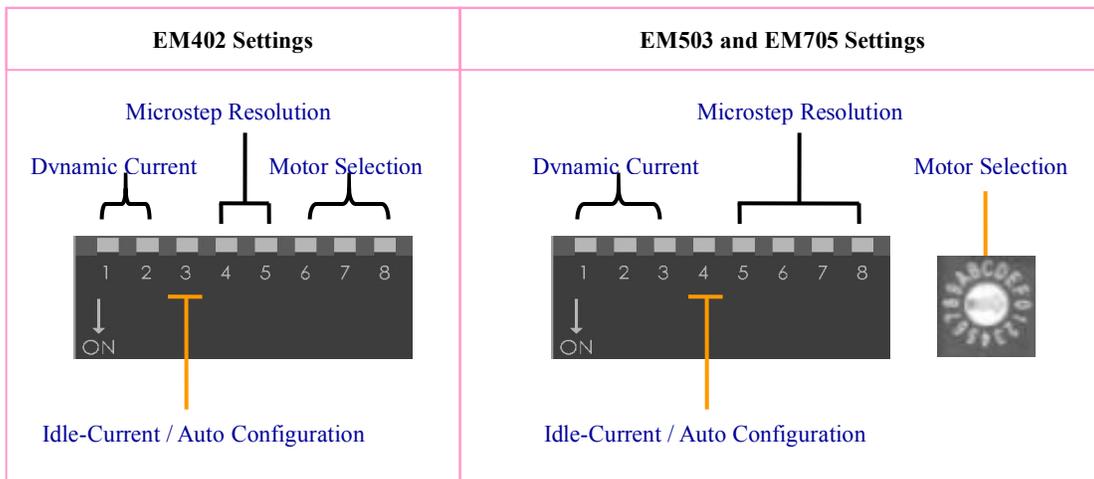
- In order to improve anti-interference performance of the drive, it is recommended to use twisted pair shield cable.
- To prevent noise incurred in PUL/DIR signal, pulse/direction signal wires and motor wires should not be tied up together. It is better to separate them by at least 10 cm, otherwise the disturbing signals generated by motor will easily disturb pulse direction signals, causing motor position error, system instability and other failures.

- If a power supply serves several drives, separately connecting the drives is recommended instead of daisy-chaining.
- It is prohibited to pull and plug power connector while the drive is powered ON, because there is high current flowing through motor coils (even when motor is at standstill). Pulling or plugging power connector with power on will cause extremely high back-EMF voltage surge, which may damage the drive.

10. Configuring the Drive

Introduction

The EM drive uses DIP switch and rotation switch to select dynamic current, idle current and motor. When the DIP switch is in software configured mode, microstep resolution and output current are programmable and set via the RS232 communication port. Refer to the EM drive's software operational manual for more information.



Configuration Procedure

If it is the first time installation and the EM drive works together with pre-matching Leadshine stepper motor, you can follow the steps below to configure the EM series stepper drive:

- Set the rotation switch according to the motor
- Select the microstep resolution according to the application and the control system
- Select the dynamic current and idle current according to the motor and the application
- Test the drive in your system

If it is the first time installation and the EM drive works together with the motor from other manufacturer, you can follow the steps below to configure the EM series stepper drive:

- Set the rotation switch to one of the custom position
- Select the microstep resolution according to the application and the control system
- Select the dynamic current and idle current according to the motor and the application
- Apply power to the EM drive and activate EM drive's Auto-configuration
- Test the drive in your system

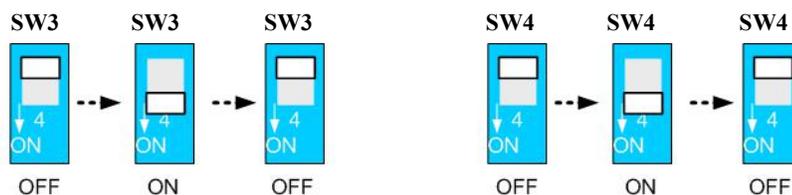
Selecting Motor

For pre-matching Leadshine stepper motors, the EM drive has been tuned and the corresponding parameters have been stored in the nonvolatile memory. The user can select the motor via DIP switch (EM402) or rotation switch (other drivers) according to the motor selection table in the drive cover.

The EM drive also offers Auto-configuration for non-leadshine stepper motors. The user needs to select one of the custom positions in the motor selection table. See more detail below.

Auto Configuration

If a non-Leadshine stepper motor is used in your system, switch SW3 (EM402) or SW4 (others) two times in one second to activate Auto-configuration for optimized performance if it is first time installation. Make sure the motor selection switch is set to one of the custom motor position. 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. Every time motor or supply voltage is changed, Auto-configuration should be performed once again. Sometimes the result of the Auto-configuration is not very good. This happens when the stepper motor has large inductance or resistance. In such situation a further tuning of current loop via the RS232 communication port is required. Please refer to the EM drive's software operational manual for more information.



Microstep Resolution Selection

The stepper motor moves one step when one pulse is applied to the stepper drive. If microstep is 1, the step angle is a full step which is 1.8 degree for 2-phase stepper motor and 1.2 degree for 3-phase stepper motor. Microstep can be taken as the divisions of one full step. For example, stepper motor moves half of the full step when the microstep is 2. For 2-phase stepper motor and drive, we have the following formula to calculate the microstep resolution, or pulse counts of one motor shaft revolution:

$$\text{Microstep Resolution} = 200 \times \text{Microstep}$$

The motor speed can be calculated as follows:

$$\text{Motor Speed (RPS)} = \frac{\text{Pulse Input Frequency}}{\text{Microstep Resolution}}$$

When selecting the drive's microstep resolution for the system:

- Consider the MAX speed needed, MAX input frequency of driver and MAX output frequency of the controller.
- 1600 pulses/revolution (8 Microstep) is suitable for most application.
- >1600 pulses/revolution only increase smoothness but not resolution.
- For digital driver, Microstep resolution is not important.

Current Settings

Dynamic Current Setting

For a given motor, higher drive current will make the motor to output more torque, but at the same time causes more heating in the motor and drive. Therefore, output current is generally set to be such that the motor will not overheat for long time operation. Since parallel and serial connections of motor coils will significantly change resulting inductance and resistance, it is therefore important to set drive output current depending on motor phase current, motor leads and connection methods. Phase current rating supplied by motor manufacturer is important in selecting drive current, however the selection also depends on leads and connections.

Idle Current Setting

When there is no pulse applied to the EM drive and the time exceeds the idle-time which can be configured via the PC based software, the drive goes into idle state. SW3 (EM402) or SW4 (others) is used to set the idle-current, OFF meaning that the motor coil current is automatic reduced, and ON meaning that current is the same as the selected dynamic current.

By default, the current automatically reduced to 60% of the selected dynamic current two second after the last pulse. Theoretically, this will reduce motor heating to 36% (due to $P=I^2 \cdot R$) of the original value. If the user wants to change the idle time and current reduction rate, please refer to EM drive's software operational manual.

11. Protection Functions

To improve reliability, the EM drive incorporates some built-in protection functions. The DM drive uses one red LED to indicate what protection has been activated. The periodic time of red is 3 s (seconds), and how many times the red LED blinks indicates what protection has been activated. Because only one protection can be displayed by red LED, so the drive will decide what error to display according to their priorities. See the following **Protection Indications** table for displaying priorities.

Over-current Protection

Over-current protection will be activated when continuous current exceeds the limit or in case of short circuit between motor coils or between motor coil and ground, and RED LED will blink once within each periodic time.

Over-voltage Protection

When power supply voltage exceeds the limit, protection will be activated and red LED will blink twice within each periodic time.

Sensorless Stall Protection

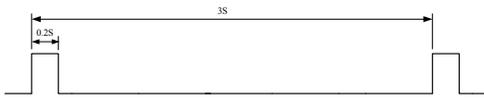
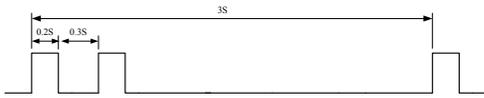
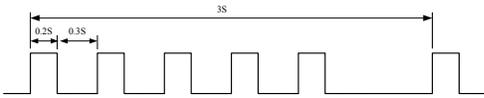
By detecting motor voltage, current, and back-EMF signal, EM series drives can detect loss-of-synchronization of stepper motors without encoders. When the detection is activated, red LED will blink five times within each periodic time.

Note:

When above protections are active, the motor shaft will be free or the LED will blink. Reset the drive by repowering it to make it function properly after removing above problems. For sensorless stall protection, you can also clear the error in ProTuner. See drive's software operational manual for more information.

Since there is no protection against power leads (+ , -) reversal, it is critical to make sure that power supply leads correctly connected to drive. Otherwise, the drive will be damaged instantly.

Protection Indications

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

12. Frequently Asked Questions

In the event that your drive doesn't operate properly, the first step is to identify whether the problem is electrical or mechanical in nature. The next step is to isolate the system component that is causing the problem. As part of this process you may have to disconnect the individual components that make up your system and verify that they operate independently. It is important to document each step in the troubleshooting process. You may need this documentation to refer back to at a later date, and these details will greatly assist our Technical Support staff in determining the problem should you need assistance.

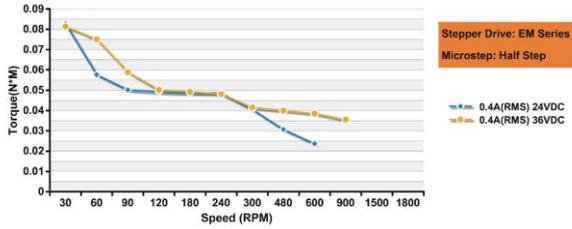
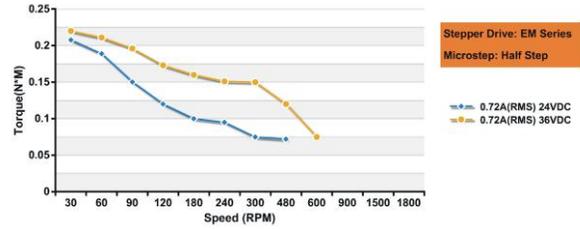
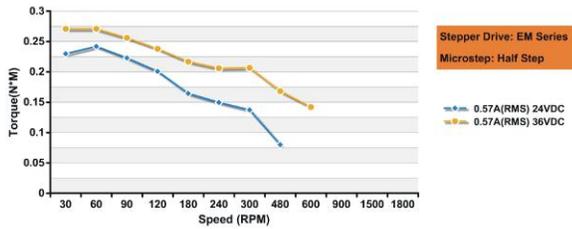
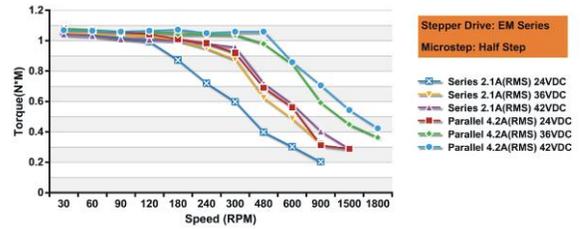
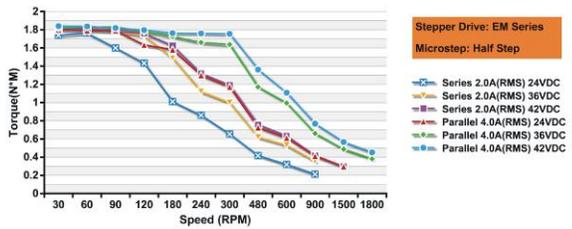
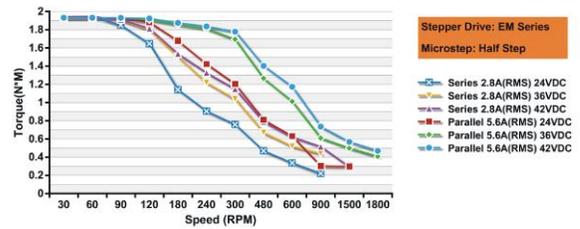
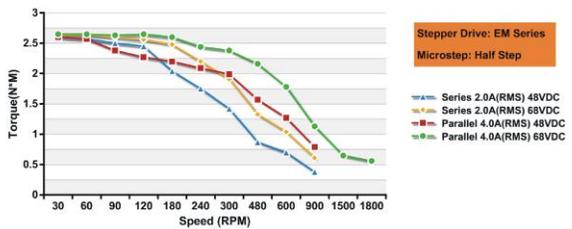
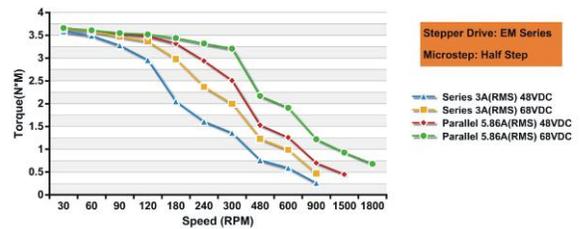
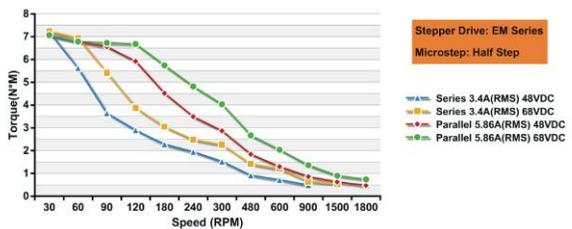
Many of the problems that affect motion control systems can be traced to electrical noise, controller software errors, or mistake in wiring.

Problem Symptoms and Possible Causes

Symptoms	Possible Problems
Motor is not rotating	No power
	Microstep resolution setting is wrong
	DIP switch current setting is wrong
	Fault condition exists
Motor rotates in the wrong direction	The drive is disabled
Motor rotates in the wrong direction	Motor phases may be connected in reverse
	DIP switch current setting is wrong
The drive in fault	Something wrong with motor coil
	Control signal is too weak
Erratic motor motion	Control signal is interfered
	Wrong motor connection
	Something wrong with motor coil
	Current setting is too small, losing steps
	Current setting is too small
Motor stalls during acceleration	Motor is undersized for the application
	Acceleration is set too high
	Power supply voltage too low
	Inadequate heat sinking / cooling
Excessive motor and drive heating	Automatic current reduction function not being utilized
	Current is set too high

Appendix

Speed Torque Curves for Pre-Matching Leadshine Motors

Stepper Motor: 35HS01

Stepper Motor: 39HS02

Stepper Motor: 42HS02

Stepper Motor: 57HS09

Stepper Motor: 57HS13

Stepper Motor: 57HS22

Stepper Motor: 86HS35

Stepper Motor: 86HS45

Stepper Motor: 86HS85


Twelve Month Limited Warranty

Leadshine Technology Co., Ltd. warrants its products against defects in materials and workmanship for a period of 12 months from shipment out of factory. During the warranty period, Leadshine will either, at its option, repair or replace products which proved to be defective.

Exclusions

The above warranty does not extend to any product damaged by reasons of improper or inadequate handlings by customer, improper or inadequate customer wirings, unauthorized modification or misuse, or operation beyond the electrical specifications of the product and/or operation beyond environmental specifications for the product.

Obtaining Warranty Service

To obtain warranty service, a returned material authorization number (RMA) must be obtained from customer service at e-mail: before returning product for service. Customer shall prepay shipping charges for products returned to Leadshine for warranty service, and Leadshine shall pay for return of products to customer.

Warranty Limitations

Leadshine makes no other warranty, either expressed or implied, with respect to the product. Leadshine specifically disclaims the implied warranties of merchantability and fitness for a particular purpose. Some jurisdictions do not allow limitations on how long and implied warranty lasts, so the above limitation or exclusion may not apply to you. However, any implied warranty of merchantability or fitness is limited to the 12-month duration of this written warranty.

Shipping Failed Product

If your product fail during the warranty period, e-mail customer service at to obtain a returned material authorization number (RMA) before returning product for service. Please include a written description of the problem along with contact name and address. Send failed product to distributor in your area or: Leadshine Technology Co., Ltd. 11/F, Block A3, iPark No.1001 Xueyuan Blvd, Nanshan Dist, Shenzhen, China. Also enclose information regarding the circumstances prior to product failure.

Contact Us

China Headquarters

Address: 11/F, Block A3, iPark No.1001 Xueyuan Blvd, Nanshan Dist, Shenzhen, China

Web: <http://www.leadshine.com>

Sales Hot Line:

Tel: 86-755-2641-7674 (for Asia, Australia, Africa areas)

86-755-2640-9254 (for Europe areas)

86-755-2641-7617 (for America areas)

Fax: 86-755-2640-2718

Email: sales@leadshine.com.

Technical Support:

Tel: 86-755-2641-8447, 86-755-2641-8774, 86-755-2641-0546

Fax: 86-755-2640-2718

Email: tech@leadshine.com(for All)

Leadshine U.S.A

Address: 25 Mauchly, Suite 318 Irvine, California 92618

Tel: 1-949-608-7270

Fax: 1-949-608-7298

Web: <http://www.leadshineUSA.com>

Email: sales@leadshineUSA.com and support@leadshineUSA.com.