

POLOLU HIGH-POWER MOTOR DRIVER

36V9

USER'S GUIDE

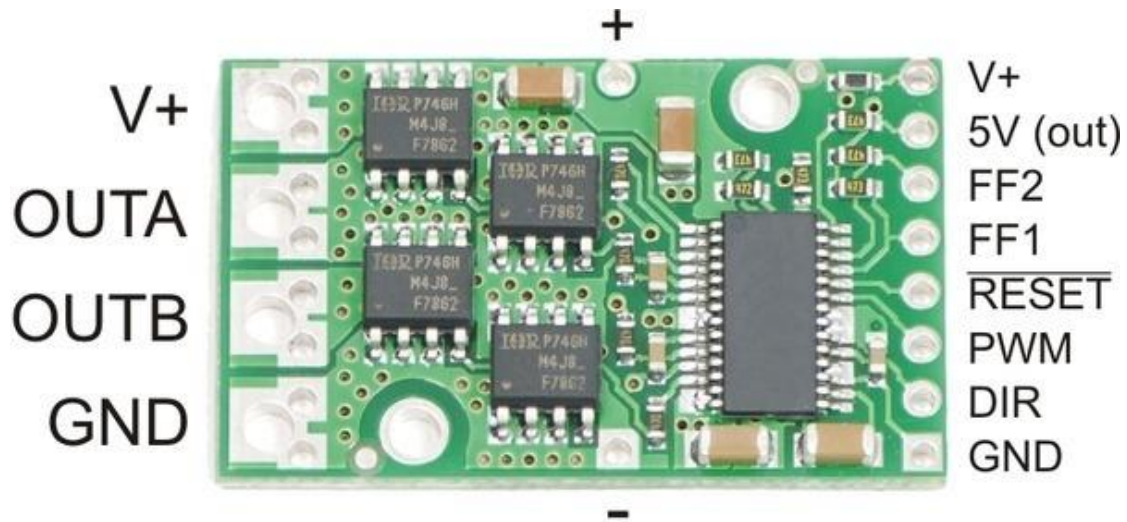
CONNECTIONS

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 delivering the high current the motor will require, and a large capacitor should be installed between V+ and ground close to the motor driver to decrease electrical noise. Two axial capacitors are included and one or both can be installed by soldering them into the V+ and GND pins (labeled '+' and '-' on the bottom silkscreen) along the long edges of the board. 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).

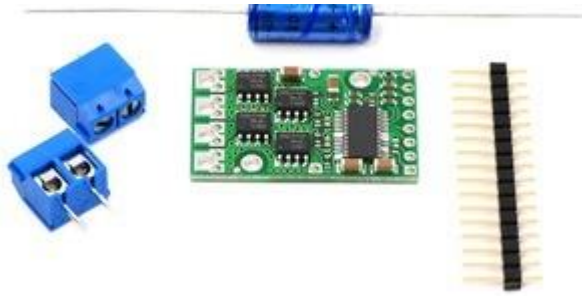


PINOUT

PIN	Default State	Description
V+		This is the main 5.5 – 50 V (absolute max) motor power supply connection, which should typically be made to the larger V+ pad. The smaller V+ pad along the long side of the board is intended for a power supply capacitor, 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 $\overline{\text{RESET}}$ pin is pulled up to V+ through a 20 k Ω 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](#), one 100 uF capacitor, and two 2-pin 5mm terminal blocks are included with each motor driver. Connecting a large capacitor 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 and included components.



Pololu high-power motor driver with included components soldered in.

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 handle large current spikes for short durations (e.g. 100 A for a few milliseconds). The peak ratings are for quick transients (e.g. when a motor is first turned on), and the continuous rating of 9 A is dependent on various conditions, such as the ambient temperature. 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. With a heat sink the motor driver can be run at up to 12 A of continuous current. For more information on power dissipation see the data sheet for the MOSFETs on the Resources tab.

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 $\pm 30\text{A}$ bidirectional current sensor carrier to monitor your current draw.

FAULT CONDITIONS

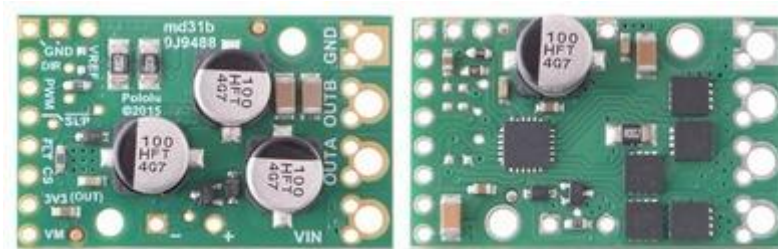
The motor driver can detect three different fault states, which are reported on the FF1 and FF2 pins. The detectable faults are short circuits on the output, under-voltage, and over-temperature. A short-circuit fault is latched, meaning the outputs will stay off and the fault flag will stay high, until 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 four versions of the G2 high-power motor driver, which all share compatible pinouts. The following table provides a comparison of the G2 drivers:

SKU	HAN	Name	Absolute max input voltage	Max nominal battery voltage	Max continuous current
Po2994	2994	G2 High-Power Motor Driver 18v25	30 V	18 V	25 A
Po2991	2991	G2 High-Power Motor Driver 18v17	30 V	18 V	17 A
Po2995	2995	G2 High-Power Motor Driver 24v21	40 V	28 V	21 A
Po2992	2992	G2 High-Power Motor Driver 24v13	40 V	28 V	13 A



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

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.

There are also nine original high-power motor driver versions. 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 these first-generation drivers:

SKU	HAN	Name	Max nominal battery voltage (V)	Max continuous current (A) w/o heat sink
po1455	1455	Pololu-High-power motor driver 18v25 CS	18	25
po758	758	Pololu-High-power motor driver 18v25	18	25
po755	755	Pololu-High-power motor driver 18v15	18	15
po1456	1456	Pololu-High-power motor driver 24v23 CS	28	23
po759	759	Pololu-High-power motor driver 24v20	28	20
po757	757	Pololu-High-power motor driver 24v12	28	12
po1457	1457	Pololu-High-power motor driver 36v20 CS	36	20
po760	760	Pololu-High-power motor driver 36v15	36	15
po756	756	Pololu-High-power motor driver 36v9	36	9