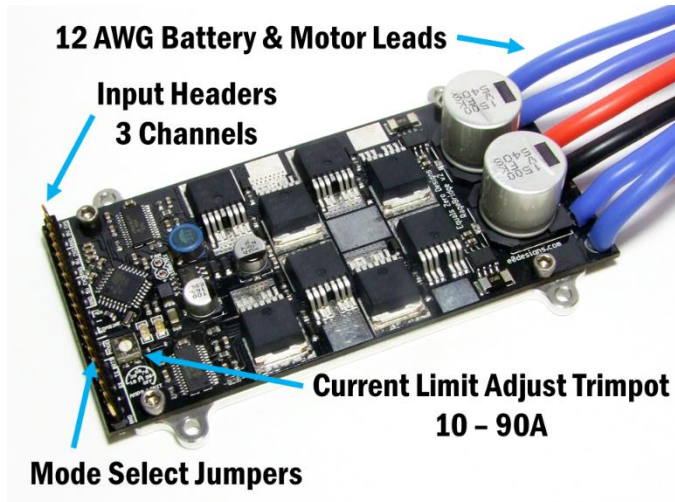


Overview

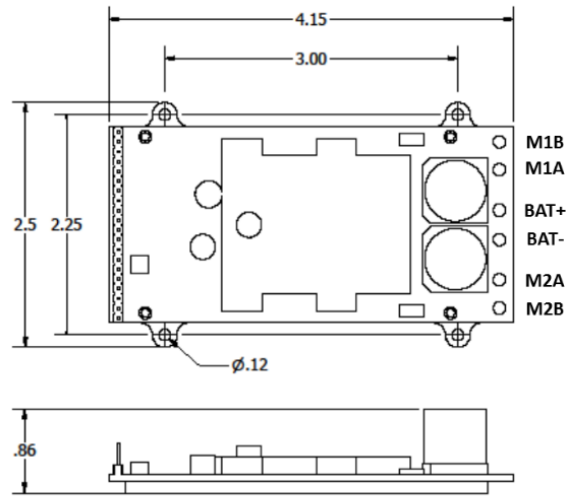


RageBridge 2 is a motor controller that can drive 2 channels of DC motors, using several types of inputs, in forward and reverse with no delay. It features signal-loss failsafes, synchronous rectification, regenerative braking, constant-current output mode, and an isolated heat sink plate. The two output channels can also be combined into a single higher-current output for driving especially large loads.

Specifications

Voltage Input Range	12 – 30V nominal 8 – 40V absolute limits
Continuous Current	40A per channel @ 50% duty cycle, 25°C ambient
Maximum Current	Up to 75A per channel, 30 sec. @ 50% duty cycle, 25°C ambient Constant-current mode limited
Dimensions	4.15" x 2.5" x 0.875"
Weight	4.8oz
Inputs	R/C Servo (3 channels) Analog Voltage (2 channels) 19200 baud 8-N-1 Serial (1 channel) Optional Enable Jumper Mixing or 1-Channel Jumper
Logic Power (BEC)	5V @ 150mA maximum
Heat Management	Isolated heat spreader plate

Mounting Dimensions



Dimensions in Inches.

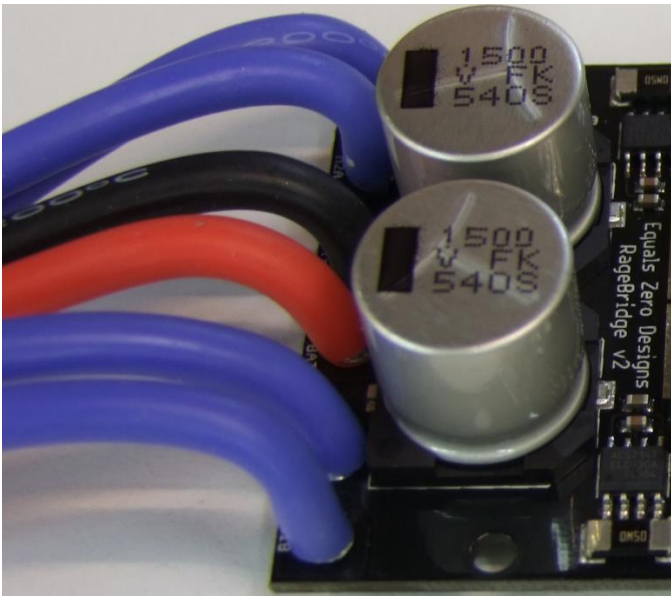
Installation

To install RageBridge 2, used the four clearance holes for #4 screws (0.120") or M3 screws (0.118"). You may bolt the heat sink plate directly to a metal chassis for better thermal performance.

RageBridge 2 may also be mounted without the heat sink to minimize dimensions. The board itself has 4x #4-40 screws which may be untightened with a 3/32" hex wrench. Use the following guidelines for best results:

1. **Use nonconductive standoffs or spacers** to offset the board from the mounting surface.
2. **Insulate the underside** using electrical tape or liquid insulation.
3. **Do not enclose the board in tape, shrink tube, or sealed cases.** Doing so will negatively affect the thermal performance and reduce continuous current rating.

RageBridge 2 has two 12 AWG battery input wires and four 12 AWG motor output wires. These may be trimmed or soldered if needed. If you choose to desolder the wires, you should dismount the unit from its heat sink first, and flush-cut completed solder joints. Remount the unit using “thumb torque” when done – do not overtighten the heat sink.



Keep your battery input wires as short as possible. We recommend using **10 or 8 AWG** extension wires for wiring runs longer than **18 inches** to minimize heating and voltage loss in the wires.

RageBridge 2 has 3,000uF of input capacitance on its main power bus. This is substantially more than similar motor controllers in its class, and is designed to aid in its current limiting feature. When connecting power using a switch or plug, you may notice a small spark as the controller powers on.

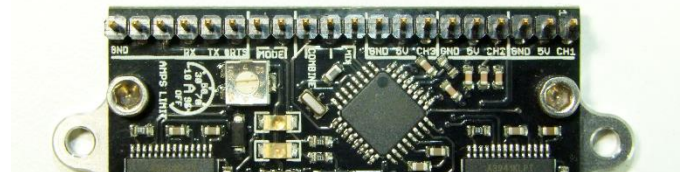
This is normal, but will cause erosion to your switch over time. For high-reliability applications or if using multiple RageBridges in a single power circuit, we recommend a precharge system.

Input Setup

RageBridge 2 can be set up to interpret multiple types of inputs, including:

- **R/C Mode:** Controlled by up to 3 R/C Servo pulsewidths between 1100us and 1900us.
- **Analog, non-mixed:** Controlled by either 1 or 2 analog signals and a switch for reversing
- **Analog, mixed:** Controlled by 2 analog signals in the fashion of a 2-axis joystick, with a switch for Enable
- **Serial:** Controlled using a stream of single-byte commands (a.k.a “Simple Serial”) with 7-bit speed resolution for each motor.

User-selectable switches affect the operation of the controller, and include the **MODE**, **MIX**, and **COMBINE** options. Depending on the input mode, these jumpers may perform different functions.



Shown above is the RageBridge 2 input header row. From left to right:

- **Ground, RX, and TX** pins for Serial mode
- **MODE** jumper to select Analog or R/C input
- **COMBINE** jumper to select single-channel output
- **MIX** jumper to select onboard signal mixing
- **CH3** through **CH1** input headers for main signaling. Each channel has a **5V** and **GND** pin for easy connections to receivers.

Status LED

RageBridge 2 has two LEDs to indicate its status.

A green LED will be on whenever the controller has a valid power source. A blue LED will flash according to the current operating state. The following table shows the meaning of the LED sequence.

1	2	3	4	5	6	7	8	Meaning
Blue	Dark	Blue	Dark	Blue	Dark	Blue	Dark	Signal Error
Blue	Dark	Dark	Dark	Dark	Dark	Dark	Dark	Analog (Non-Mix) Mode
Blue	Dark	Blue	Dark	Dark	Dark	Dark	Dark	Analog (Mix) Mode
Blue	Blue	Blue	Blue	Dark	Dark	Dark	Dark	Serial Mode
Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	R/C Mode

If the SIGNAL ERROR blink is present at power-on, refer to your intended mode's operation section (e.g. R/C, Analog) to double check that your signal is proper for mode detection. If the signal is lost at any time, the Signal Error blink will be visible as the controller shuts down its outputs.

Mode Jumper

The **MODE** jumper determines if RageBridge 2 will search for analog or digital inputs.

If **MODE** is not selected (default), RageBridge 2 will only look for R/C pulsewidths on its **CH1**, **CH2**, and **CH3** inputs, or incoming serial bytes. If **MODE** is selected with a jumper, RageBridge 2 will attempt to look for valid **analog voltage** inputs on its **CH1**, **CH2**, and **CH3** pins

Mode Summary

RageBridge has many built-in operating modes. This table summarizes the important characteristics of each mode.

Selection means the conditions that must be true for RageBridge 2 to recognize the mode.

Inputs in between a Valid and Response interval will be treated as saturated, e.g. 100% or 0%.

The failsafe state is all outputs shut off (motor coasting).

Mode	Selection	Response	Failsafe
R/C	Ch1 & Ch2 1500 +/- 25us (+MIX)	800 – 2200us valid 1100 – 1900 response	after 0.1s invalid
R/C Combine	Ch1 1500 +/- 25us +COMBINE	800 – 2200us valid 1100 – 1900 response	after 0.1s invalid
Analog Non-Mix	Ch1 only; or Ch1 & Ch2 0.9 – 1.0v +MODE	0.5 – 4.5v valid 1.0 – 4.0v response	after 0.1s invalid
Analog Non-Mix Combine	Ch1 0.9 – 1.0v +MODE +COMBINE	0.5 – 4.5v valid 1.0 – 4.0v response	after 0.1s invalid
Analog Mix	Ch1 & Ch2 2.5 +/- 0.05V Ch3 LOW +MIX +MODE	0.1 – 4.9v valid 0.5 – 4.5v response	Ch3 HIGH or after 0.1s invalid
Serial	Received 0x40 or 0xC0 CH3 LOW	0x01 – 0x7F, 0x80 – 0xFF, 0x00	0x00 received or 0.5s timeout
Serial Combine	Received 0x40 or 0xC0 CH3 LOW +COMBINE	0x01 – 0x7F, 0x00	0x00 received or 0.5s timeout

R/C Mode Operation

R/C mode is designed for most teleoperated robotics applications.

To use RageBridge 2 with R/C mode, simply connect **at least two** valid sources of R/C Servo “PWM” to **CH1** and **CH2**, then apply power. Valid pulsewidths are between **800 and 2200us duration**. To select the mode, **1500 +/- 25us** (center) must be present for 0.1s on both channels.

RageBridge 2 will respond to the range **1100 to 1900us**. This is the most common setting for a hobby radio system. A small control deadband of **25us** is built in to tolerate different radio models. If your motors move slowly when RageBridge 2 enters R/C mode, check the trim settings on your radio and make sure they are centered.

Connecting the **MIX** header will cause RageBridge 2 to perform single-stick mixing, commonly called “Elevon” mixing. Most commonly, **CH1** is connected to the Aileron (left-right) channel of a two-stick radio or the steering channel of a pistol-grip radio, and **CH2** is connected to the Elevator (up-down) channel or Throttle channel respectively.

If **CH3** is connected and its pulsewidth is **> 1500us**, the two output channels will be swapped. This mode is commonly called “Invert” in mobile robotics, and is used when your robot needs to drive upside-down or you wish to “swap ends” to operate. **CH3** does not need to be connected for R/C mode operation.

Connecting the **COMBINE** header will cause RageBridge 2 to drive both outputs in parallel according to the signal on **CH1**, ignoring other inputs. Please see the section on **COMBINE** mode for details.

Analog Mode Operation, Non-Mixed

Analog, Non-Mixed mode is designed for devices where an operator manipulates a resistive potentiometer or analog Hall Effect (“inductive”) throttle. We recommend that potentiometers be linear-type and 10Kohm resistance or lower. Higher resistances may result in non-linear behavior. A spring-loaded Hall Effect active throttle is highly recommended for safety.

To use RageBridge 2 in Analog, Non-Mixed mode, connect the **MODE** jumper and at least one valid analog voltage to **CH1** referenced to **GND**, then apply power. Valid analog voltage range for selection is **0.9 to 1.0 volts**.

RageBridge 2 will respond to the range **1.0 to 4.0 volts**, with 4.0 volts as “100% forward”. This is the most common output voltage output range of Hall Effect active throttles.

If **only CH1** is connected, the signal present on **CH1** is duplicated to the other channel automatically; there is no need to connect **CH2**, or short **CH2** to **GND**. This is for applications with two drive motors which only need one throttle for control. **CAUTION: THIS IS NOT THE SAME AS “COMBINE” MODE. DO NOT CONNECT BOTH OUTPUT CHANNELS TO THE SAME MOTOR IN THIS MODE.**

If valid analog voltages are present on both **CH1** and **CH2**, the two motors may be controlled separately in the same direction using two throttles.

If **CH3** is connected to **GND**, the outputs will switch polarity. This functions as reversing, and is typically connected to a button or switch separately from the

throttle. If reversing is not needed, simply leave **CH3** unconnected.

Connecting the **COMBINE** header will cause RageBridge 2 to drive both outputs in parallel according to the signal on **CH1**, using **CH3** as a reversing signal. Please see the section on **COMBINE** mode for details.

Analog Mode Operation, Mixed

Analog Mixed mode is designed for small user-operated devices where the operator manipulates a 2-axis joystick. We recommend that potentiometer joysticks be linear-type and 10Kohm resistance or lower. A spring-loaded analog Hall Effect joystick is highly recommended for safety.

To use RageBridge 2 in Analog, Mixed mode, connect the **MODE** jumper, **MIX** jumper, and **two** valid analog signal sources to **CH1** and **CH2** relative to **GND**, and a **CH3** switch to **GND**, then apply power. Valid analog voltages for selection are **2.5v +/- 0.05V for CH1 and CH2** (Both must be connected).

RageBridge 2 will respond to the voltage range **0.5 to 4.5V**, with 0.5V as “100% reverse” and 4.5V as “100% forward”. The margins are for safety –the most typical joystick malfunction is “railing”, or becoming connected to **5V** or **GND** accidentally, and this margin prevents loss of control.

CH3 must be shorted to **GND** to enable the outputs. This is a common safety measure, variously termed “Dead Man’s Switch” or “Operator Interlock”, and is typically wired to an operator-present sensor such as a weight switch or trigger button to ensure the device cannot run without an operator.

Serial Mode Operation

Serial mode is intended for applications where a microcontroller or computer communicates with RageBridge 2 directly. Typically, this is used for closed-loop feedback control purposes. RageBridge 2 can accept command updates at up to 1 kHz.

To use RageBridge 2 in Serial mode, simply connect it to a **TTL (5v or 3.3v level) 19200 baud 8-N-1** serial UART using the **Rx** pin, and **CH3** to either a pin used as a “Select”, or to **GND**, then apply power. The only valid bytes for Serial mode selection are **0x40** (64) and **0xC0** (192). At least four total bytes of either value must be sent to select Serial mode.

Sending **0x01 – 0x7F** (1 to 127) controls motor 1 (M1A, M1B) and **0x80 – 0xFF** (128 – 255) controls motor 2 (M2A, M2B). **0x40** (64) and **0xC0** (192) are ‘stop’ commands for each motor respectively.

0x00 is reserved as a shutdown command – both motors will coast as if the controller were powered off.

CH3 is used as a signal to accept commands, commonly called “Slave Select” or “Serial Enable”. This enables multiple RageBridge 2s to occupy the same Serial bus.

Commands will only be accepted if **CH3** is connected to **GND** (Active-low logic), either by an external microcontroller pin or by a computer-controlled pin. The select event is interrupt driven, so the command may be sent immediately after driving the **CH3** pin low. A typical pseudocode for this operation might be:

```
pinwrite(SELECT_PIN, LOW);
SerialPort.write(command_byte_1);
SerialPort.write(command_byte_2);
pinwrite(SELECT_PIN, HIGH);
```


If you do not wish to use this feature, simply short **CH3** to **GND** with the provided 3-pin jumper.

CAUTION: NOT DRIVING THE SELECT PIN IS NOT A FAILSAFE. RAGEBRIDGE 2 WILL MAINTAIN THE LAST COMMAND SENT FOR 0.5 SECONDS. SEND 0x00 TO SHUT DOWN MOTORS IMMEDIATELY.

MIX, MODE, and **CH1 – CH2** are all ignored if Serial mode is selected. **COMBINE** causes normal behavior – bytes above **0x7F** (commands for motor 2) are ignored.

Combine Mode

RageBridge 2 is designed to be a 2-channel DC motor controller, but its two output channels may be used to control a single larger DC motor.

To use RageBridge 2 in Combine mode, connect the **COMBINE** jumper. Combine mode is only valid for R/C non-mixed, Analog non-mixed, and Serial operation. In each case, only the signal or command for **CH1** will be acknowledged.

To connect RageBridge 2 in Combine mode to your motor, connect the **MxA** wires to one input of your motor and the **MxB** wires to the other. The total current limit your motor sees will be twice the setting on the Current Limit Adjust Trimpot.

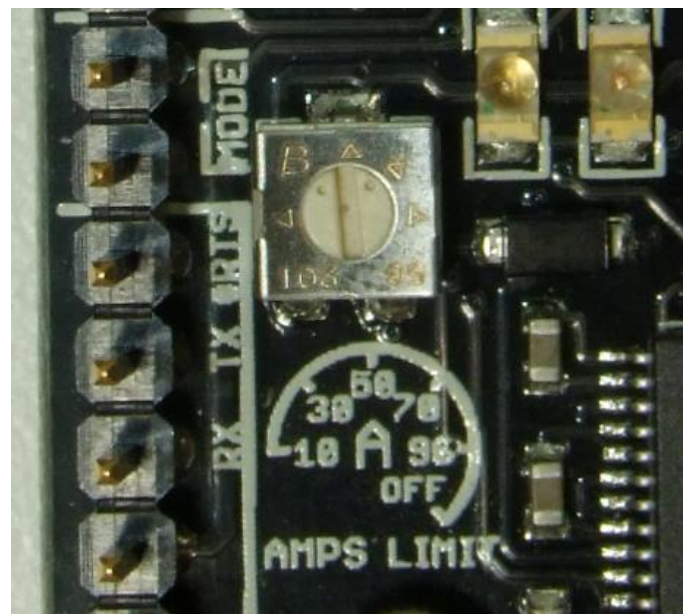
DO NOT CONNECT MxA to MxB WIRES. DO NOT DRIVE TWO INDEPENDENT MOTORS ON COMBINE MODE – THE TWO SIDES MUST DRIVE THE SAME LOAD.

If you need to drive 2 independent motors from 1 command source in R/C mode, jump CH1's signal to CH2 via a wire. In Analog Non-Mix mode, supply a valid signal only to CH1.

Current Limit Adjustment

A unique feature of RageBridge 2 is its ability to output exactly as much current as you limit it to. It will modulate its output voltage 15,000 times a second, offering protection against stalled motors and over-torquing actuators. This is a departure from generic “smart” overcurrent protection, in which you have no control over when the controller will shut down!

To adjust the current limit, turn the Max Current trim potentiometer to your desired setting using a **nonconductive** screwdriver:



Use a **DC ammeter** connected to the motor output wire side to verify exact current.

The accuracy of the current limit is strongly dependent on motor inductance; for typical iron core motors, the accuracy is $\pm 1-3$ amps.

The current limit is bidirectional. When designing applications for direct operation (such as Analog mode), please keep in mind that the device will decelerate as hard as it accelerates.

Advice & Warnings

1. **Do not use RageBridge 2 with a power supply.** The regenerative nature of RageBridge 2 will cause the motor's kinetic energy to be directed into the supply upon stopping, and can cause damage to both supply and controller. A battery **must** be placed between the supply and controller to absorb this energy if a supply must be used.
2. **Do not reverse battery polarity.** Double-check your wiring! Reverse polarity damage is NOT covered under warranty. See the Shipping and Warranty section on e0designs.com for more information.
3. **Controller will be hot during and after operation.** Do not place controller in contact with low temperature melting materials, or handle the controller during/immediately after use.
4. **Do not cover the controller or wrap it in insulating materials.** Doing so will reduce the continuous current rating since the controller cannot dissipate heat.
5. **Do not short the controller or allow conductive materials to contact the board directly.** The current limit is not guaranteed to protect against instantaneous "dead" shorts, such as output wires touching.
6. **The current limit may be set over the controller's continuous power handling ability.** Make sure RageBridge 2 is a right fit for your application.
7. **Secure the controller against shock loads.** Heavier components such as the main power capacitors should be secured in high-vibration applications with a silicone or epoxy adhesive to the board and themselves.

Troubleshooting

It's not turning on):

- RageBridge 2 is designed to operate from 12 to 30 volts. It will not turn on with voltage under 8V. Voltages higher than 40V will cause permanent damage.
- Check your battery input for continuity (no broken solder joints or loose connectors)
- Check for the presence of the green LED. If the LED is off, the controller is either not receiving power, or damaged.

It's on, but blinking angrily at me!):

- Check that you are in the mode you intended.
- Check that your signal is correct for the mode you are in. For instance, R/C mode requires both CH1 and CH2 to have valid signals. Analog modes require a relatively narrow range to validate.
- If your analog signals are just barely out of range, adding a high-value resistor to +5V or GND (depending on which way you need to adjust it) may help bring it within range. We couldn't test every throttle or potentiometer on the market, sadly.

The operation is sporadic or it resets often.):

- Power supply stability is a must. Check that your battery connections are sound, and that the wires are not overly long.
- Some motors are very electrically "noisy", such as high speed power tool motors. You may want to add a 0.1uF ceramic capacitor (non-polarized) as close to the motor's

brushes as possible, typically directly across the motor's terminals

- If the status LED sporadically blinks an error state, check your signal stability and range. For example, both R/C Servo pulsewidths and Analog voltages need to be within a certain range, or RageBridge 2 could enter and exit failsafe mode sporadically.
- For R/C mode in particular, check that **NO OTHER 5V SOURCE IS PRESENT** in your circuit. Often, other controllers or devices will try to power the common 5V line. In this case, you will need to “pick” which device powers your receiver. You will need to cut or disconnect the middle (+5V) wires in the servo connectors to prevent RageBridge 2 from powering the receiver in this case. Conflicting power supplies is often the cause of resets in otherwise perfect systems.

My RageBridge 2 is on fire):

- Please see the Shipping and Warranty section on e0designs.com for more information on returns and replacements.
- Mount RageBridge 2 away from heat-sensitive materials that could melt or burn.