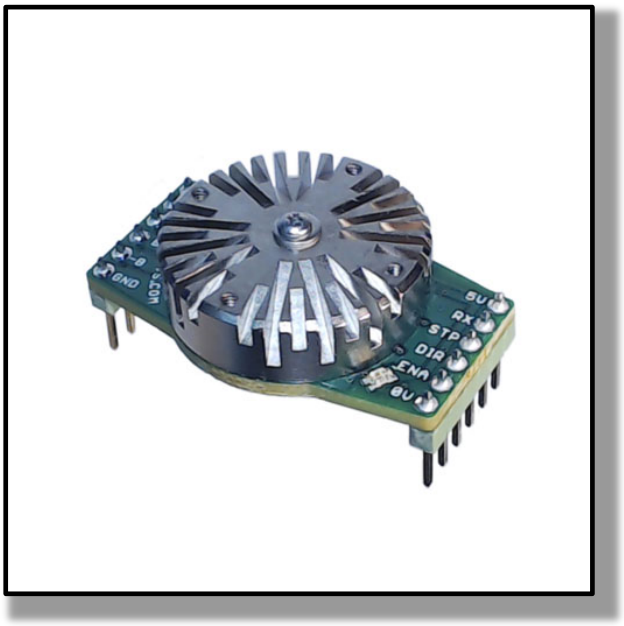


## Features

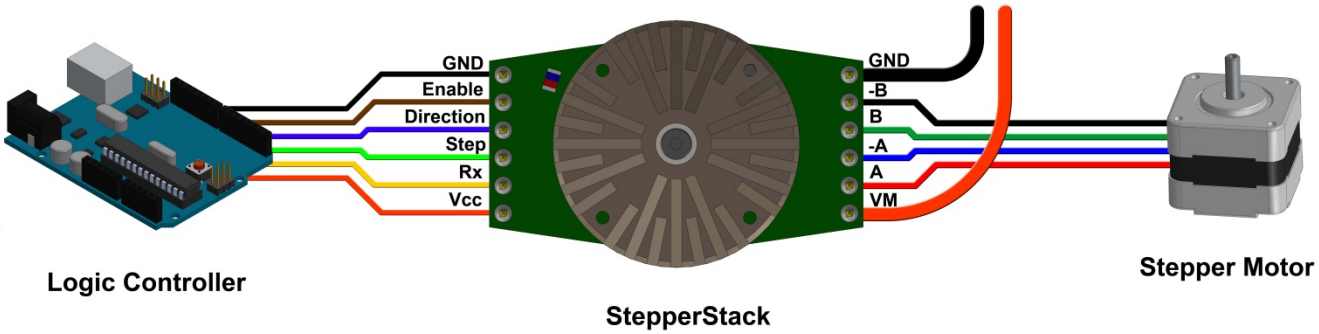
- Ideal for NEMA 23 motors and smaller
- Up to 3.500-A current per winding
- Defaults to “step, direction, enable” mode
- Multiple operating modes
- Digitally adjustable
- High quality thermal management system
- Over-current and over-temperature protection
- High efficiency
- Red/blue LED indicator
- Pluggable module

StepperStack R5 is a digitally-integrated stepper motor motion controller.

The controller can be adjusted to accommodate almost any motor, including parameters for current, decay mode, steps per revolution, velocity and acceleration.

The system is built into a small pluggable form factor with 0.1” DIP headers. Its durable construction and highly effective thermal management system make it ideal in a wide range of applications.

### TYPICAL CONNECTION DIAGRAM



# 1. Communication

## 1.1 Pin Description

| No. | Name | Type | Function |
|---|---|---|---|
| 1 | GND | Power | 0 Volts. |
| 2 | Enable | I | Active low enables driver output to motor. Internal pull-up resistor provided. |
| 3 | Step | I | Step input pin. |
| 4 | Direction / Done | I/O | Direction input pin. HI = CW, LOW = CCW<br>Also serves as a “done” indicator during Relative mode. |
| 5 | Rx | I | Receive serial data for configuration and commands.<br>8-Bit UART, 1 start bit, 1 stop bit, 9600 Baud, LSB first |
| 6 | VCC | Power | 5 VDC Power Supply for Logic and Fan. |
| 7 | VM | Power | Motor Power Supply.<br>Consult DRV8818 Datasheet for proper power supply selection. |
| 8 | A | Motor | Coil A positive. |
| 9 | -A | Motor | Coil A negative |
| 10 | B | Motor | Coil B positive |
| 11 | -B | Motor | Coil B negative. |
| 12 | GND | Power | 0 Volts. |

## 1.2 Command Summary

Commands are in the format of two consecutive ASCII characters. In order to avoid errors transmissions received without **two** command characters preceding are rejected (see section 3.1).

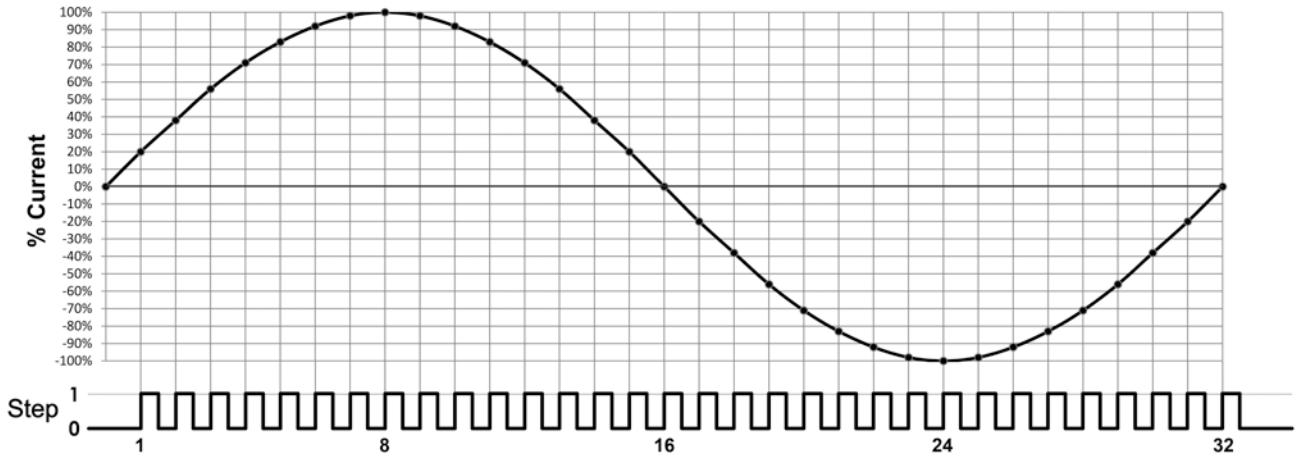
| Command | Name | Type | Description |
|---|---|---|---|
| PP | Passive | Passive | Device operates with standard Step, Direction, and Enable interface. |
| JJ | Jog | Active | Go and Direction signals are provided to rotate motor indefinitely. |
| RR | Relative | Active | Perform precision motions using UART interface. |
| AA | Address | Configuration | Specify an address for each individual device. |
| KK | Kinematics | Configuration | Specify velocity and acceleration. |
| CC | Current | Configuration | Specify drive current. |
| TT | Tune | Configuration | Specify decay mode. |
| DD | Divisions | Configuration | Specify number of steps per revolution. Resets step index. |

# 2. Modes of Operation

## 2.1 Passive Mode

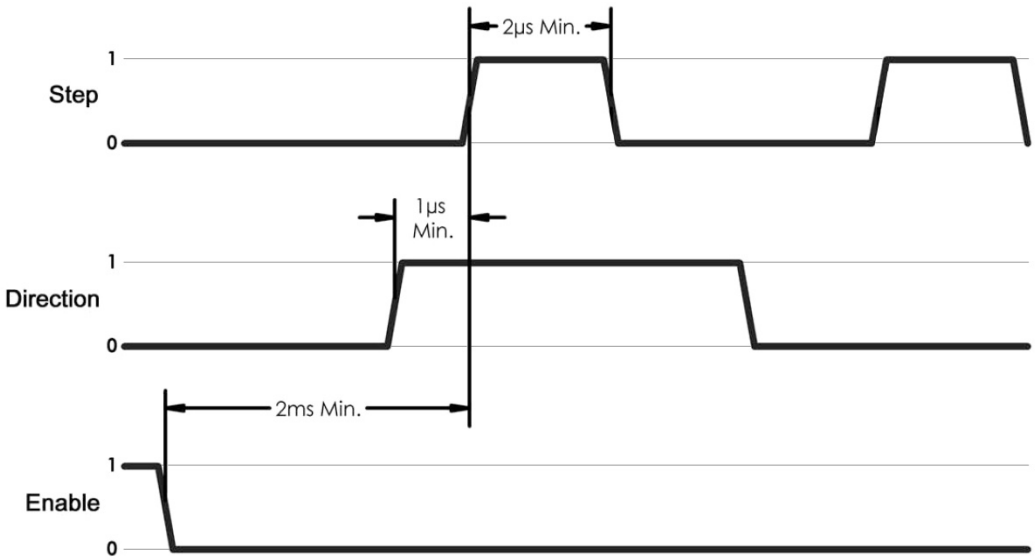
Passive mode is the default operating mode of StepperStack. The device initializes to Passive mode upon power up. Once an active command is received Passive mode is disabled. Passive mode can be re-enabled by sending the PP command.

In passive mode a transition from LOW to HI on the Step pin increments the drive 1/8$^{th}$ of a step. The driver scales current through the coils to achieve each mircostep as shown below.




Direction is controlled by the Direction Input. Connecting Enable pin to ground enables drive. Characteristics such as Peak Current can be adjusted through UART without disabling Passive mode (see section 3).

Timing requirements for Step, Direction and Enable signals are shown below.



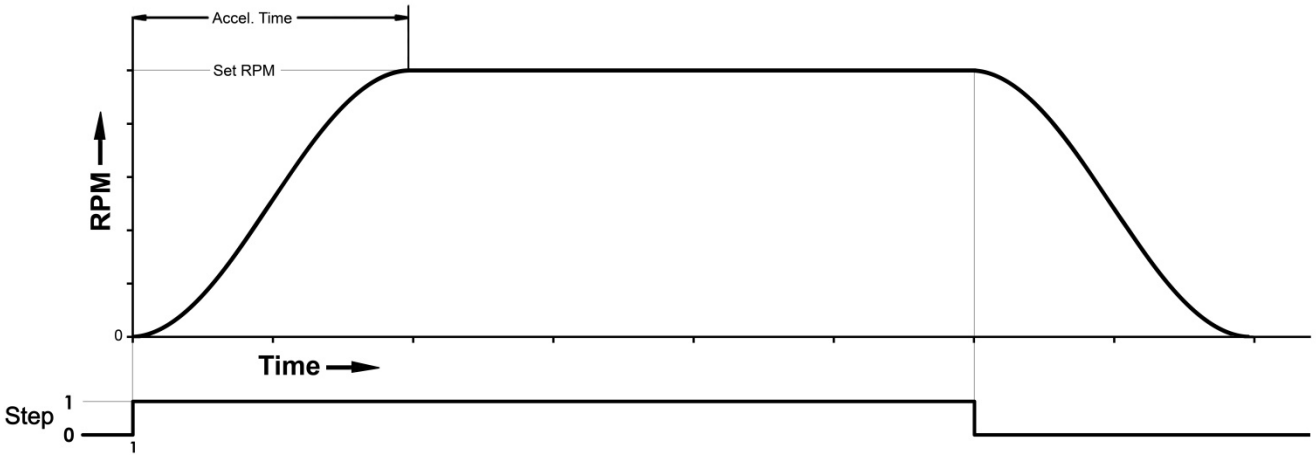
## 2.2 Jog Mode

Jog mode provides continuous rotation of the motor without external pulse generation.

When the Jog command is received the Step pin acts as a momentary input. When Step is logic HI the motor will rotate in the direction specified by the Direction pin.

Configuration such as RPM and Acceleration can be adjusted without disabling Jog mode.

When the Step pin transitions to HI StepperStack will begin accelerating the motor to the specified RPM. When Step transitions from HI to LOW StepperStack begins decelerating the motor to 0 RPM.




## 2.3 Relative Mode

| R | R | d, $b^{30}$-$b^{24}$ | $b^{23}$-$b^{16}$ | $b^{15}$-$b^{8}$ | $b^{7}$-$b^{0}$ |
|---|---|---|---|---|---|
| Command | | Steps | | | |

Relative mode enables precision motions performed via UART interface.

Direction and number of micro Steps are specified during command. The Relative command is sent followed by a signed long integer. Positive numbers indicate clockwise rotation. Negative numbers indicate counterclockwise rotation.

During relative mode the Direction pin serves as a Done output. When a motion is completed the Direction pin is held HI to indicate the motion is complete.

An internal resistor limits current of Done pin to 4mA in the event it is connected to ground during Relative mode.

Note: Done output signal is 3.5 volts.

# 3. Configuration Commands

## 3.1 Address

| A | A | $b^7$-$b^0$ |
|---|---|---|
| Command | | Address |

Each device can be assigned its own address. The maximum number of addresses is 255.

Upon reset StepperStack assumes no address. In order to specify an address, the Enable pin must be held logic LOW while the Address command is sent, followed by one address byte.

Once the address is assigned StepperStack will ignore any commands unless preceded by its address number.

The address can be changed at any time by repeating the Address command sequence. An address of 0 will disable the address feature.

## 3.2 Divisions

| D | D | $b^{15}$-$b^8$ | $b^7$-$b^0$ |
|---|---|---|---|
| Command | | SPR | |

Stepper motor variations commonly have anywhere between 24 and 400 steps in a full revolution. StepperStack can be adjusted to accommodate any number of steps per revolution (SPR) using the Divisions command.

Kinematics values are automatically adjusted by StepperStack based on the SPR value. The default value is 200.

SPR is adjusted by sending the Divisions command, followed by and unsigned integer representing SPR.

Sending the Divisions adjustment sequence will also reset the step index to the home position.

## 3.3 Kinematics

| K | K | $b^{15}$-$b^8$ | $b^7$-$b^0$ | $b^{15}$-$b^8$ | $b^7$-$b^0$ |
|---|---|---|---|---|---|
| Command | | RPM | | Acceleration | |

Jog and Relative modes require Velocity and Acceleration to be specified for rotation.

The angular Velocity and Acceleration values are adjusted by sending the Kinematics command followed by an unsigned integer representing the RPM, and then followed by an unsigned integer representing the number of milliseconds for acceleration.

The acceleration period is limited to a range of 0-1605 milliseconds. The maximum RPM depends on the SPR of the motor. Maximum step frequency is 120 kHz.

Upon reset StepperStack is initialized with a Velocity of 100 RPM, and an acceleration period of 100 milliseconds by default.

### 3.4 Current

| C | C | $b^{15}$-$b^{8}$ | $b^{7}$-$b^{0}$ |
|---|---|---|---|
| Command | | Current | |

Drive current is adjusted by sending the Current command, followed by an unsigned integer representing the number of milliamps. The default current setting is 1000mA upon power-up.

The acceptable input range is 0-3500. Values above 3500 will be changed to 3500mA.

The Controller regulates current through the coils in a 20kHz cycle. The cycle begins by enabling the H bridge; causing the current to increase. When the peak Current is reached the controller decreases the current for the remainder of the cycle. This high-speed alternation results in a PWM Current Chopping waveform. Extensive information regarding current regulation can be found in the DRV8818 Datasheet from Texas Instruments Incorporated.

### 3.5 Tune

| T | T | $b^{7}$-$b^{0}$ |
|---|---|---|
| Command | | Tune |

The DRV8818 provides adjustable Decay mode. Decay mode refers to the method of current circulation during PWM Chopping.

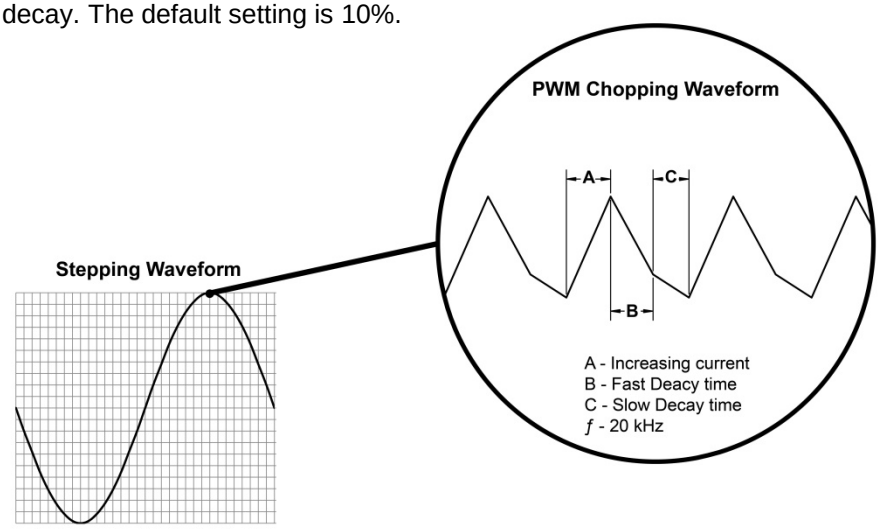
For the decreasing portion of the PWM Current Chopping waveform; induction current from the motor must be recirculated through the driver in order to decrease the EMF. The DRV8818 supports multiple Decay Modes.

In Fast Decay mode the H-bridge reverses polarity to allow current flow in the opposite direction; quickly decreasing the EMF.

In Slow Decay mode both lower FETs of the H-bridge are enabled; circulating current through the chip.

Characteristics such as noise, torque and efficiency can be affected by the Decay mode. Mixed Decay mode enables fine tuning of the current regulation method in order to optimize the waveform. In Mixed Decay mode the Driver begins decreasing the current in Fast Decay, then switches to Slow Decay some time later.

The percentage of Fast Decay can be adjusted by sending the Tune command followed by a byte equal to the percentage of Fast decay. The default setting is 10%.



# 4. Characteristics

## 4.1 Absolute Maximum Ratings

| Symbol | Parameter | Max. | Unit |
|---|---|---|---|
| $V_M$ | Motor Supply Voltage | 30 | V |
| $I_{O(peak)}$ | Peak motor drive output current | 3.5 | A |
| $V_{IO}$ | Logic input voltage | 5.2 | V |
| $f$step | Step frequency | 120 | kHz |
| $T_{MAX}$ | Operating Temperature | 90 | °C |

## 4.2 Electrical Characteristics

| Symbol | Parameter | Min. | Nom. | Max. | Unit |
|---|---|---|---|---|---|
| $V_M$ | Motor Supply Voltage | 8 | - | 30 | V |
| $I_{O(peak)}$ | Peak motor drive output current | 0 | - | 3.5 | A |
| $I_{RMS}$ | RMS VM current | 0.01 | - | 2.5 | A |
| VCC | Logic supply voltage | 4.7 | 5.0 | 5.2 | V |
| $VCC_{NF}$ | Logic supply voltage with no fan attached | 4.7 | 5.0 | 24 | V |
| $I_{LOGIC}$ | VCC current for logic | 6 | 12 | 25 | mA |
| $I_{FAN}$ | VCC current for fan | 110 | 120 | 150 | mA |
| $V_{IH}$ | Logic HI input voltage | 4.4 | 5.0 | 5.2 | V |
| $V_{IL}$ | Logic LOW input voltage | 0 | 0 | 0.8 | V |
| $V_{DH}$ | Logic HI output voltage (Step/Done) | 3.4 | 3.5 | 3.6 | V |

## 4.3 Thermal Characteristics

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $T_{HS}$ | Operating temperature (measured at heatsink) | -20 | 20 | 90 | °C |
| $T_{SD}$ | Shut down temperature | 84 | 89 | 90 | °C |
| $R_{\Theta FAN}$ | Thermal resistance with fan on | - | 18 | - | °C/W |
| $L_{TH}$ | Thermal Capacitance | - | 5.3 | - | J/°C |

## 5. Thermal Management

PowerPeg™ Thermal Management System provides unmatched dissipation characteristics in FR4 Circuit board assemblies. StepperStack Utilizes the TCAP-4325 Thermal Connector to efficiently transfer heat out of the driver chip. The precision aluminum heatsink and optional fan keep the system stable during high-current operation.

An integrated temperature sensor and thermostat ensure proper cooling and safety across the temperature range.

In order to conserve power in low current applications the fan remains turned off until the temperature exceeds 34°C. The fan consumes 120mA and is powered through the VCC pin.

If the temperature exceeds 70°C the fan will remain on, and the Red LED will remain lit to indicate high temperature.

If the temperature reaches 90°C the current is reduced to 20% until the temperature decreases to 70°C.

StepperStack can also operate without a fan attached. This power limit depends on ambient temperature, RPM, supply voltage and motor size.

The benefit of operating without a fan is increased VCC range. Without a fan the VCC pin can be coupled with the VM pin to operate from a single supply voltage (see Section 4.2).

## 6. Mechanical