MP6500 Stepper Motor Driver Carrier, Potentiometer Current Control
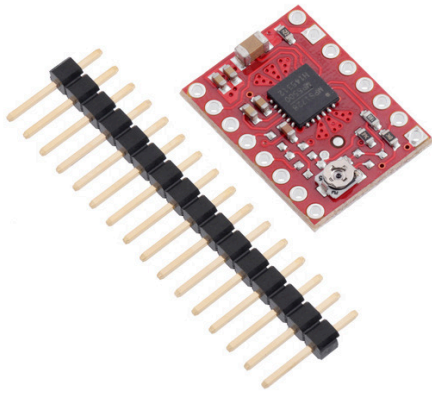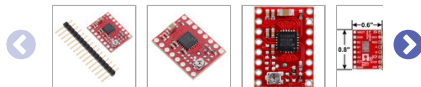
Pololu item #: 2966   **369** in stock
Brand: **Pololu**   **supply outlook**
Status: Active and Preferred ❓

✔ **RoHS 3**

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This breakout board for the MPS MP6500 microstepping bipolar stepper motor driver has a pinout and interface that are very similar to that of our popular **A4988 carriers**, so it can be used as a drop-in replacement for those boards in many applications. The MP6500 offers up to 1/8-step microstepping, operates from 4.5 V to 35 V, and can deliver up to approximately 1.5 A per phase continuously without a heat sink or forced air flow (up to 2.5 A peak). This version of the board uses an **on-board trimmer potentiometer for setting the current limit**, and the board ships with 0.1″ male header pins included but not soldered in.

Alternatives available with variations in these parameter(s): current limit control   header pins soldered? **Select variant…**
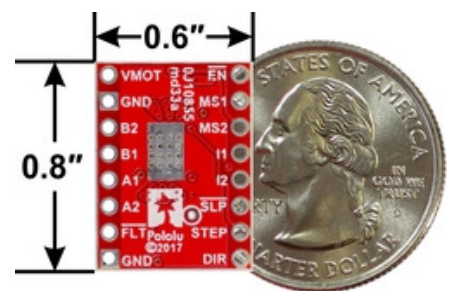
or .

Description   **Specs (14)**   **Pictures (10)**   **Resources (9)**   **FAQs (4)**   **On the blog (2)**   **Distributors (50)**

Overview

This product is a carrier board or breakout board for the MP6500 stepper motor driver from Monolithic Power Systems (MPS); we therefore recommend careful reading of the **MP6500 datasheet** (1MB pdf) before using this product. This stepper motor driver lets you control one **bipolar stepper motor** at up to approximately 1.5 A per phase continuously without a heat sink or forced air flow (see the *Power dissipation considerations* section below for more information). Here are some of the driver's key features:

MP6500 Stepper Motor Driver Carrier, bottom view.

- Simple step and direction control interface

- Four different step resolutions: full-step, half-step, 1/4-step, and 1/8-step

- Adjustable current control lets you set the maximum current output, which lets you use voltages above your stepper motor's rated voltage to achieve higher step rates

- Two current limit control options available, each with two header pin assembly options, making four versions in all:

- - **Potentiometer Current Control** uses an on-board trimmer pote
      up to 2.5 A
    - **with header pins included but not soldered**
    - **with header pins soldered**
  - **Digital Current Control** allows a microcontroller to dynamical
    around 2 A
    - **with header pins included but not soldered**
    - **with header pins soldered**
- Internal current sensing allows the driver to automatically adjust the de
  the smoothest current waveform
- 4.5 V to 35 V supply voltage range
- Can deliver 1.5 A per phase continuously without additional cooling
- Built-in regulator (no external logic voltage supply needed)
- Can interface directly with 3.3 V and 5 V systems
- Over-temperature thermal shutdown, over-current shutdown, short ci
  lockout
- 4-layer, 2 oz copper PCB for improved heat dissipation
- Exposed solderable ground pad below the driver IC on the bottom of th
- Module size, pinout, and interface match those of our **A4988 stepp**
  respects

This product ships with all surface-mount components—including the MP6500 driver IC—installed as shown in the product picture.

We also have a variety of other **stepper motor driver options in this same form factor** with different operating profiles and features.

> Some unipolar stepper motors (e.g. those with six or eight leads) can be controlled by this driver as bipolar stepper motors. For more information, please see the **frequently asked questions**. Unipolar motors with five leads <u>cannot</u> be used with this driver.

Details for item #2966

This version of the MP6500 Stepper Motor Driver Carrier uses an on-board trimmer potentiometer to set the current limit. Header pins are included but not soldered (see **item #2967** for a version of this carrier with header pins already installed).

We also carry a version of this carrier **that offers digital current control**, which allows a microcontroller to make dynamic current limit adjustments.

Included hardware

The MP6500 stepper motor driver carrier ships with one 1×16-pin breakaway **0.1″ male header**. The headers can be soldered in for use with **solderless breadboards** or **0.1″ female connectors**. You can also solder your motor leads and other connections directly to the board.
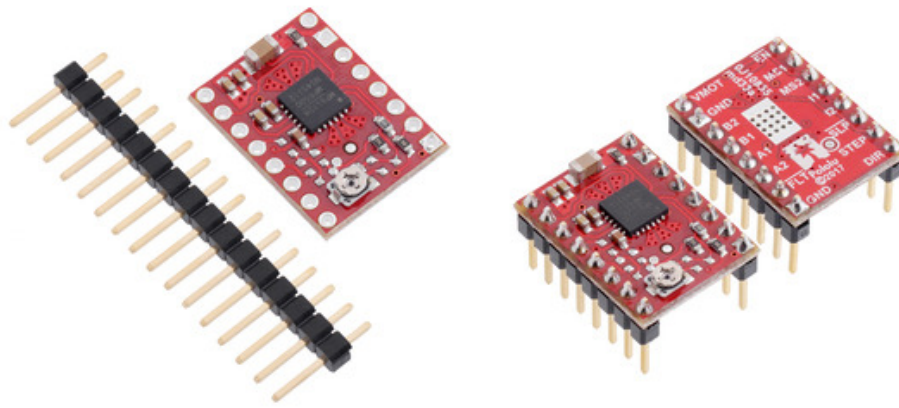
Using the driver
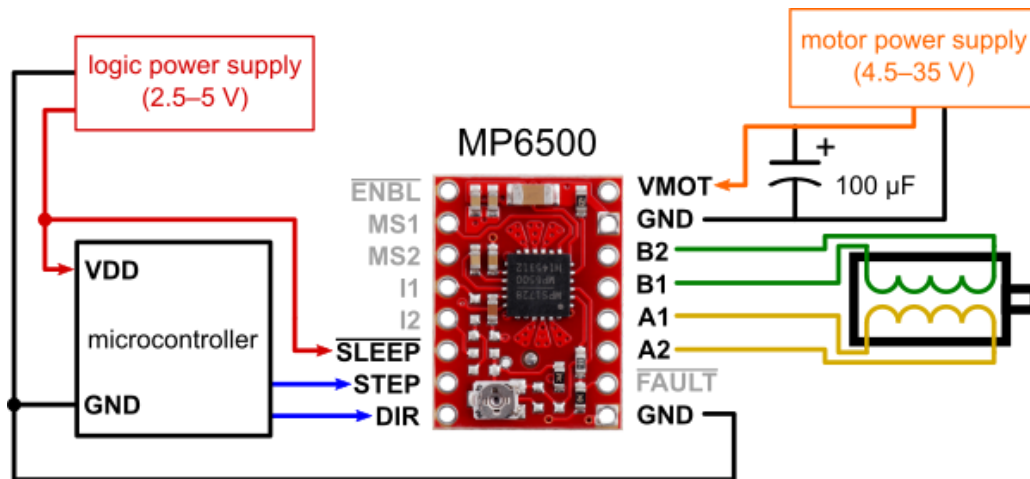
Minimal wiring diagram for connecting a microcontroller to an MP6500 Stepper Motor Driver Carrier, Potentiometer Current Control (full-step mode).

Power connections

The driver requires a motor supply voltage of 4.5 V to 35 V to be connected across VMOT and GND. This supply should have appropriate decoupling capacitors close to the board, and it should be capable of delivering the expected stepper motor current. The driver has an internal voltage regulator, so it does not require a logic voltage supply.

> **Warning:** This carrier board uses low-ESR ceramic capacitors, which makes it susceptible to destructive **LC voltage spikes**, especially when using power leads longer than a few inches. Under the right conditions, these spikes can exceed the 40 V absolute maximum voltage rating for the MP6500 and permanently damage the board, even when the motor supply voltage is as low as 12 V. One way to protect the driver from such spikes is to put a large (at least 47 μF) electrolytic capacitor across motor power (VMOT) and ground somewhere close to the board.

Motor connections

Four, six, and eight-wire stepper motors can be driven by the MP6500 if they are properly connected; a **FAQ answer** explains the proper wirings in detail.

> **Warning:** Connecting or disconnecting a stepper motor while the driver is powered can destroy the driver. (More generally, rewiring anything while it is powered is asking for trouble.)

Step (and microstep) size

Stepper motors typically have a step size specification (e.g. 1.8° or 200 steps per revolution), which applies to full steps. A microstepping driver such as the MP6500 allows higher resolutions by allowing intermediate step locations, which are achieved by energizing the coils with intermediate current levels. For instance, driving a motor in quarter-step mode will give the 200-step-per-revolution motor 800 microsteps per revolution by using four different current levels.

The resolution (step size) selector inputs (MS1 and MS2) enable selection from the four step resolutions according to the table below. These two pins are pulled low through internal 500 kΩ pull-down resistors, so the driver defaults to full-step mode when these inputs are left disconnected. For the microstep modes to function correctly, the current limit must be set low enough (see below) so that current limiting gets engaged. Otherwise, the intermediate current levels will not be correctly maintained, and the motor will skip microsteps.

| MS1	MS2	Microstep Resolution
Low	Low	Full step
High	Low	Half (1/2) step
Low	High	Quarter (1/4) step
High	High	Eighth (1/8) step

Control inputs

Each pulse to the STEP input corresponds to one microstep of the stepper motor in the direction selected by the DIR pin. These inputs are both pulled low by default through internal 500 kΩ pull-down resistors. If you just want rotation in a single direction, you can leave DIR disconnected.

The chip has two different inputs for controlling its power states: $\overline{\text{SLEEP}}$ and $\overline{\text{ENBL}}$. For details about these power states, see the datasheet. Please note that the driver pulls both of these pins low through internal 500 kΩ pull-down resistors. The default $\overline{\text{SLEEP}}$ state prevents the driver from operating; this pin must be high to enable the driver (it can be connected directly to a logic "high" voltage between 2.5 V and 5 V, or it can be dynamically controlled by connecting it to a digital output of an MCU). The default state of the $\overline{\text{ENBL}}$ pin is to enable the driver, so this pin can be left disconnected.

The datasheet does not describe how $\overline{\text{SLEEP}}$ and $\overline{\text{ENBL}}$ affect the driver's internal logic, but based on our testing, bringing $\overline{\text{SLEEP}}$ low disables and resets the entire driver (including the microstep position) while bringing $\overline{\text{ENBL}}$ high disables only the motor outputs while retaining the microstep position.

The MP6500 also features an open-drain $\overline{\text{FAULT}}$ output that drives low whenever the H-bridge FETs are disabled as the result of over-current protection, over-voltage protection, thermal shutdown, or under-voltage lockout protection. The carrier board connects this pin to the $\overline{\text{SLEEP}}$ pin through a 10 kΩ resistor that acts as a $\overline{\text{FAULT}}$ pull-up whenever $\overline{\text{SLEEP}}$ is externally held high, so no external pull-up is necessary on the $\overline{\text{FAULT}}$ pin. Note that the carrier includes a 1.5 kΩ protection resistor in series with the $\overline{\text{FAULT}}$ pin that makes it is safe to connect this pin directly to a logic voltage supply, as might happen if you use this board in a system designed for the pin-compatible **A4988 carrier**. In such a system, the 10 kΩ resistor between $\overline{\text{SLEEP}}$ and $\overline{\text{FAULT}}$ would then act as a pull-up for $\overline{\text{SLEEP}}$, making the MP6500 carrier more of a direct replacement for the A4988 in such systems (the A4988 has an internal pull-up on its $\overline{\text{SLEEP}}$ pin).
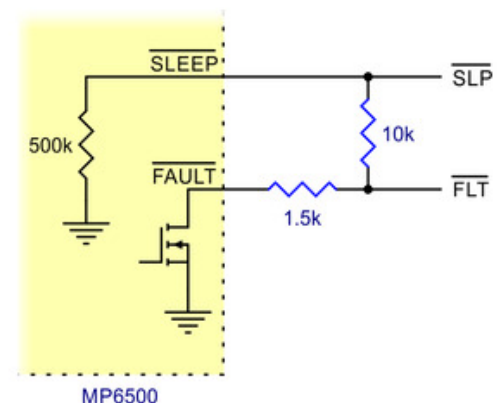
Schematic of nSLEEP and nFAULT pins on MP6500 carrier.

As a consequence of the connection between $\overline{\text{SLEEP}}$ and $\overline{\text{FAULT}}$, active faults can pull the $\overline{\text{SLEEP}}$ pin low (below 2.1 V) if it is not externally pulled up strongly enough. We recommend any pull-up resistor used with $\overline{\text{SLEEP}}$ be 4.7 kΩ or stronger (or just connect $\overline{\text{SLEEP}}$ directly to VCC).
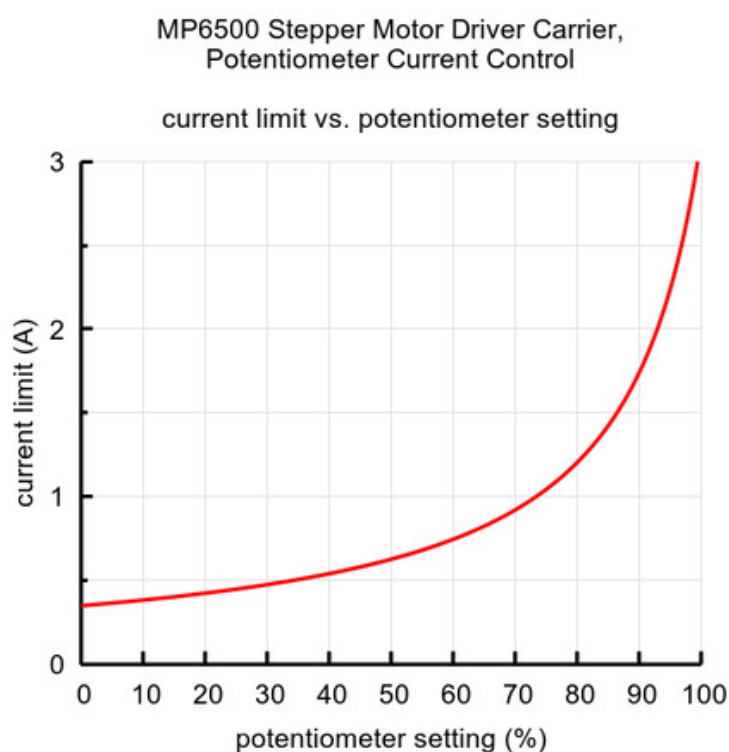
Current limiting

Setting the Current Limit on Pololu Stepper Motor Driver Carriers

To achieve high step rates, the motor supply is typically higher than would be permissible without active current limiting. For instance, a typical stepper motor might have a maximum current rating of 1 A with a 5 Ω coil resistance, which would indicate a maximum motor supply of 5 V. Using such a motor with 9 V would allow higher step rates, but the current must actively be limited to under 1 A to prevent damage to the motor.

The MP6500 supports such active current limiting, and the trimmer potentiometer on the board can be used to set the current limit:

MP6500 Stepper Motor Driver Carrier, Potentiometer Current Control

current limit vs. potentiometer setting

You will typically want to set the driver's current limit to be at or below the current rating of your stepper motor. One way to set the current limit is to put the driver into full-step mode and to measure the current running through

a single motor coil without clocking the STEP input. The measured current will be 0.7 times the current limit (since both coils are always on and limited to approximately 70% of the current limit setting in full-step mode).

Another way to set the current limit is to measure the VREF voltage and calculate the resulting current limit. The VREF pin voltage is accessible via a small hole that is circled on the bottom silkscreen of the circuit board. The current limit in amps relates to the reference voltage in volts as follows:

$$\text{Current Limit} = \text{VREF} \cdot 3.5$$

or, rearranged to solve for VREF:

$$\text{VREF} = \frac{\text{Current Limit}}{3.5}$$

So, the current limit in amps (A) is equal to 3.5 times the VREF voltage in volts (V), and if you have a stepper motor rated for 1 A, for example, you can set the current limit to about 1 A by setting the reference voltage to about 0.28 V. In practice, we have often observed the actual current limit to be about 10% (sometimes up to 15%) lower than what the equation and graph show.

The I1 and I2 pins are not used on this version of the MP6500 Stepper Motor Driver Carrier, and any signals applied to these pins will have no effect on the operation of the driver.

> **Note:** The coil current can be very different from the power supply current, so you should <u>not</u> use the current measured at the power supply to set the current limit. The appropriate place to put your current meter is in series with one of your stepper motor coils. If the driver is in full-step mode, both coils will always be on and limited to approximately 70% of the current limit setting. If your driver is in one of the microstepping modes, the current through the coils will change with each step, ranging from 0% to 100% of the set limit. See the MP6500 datasheet for more information.

Power dissipation considerations

The MP6500 driver IC has a maximum current rating of 2.5 A per coil, but the actual current you can deliver depends on how well you can keep the IC cool. The carrier's printed circuit board is designed to draw heat out of the IC, but to supply more than approximately 1.5 A per coil, a heat sink or other cooling method is required. Note that the version of this board with digital current control has a maximum current limit setting of around 2 A.

> This product can get **hot** enough to burn you long before the chip overheats. Take care when handling this product and other components connected to it.

<u>Please note that measuring the current draw at the power supply will generally not provide an accurate measure of the coil current.</u> Since the input voltage to the driver can be significantly higher than the coil voltage, the measured current on the power supply can be quite a bit lower than the coil current (the driver and coil basically act like a switching step-down power supply). Also, if the supply voltage is very high compared to what the motor needs to achieve the set current, the duty cycle will be very low, which also leads to significant differences between average and RMS currents. Additionally, please note that the coil current is a function of the set current limit, but it does not necessarily *equal* the current limit setting as the actual current through each coil changes with each microstep.

Schematic diagram

Schematic diagram for the MP6500 Stepper Motor Driver Carrier.

This schematic is also available as a **downloadable pdf** (106k pdf).

People often buy this product together with:

Stepper Motor: Bipolar, 200 Steps/Rev, 42×38mm, 2.8V, 1.7 A/Phase

MP6500 Stepper Motor Driver Carrier, Digital Current Control

DRV8834 Low-Voltage Stepper Motor Driver Carrier