

# User's Manual

For

## 3MD560

### Extremely low noise 3-phase Microstepping Driver

Version 1.0

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



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**Table of Contents**

1. Introduction, Features and Applications..... 1  
     Introduction ..... 1  
     Features ..... 1  
     Applications ..... 1  
 2. Specifications and Operating Environment..... 1  
     Electrical Specifications ..... 1  
     Operating Environment ..... 2  
     Mechanical Specifications..... 2  
     Elimination of Heat ..... 2  
 3. Pin Assignment and Description ..... 2  
     Connector P1 Configurations ..... 3  
         Selecting CW/CCW or PUL/DIR Mode ..... 3  
     Connector P2 Configurations ..... 4  
 4. Connections to Controller ..... 4  
 5. Connections to Stepping Motors ..... 5  
 6. Power Supply Selection ..... 5  
     Regulated or Unregulated Power Supply ..... 6  
     Multiple Drivers ..... 6  
     Selecting Supply Voltage: ..... 6  
 7. Output Current and Microstep Resolution Settings..... 6  
     Current Setting ..... 6  
         DIP Setting for Dynamic Current ..... 7  
         DIP Setting for Standstill Current ..... 7  
     Microstep Resolution Setting ..... 8  
 8. Wiring Notes ..... 8  
 9. Typical Connection..... 8  
 10. Sequence Chart of Control Signals ..... 9  
 11. Protection Functions..... 10  
     Over-voltage Protection ..... 10  
     Short-voltage Protection..... 10

Short Circuit Protection..... 10  
     Over-current Protection..... 10  
 12. Frequently Asked Questions ..... 10  
     Problem Symptoms and Possible Causes..... 11  
 APPENDIX..... 12  
     TWELVE MONTH LIMITED WARRANTY ..... 12  
     EXCLUSIONS..... 12  
     OBTAINING WARRANTY SERVICE ..... 12  
     WARRANTY LIMITATIONS ..... 12  
     SHIPPING FAILED PRODUCT ..... 12

# 1. Introduction, Features and Applications

## Introduction

The 3MD560 is a high resolution 3-phase microstepping driver based on precision current control technology. They are suitable for driving 3-phase hybrid stepping motors from NEMA size 17 to 34. By using the advanced pure-sinusoidal current control technology, both the noise and vibration of the stepping motor have been greatly reduced, which makes the stepping motors offer servo-like performances. Furthermore, compared with most of the microstepping drivers in the market, both driver heating and motor heating have been reduced by 15-30%.

## Features

- High performance, low noise and low cost
- Low driver heating and low motor heating
- Supply voltage up to 50 VDC
- Output peak current up to 8.4A (RMS6.0A)
- Input signal TTL compatible
- Automatic idle-current reduction
- Suitable for 3-phase stepping motors, including 3 lead and 6 lead motors
- Optically isolated differential input signals,
- pulse frequency up to 200 KHz
- 8 selectable resolutions up to 10000 steps/rev
- DIP switch current setting with 16 different values
- Over-voltage, short-voltage, over-current, and short-circuit protection
- Small size for easy mounting

## Applications

Suitable for a wide range of 3-phase stepping motors from NEMA size 17 to 34. It can be used in various kinds of machines, such as X-Y tables, labeling machines, laser cutters, engraving machines, and pick-place devices, and etc. They are extremely suitable for the applications desired with low noise, low vibration, high speed and high precision.

# 2. Specifications and Operating Environment

## Electrical Specifications (T<sub>j</sub>=25°C)

Parameters	3MD560			Unit
	Min	Typical	Max	
Output current	1.5	-	6.0(RMS)	Amps
Supply voltage	18	36	50	VDC
Logic signal current	7	10	16	mA
Pulse input frequency	0	-	200	KHz
Isolation resistance	500			MΩ

## Operating Environment

Cooling	Natural cooling or forced cooling	
Operating Environment	Environment	Avoid dust, oil fog and corrosive gases
	Ambient Temperature	0°C — +50°C
	Operating Temperature	70°C
	Humidity	40—90%RH
	Vibration	5.9m/s <sup>2</sup> Max
Storage Temperature	-20°C — +125°C	
Weight	Approx. 410 gram (14.46 oz)	

## Mechanical Specifications (unit=mm, 1 inch = 25.4 mm)

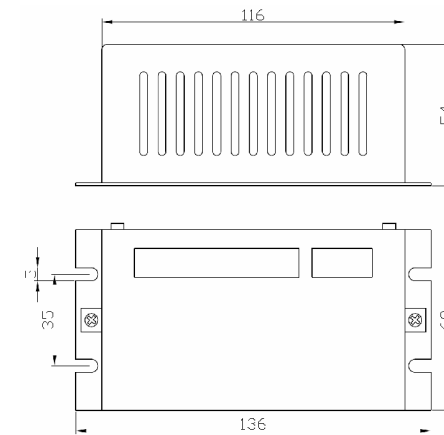


Figure 1: Mechanical specifications

## Elimination of Heat

- Driver's reliable working temperature should be <65°C, and motor working temperature should be <80°C;
- Recommend use automatic idle-current reduction mode, namely current automatically be reduced to 60% when motor stops, so as to reduce driver heating and motor heating.

# 3. Pin Assignment and Description

The 3MD560 has two connectors, connector P1 for control signals connections, and connector P2 for power and motor connections. The following tables are brief descriptions of the two connectors. More detailed descriptions of the pins and related issues are presented in section 4, 5, 9.

### Connector P1 Configurations

Pin Function	Details
PUL+(+5V)	<b>Pulse signal:</b> In single pulse (pulse/direction) mode, this input represents pulse signal, active at each rising edge or falling edge (set by inside jumper SEL1); 4-5V when PUL-HIGH, 0-0.5V when PUL-LOW. In double pulse mode (pulse/pulse) this input represents clockwise (CW) pulse. For reliable response, pulse width should be longer than 2.5μs. Series connect resistors for current-limiting when +12V or +24V used.
PUL-(PUL)	
DIR+(+5V)	<b>DIR signal:</b> In single-pulse mode, this signal has low/high voltage levels, representing two directions of motor rotation; in double-pulse mode (set by inside jumper SEL2), this signal is counter-clock (CCW) pulse, active at high level or low level (set by inside jumper SEL1). 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.
DIR-(DIR)	
ENA+(+5V)	<b>Enable signal:</b> This signal is used for enabling/disabling the driver. High level (NPN control signal, PNP and Differential control signals are on the contrary, namely Low level for enabling.) for enabling the driver and low level for disabling the driver. Usually left <b>UNCONNECTED (ENABLED)</b> .
ENA-(ENA)	

**Notes:** The 3MD560-CCW can accept CW/CCW control signal, while the 3MD560 can't. Please note this difference when you place an order. As to the 3MD560-CCW, PUL/DIR mode is the default mode, and under-cover jumpers SEL1 and SEL2 can be used to switch it to CW/CCW mode.

#### Selecting CW/CCW or PUL/DIR Mode

There are two jumpers SEL1 and SEL2 inside the 3MD560-CCW specifically for selecting pulse signal mode. Settings for the one-pulse mode (PUL/DIR) and for the double-pulse mode (CW/CCW) are shown in the following figure. Default mode out of factory is PUL/DIR mode.

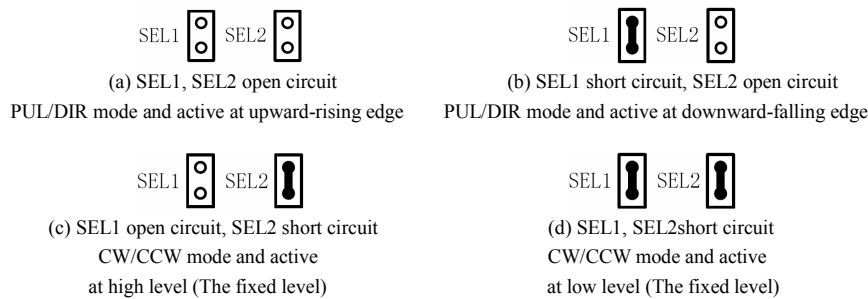


Figure 2: Control signal mode setting jumpers (3MD560-CCW)

### Connector P2 Configurations

Pin Function	Details
GND	DC power ground
VDC	DC power supply, +18VDC—+50VDC, Including voltage fluctuation and EMF voltage.
U	Motor phase U
V	Motor phase V
W	Motor phase W

**Remark:** Please note that motion direction is also related to motor-driver wiring matches. Exchanging the connections of two phases to the driver will reverse motor motion direction.

### 4. Connections to Controller

These two drivers can accept differential and single-ended control signals (including open-collector, namely common-anode and PNP output, namely common-cathode). The 3MD560 has 3 optically isolated logic inputs which are located on connector P1 to accept line driver control signals. These inputs are isolated to minimize or eliminate electrical noises coupled onto the control signals. It's recommended to use line driver control signals to increase noise immunity of the driver under an interference environment. Connections to open-collector and PNP signals are illustrated in the figure 3 and the figure 4.

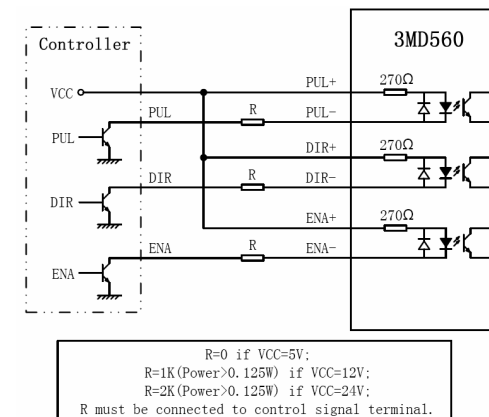


Figure 3: Connections to open-collector signal (common-anode)

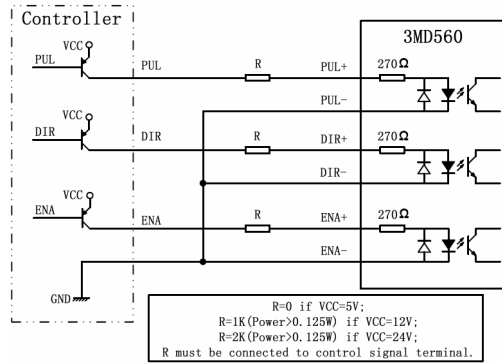


Figure 4: Connections to PNP signal (common-cathode)

## 5. Connections to Stepping Motors

The connection between these two drivers and 3-phase stepping motors includes two different kinds of connections, namely delta-connection and star-connection. Using delta-connection, the performances of the motor under high speed condition are better, but the driver current is higher too (about 1.73 times the motor coil current); while using star-connection, the driver current equals to the motor coil current.

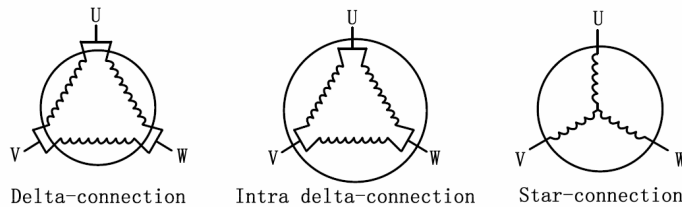


Figure 5: Motor connections

## 6. Power Supply Selection

The 3MD560 and 3MD560-CCW can match medium and small size stepping motors (from NEMA size 17 to 34) made by Leadshine or other motor manufacturers 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 driver. However, unregulated power supplies are preferred due to their ability to withstand current surge. If regulated power supplies (such as most switching supplies) are indeed used, it is important to have large current output rating to avoid problems like current clamp, for example using 4A supply for 3A motor-driver operation. On the other hand, if unregulated supply is used, one may use a power supply of lower current rating than that of motor (typically 50%~70% of motor current). The reason is that the driver draws current from the power supply capacitor of the unregulated supply only during the ON duration of the PWM cycle, but not during the OFF duration. Therefore, the average current withdrawn from power supply is considerably less than motor current. For example, two 3A motors can be well supplied by one power supply of 4A rating.

## Multiple Drivers

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

## Selecting Supply Voltage:

The power MOSFETS inside the 3MD560 and the 3MD560-CCW can actually operate within +18~50VDC, including power input fluctuation and back EMF voltage generated by motor coils during motor shaft deceleration. 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 driver 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 +24~+45V, leaving room for power fluctuation and back-EMF.

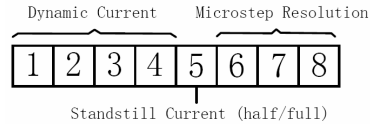
## 7. Output Current and Microstep Resolution Settings

### Current Setting

For a given motor, higher driver current will make the motor output more torque, but at the same time causes more heating in the motor and driver. Therefore, output current is generally set to be such that the motor will not overheat for long time operation. Phase current rating supplied by motor manufacturer is important in selecting driver current, however the selection also depends on leads and connections.

### DIP Setting for Dynamic Current

The 3MD560 and the 3MD560-CCW use an 8-bit DIP switch to set motor dynamic current, standstill current and microstep resolution, as shown below:



The first four bits (SW1, 2, 3, 4) of the DIP switch are used to set the dynamic current. Select a setting closest to your motor's required current.

Peak current (A)	RMS (A)	SW1	SW2	SW3	SW4
2.1	1.5	OFF	OFF	OFF	OFF
2.5	1.8	ON	OFF	OFF	OFF
2.9	2.1	OFF	ON	OFF	OFF
3.2	2.3	ON	ON	OFF	OFF
3.6	2.6	OFF	OFF	ON	OFF
4.0	2.9	ON	OFF	ON	OFF
4.5	3.2	OFF	ON	ON	OFF
4.9	3.5	ON	ON	ON	OFF
5.3	3.8	OFF	OFF	OFF	ON
5.7	4.1	ON	OFF	OFF	ON
6.2	4.4	OFF	ON	OFF	ON
6.4	4.6	ON	ON	OFF	ON
6.9	4.9	OFF	OFF	ON	ON
7.3	5.2	ON	OFF	ON	ON
7.7	5.5	OFF	ON	ON	ON
8.4	6.0	ON	ON	ON	ON

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

### DIP Setting for Standstill Current

SW5 is used for this purpose. OFF meaning that the standstill current is set to be half of the selected dynamic current, and ON meaning that standstill current is set to be the same as the selected dynamic current. The current automatically reduced to 60% of the selected dynamic current 0.5 second after the last pulse when use automatic idle-current reduction mode. Theoretically, this will reduce motor heating to 36% (due to  $P=I^2 \cdot R$ ) of the original value.

### Microstep Resolution Setting

Microstep resolution is set by SW6, 7, 8 of the DIP switch as shown in the following table:

Steps/rev.	SW6	SW7	SW8
200	ON	ON	ON
400	OFF	ON	ON
500	ON	OFF	ON
1000	OFF	OFF	ON
2000	ON	ON	OFF
4000	OFF	ON	OFF
5000	ON	OFF	OFF
10000	OFF	OFF	OFF

### 8. Wiring Notes

- In order to improve anti-interference performance of the driver, it is recommended to use twisted pair shield cable.
- To prevent noise incurred in pulse/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 drivers, separately connecting drivers is recommended instead of daisy-chaining.
- It is prohibited to pull and plug connector P2 while the driver is powered ON, because there is high current flowing through motor coils (even when motor is at standstill). Pulling or plugging connector P2 with power on will cause extremely high back-EMF voltage surge, which may damage the driver.

### 9. Typical Connection

A complete stepping system should include stepping motor, stepping driver, power supply and controller (pulse generator). A typical connection is shown in the Figure 6.

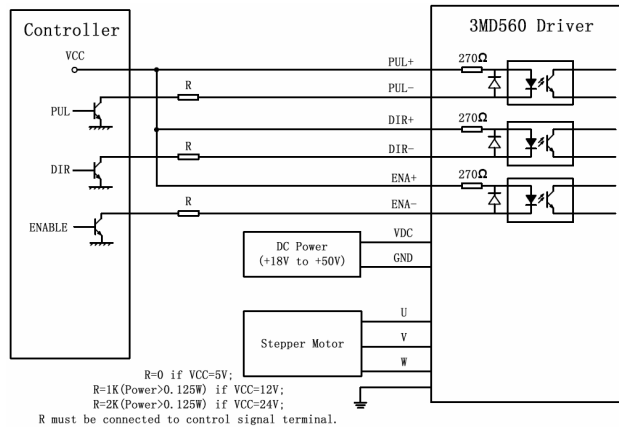


Figure 6: Typical connection

## 10. Sequence Chart of Control Signals

In order to avoid some fault operations and deviations, PUL, DIR and ENA signals should abide by some rules, as shown in the figure 7:

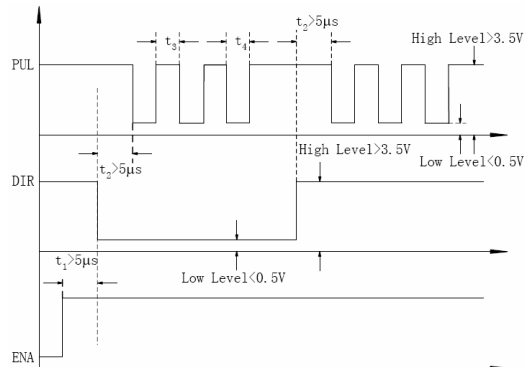


Figure 7: Sequence chart of control signals

### Remark:

- (1)  $t_1$ : ENA must be ahead of DIR by at least  $5\mu s$ . Usually, ENA+ and ENA- are NC (not connected). See “Connector P1 Configurations” for more information.
- (2)  $t_2$ : DIR must be ahead of PUL active edge by at least  $5\mu s$  to ensure correct direction;
- (3)  $t_3$ : Pulse width not less than  $2.5\mu s$ ;
- (4)  $t_4$ : low level width not less than  $2.5\mu s$ .

## 11. Protection Functions

To improve reliability, the driver incorporates some built-in protections features.

### Over-voltage Protection

When power supply voltage exceeds +52VDC, protection will be activated and power indicator LED will turn red.

### Short-voltage Protection

When power supply voltage is lower than +18VDC, the driver will not works properly.

### Short Circuit Protection

Protection will be activated in case of short circuit between motor coil and ground.

### Over-current Protection

Protection will be activated in case of over current which may otherwise damage the driver.

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

## 12. Frequently Asked Questions

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

**APPENDIX**

**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 prove to be defective.

**EXCLUSIONS**

The above warranty shall not apply to defects resulting from: improper or inadequate handling by customer; improper or inadequate customer wiring; unauthorized modification or misuse; or operation beyond the electrical specifications of the product and/or 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: [tech@leadshine.com](mailto:tech@leadshine.com) 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.

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**SHIPPING FAILED PRODUCT**

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