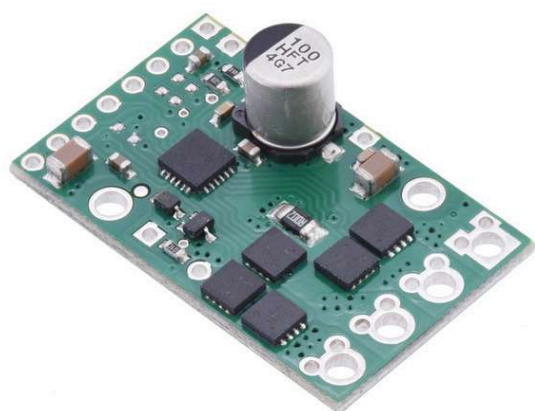


# Pololu G2 High-Power Motor Driver 24v13



**Pololu item #:** 2992

**Brand:** [Pololu](#)

[supply outlook](#)

**Status:** Active and Preferred [?](#)

**✓RoHS3**

Price break	Unit price (US\$)
1	39.95
5	36.75
25	33.81
100	31.11

**Quantity:**

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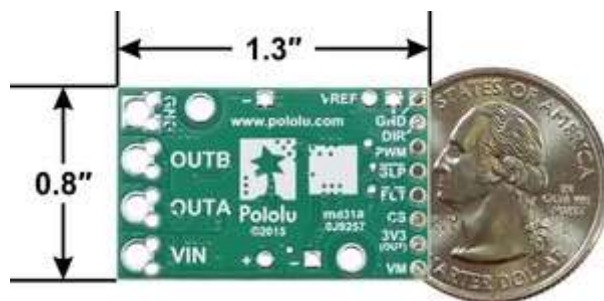
This discrete MOSFET H-bridge motor driver enables bidirectional control of one high-power DC brushed motor. The small 1.3" × 0.8" board supports a wide **6.5 V to 40 V** voltage range and is efficient enough to deliver a continuous **13 A** without a heat sink. Additional features of this second-generation (G2) driver include reverse-voltage protection along with basic current sensing and current limiting functionality.

or .

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## Overview

The Pololu G2 high-power motor driver is a discrete MOSFET H-bridge designed to drive large brushed DC motors. The H-bridge is made up of one N-channel MOSFET per leg; the rest of the board contains the circuitry to take user inputs and control the MOSFETs. The absolute maximum voltage for this motor driver is 40 V, and higher voltages can permanently destroy the motor driver. Under normal operating conditions, ripple voltage on the supply line can raise the maximum voltage to more than the average or intended voltage, so a safe maximum voltage is approximately 34 V.



**Note:** Battery voltages can be much higher than nominal voltages when they are charged, so the maximum nominal battery voltage we recommend is **28 V** unless appropriate measures are taken to limit the peak voltage.

The versatility of this driver makes it suitable for a large range of currents and voltages: it can deliver up to 13 A of continuous current with a board size of only 1.3" × 0.8" and no required heat sink. The module offers a simple interface that requires as few as two I/O lines while still allowing for your choice of sign-magnitude or locked-antiphase operation. A current sense output gives an indicator of motor current, and the driver can limit the motor current to a configurable threshold. The power supply inputs feature reverse-voltage protection, while integrated detection of various fault conditions helps protect against other common causes of catastrophic failure; however, please note that the board does not include over-temperature protection.

The G2 High-Power Motor Driver **24v13** is a second-generation successor to our original [High-Power Motor Driver 24v12](#) and can be used as a near drop-in replacement in typical applications. See “Differences from original high-power motor drivers” below for more details.

This version can be distinguished from the 18v17 by the number **100** on top of the tall silver electrolytic capacitor.

## Features

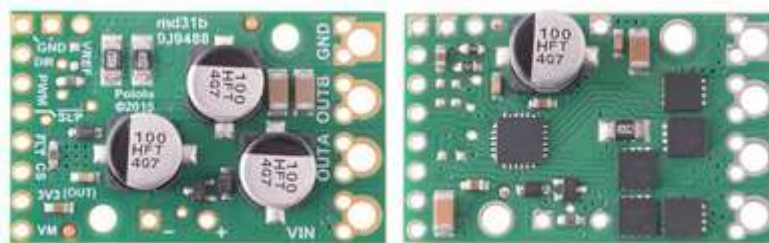
- Operating voltage: 6.5 V to 40 V (absolute maximum)
- Output current: 13 A continuous
- Inputs compatible with 1.8 V, 3.3 V, and 5 V logic
- PWM operation up to 100 kHz
- Current sense output proportional to motor current (approx. 40 mV/A; only active while H-bridge is driving)
- Active current limiting (chopping) with default threshold of 30 A (can be adjusted lower)
- Reverse-voltage protection
- Undervoltage shutdown
- Short circuit protection

## G2 high-power motor driver versions

There are four versions of the single-channel G2 high-power motor drivers that share compatible pinouts, and eight versions of the dual-channel G2 high-power motor drivers. Four of the dual-channel drivers have the form factor of an Arduino shield, but they can also be used with other

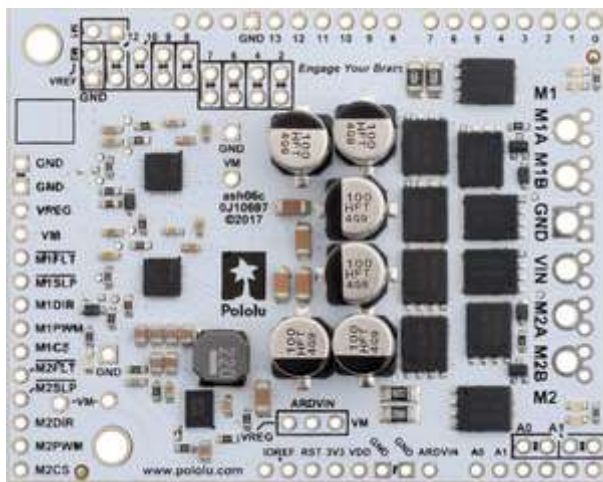
controllers as general-purpose motor drivers. The other four dual-channel drivers are in the form factor of a Raspberry Pi HAT and compatible [Raspberry Pi](#) boards (Model B+ or newer). The following table provides a comparison of the G2 drivers:

Pololu G2 High-Power Motor Drivers					
Motor channels	Name	Absolute max input voltage	Max nominal battery voltage	Max continuous current per channel	Default active current-limiting threshold
1	<a href="#">G2 High-Power Motor Driver 18v25</a>	30 V	18 V	25 A	60 A
	<a href="#">G2 High-Power Motor Driver 18v17</a>			17 A	40 A
	<a href="#">G2 High-Power Motor Driver 24v21</a>	40 V	28 V	21 A	50 A
	<a href="#">G2 High-Power Motor Driver 24v13</a>			13 A	30 A
2	<a href="#">Dual G2 High-Power Motor Driver 18v22 Shield</a>	30 V	18 V	22 A	60 A
	<a href="#">Dual G2 High-Power Motor Driver 18v18 Shield</a>			18 A	50 A
	<a href="#">Dual G2 High-Power Motor Driver 24v18 Shield</a>	40 V	28 V	18 A	50 A
	<a href="#">Dual G2 High-Power Motor Driver 24v14 Shield</a>			14 A	40 A
	<a href="#">Dual G2 High-Power Motor Driver 18v22 for RPi</a>	30 V	18 V	22 A	60 A
	<a href="#">Dual G2 High-Power Motor Driver 18v18 for RPi</a>			18 A	50 A
	<a href="#">Dual G2 High-Power Motor Driver 24v18 for RPi</a>	40 V	28 V	18 A	50 A
	<a href="#">Dual G2 High-Power Motor Driver 24v14 for RPi</a>			14 A	40 A

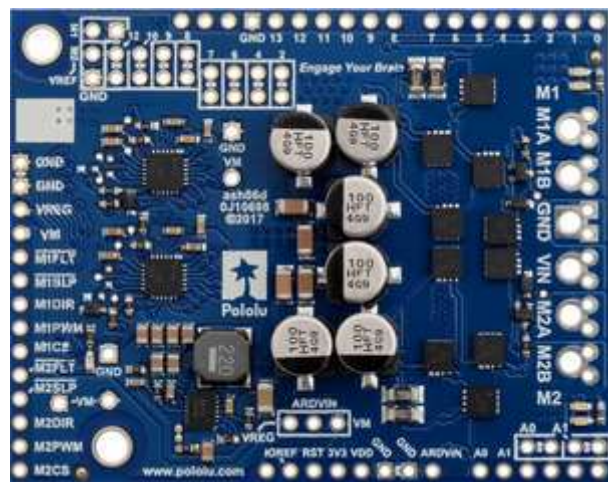


**Pololu G2 High-Power Motor Driver 24v21 and 24v13.**

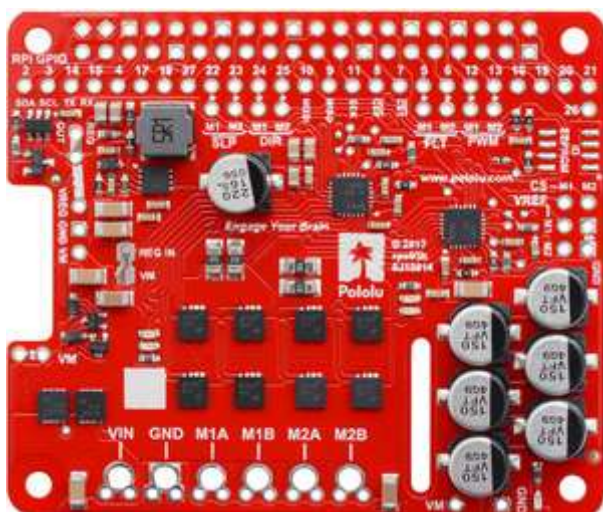




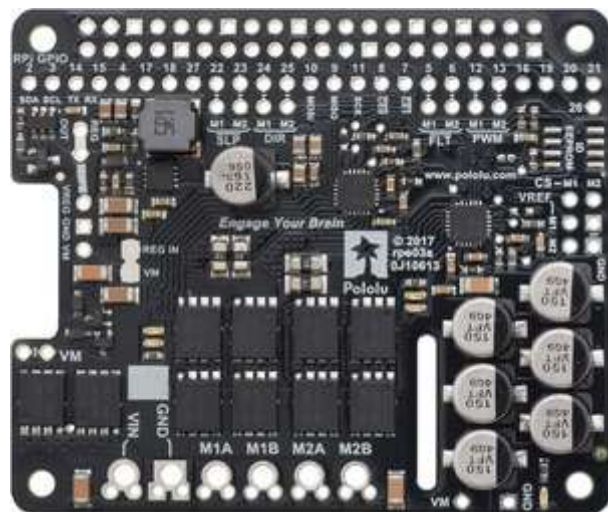
**Pololu Dual G2 High-Power Motor Driver 24v18 Shield for Arduino.**



**Pololu Dual G2 High-Power Motor Driver 24v14 Shield for Arduino.**



**Pololu Dual G2 High-Power Motor Driver 18v18 for Raspberry Pi.**



**Pololu Dual G2 High-Power Motor Driver 18v22 for Raspberry Pi.**

**Note:** As an alternative to these motor drivers, our [Simple Motor Controllers](#) have similar power characteristics and offer high-level interfaces (e.g. USB, RC hobby servo pulses, analog voltages, and TTL serial commands) that make them easier to use for some applications.

## Using the motor driver

### Connections

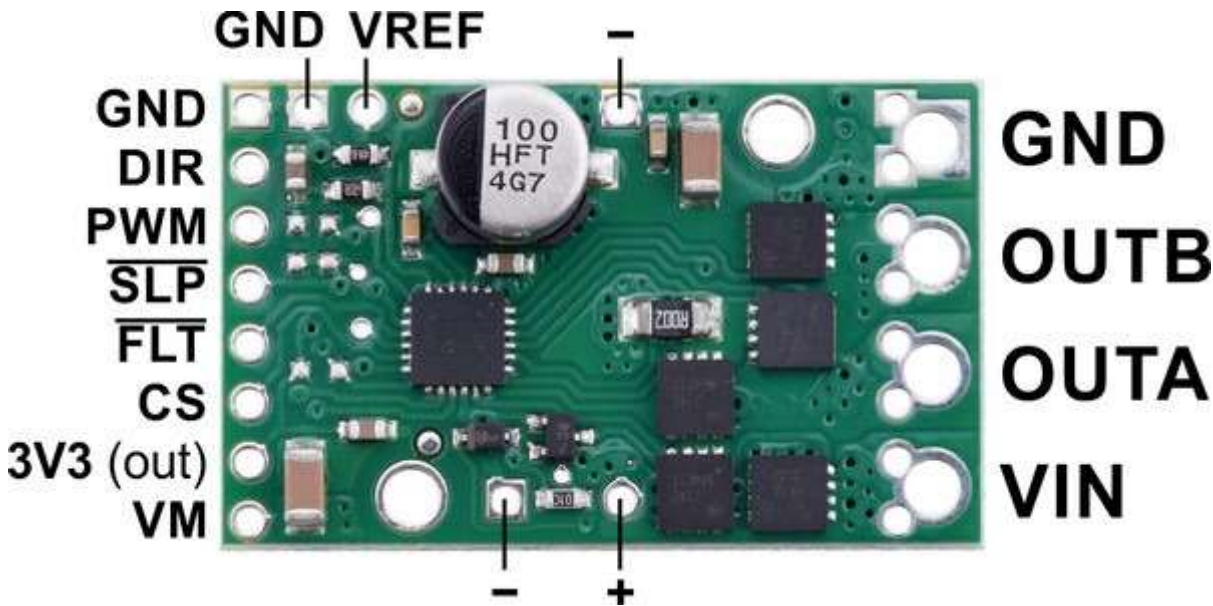
The motor and motor power connections are on one side of the board, and the control connections (1.8 V to 5 V logic) are on the other side. The motor supply should be capable of supplying high current. There are two options for making the high-power connections (VIN, OUTA, OUTB, GND): large holes spaced 5 mm apart, which are compatible with the included terminal blocks, and pairs of 0.1"-spaced holes that can be used with perfboards, [breadboards](#), and 0.1" [connectors](#).

For good performance, it is **very important** to install a large capacitor across the motor supply and ground close to the motor driver. We generally recommend using a capacitor of at least a few hundred  $\mu\text{F}$  and rated well above the maximum supply voltage; the required capacitance will be greater if the power supply is poor or far (more than about a foot) from the driver, and it will also depend on other factors like motor characteristics and applied PWM frequency. A through-hole capacitor can be installed directly on the board in the holes labeled '+' and '-' (connected to VM and GND, respectively). The driver includes an on-board 100  $\mu\text{F}$  capacitor, which might be sufficient for brief tests and limited low-power operation, but adding a bigger capacitor is strongly recommended for most applications.

**Warning:** Take proper safety precautions when using high-power electronics. Make sure you know what you are doing when using high voltages or currents! During normal operation, this product can get **hot** enough to burn you. Take care when handling this product or other components connected to it.

The logic connections are designed to interface with 1.8 V to 5 V systems (5.5 V max).

Pinout



PIN	Default State	Description
VIN		This is the main 6.5 V to 40 V (absolute max) motor power supply connection.
VM		This pin gives you access to the motor power supply after reverse-voltage protection. It can be used to supply reverse-protected power to other components in the system, but it

should not be used for high currents. This pin should only be used as an output.

+, -

These pads are intended for a power supply capacitor (they are connected to VM and GND, respectively).

3V3 (out)

This regulated 3.3 V **output** provides a few milliamps, which can be useful as a reference or for powering small external circuits. This output should not be connected to other external power supply lines. It is disabled when the driver is in sleep mode. **Be careful not to accidentally short this pin to the neighboring VM pin while power is being supplied** as doing so will instantly destroy the board!

GND

Ground connection for logic and motor power supplies.

OUTA

Motor output pin A (connects to one terminal of a DC motor).

OUTB

Motor output pin B (connects to the other terminal of a DC motor).

PWM

LOW

Pulse width modulation input: a PWM signal on this pin corresponds to a PWM output on the motor outputs.

DIR

LOW

Direction input: when DIR is high, current will flow from OUTA to OUTB; when it is low, current will flow from OUTB to OUTA.

Inverted sleep input: This pin is pulled high by the driver board, enabling the driver by default; drive  $\overline{\text{SLP}}$  low to put the motor driver into a low-power sleep mode.

$\overline{\text{SLP}}$

HIGH

*Note:* On the original version of this board, labeled “md31a” on the bottom silkscreen, this pin is pulled low by default. The description above applies to the current version of this board, “md31c”.

$\overline{\text{FLT}}$

Fault indicator: This open-drain output is driven low when a fault has occurred. See below for details. In order to use this output, you should externally pull this pin up to your system’s logic voltage.

CS

Current sense output: This pin outputs a voltage proportional to the motor current when the H-bridge is driving (but not while it is braking, including when current limiting is active). The output voltage is about 40 mV/A plus a 50 mV offset.

VREF

Reference voltage input: An additional resistor can be connected between this pin and GND to lower the current limiting (chopping) threshold. Without an additional resistor, the current limit defaults to about 30 A. See below for details.

## Motor control options

With the PWM pin held low, both motor outputs will be held low (a brake operation). With PWM high, the motor outputs will be driven according to the DIR input. This allows two modes of operation: sign-magnitude, in which the PWM duty cycle controls the speed of the motor and DIR controls the direction, and locked-antiphase, in which a pulse-width-modulated signal is applied to the DIR pin with PWM held high.

In locked-antiphase operation, a low duty cycle drives the motor in one direction, and a high duty cycle drives the motor in the other direction; a 50% duty cycle turns the motor off. A successful locked-antiphase implementation depends on the motor inductance and switching frequency smoothing out the current (e.g. making the current zero in the 50% duty cycle case), so a high PWM frequency might be required.

Motor Driver Truth Table				
PWM	DIR	OUTA	OUTB	Operation
H	H	H	L	Forward
H	L	L	H	Reverse
L	X	L	L	Brake

## PWM frequency

The motor driver supports PWM frequencies as high as 100 kHz, but note that switching losses in the driver will be proportional to the PWM frequency. Typically, around 20 kHz is a good choice for sign-magnitude operation since it is high enough to be ultrasonic, which results in quieter operation.

A pulse on the PWM pin must be high for a minimum duration of approximately 0.5  $\mu$ s before the outputs turn on for the corresponding duration (any shorter input pulse does not produce a change on the outputs), so low duty cycles become unavailable at high frequencies. For example, at 100 kHz, the pulse period is 10  $\mu$ s, and the minimum non-zero duty cycle achievable is 0.5/10, or 5%.

## Current sensing and limiting

The driver's current sense pin, CS, outputs a voltage proportional to the motor current while the H-bridge is driving. The output voltage is about 40 mV/A plus a small offset, which is typically about

50 mV.

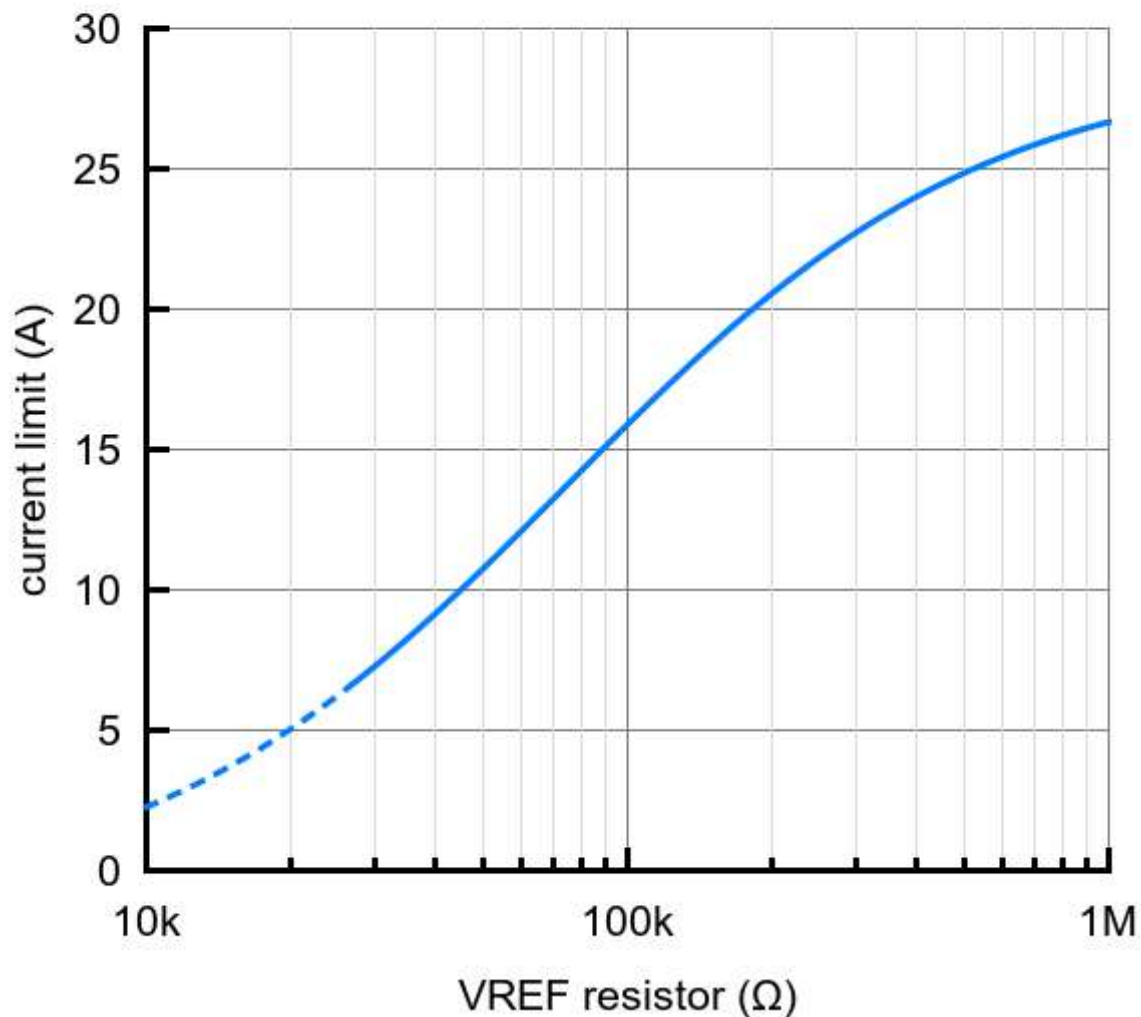
The CS output is only active while the H-bridge is in drive mode; it is inactive (low) when the driver is in brake mode (slow decay), which happens when the PWM input is low or when current limiting is active. Current will continue to circulate through the motor when the driver begins braking, but the voltage on the CS pin will not accurately reflect the motor current in brake mode. The CS voltage is used internally by the motor driver, so to avoid interfering with the driver's operation, you should not add a capacitor to this pin or connect a load that draws more than a few mA from it.

The G2 driver has the ability to limit the motor current through current chopping: once the motor drive current reaches a set threshold, the driver goes into brake mode (slow decay) for about 25  $\mu$ s before applying power to drive the motor again. This makes it more practical to use the driver with a motor that might only draw a few amps while running but can draw many times that amount (tens of amps) when starting.

The current limiting threshold is set to about 30 A by default. You can lower the limit by connecting an additional resistor between the VREF pin and the adjacent GND pin; the graph below shows how the current limit relates to the VREF resistor value. For example, adding a 100 k $\Omega$  resistor between VREF and GND lowers the current limit to approximately 16 A. Note that the current limiting is less accurate at especially low settings (indicated by the dashed portion of the curve).



## Pololu G2 High-Power Motor Driver 24v13 current limit vs. VREF resistor



### Fault conditions

The motor driver can detect several fault states that it reports by driving the  $\overline{\text{FLT}}$  pin low; this is an open-drain output that should be pulled up to your system's logic voltage. The detectable faults include short circuits on the outputs, under-voltage, and over-temperature. All of the faults disable the motor outputs but are not latched, meaning the driver will attempt to resume operation when the fault condition is removed (or after a delay of a few milliseconds in the case of the short circuit fault). The over-temperature fault provides a weak indication of the board being too hot, but it does not directly indicate the temperature of the MOSFETs, which are usually the first components to overheat, so you should not count on this fault to prevent damage from over-temperature conditions.

### Real-world power dissipation considerations

The MOSFETs can handle large current spikes for short durations (e.g. 100 A for a few milliseconds), and the driver's current chopping will keep the average current under the set limit. The peak ratings are for quick transients (e.g. when a motor is first turned on), and the continuous

rating of 13 A is dependent on various conditions, such as the ambient temperature. PWMing the motor will introduce additional heating proportional to the frequency. The actual current you can deliver will depend on how well you can keep the motor driver cool. The driver's printed circuit board is designed to draw heat out of the MOSFETs, but performance can be improved by adding a heat sink.

**Warning:** This motor driver has no over-temperature shut-off. An over-temperature or over-current condition can cause **permanent damage** to the motor driver. You might consider using either the driver's integrated current sense output or an [external current sensor](#) to monitor your current draw.

## Included hardware



**Pololu G2 High-Power Motor Driver 18v17 or 24v13 with included hardware.**



**Pololu G2 High-Power Motor Driver 18v17 or 24v13 assembled with headers and terminal blocks.**

Two 8-pin [straight breakaway male headers](#) and two [2-pin 5mm terminal blocks](#) are included with each motor driver. You can solder the terminal blocks to the four large through-holes to make your motor and motor power connections, or you can solder one of the 1×8 0.1" header strips into the smaller through-holes that border these larger holes. Note, however, that the terminal blocks are only rated for 16 A, and each header pin pair is only rated for a combined 6 A, so for higher-power applications, thick wires should be soldered directly to the board.

The other 1×8 header strip can be soldered into the small holes on the logic connection side of the board to enable use with [solderless breadboards](#), perfboards, or [0.1" connectors](#), or you can solder wires directly to these holes for the most compact installation.

**Note:** In most applications, it is necessary to connect an additional large capacitor (not included) across the power supply, as described under "Connections" above.

The board has two 0.086" (2.18 mm) diameter mounting holes intended for #2 or M2 [screws](#) (not included); they are separated by 0.62" (15.75 mm) both horizontally and vertically.

## Differences from original high-power motor drivers

The G2 high-power motor driver is designed to work as a near drop-in replacement for our original high-power motor drivers; this version, the **24v13**, is comparable to the original [24v12](#) but can provide slightly higher output currents in most situations. The overall board dimensions and locations of the mounting holes and all required pins are the same for both versions.

This second-generation driver adds new features including reverse-voltage protection on the power supply inputs and basic current sensing and current limiting functionality. It also works with lower logic voltages, making it compatible with 3.3 V systems; however, note that it has a slightly higher minimum motor supply voltage than the original HPMD (6.5 V vs. 5.5 V).

The pinout of the G2 driver differs from the original in several ways:

- The G2 driver has only one fault pin, which is an open-drain output that is driven *low* when a fault occurs. (The original driver had two fault pins that were driven high to indicate faults.)
- A current sense output is available on the G2 driver in place of the second fault pin.
- A new VREF pin and adjacent GND pin let you connect a resistor to adjust the G2 driver's current limit.
- The G2 driver provides a 3.3 V output instead of the original driver's 5 V output.

## People often buy this product together with:



[Pololu G2 High-Power Motor Driver 24v21](#)