User Manual

EM870S

Digital Microstep Drive

Revision 3.2

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Important Notice

Read this manual carefully before any assembling and using. Incorrect handling of products in this manual can result in injury and damage to persons and machinery. Strictly adhere to the technical information regarding installation requirements.

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Record of Revisions

Revision	Date	Description of Release
3.0	*Jan, 2019*	*Add Brake, control signal circuit, etc.*
3.1	*Sept, 2019*	*Modified the description of filter time setting in Chapter 7.4*
3.2	*Dec, 2020*	*Delete the description of "*lower than and including 4.5N.m motors*", delete motor cable error, etc.*

Table of Contents

1. Introduction....1
1.1 Features....1
1.2 Applications....1
2. Specifications....2
2.1 Electrical Specifications....2
2.2 Environment....2
2.3 Mechanical Specifications....2
2.4 Elimination of Heat....3
3. Connection Pin Assignments and LED Indication....3
3.1 P1 - Control Connector Configurations....3
3.2 P2 - Fault and Brake Output Connector....4
3.3 P3 - Power Connector....4
3.4 P4 - Motor Connector....4
3.5 P5 - Tuning Port....4
3.6 Status LED Lights....4
4. Control Signal and Fault Output....5
4.1 Control Signal Connection....5
4.2 Fault and Brake Output Connection....5
5. Stepper Motor Connections....6
5.1 4-lead Motor Connection (recommended)....6
5.2 6-lead Motor Connection....6
5.3 8-lead Motor Connection....7
6.Power Supply Selection....7
6.1 Regulated or Unregulated Power Supply....7
6.2 Power Supply Sharing....8
6.3 Selecting Supply Voltage....8
7.DIP Switch Configurations....8
7.1 Output Current Configuration (SW1-3)....8
7.2 Idle Current Configuration (SW4)....9
7.3 Micro Step Configuration (SW5-8)....9
7.4 Smoothing Filter Time Configuration (SW9-10)....10
7.5 No Auto Tuning Configuration (SW11)....10
7.6 Alarm Output Configuration (SW12)....10
7.7 Activated Pulse Edge Configuration (SW13)....10
7.8 Control Mode Configuration (SW14)....10
7.9 Shaft Lock Configuration (SW15)....10
7.10 Self-Test Configuration (SW16)....10
8. Wiring Notes....11
9. Typical Connection....11
10. Sequence Chart of Control Signals....11
11. Protection Functions....12
12. Troubleshooting....13
13. Warranty....14

1. Introduction

The EM870S is a new digital stepper drive based on Leadshine's widely implemented DM stepper drives (10+ millions of units in field). While retaining features of simple design, easy setup, high precision and reliability, Leadshine has also upgraded it by adopting the latest stepper control technology and added additional advanced features for better torque (10-25%), quicker response time, control command smoothing, easy self-test, etc.

The EM870S is able to power 2 phase (1.8°) and 4 phase (0.9°) stepper motors smoothly with very low motor heating & noise. It can take 20-80VDC supply voltage and output 0.5 to 7.0A current. All the micro step and output current configurations can be easily done via built in DIP switches. Its control type (step & direction or CW/CCW) and command smooth filtering can also be configured via DIP switches. Therefore, the EM870S is an ideal choice for many applications requiring simple step & direction or CW/CCW control of NEMA 23, NEMA24 and NEMA 34 stepper motors.

1.1 Features

- Step & direction (PUL/DIR) or CW/CCW (double pulse) control
- 20-80VDC supply voltage
- 200 KHz max pulse input frequency
- 16 microstep resolutions of 200-25,600 via DIP switches, or 200-51,200 via software (increase by 200)
- 8 output current settings of 1.4 -7.0A via DIP Switches, or 0.5-7.0A via software (increase by 0.1)
- Configurable control command smoothing for reducing motor vibration
- Idle current reduction to 50% or 90% selection via SW4
- Convenient self-test for easy diagnosis
- Auto-tuning to match wide-range NEMA 23, 24, 34 stepper motors
- Anti-Resonance for optimal torque, extra smooth motion, low motor heating and noise
- Soft-start with no "jump" when powered on
- Optically isolated inputs with 5V or 24V
- Fault and Brake output
- Over-voltage and over-current protections
- CE certified and RoHS compliant

1.2 Applications

The EM870S stepper drive is designed to power 2 phase (1.8°) or 4-phase (0.9°) NEMA23, 24 and 34 hybrid stepper motors. It can be adopted in many industries (CNC machinery, electronics, medical, automation, packaging…) for applications such as CNC routers, mills, plasma, laser cutters, factory assembly lines, vending machines, etc. Its excellent performance, simple design, and easy setup features make EM870S ideal for many step & direction control type applications.

2. Specifications

2.1 Electrical Specifications

Parameters	Min	Typical	Max	Unit
Output Current	0.5	-	7.0 (5.0 RMS)	A
Supply Voltage	20	24 - 72	80	VDC
Logic signal current	7	10	16	mA
Pulse input frequency	0	-	200	kHz
Minimal pulse width	2.5	-	-	μs
Minimal direction setup	5.0	-	-	μs
Isolation resistance	500	-	-	MΩ

2.2 Environment

Cooling	Natural Cooling or Forced cooling	
Operating Environment	Environment	Avoid dust, oil fog and corrosive gases
	Ambient Temperature	0 — 65°C (32 - 149°F)
	Humidity	40 — 90%RH
	Operating Temperature	0 — 50°C (32 - 122°F)
	Vibration	10-50Hz / 0.15mm
Storage Temperature	-20°C — 65°C (-4°F - 149°F)	
Weight	Approx. 250g (8.8 oz)	

2.3 Mechanical Specifications

(unit: mm [1inch=25.4mm])

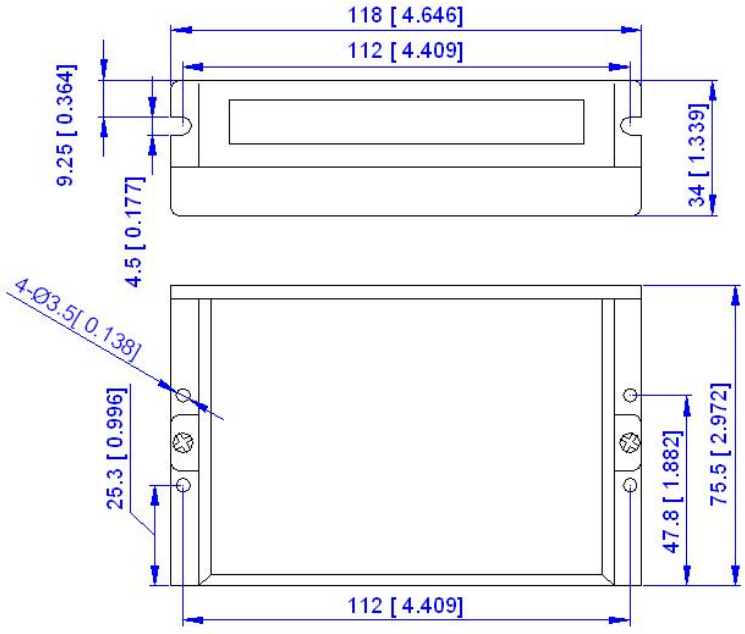


Figure 1 Mechanical specifications

* Side mounting recommended for better heat dissipation

2.4 Elimination of Heat

- EM870S's working temperature is less than 60℃ (140°F)
- It is recommended to use automatic idle-current mode to reduce motor heating. That means set the SW4 pin of DIP switch at "OFF" position.
- It is recommended to mount the drive vertically to maximize heat sink area. Use forced cooling method to cool if necessary.

3. Connection Pin Assignments and LED Indication

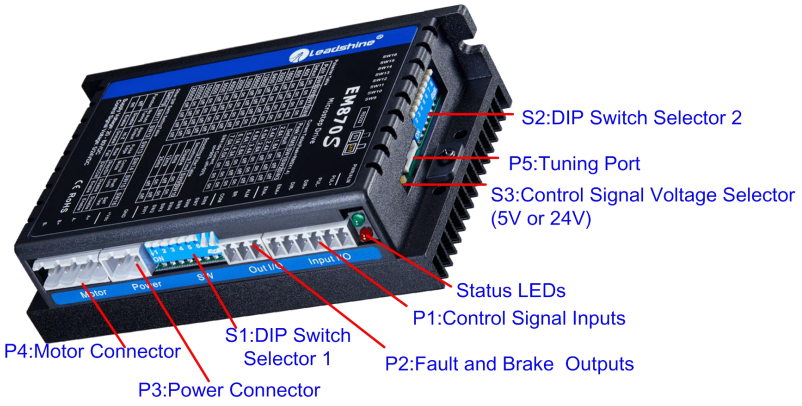


Figure 2 Connectors, DIP switches, and LED locations

The EM870S has 5 connectors P1, P2, P3, P4 and P5, 3 DIP switches S1, S2 and S3. P1 is for control signal connections, P2 is for fault output, P3 is for power connection, P4 is for motor connection and P5 is for fine tuning.

3.1 P1 - Control Connector Configurations

PIN	Details
PUL+ (CW+)	Pulse and Direction Connection: **(1)** Optically isolated, high level 4.5-5V or 24V, low voltage 0-0.5V **(2)** Maximum 200 KHz input frequency **(3)** The width of PUL signal is at least 2.5μs, duty cycle is recommended 50% **(4)** Single pulse (step & direction) or double pulse (CW/CCW) is set by DIP Switch SW14 **(5)** DIR signal requires advance PUL signal minimum 5 μs in single pulse mode **(6)** The activated edge of PUL and DIR is set by DIP Switch SW13 **(7)** The factory setting of control signal voltage is 24V, must need to set S3 (figure 2) if it is 5V
PUL- (CW-)	
DIR+ (CCW+)	
DIR- (CCW-)	
ENA+	Enable Connection: Optional. **(1)** Optically isolated, differential. **(2)** Disable the drive by 4.5-5.0V or 24V input connection; enable the drive by 0-0.5V connection(default no connection) **(3)** ENA signal requires advance DIR signal minimum 5μs in single pulse mode **(4)** The default control signal voltage is 24V, to set S3 (figure 2) if it is 5V **(5)** Enable time to be at least 200ms
ENA-	

Notes: (1) shield cables are required for P1; (2) don't tie P1/P2 cables and P3/P4 cables together.

3.2 P2 - Fault and Brake Output Connector

Pin	Details
ALM	Output Connection: Optional. **(1)** Maximum 30V/100mA output **(2)** Sinking or sourcing **(3)** The resistance between ALM and COM- is low impedance as default (configurable by DIP switch SW12), and will change to high when the drive goes into error protection. **(4)** Fault and Brake connection refer to chapter 4.2
BR	
COM-	

3.3 P3 - Power Connector

Pin	Details
GND	Connect to power supply ground connection.
+VDC	Connect to power supply positive connection. Suggest 24-72VDC power supply voltage

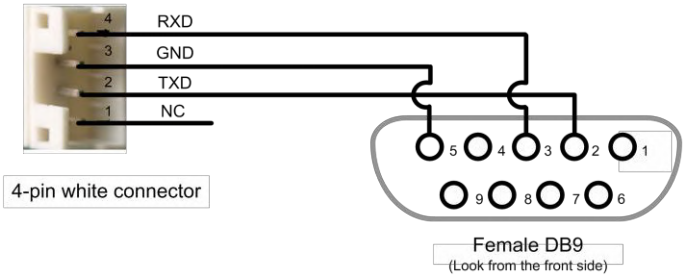
Warning: Don't plug/unplug P3 or P4 connector to avoid drive damage or injury while powered on.

3.4 P4 - Motor Connector

PIN	Details
A+	Connect to motor A+ wire
A-	Connect to motor A- wire
B+	Connect to motor B+ wire
B-	Connect to motor B- wire

3.5 P5 - Tuning Port

EM870S has a tuning port with RS232 to modify the drive parameters, it's only for tuning, not for equipment control because neither precision nor stability is sufficient. If you need a field bus drive, use a Leadshine RS485 or EtherCAT type drives:
(http://www.leadshine.com/ProductSubType.aspx?type=products&category=stepper-products&producttype=stepper-drives&subtype=network-stepper-drives
The interface definition is as follows:



3.6 Status LED Lights

There are two LED lights for EM870S. The GREEN one is the power indicator which should be always on in normal circumstance. The RED one is a drive status indication light, which will be OFF while working normally but ON and flash 1 or 2 times in a 3-second period in the case of enabled over-current or over-voltage protection.

4. Control Signal and Fault Output

4.1 Control Signal Connection

The EM870S can accept differential or single-ended control signals (pulse, direction, and enable) in open-collector or PNP connection through the P1 connector (figure 2). It is recommend to add an EMI line filter between the power supply and the drive to increase noise immunity for the drive in interference environments.

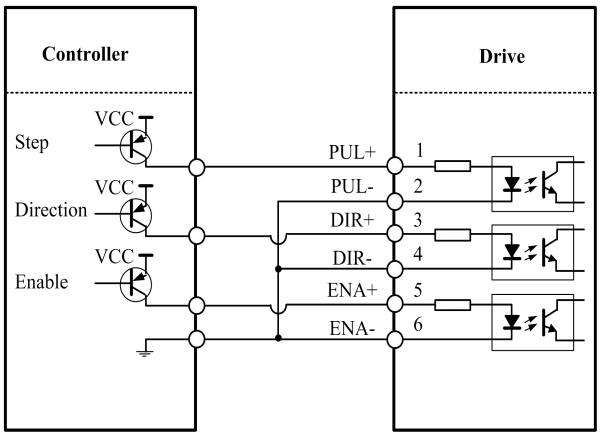


Figure 3 Connections to open-collector signals (Common-anode)

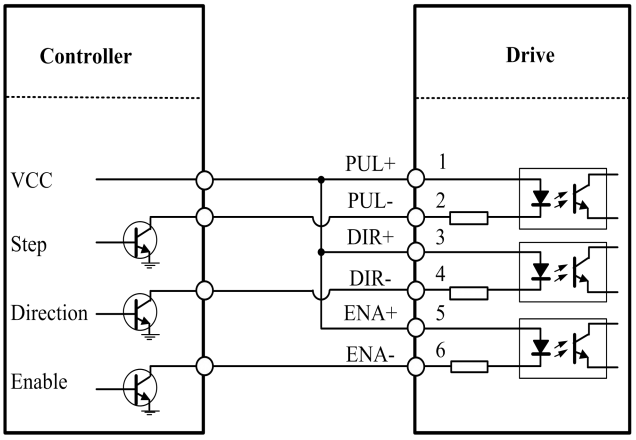


Figure 4 Connections to PNP signals (Common-cathode)

4.2 Fault and Brake Output Connection

- *Fault Output*

When over voltage or over current protection happens, EM870S red status LED light will blink and the impedance state between ALM and COM- will change (from low to high or high to low depending on configuration) and can thus be detected. Fault output connection is optional, and it can be connected either in sinking or sourcing.

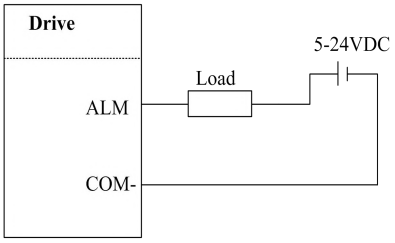


Figure 5 Sinking output

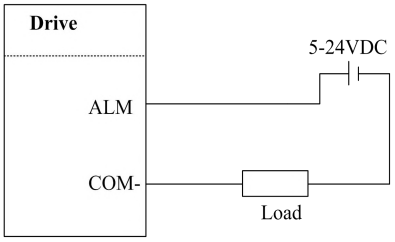


Figure 6 Sourcing output

- *Brake Control*

It is recommended to connect a fly-wheel diode in parallel to a 24VDC relay and brake coil connection. Refer to the following figure for brake connection.

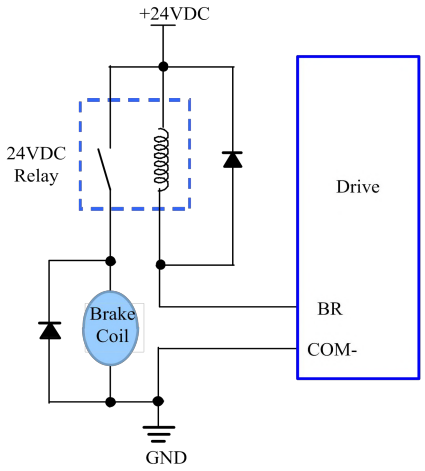


Figure 7 Brake Output Connection

5. Stepper Motor Connections

EM870S can drive 2-phase and 4-phase bipolar hybrid stepper motors with 4, 6, or 8 leads, Leadshine also offers easy-to-use and good-performance motors with 4-lead that have been tested with EM870S: (http://www.leadshine.com/series.aspx?type=products&category=stepper-products&producttype=stepper-motors&subtype=hybrid-stepper-motors&series=cm)

5.1 4-lead Motor Connection (recommended)

4-lead motor is easy to use with excellent performance. Refer to figure 8 for how to connect a 4-lead stepper motor.

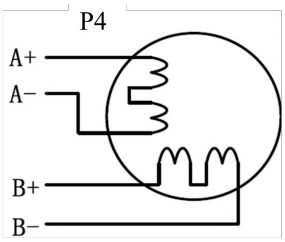


Figure 8 4-lead Motor Connection

5.2 6-lead Motor Connection

EM870S can power 6-lead stepper motors through half coil connection (half chopper) or full coil (full copper) connection. The half coil connection only uses one half of the motor's winding and is usually selected in applications requiring high speed but lower torque. The full coil connection uses the full coil winding and is usually selected in high-torque required applications. Refer to figure 9 and 10 for those two connections.

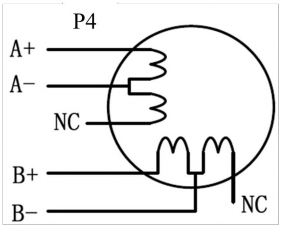


Figure 9 6-lead motor half coil connection

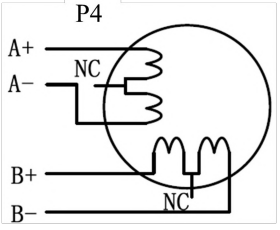


Figure 10 6-lead motor full coil connection

5.3 8-lead Motor Connection

EM870S can power 8-lead in series or parallel connection in series or parallel.

Series connected 8-lead stepper motors are typically implemented in applications which higher torque at lower speed movement is required. Because a stepper motors under series connection has the most inductance, the performance will start to degrade when the motor runs at higher speed. For this connection, it is suggested to set an EM870S's output RMS current to no more than 70% of the stepper motor's phase current to prevent overheating. See the figure 11 for how to connect an 8-lead stepper motor for series connection.

Parallel connected 8-lead stepper motors are typically implemented in applications which higher torque at high speed movement is required. Compared with series connection, a parallel connected stepper motor has lower inductance and therefore have better torque performance at higher speed movement. Although setting the drive output current to 1.4 times of driven motor phase current will get the most torque, it is suggested to set an EM870S's output current (peak of sinusoidal) to no more than 1.2 times the stepper motor's phase current to prevent overheating. Refer to the figure 12 for how to connect an 8-lead stepper motor for parallel connection.

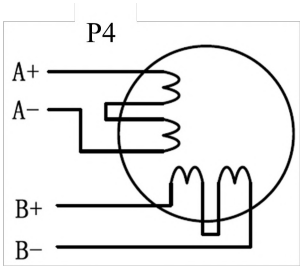


Figure 11 8-lead motor series connection

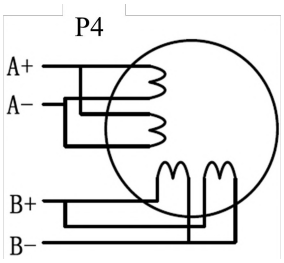


Figure 12 8-lead motor parallel connection

6. Power Supply Selection

EM870S is designed to power stepper motors (frame sizes NEMA 23 to 34) made by Leadshine or other motor manufacturers. To get optimal performances, it is important to select proper power supply type, voltage, and supply output current. In general power supply voltage determines the high speed performance of a stepper motor, while drive output current determines the driven motor torque output. Higher supply voltage can increases motor speed torque performance, but at the same time result in more noise and motor heating. For low motor speed applications, it is suggested to use lower supply voltage power supplies.

6.1 Regulated or Unregulated Power Supply

Both regulated and unregulated power supplies can be used to power an EM870S. Theoretically unregulated power supplies are preferred due to their ability to withstand back EMF current surge and faster response for current change. If you prefer to use a regulated power supply instead, it is suggested to choose one specially designed for stepper or servo controls such as one Leadshine RPS series power supply: http://www.leadshine.com/ProductSubType.aspx?type=products&category=other-products&producttype=power-supplies&subtype=regulated-switching-power-supplies.In the case when only general purpose switching power supplies are available, choose one with "OVERSIZED" current output rating (for example, using a 4A power supply for 3A stepper motor) to avoid current clamp. 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 phase current). The reason is that the drive only draws current from an unregulated power supply during the ON duration of the PWM cycle, but not during the OFF duration.

6.2 Power Supply Sharing

Multiple EM870S drives can share the same power supply, if that power supply has enough capacity. To avoid cross interference, connect each EM870S DIRECTLY to that shared power supply separately instead of connecting those power connectors of drives in daisy-chain connection.

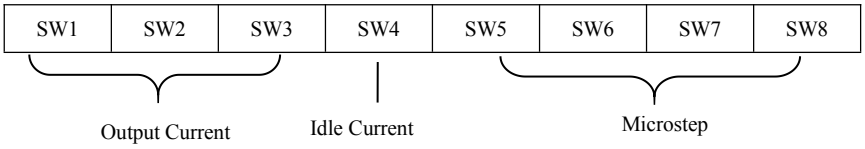
6.3 Selecting Supply Voltage

EM870S's operating voltage is 20-80 VDC. Because of voltage increasing from potential power line voltage fluctuation and back EMF voltage generated during motor deceleration, it is suggested to use a 24-72 VDC power supply.

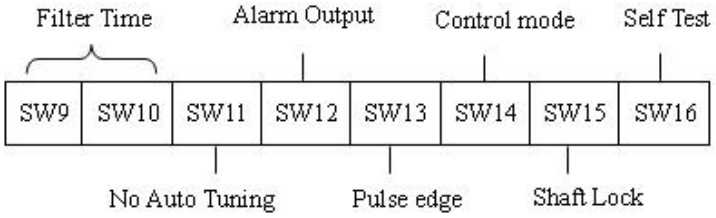
7. DIP Switch Configurations

The EM870S has two 8-bit and one 1-bit DIP switch selector. "Default" means that parameters can be modified by Leadshine PC software software.

The first 8-bit is located on the side (DIP switch selector 1 in Figure 2) and used to configure settings of micro step resolution, output current, and motor standstill current as shown below, the factory setting of SW1-SW8 is OFF, OFF, OFF, OFF, OFF, OFF, ON, ON.



The second 8-bit DIP switch is located on the top (DIP switch selector 2 in figure 2), and used to configure settings of control command filtering time, motor auto-configuration, fault output impedance, pulse active edge, control mode, lock shaft, and self-test as shown below, the factory setting of SW1-SW8 is OFF, OFF, OFF, ON, ON, OFF, OFF, OFF.



The Third 1-bit selector is located on the top (DIP switch selector 3 in figure 2), used to configure the voltage of control signals. For the safety of optically coupled, the factory setting is 24V, which no need to connect 2K resistors like the old drives, making it easier to use. When the voltage of the control signal is 5V, the S3 must be set to 5V，otherwise, the motor won't work.

7.1 Output Current Configuration (SW1-3)

The EM870S has 8 output current settings which can be configured through DIP switch SW1, SW2 and SW3.

For a given stepper motor, as normal setting the output current to 1.4 times of motor phase current, will make it output larger torque, but at the same time cause more heating for both the motor and drive. Therefore, it is suggested to set a output current (peak of sinusoidal) to no more than 1.2 times the stepper motor's (for 4-lead motor) phase current to prevent overheating .

The SW1, SW2 and SW3 are used to set the dynamic current. Select a setting closest to your motor's required current. When they are set to ON, ON, ON, the output current can be set by Leadshine PC software.

Peak Current	RMS Current	SW1	SW2	SW3
1.4A	1.0A (default)	OFF	OFF	OFF
2.6A	1.8A	ON	OFF	OFF
3.4A	2.4A	OFF	ON	OFF
4.0A	2.8A	ON	ON	OFF
4.8A	3.4A	OFF	OFF	ON
5.4A	3.8A	ON	OFF	ON
6.1A	4.3A	OFF	ON	ON
7.0A	5.0A	ON	ON	ON

7.2 Idle Current Configuration (SW4)

The SW4 of an EM870S is used to set output current percentage when motor is standstill. Idle current percentage will be set to 50% at OFF position, and 90% at ON position. When the driven stepper motor is idle (no movement) for 0.4 second, the output current of EM870S will be automatically reduced to the configured percentage.

7.3 Micro Step Configuration (SW5-8)

Each EM870S has 16 micro step settings which can be configured through DIP switch SW5, SW6, SW7 and SW8. See the following table for detail. When they are set to ON, ON, ON,ON, the microstep can be set via Leadshine PC software.

Micro step	Pulses/Rev. (for 1.8°motor)	SW5	SW6	SW7	SW8
1	200 (default)	ON	ON	ON	ON
2	400	OFF	ON	ON	ON
4	800	ON	OFF	ON	ON
8	1600	OFF	OFF	ON	ON
16	3200	ON	ON	OFF	ON
32	6400	OFF	ON	OFF	ON
64	12800	ON	OFF	OFF	ON
128	25600	OFF	OFF	OFF	ON
5	1000	ON	ON	ON	OFF
10	2000	OFF	ON	ON	OFF
20	4000	ON	OFF	ON	OFF
25	5000	OFF	OFF	ON	OFF
40	8000	ON	ON	OFF	OFF
50	10000	OFF	ON	OFF	OFF
100	20000	ON	OFF	OFF	OFF
125	25000	OFF	OFF	OFF	OFF

7.4 Smoothing Filter Time Configuration (SW9-10)

EM870S has an advanced feature called control command smoothing to make the input pulse from pulse generator (controller, PLC, etc.) S-curve acceleration, to improve motion smoothness and high-speed start frequency in many circumstances.

This is achieved through adding filtering time which is configured SW9-SW10. See the following table for how to configure.

Filter Time	SW9	SW10
0 ms (disabled)	ON	ON
6 ms	OFF	ON
12 ms	ON	OFF
25 ms	OFF	OFF

Warning The Filter Time value must be set to the same for each EM870S in multi-axis applications

7.5 No Auto Tuning Configuration (SW11)

EM870S can configure itself with the best match to the driven stepper motor. This feature may need to be disabled for some applications or when it is used to drive a specially designed stepper motor. To do that, set the DIP switch SW11 to ON position and the drive will be set to its default settings.

7.6 Alarm Output Configuration (SW12)

DIP switch SW12 is used to configure the impedance state of alarm output (fault output). At OFF position (factory setting) the resistance between ALM and COM- is set to low impedance in normal operation, and will change to high impedance when the drive goes into fault. When SW12 is set to ON position, that resistance will be set to high impedance in normal condition and changed to low impedance under error protections.

7.7 Activated Pulse Edge Configuration (SW13)

DIP switch SW13 is used to configure pulse edge. Set it to OFF position (factory setting) means that a pulse is activated at voltage rising edge, and ON position means a pulse is activated at falling edge. Make sure this setting will match the pulse generator (controller, PLC, etc.). When the stepper motors loss step, first reverse the SW13 for a test.

7.8 Control Mode Configuration (SW14)

DIP switch SW14 is used to configure the control mode. Factory setting is single pulse (step & direction, or pulse & direction) control. Setting to ON to change the control model to double pulse (CW/CCW) control type.

7.9 Shaft Lock Configuration (SW15)

Use DIP switch SW15 to set shaft lock mode when EM870S is disabled (read ENA+ and ENA- explanation of control connector for how to disable EM870S). Set it to OFF position (default) for no motor shaft lock (free spin) when drive disabled. Set it to ON position for motor shaft lock.

7.10 Self-Test Configuration (SW16)

For test and system diagnosis purpose, EM870S is featured with Self-Test. Anytime SW16 is switched to ON position, the drive will automatically rotate the driven stepper motor back and forth for one round in each direction. Set this

switch position to OFF for normal operation.

8. 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 only one power supply serves multiple EM870S drives, separately connecting the drives to the power supply is recommended instead of daisy-chaining.
- It is prohibited to pull and plug connector P3&P4 while the drive is powered ON, because there is high current flowing through motor coils (even when motor is at standstill). Pulling or plugging connector P4 with power on will cause extremely high back-EMF voltage surge, which may damage the drive.

9. Typical Connection

A complete stepping system should include stepping motor, stepping drive, power supply and controller (pulse generator). A typical connection is shown as figure 12.

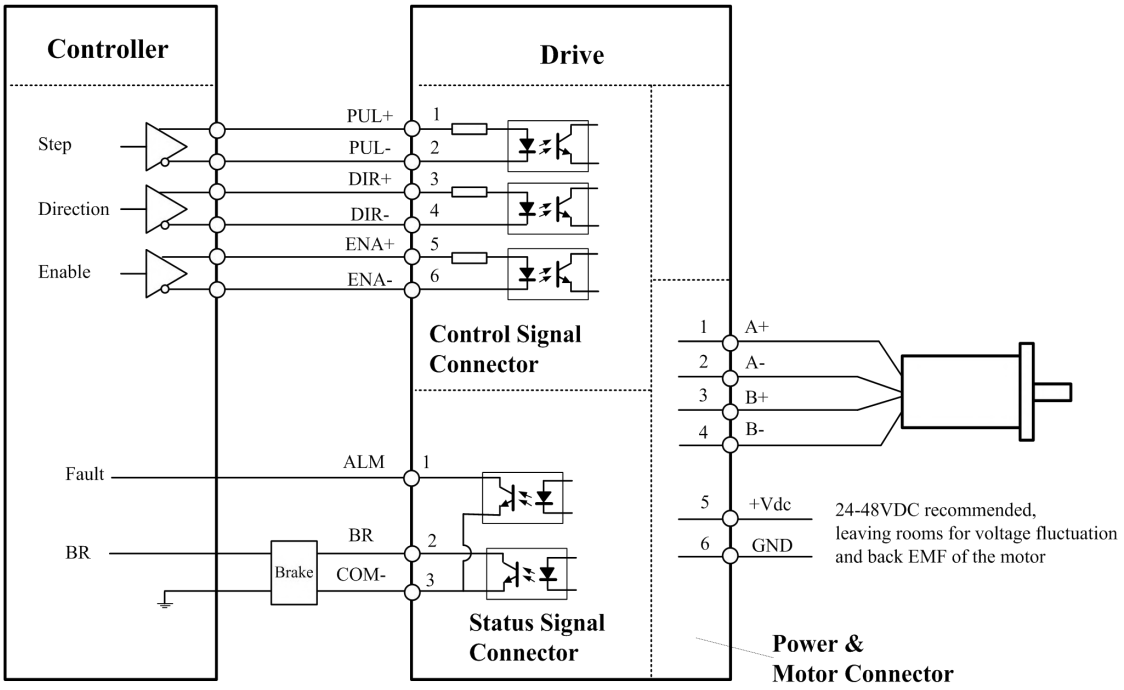


Figure 12 Typical connection

10. Sequence Chart of Control Signals

In order to avoid some fault operations and deviations, PUL, DIR and ENA should abide by some rules, shown as following diagram:

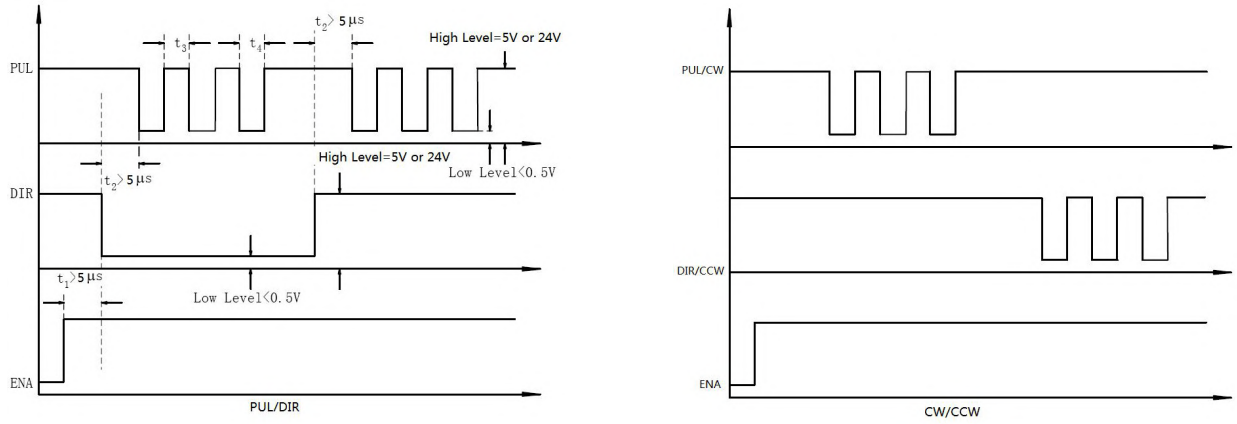


Figure 13 Sequence chart of control signals

Remark:

a) t_1: ENA must be ahead of DIR by at least 500ms for auto-tuning. Usually, ENA+ and ENA- are NC (not connected). See "Connector P1 Configurations" for more information.

b) t_2: DIR must be ahead of PUL effective edge by 5μs to ensure correct direction;

c) t_3: Pulse width not less than 2.5μs, duty cycle recommend 50%

d) t_4: Low level width not less than 2.5μs

11. Protection Functions

EM870S incorporates are built with over-voltage and over-current error protections. When it is under error protection, the red LED light will blink for 1 or 2 or 4 times in a period of 3 seconds. If fault output connection is connected, the impedance mode between ALM+ and ALM- will be changed (See "Fault Output Configuration" section for detail).

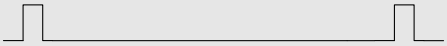
Priority	Time(s) of Blink	Sequence wave of red LED	Description
1st	Always on		The drive was short-circuited or burned out.
1st	1		Over-current protection activated when peak current exceeds the limit.
2nd	2		Over-voltage protection activated when drive working voltage is greater than 92VDC

Figure 14 Error Protections

When over-current and over-voltage protections are activated, the motor shaft will be free or the red LED blinks. Reset the drive by restart it to make it function properly after removing above problems.

12. Troubleshooting

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

Trouble	Solution Measures
Motor is not rotating	No power, to start power supply
	Pulse/revolution setting is wrong
	DIP switch current setting is wrong
	Fault condition exists or the drive is disabled
Motor rotates in the wrong direction	Motor phases may be connected in reverse
	Pulse mode may be wrong
Red light blinking	Red light blinks 1 time or always on, try not to connect the motor and restart the power supply
	Red light blinks 2 times, check the power voltage and restart the power supply
	Red light blink 4 times, the motor is not connected or has broken circuit.
Erratic motor motion	Current setting is too small, losing steps
	Wrong motor connection or has broken circuit in motor coil.
	The current of the control signals is not in the range of 7-15mA
	Control signals don't meet the requirements of chapter 10 , check the waveform of the control signals
Motor stalls or loss steps	Output current of the drive is too small or motor torque is not enough
	Acceleration is set too high
	Power supply voltage too low
	Modify the activated edge value in the PC software or the control signal is interfered with.
Excessive motor and drive heating	Inadequate heat sinking / cooling
	Automatic current reduction function not being utilized
	Reduce output current

13. Warranty

Twelve Month 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, please contact your seller to obtain a returned material authorization number (RMA) before returning product for service.

Shipping Failed Products

If your product fail during the warranty period, please contact your seller for how and where to ship the failed product for warranty or repair services first, you can also 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.