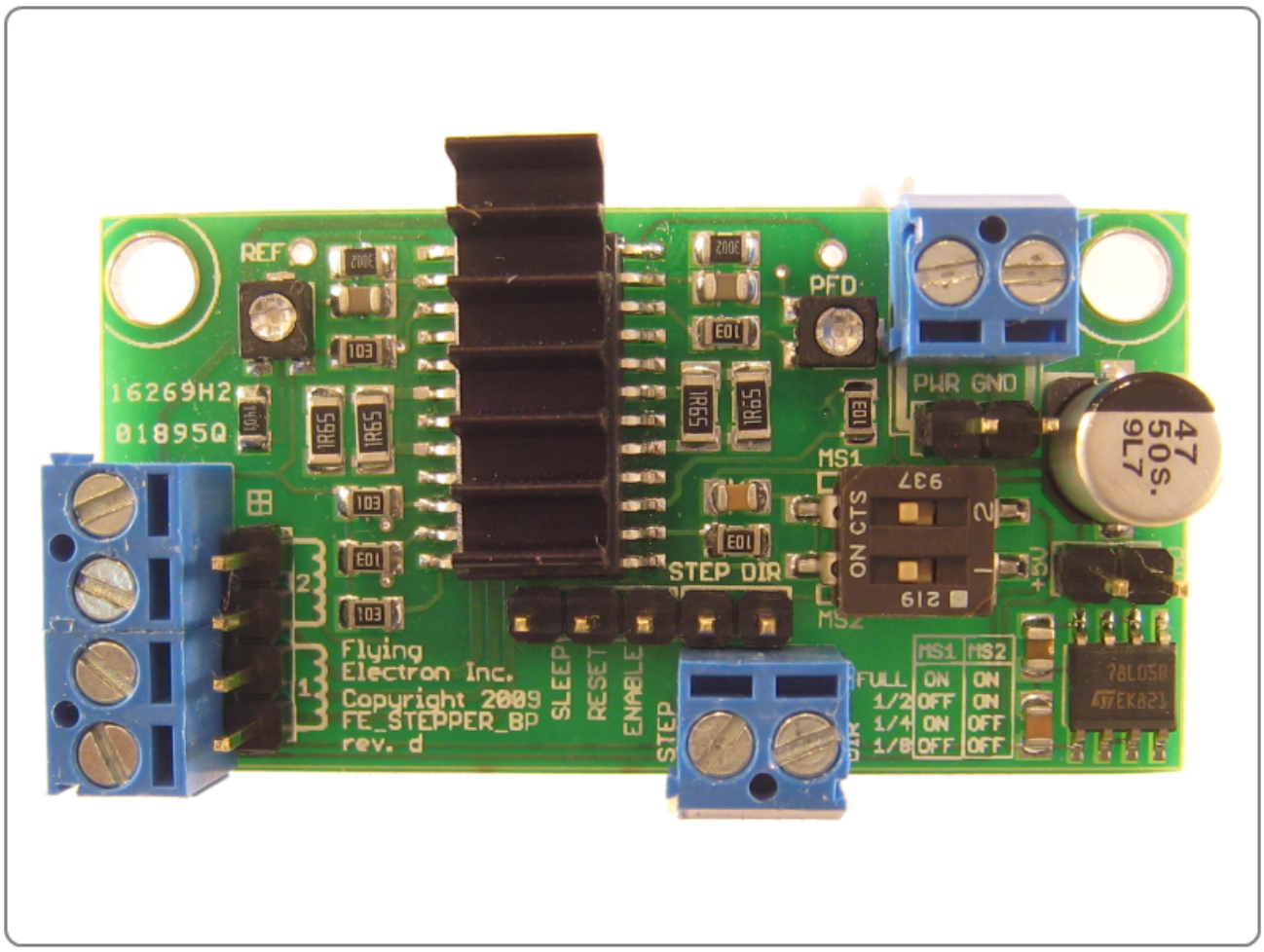
Flying Electron Inc.
Bipolar Stepper Motor Driver
Datasheet

Part Number: FE_STEPPER_BP rev. d

Notice: To the best of our knowledge the information contained in this datasheet is accurate and is represented in good faith, however, no expressed or implied warranty is made in this regard.

Overview

The FE_STEPPER_BP is a bipolar stepper driver for use in the control and sequencing of stepper motors. The driver incorporates many of the complicated functions needed to efficiently drive a stepper motor such as current chopping, microstep sequencing, and H-Bridge control. The driver has many safety features such as overheat protection, safe power up sequencing, and undervolt lock out protection. The driver has been designed to work with most popularly available stepper motors.



Key Features

- Designed for use with Stepper Motor sizes NEMA 8, 11, 14, 17, and 23
- Bipolar drive for maximum stepper motor torque
- Can be used with Stepper Motors in Bipolar Series, Bipolar Half Coil, and Bipolar Parallel configurations
- Terminal blocks for quick and easy connection of all external wires such as stepper motor coils, power, direction, and step signals
- Dipswitch selectable microstepping - full (1/1), half (1/2), quarter (1/4), and eighth (1/8)
- Easy trimpot adjustable current limiting from 150ma to 750ma
- Easy trimpot adjustment for slow decay mode, mixed decay mode, and fast decay mode

- Onboard 5V regulator, 20ma available to power external devices
- Heatsink for high heat dissipation
- Drive voltage range from 5V to 28V
- Overheat protection
- Safe power on sequencing
- Undervolt lockout protection
- Star ground PCB layout for excellent noise immunity
- Standard 0.1" Headers for easy connection to other devices
- Standard 3mm Terminal Blocks for easy connection to other devices

Quick Start

It is recommended to fully read this datasheet, especially the Initial Setup section, before using the driver board. However, for impatient people, quick start is provided.

1. Turn REF trimpot full counter clockwise until hard stop is reached. This provides minum current of 150ma.
2. Turn PFD trimpot full clockwise until hard stop is reached. This sets slow decay mode.
3. Connect stepper motor to Stepper Motor COIL #1 and Stepper Motor COIL #2 terminal blocks.
4. Gently pull on each individual stepper motor wire to ensure that it is firmly connected to the terminal block. A loose connection between the stepper motor wire and the terminal block will permanently damage the board due to high voltage spikes.
5. Set the microstep dipswitch MS1 to OFF, MS2 to OFF. This sets 1/8 microstepping mode.
6. Connect STEP and DIR wires to the STEP and DIR terminal block.
7. Connect Power supply (5V - 28V) and ground to PWR and GND terminal block.
8. Connect an additional ground wire from the GND terminal block to the STEP / DIR signal source's ground (i.e. parallel port, microcontroller, PLC unit, etc.) Two wires will be coming out of the GND terminal block, one to the ground of the power supply and one to the ground of the STEP / DIR signal source's ground.

Stepper Motors

The driver is compatible with all stepper motors which meet the following minimum requirements:

- 4, 6, or 8 wires
- Minimum drive voltage of 5V *(This is a minimum, higher voltages will provide better performance)*
- Minimum current rating of 150ma in bipolar mode *(This is a minimum, higher current will provide better performance)*

The following checklist can be used to ensure that your stepper motor is compatible with the driver.

1. Does the stepper motor have 4, 6, or 8 wires? If yes, then proceed to the next question. If no, then most likely the stepper motor is not compatible with the driver.

If it is known that the stepper motor is a unipolar or bipolar stepper motor, then most likely it is compatible and you may proceed to the next question.

If the motor has 4 or 6 wires and the datasheet is not available for the stepper motor, the coil connections can be derived from measurements taken with a multimeter in resistance measurement mode. If the motor has 8 wires, the datasheet for the motor will most likely be necessary to ensure correct coil connections.

2. From the markings on the stepper motor or from the stepper motor's datasheet, can the motor handle a current capacity of at least 150ma? If yes, then proceed to the next question.

150ma is the minimum amount of current that can be supplied by the driver. Higher current will produce more torque and a higher maximum RPM from the stepper motor. In general it is best to use the minimum current needed by your application because lower currents will

produce less heat in the stepper motor. See "Adjusting Stepper Motor Current" for more information on how to adjust the stepper motor current output by the driver.

There are several ways to wire the stepper motors to the driver, each with their own advantage and disadvantages. The recommended method is bipolar series for ease of setup. Stepper motors with 4 wires can only be used as bipolar series. Stepper motors with 6 wires can be used as bipolar series or bipolar half coil. Stepper motors with 8 wires can be used as bipolar series, bipolar half coil, or bipolar parallel. The table below assumes that the initial ratings of the stepper motor are given as a unipolar motor with is very common.

Configuration	***Wires***	***Resistance***	***Inductance***	***Current***	***Torque***
Bipolar Series	*4, 6, or 8*	*2.000*	*4.000*	*0.707*	*1.414*
Bipolar Half Coil	*6 or 8*	*1.000*	*1.000*	*1.000*	*1.000*
Bipolar Parallel	*8*	*0.500*	*1.000*	*1.414*	*1.414*

For example to find the torque of the stepper motor if configured as a bipolar series, multiply the rated unipolar torque of the stepper motor by 1.414 to find the bipolar series torque.

Generally the higher the inductance the more torque produced for a given amount of current, but torque will drop off more rapidly as motor speed increases.

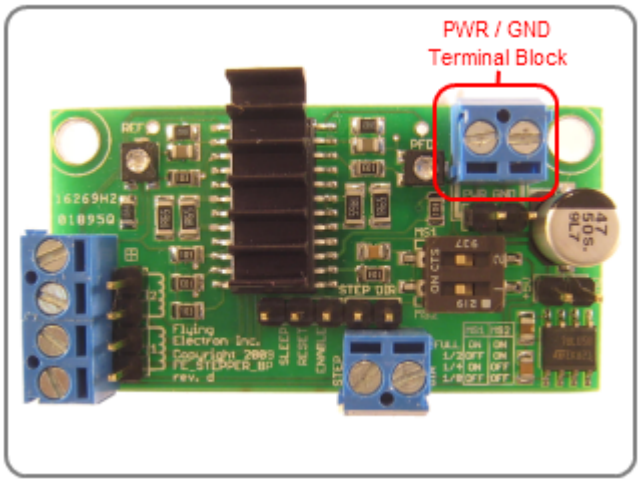
3. No more questions. The stepper motor is most likely compatible with the driver.

Initial Setup

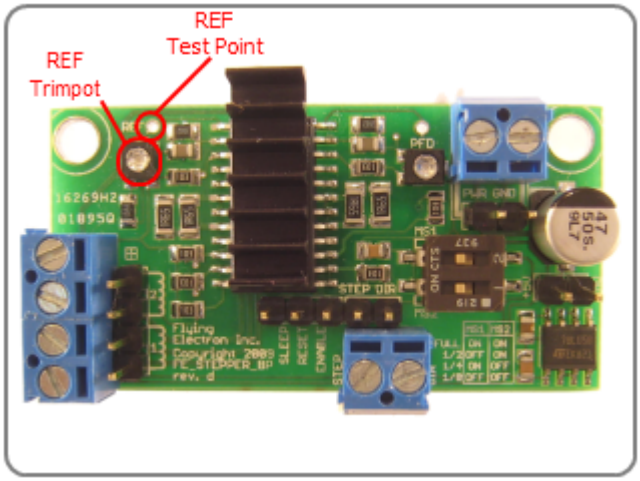
Do not connect the stepper motor to the motor driver until fully reading these initial setup instructions. Failure to do so may result in permanent damage to the stepper motor and the drive. The current limiting of the driver should be set appropriately for the stepper motor being used **before** the stepper motor is connected. The stepper motor wires must be securely connected to the driver board. A loose wire or bad connection combined with the inductance inherent in the stepper motor may cause uncontrollable voltage spikes measuring in the hundreds or thousands of volts which will damage the driver board and any equipment connected to the driver board.

Connecting the Power Supply

With the power source turned off, connect a suitable power source to the PWR and GND terminal block. PWR should be a voltage between 5V and 28V. Important! Double check that the power wire is attached to PWR and the ground wire is attached to GND. A reversal of the power connection wires may cause permanent damage to the driver board.



Adjusting Stepper Motor Current



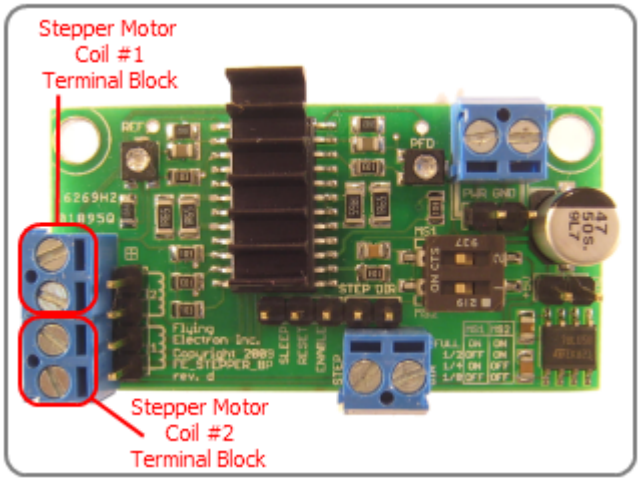
Using a small screwdriver, gently adjust the trimpot marked REF to adjust the current output of the driver. There are stops at either end of the range of adjustment and it is important not to force the trimpot and overturn past the stops. Ideally the motor current should be set at 80% of the maximum current capacity of the stepper motor or the maximum output of 750ma available from the driver, whichever is lower. Turning the trimpot counter clockwise reduces the current, turning the trimpot clockwise increases the current. When the trimpot is turned all the way counter clockwise, the driver output current will be 150ma. When the trimpot is turned all the way clockwise, the driver output current will be 750ma. The output current varies linearly within the range of the trimpot adjustment, so turning the trimpot halfway between the two stops will produce an output current of 450ma. If in doubt, it is safer to set the current lower then higher.

Advanced Method: The most accurate way of setting the current is to use a multimeter and probe the REF testpoint while adjusting the trimpot while the power supply is on. This involves adjusting the trimpot while power is applied to the board so extreme caution must be applied not to touch anything but the trimpot and the test point or electrocution may occur. Only advanced users with proper insulated test equipment should proceed with this procedure. The relationship between the output current and the voltage measured at the REF testpoint is as follows:

$I_{current} = V_{ref} / 6.6$

V_{ref} Voltage	Output Current (ma)
1.0	150
1.5	225
2.0	300
2.5	375
3.0	450
3.5	525
4.0	600
4.5	675
5.0	750

Connecting the Stepper Motor



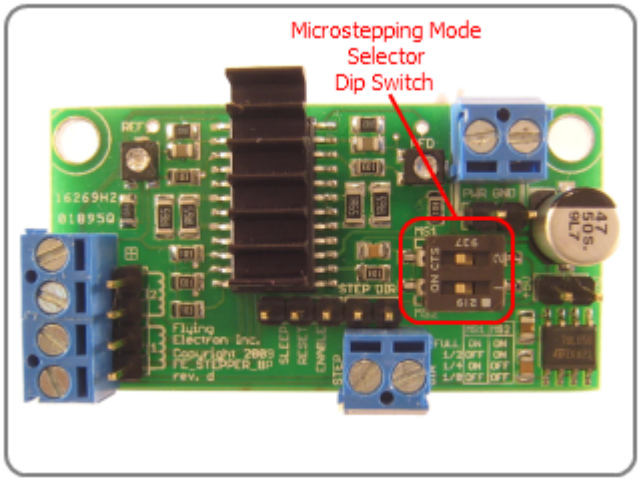
Make sure the power to the driver board is off. Connecting the stepper motor while power is applied to the driver board will cause permanent damage to the driver board and may cause serious injury to the person connecting the wires. Connect coil 1 of the stepper motor to the terminal blocks marked coil 1 on the stepper driver. Connect coil 2 of the stepper motor to the terminal blocks marked coil 2 on the stepper driver. To reverse the direction of rotation of the stepper motor, reverse the wires connected to coil 1. Coil 1 and Coil 2 are interchangeable so if the coils of the stepper motor are not labeled, either coil can be connected to Coil #1 and the remaining coil can be connected to Coil #2.

Important! After connecting the wires to the terminal blocks, gently pull on the wires to make sure they are securely attached to the terminal blocks. A loose wire or bad connection will cause permanent damage to the drive board.

Turn on the power to the board. The stepper motor should hold it's position and the shaft of the stepper motor should be difficult if not impossible to turn. A hissing noise from the stepper motor is normal and is caused by the current limiting of the driver.

Turn off the power to the board before proceeding to the next step.

Adjust Microstepping Mode

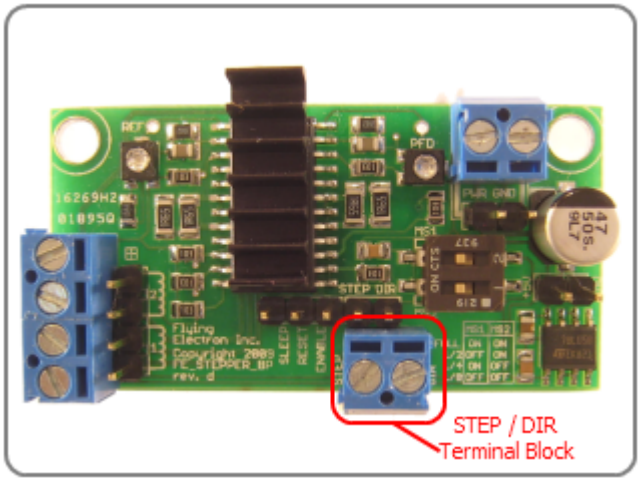


The driver has the capability to subdivide discreet stepper motor steps into finer microsteps for more accurate positioning. For example if the stepper motor is listed as having 200 steps / rev (also known as a 1.8 degree per step motor) then it would normally only have 200 discreet positions per revolution. With the use of microstepping, the number of discreet positions can be increased by up to a factor of eight with 1/8 microstepping to provide 1600 discreet positions. Microstepping is generally recommended only for application where the stepper motor experiences a low torque load since the torque available between microsteps may not be enough to overcome a high torque load on the stepper motor causing inaccurate positioning between microsteps.

The microstepping mode is adjusted through the MS1 and MS2 dipswitches. The dipswitch has a label "ON" to signify which position of the dipswitch is the "ON" position. The "ON" position is towards the left side of the board, MS1 is towards the top of the board, and MS2 is towards the bottom of the board. The settings are as follows:

Mode	MS1	MS2
FULL (1/1)	ON	ON
HALF (1/2)	OFF	ON
QUARTER (1/4)	ON	OFF
EIGHTH (1/8)	OFF	OFF

Connecting the Step and Dir Signals

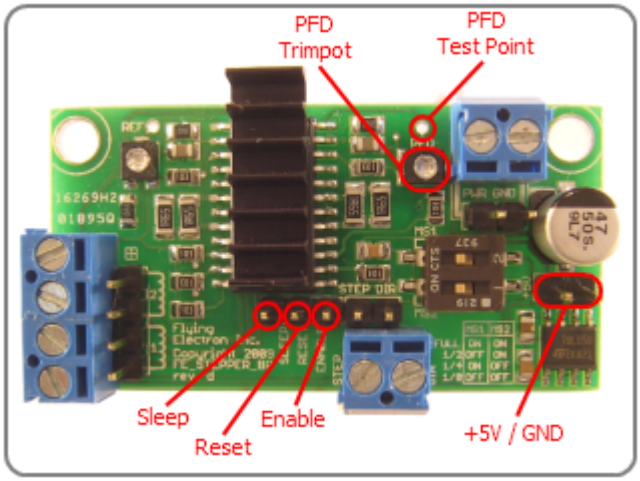


The stepper motor is controlled by Step and Dir signals. These signals are pulled high to 5V internally on the driver. To make the motor turn, apply pulses to the Step signal by pulling it low. Each pulse will turn the motor one microstep. For example, if the stepper motor is a 200/rev stepper motor and microstepping is set at 1/8, it will take 1600 pulses of the step line to turn the motor one complete revolution. To change the direction that the motor turns when step pulses are applied, pull the Dir signal low. The motor will rotate one direction when the Dir signal is high, and the opposite direction when the Dir signal is low. The Step and Dir signals should only be connected to equipment which is 5V tolerant. To reverse the direction the motor turns relative to the DIR signal, turn the power to the driver board off and reverse the wires connected to COIL #1.

Important! The equipment connected to the Step and Dir signals must share a common ground with the driver board. If in doubt, the ground of the equipment supplying the Step and Dir signals should also be connected to the GND terminal block. If the Step and Dir signals appear to work erratically or not at all, make sure there is a common ground shared by the source of the Step and Dir signals and the driver board.

Advanced Features

The following are advanced features not normally needed for general operation of the stepper motor.



Slow Decay, Mixed Mode Decay, Fast Decay

The drive supports slow decay, mixed mode decay, and fast decay. For most applications, Slow Decay should be used. To adjust the decay mode use a small screwdriver and adjust the PFD trimpot. Turn the trimpot all the way clockwise to enable slow decay. Turn the trimpot all the way counter clockwise to enable fast decay. Mixed decay is set by setting the trimpot between the fast decay and slow decay settings.

Advanced Method: To obtain the optimal mixed decay mode setting connect an oscilloscope with a current probe (not a voltage probe) inline with one of the stepper motor coils to measure the current flowing through the stepper motor. Apply step pulses to spin the motor at the maximum speed the application will be using. Adjust the PFD trimpot until the current flowing through the stepper motor as shown on the oscilloscope best matches a sine wave. This will be the optimal mixed mode setting for this motor at that particular RPM.

Sleep Mode

Sleep mode is available through an unpopulated header labeled SLEEP. The Sleep signal is active low and can be enabled by pulling the Sleep signal low. Sleep mode will place the driver into a low power consumption mode. Upon waking from sleep mode when the Sleep signal is brought high, the driver will reboot. The driver will not retain positional accuracy when waking from Sleep so care should be used when activating the Sleep mode.

Enable Mode
Enable mode is available through an unpopulated header labeled ENABLE. The driver is enabled when the Enable signal is pulled low. By default a 10k pull down resistor is used to pull the Enable signal low. When the driver is disabled by pulling the Enable signal high, the motor current drivers as disabled. By disabling the motor driver, the stepper motor is allowed to spin freely until the motor driver is enabled again. Please be aware that the motor driver will still respond to STEP pulses and update it's internal microstepping state while the motor current drivers are disabled.

Reset Mode
The Reset signal is available through an unpopulated header labeled RESET. The driver can be reset to it's initial state by pulling the Reset signal low. While the Reset signal is low the motor current drivers are disabled and all Step signals are ignored.

+5V for External Devices
A small amount of +5V regulated current (20ma) is available to power external devices through the unpopulated header marked +5V and GND. If 20ma of current draw is exceeded, the motor driver may behave erratically because not enough current is available for the motor driver logic circuits.

Frequently Asked Questions

Question: Where can I find more information about the advanced features of the driver board?

Answer: The driver uses the Allegro Micro A3967 IC chip. Please consult the datasheet for the A3967 for more detailed information about the advanced features which are outside the scope of this document.

Question: Can I run a stepper motor at less then it's rated current?

Answer: There is no harm in running a stepper motor at less then it's rated current. Torque is proportional to the current, so if a stepper motor has a maximum torque of 100oz-in @ 1.0A and the stepper motor is run at 0.75A, the corresponding torque would be 75oz-in. However, please be aware that there are different torque and current specifications depending on if the stepper motor is wired in a unipolar, bipolar series, bipolar half coil, or bipolar parallel configuration. Also be aware that the stepper motor rated torque and current can also be specified as unipolar, bipolar series, bipolar half coil, or bipolar parallel configuration, so it may not be a straight comparison between two stepper motors because they may have their ratings stated for different configurations.

Question: Is there any benefit to running a stepper motor at less then it's rated current?

Answer: A stepper motor running at less then it's rated current will run much cooler. Generally running a stepper motor at 75% of it's rated current will dramatically reduce the temperature of the stepper motor and may increase the life and reliability of the motor while only reducing the torque available from the stepper motor by 25%.

Troubleshooting

Problem
- The driver behaves erratically with random steps appearing on the motor
- The driver only turns the motor in one direction, when the DIR signal is switched to the other direction the motor oscillates back and forth randomly

- The driver does not respond to STEP or DIR signals

Solution

- Check that there is a common ground connection between the source of the STEP and DIR signals and the motor driver. If there not a common ground, run an extra ground wire from the GND terminal to the ground of the device which is the source of the STEP and DIR signals

Problem

- One of the stepper motor wires was loose, and now the driver does not work

Solution

- The driver may have been damaged by the voltage spikes caused by the loose stepper motor wire. The stepper motor acts as a large inductor and if there is a loose connection while the driver is applying current to the motor and the connection suddenly breaks, the stepper motor acts like the coil in a taser and sends a high voltage spike back into the driver damaging the driver. Please contact us for repair information.

Problem

- The driver STEP or DIR signal is connected to the pins of a parallel port, but the driver behaves erratically or not at all

Solution

- Check that their is a connection between the ground of the parallel port and the ground of the driver board.

Problem

- The driver behaves erratically with random steps appearing on the motor, or the motor loses random steps

Solution

- The STEP and DIR signal wires may be picking up unintended RF noise from an outside source which is misread as STEP pulses or DIR signal changes. Use shielded cable for the STEP and DIR signals and ground the shield of the cable to the GND terminal block of the driver board, but do not ground the shield to the source of the STEP and DIR signals.

Electrical Characteristics

Absolute Maximum Ratings

Parameter	Max	Units
Maximum Operating Temperature	80	°C
Maximum Storage Temperature	80	°C
Maximum Power Voltage[2]	30	V
Maximum Output Driver Junction Temperature	150	°C
Maximum Current +5V for External Devices	20	ma

[2] Maximum transient voltage

DC Characteristics

Parameter	Min	Max	Units
Power Voltage	5.0	28.0V	V
Stepper Motor Current	150	750	ma

Logic Input High	0.7	---	V
Logic Input Low	---	0.3	V
Logic Pull Up / Pull Down	10	---	kOhm
Maximum Step Frequency	500		kHz

Mechanical

Dimensions
Height 0.4"
Width 1"
Length 2"

Terminal Blocks
Wire Size: 16 - 26 AWG

Mounting Diagram