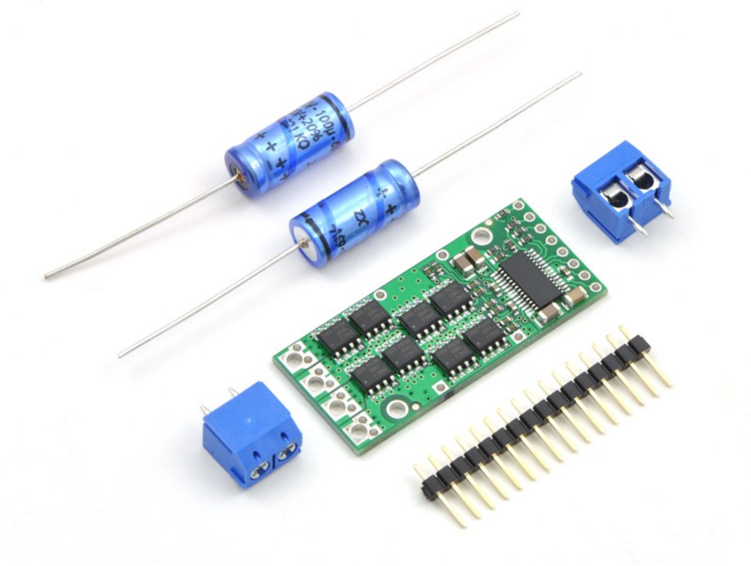
Pololu High-Power Motor Driver 18v25



The Pololu high-power motor driver is a discrete MOSFET H-bridge designed to drive large DC brushed motors. The H-bridge is made up of two N-channel MOSFET per leg, and most of the board's performance is determined by these MOSFETs (the rest of the board contains the circuitry to take user inputs and control the MOSFETs). The MOSFET datasheet is available under the "Resources" tab. The MOSFETs have an absolute maximum voltage rating of 30 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 24 V.

Note: Batteries that are nominally 24 V can be much higher than that when fully charged; this product is therefore not recommended for use with 24 V batteries unless appropriate measures are taken to limit the peak voltage.

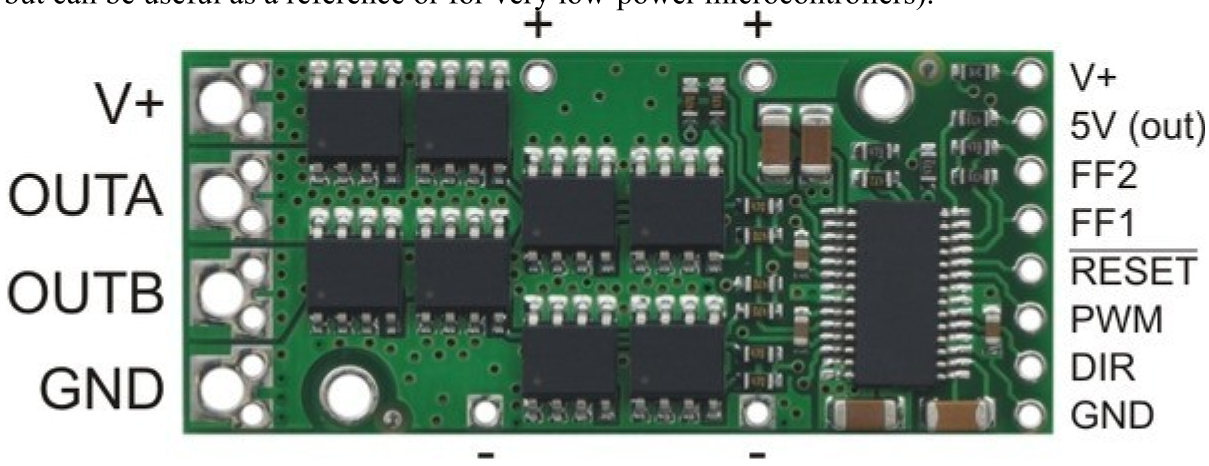
The versatility of this driver makes it suitable for a large range of currents and voltages: it can deliver up to 25 A of continuous current with a board size of only 1.8" by 0.8" and no required heat sink. With the addition of a heat sink, it can drive a motor with up to about 35 A of continuous current. The module offers a simple interface that requires as little as two I/O lines while allowing for both sign-magnitude and locked-antiphase operation. Integrated detection of various short-circuit conditions protects against common causes of catastrophic failure; however, please note that the board does not include reverse power protection or any over-current or over-temperature protection.

Using the Motor Driver

The motor and motor power connections are on one side of the board, and the control connections (5V logic) are on the other side. The motor supply should be capable of supplying high current, and a large capacitor should be installed close to the motor driver. The included axial capacitors can be installed directly on the board in the pins labeled '+' and '-' as shown below. Such installations are compact but might limit heat sinking options; also, depending on the power supply quality and motor characteristics, a larger capacitor might be required. There are two options for connecting to the high-power signals (V+, OUTA, OUTB, GND): large holes on 0.2" centers, 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.

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 5V systems (5.5 V max); the minimum high input signal threshold is 3.5 V, so we do not recommend connecting this device directly to a 3.3 V controller. In a typical configuration, only PWM and DIR are required. The two fault flag pins (FF1 and FF2) can be monitored to detect problems (see the Fault Flag Table below for more details). The RESET pin is pulled up to V+ through a 20 kΩ resistor. When held low, it puts the driver into a low-power sleep mode and clears any latched fault flags. The V+ pin on the logic side of the board gives you access to monitor the motor's power supply (it should not be used for high current). The board also provides a regulated 5 V pin which can provide a few milliamps (this is typically insufficient for a whole control circuit but can be useful as a reference or for very low-power microcontrollers).



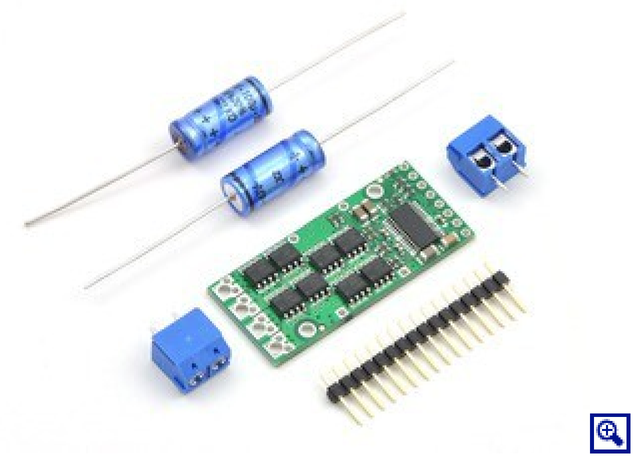
Pinout

PIN	Default State	Description
V+		This is the main 5.5 – 30 V (absolute max) motor power supply connection, which should typically be made to the larger V+ pad. The smaller V+ pads along the long side of the board are intended for power supply capacitors, and the smaller V+ pad on the logic side of the board gives you access to monitor the motor's power supply (it should not be used for high current).
5V (out)		This regulated 5V **output** provides a few milliamps. This output should not be connected to other external power supply lines. **Be careful not to accidentally short this pin to the neighboring V+ pin while power is being supplied** as doing so will instantly destroy the board!
GND		Ground connection for logic and motor power supplies.
OUTA		A motor output pin.
OUTB		B motor output pin.
PWM	LOW	Pulse width modulation input: a PWM signal on this pin corresponds to a PWM output on the motor outputs.
DIR	FLOAT	Direction input: when DIR is high current will flow from OUTA to OUTB, when it is low current will flow from OUTB to OUTA.

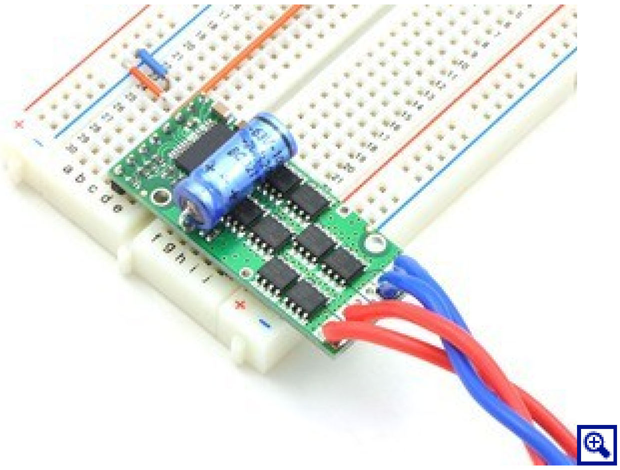
RESET	HIGH	The RESET pin is pulled up to V+ through a 20 kΩ resistor. When held low, it puts the driver into a low-power sleep mode and clears any latched fault flags.
FF1	LOW	Fault flag 1 indicator: FF1 goes high when certain faults have occurred. See table below for details.
FF2	LOW	Fault flag 2 indicator: FF2 goes high when certain faults have occurred. See table below for details.

Included Hardware

A 16-pin straight breakaway male header, two 150 uF capacitors, and two 2-pin 5mm terminal blocks are included with each motor driver. (Note: The terminals blocks are only rated for 15 A; for higher power applications, use thick wires soldered directly to the board.) Connecting large capacitors across the power supply is recommended; one way to do it is between the '+' and '-' holes, as shown below. The two mounting holes are intended to be used with #2 screws (not included).



Pololu high-power motor driver with included hardware.



Pololu high-power motor driver in a breadboard.

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	L	L	H	Forward
H	H	H	L	Backward

L	X	L	L	Brake

PWM Frequency

The motor driver supports PWM frequencies as high as 40 kHz, though higher frequencies result in higher switching losses in the motor driver. Also, the driver has a dead time (when the outputs are not driven) of approximately 3 us per cycle, so high duty cycles become unavailable at high frequencies. For example, at 40 kHz, the period is 25 us; if 3 us of that is taken up by the dead time, the maximum available duty cycle is 22/25, or 88%. (100% is always available, so gradually ramping the PWM input from 0 to 100% will result in the output ramping from 0 to 88%, staying at 88% for inputs of 88% through 99%, and then switching to 100%.)

Real-World Power Dissipation Considerations

The motor driver can tolerate peak currents in excess of 200 A. The peak current ratings are for quick transients (e.g. when a motor is first turned on), and the continuous rating of 25 A is dependent on various conditions, such as the ambient temperature. The main limitation comes from heating and power dissipation; therefore, at high currents, the motor driver will be extremely hot, and performance can be improved by adding heat sinks or otherwise cooling the board. 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. With a proper heat sink, the motor driver can deliver up to 35 A of continuous current. For more information on power dissipation see the data sheet for the MOSFETs on the Resources tab.

Because there is no internal temperature limiting on the motor driver, the entire system should be designed to keep the load current below the 25 A limit. An easy way to achieve this is to select a motor with a stall current below that limit. However, because a good motor can have stall currents dozens of times higher than the typical operating current, motors with stall currents that are hundreds of amps can be used with this driver as long as the running current is kept low. For example, a motor with a 100 A stall current might run well at 10 A, leaving a safe margin for the current to double for several minutes at a time or to triple for several seconds. If the motor does stall completely for a prolonged period, however, the motor or driver are likely to burn out.

Warning: This motor driver has no over-current or over-temperature shut-off. Either condition can cause **permanent damage** to the motor driver. You might consider using an external current sensor, such as our ACS714 ±30A bidirectional current sensor carrier to monitor your current draw.

Fault Conditions

The motor driver can detect three different fault states, which are reported on the FF1 and FF2 pins. The detectable faults are short circuits on the output, under-voltage, and over-temperature. A short-circuit fault is latched, meaning the outputs will stay off and the fault flag will stay high, until the board is reset (RESET brought low). The under-voltage fault disables outputs but is not latched. 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. The fault flag operation is summarized below.

Flag State		**Fault Description**	**Disable Outputs**	**Latched Until Reset**
FF1	**FF2**			

L	L	No fault	No	No
L	H	Short Circuit	Yes	Yes
H	L	Over Temperature	No	No
H	H	Under Voltage	Yes	No

High-Power Motor Driver Versions

There are currently nine versions of the high-power motor driver. The three CS versions have the same pinout, and the six non-CS versions have the same pinout. The following table provides a comparison of the high-power motor drivers:

Pololu high-power motor drivers

Name	Max nominal battery voltage (V)	Max continuous current (A) w/o heat sink
High-power motor driver 18v25 CS	18	25
High-power motor driver 18v25	18	25
High-power motor driver 18v15	18	15
High-power motor driver 24v23 CS	28	23
High-power motor driver 24v20	28	20
High-power motor driver 24v12	28	12
High-power motor driver 36v20 CS	36	20
High-power motor driver 36v15	36	15
High-power motor driver 36v9	36	9

Note: Please consider our Simple Motor Controllers as alternatives to these motor drivers. They have very similar power characteristics and offer high-level interfaces (e.g. USB, RC hobby servo pulses, analog voltages, and TTL serial commands) that make them much easier to use for many applications.