DUAL MAX14870 MOTOR DRIVER FOR RASPBERRY PI (PARTIAL KIT)

USER'S GUIDE

CONNECTIONS

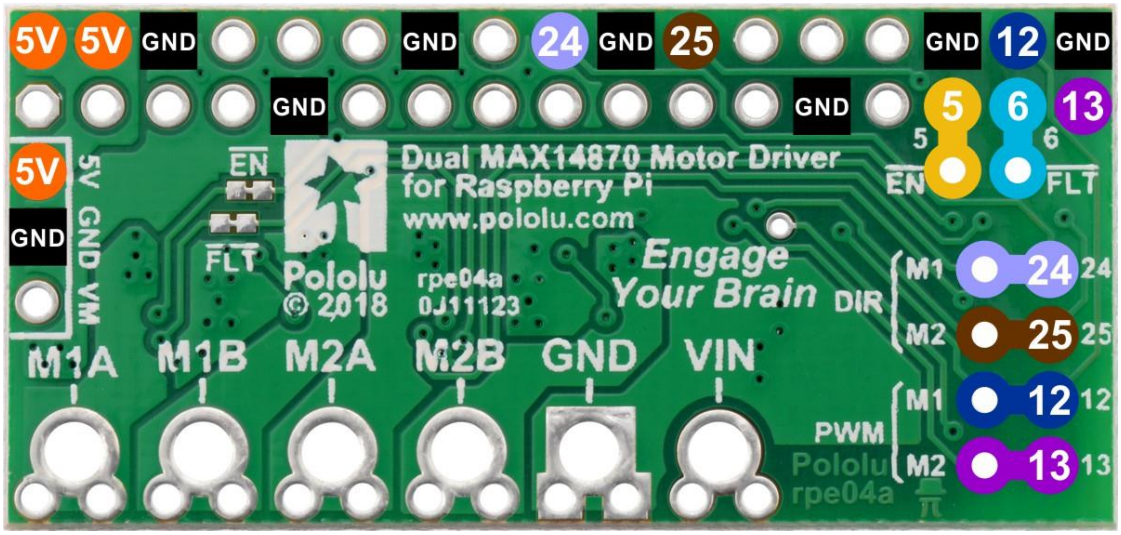
The motor and motor power connections are on one side of the board, and the control connections (1.8 V to 5 V logic) are on the other side. The motor supply should be capable of supplying high current. There are two options for making the high-power connections (VIN, OUTA, OUTB, GND): large holes spaced 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 µF 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 three on-board 150 µF capacitors, 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). In a typical configuration, only PWM and DIR are required.

PINOUT



RPi GPIO pin	Motor driver pin	Description
5	$\overline{\text{EN}}$	Inverted enable input: The Raspberry Pi pulls this pin high by default, putting the motor driver IC into a low-current sleep mode and disabling the motor outputs (setting them to high impedance). $\overline{\text{EN}}$ must be driven low to enable the motor driver.
6	$\overline{\text{FAULT}}$	Fault output: When the drivers are functioning normally, this pin should be pulled high by the Raspberry Pi. In the event of an over-current or over-temperature condition, the driver IC experiencing the fault drives $\overline{\text{FAULT}}$ low.
12	Motor 1 PWM	Motor speed input: A PWM (pulse-width modulation) signal on this pin corresponds to a PWM output on the corresponding driver's motor outputs. When this pin is low, the motor brakes low. When it is high, the motor is on. The maximum allowed PWM frequency is 50 kHz.
13	Motor 2 PWM	
24	Motor 1 DIR	Motor direction input: When DIR is low, motor current flows from output A to output B; when DIR is high, current flows from B to A.
25	Motor 2 DIR	

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 µs 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 µs, and the minimum non-zero duty cycle achievable is 0.5/10, or 5%.

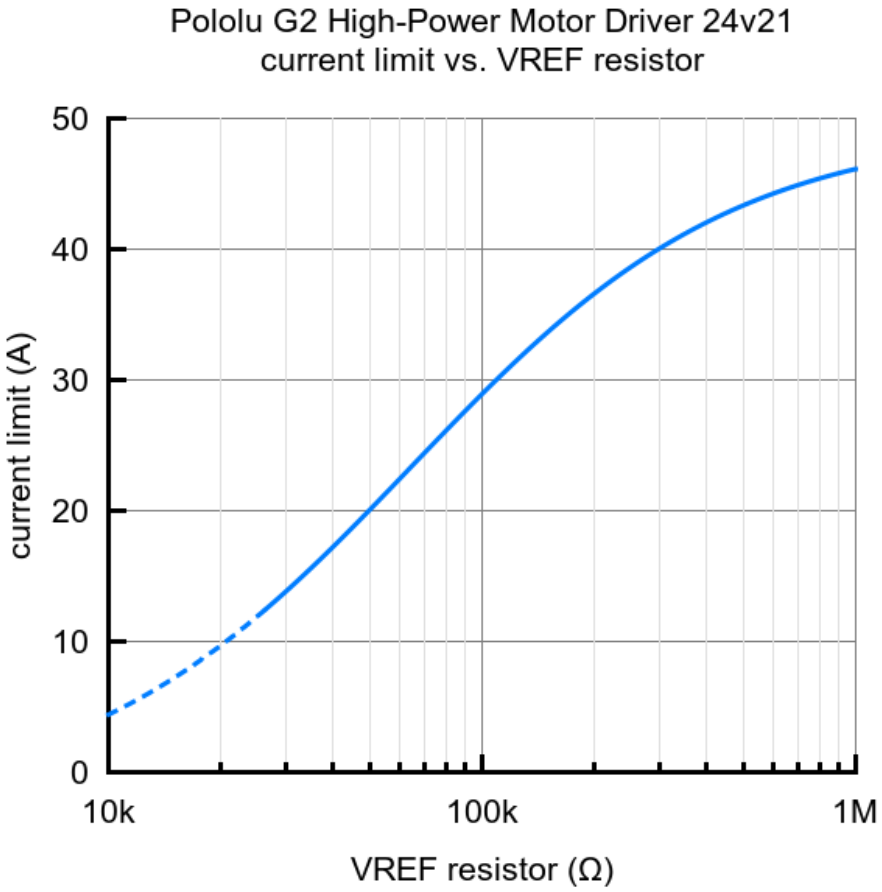
CURRENT SENSING AND LIMITING

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 20 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 µs 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 nominally set to about 50 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 kΩ resistor between VREF and GND lowers the current limit to approximately 29 A. Note that the current limiting threshold is not highly precise (we have seen some units limit the current as low as about 40 A when the threshold is set to the board's default of 50 A), and it is less accurate at especially low settings (indicated by the dashed portion of the curve).



FAULT CONDITIONS

The motor driver can detect several fault states that it reports by driving the 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 21 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 18v25 or 24v21 with included hardware.

Pololu G2 High-Power Motor Driver 18v25 or 24v21 assembled with headers and terminal blocks.

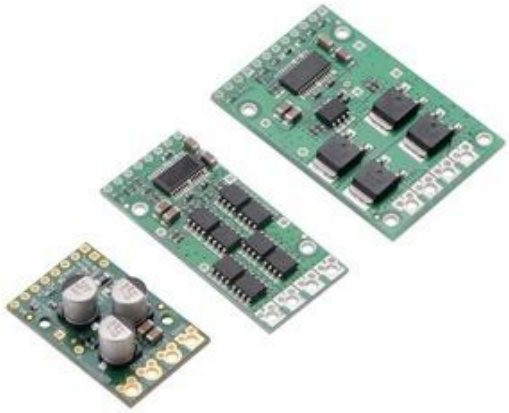
Two 8-pin straight breakaway male headers and two 2-pin 5mm terminal blocks are included with each motor driver. You can solder the terminal blocks to the four large through-holes to make your motor and motor power connections, or you can solder one of the 1×8 0.1″ header strips into the smaller through-holes 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 DRIVER



Pololu G2 High-Power Motor Driver 24v21 next to original high-power motor driver 24v20 and 24v23 CS.

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 **24v21**, is comparable to the original 24v20 but can provide slightly higher output currents in most situations. The board width and the arrangement of the required pins are the same for both versions, but the G2 24v21 is smaller in size, matching the board dimensions of the original 24v12 as well as the lower-power G2 drivers (18v17 and 24v13).

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:

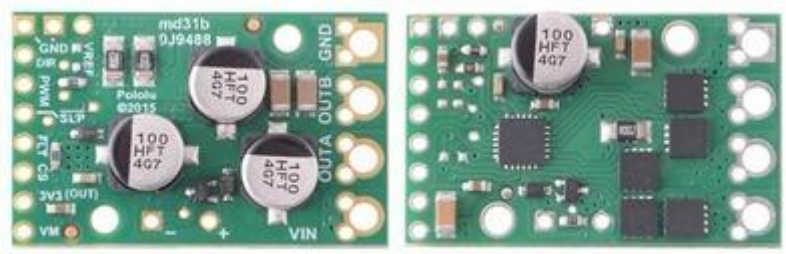
- The G2 driver has only one fault pin, which is an open-drain output that is driven *low* when a fault occurs. (The original driver had two fault pins that were driven high to indicate faults.)
- A current sense output is available on the G2 driver in place of the second fault pin.
- A new VREF pin 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.

Note that unlike the G2 High-Power Motor Driver 18v17 and 24v13, the 24v21 driver includes a circuit to pull the SLP pin high to enable the driver by default. This makes it more similar to the original high-power motor drivers, whose corresponding RESET pin could similarly be left disconnected if unused.

G2 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.