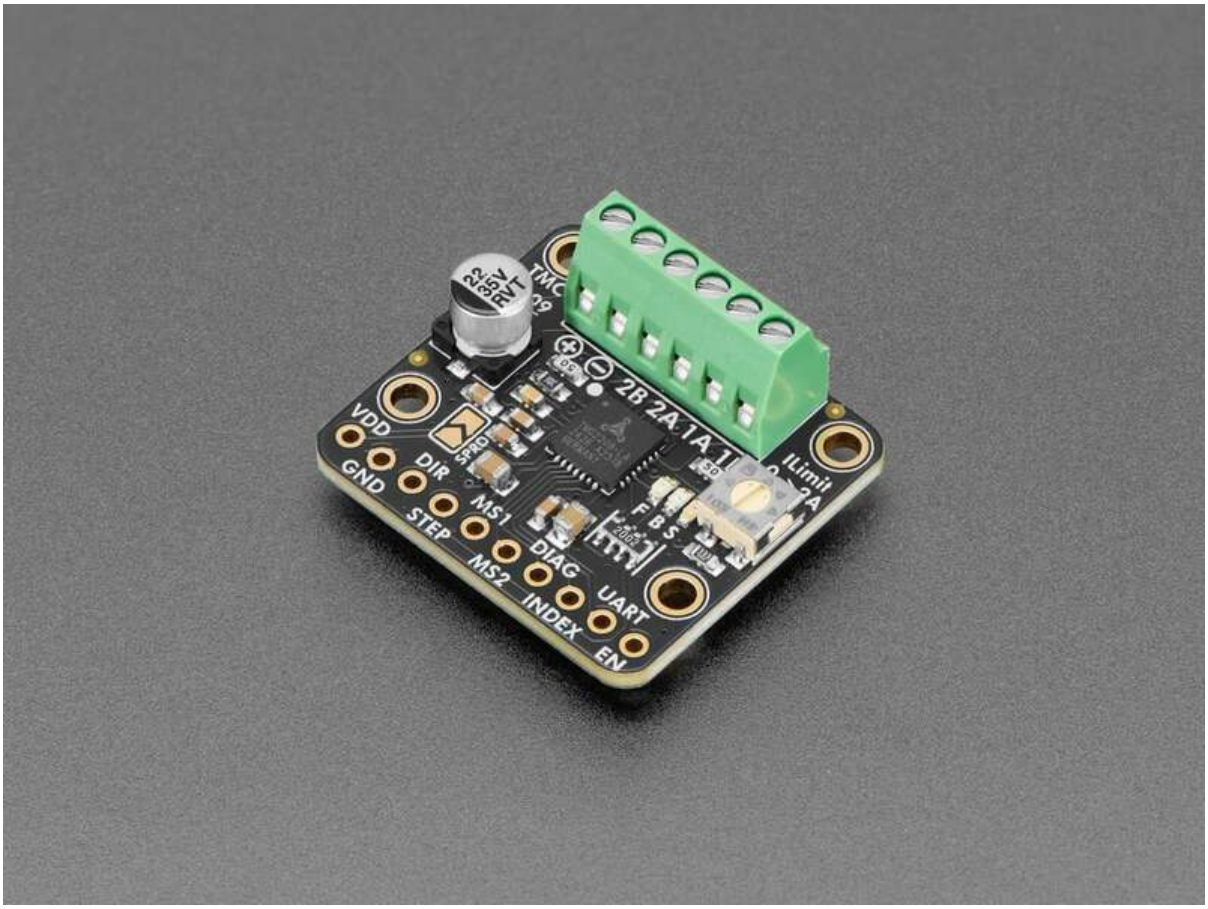
Adafruit TMC2209 Stepper Motor Driver Breakout Board

Created by Tim C



https://learn.adafruit.com/adafruit-tmc2209-stepper-motor-driver-breakout-board

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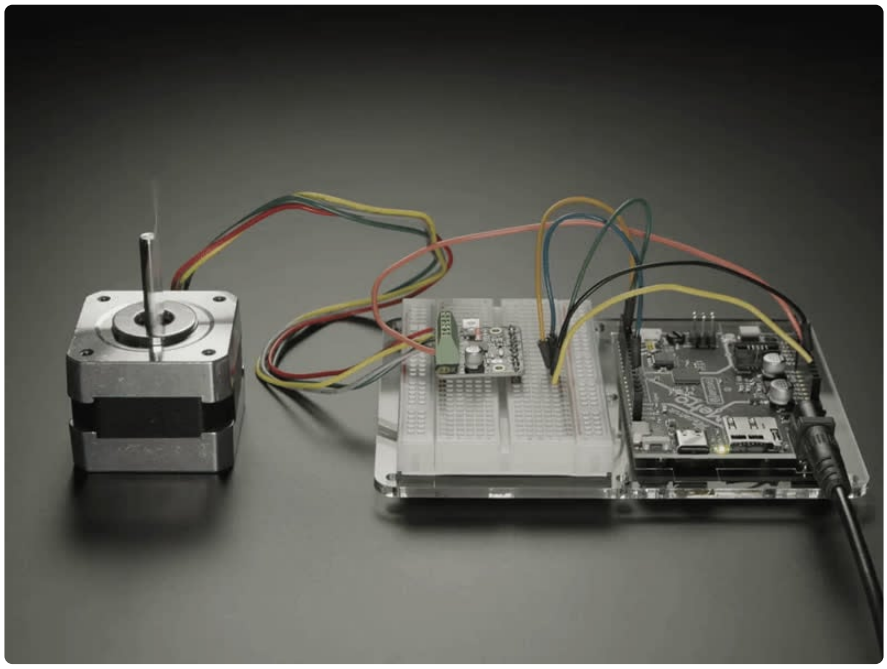
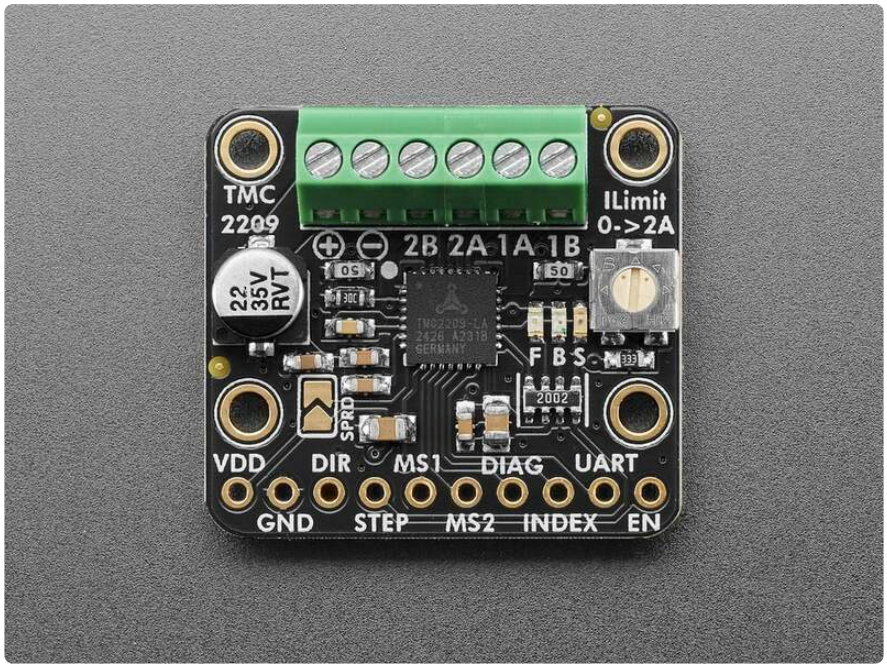
Table of Contents

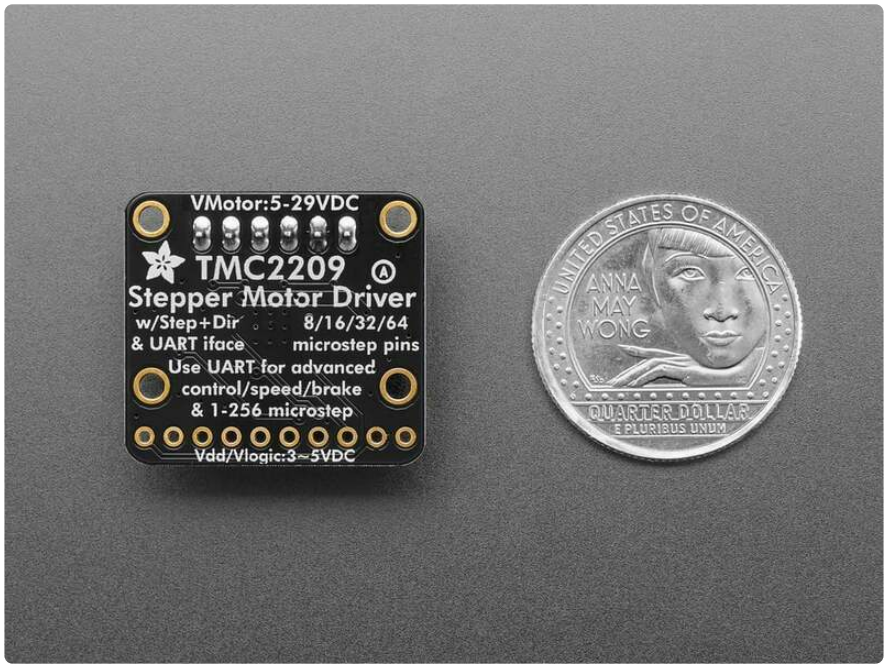
Overview



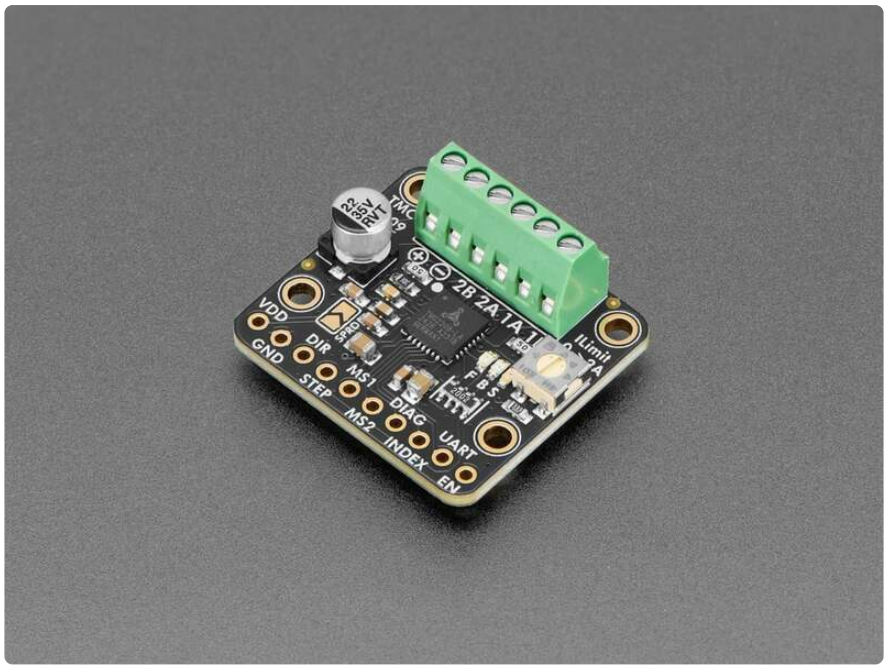
Stepper motors are used for CNC machines, 3D printers, and whenever else one needs precise, powerful motion. But to get good behavior from steppers, you need a motor driver chip that can provide high bursts of current. And for smooth motion, the driver must be able to PWM that current for microstepping support. You can DIY this with a lot of timers, a microcontroller and an H-Bridge chip - or you could take the easy way out and use an **Adafruit TMC2209 Stepper Motor Driver Breakout Board** which makes controlling stepper motors easy-breezy and super-silent.



All you need is two output pins, no timers, PWM or real-time microcontroller. Set the DIRection pin high or low to set the spin orientation. Then toggle the STEP pin to take one microstep at a time. You can set whether you want to go faster with 1/8 microsteps, or increase the precision to 1/16, 1/32 or 1/64 microsteps per STEP toggle. If you want more control, say to single-step or up to 1/256 microsteps, you can do so via the UART interface (more on that later). By default the driver is set to 1/8 microstep mode, you can change it by tying the MS1/MS2 pins high, either with jumpers or with 2 more output pins. The step/microstep mode can even be adjusted on the fly! LEDs on the DIR and STEP pins let you get visual feedback of your motor signal.

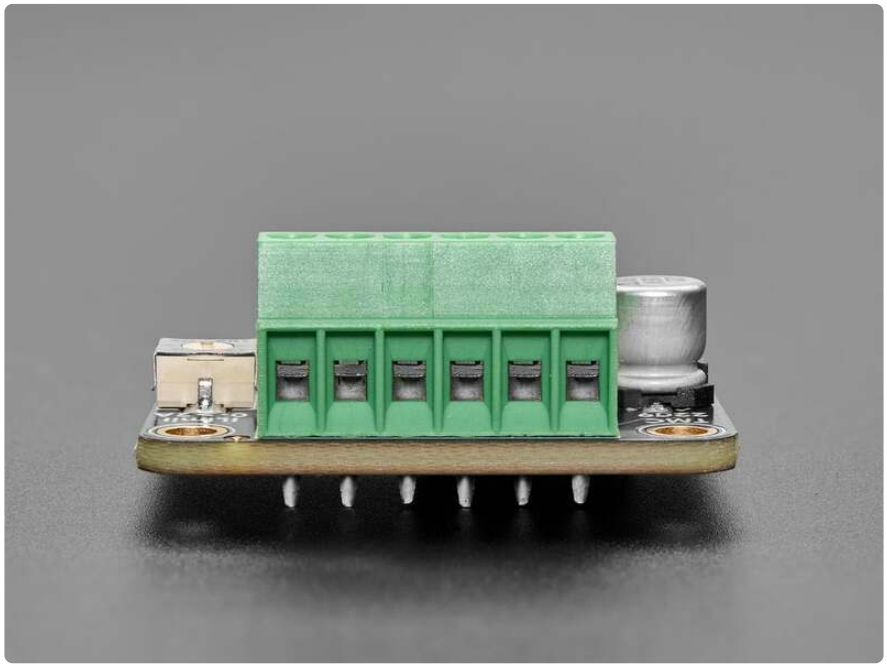


The Trinamic drivers are often known as "silent" or "stealth" chips - compared to the A4988 they are unbelievably quiet. You can barely tell they are running thanks to the microstepping techniques used. This reduces noise and wear, to make users happy. There's also a lot of niceties like index output which will pulse when the microstepping counter cycles back to 'zero', and a diagnostic output to quickly alert the microcontroller of a big error like short or open circuits. It can also do 'sensor-less stop detection' with a feature called StallGuard - but for that you will need to use the UART interface.



The UART interface is a single-pin serial port with auto-baud detection that allows more precise communication, diagnostics and control. You can do things like set microsteps from 1 to 256, or set the speed with a single command. You can also configure settings like current limiting, over-heat temperature limit, PWM frequency, etc. You'll need a microcontroller library to use UART and it's an 'extra' - not essential for basic motion control!

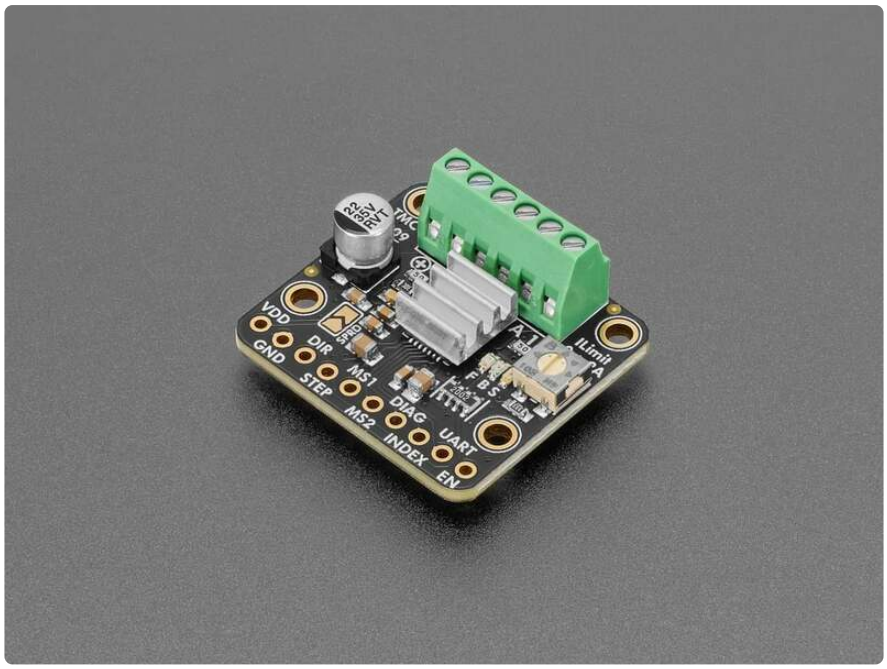
The Trinamic TMC2209 is a popular driver chip, with small breakout boards used in many 3D printers. Those breakouts are great for plugging into motherboards, but are a little tough to use for prototyping. Our version comes with terminal blocks for the motor power and stepper wires, plus nicely labeled pins for control and mounting holes.



We fabricated the board with 2 oz copper to give it a hand with the 2A-max current that this driver can handle. To use the current limiting capability, twist the onboard potentiometer: when all the way to the right we can get to up to 2A max. Note that the higher currents will heat up both the motor driver and stepper so you may need to add heatsinking to the chip. We don't include a heatsink but you can get a tall ~80°C/W (http://adafru.it/1493) or short ~90°C/W heatsink (http://adafru.it/1515) to attach on top.

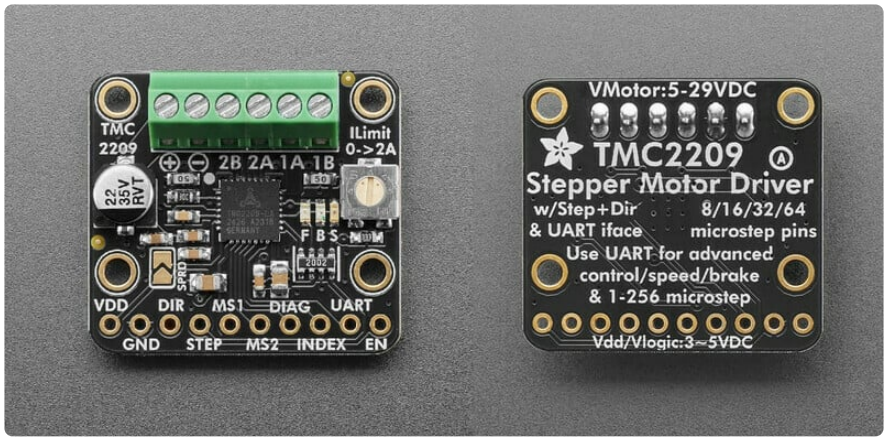
Features:

- Trinamic TMC2209 (https://adafru.it/1abZ) silent "Stealth Chopper" DMOS microstepping driver with translator and overcurrent protection
- Motor voltage from 5V to 29VDC
- Vdd/Logic voltage from 3V to 5V, use with anything from an Arduino-compatible or ESP32 to Raspberry Pi other Single Board Computer
- Terminal screw block connections for easy VMotor power and 4-wire bi-polar stepper motor connection with 26-20AWG slots, 2.54mm / 0.1" spacing
- Control steppers using only two pins: DIRection and STEP
- Defaults to 1/8 microstep mode, change by pulling MS1/MS2 high (see TMC2209 datasheet (https://adafru.it/1abZ) for pin configuration) or via UART
- Red and Green LEDs on DIR signal to let you know forward or backward motion
- Yellow LED on STEP to let you know that motor driver is being moved
- Enable control line for low power / deactivation
- Index output will toggle when passing through the 'zero point' of the microsteps
- Diagnostic output will trigger on errors like shorted output or with "stall detection" (which requires UART configuration)
- Potentiometer to set current limiting, up to 2A
- 22uF 35V electrolytic capacitor on motor power
- 2 Oz copper for better current carrying and heatsinking
- Four mounting holes



Comes as one assembled and tested breakout plus a small strip of header. You'll need to do some light soldering to attach the header onto the breakout PCB. Microcontroller, motors, and power supply not included. You will need some sort of driver board that will toggle the DIR/STEP pins for you.

Pinouts



Power

- **VDD** - This is the logic voltage input. To power the board, give it the same power as the logic level of your microcontroller - e.g. for a 5V micro like Arduino, use 5V. It can be powered between from 3.3V to 5V.
- + (terminal block) - This is the motor voltage input. Supply 5V to 29VDC for your motor.
- **GND** / **-** (terminal block) - common ground for power and logic.

Current Potentiometer

On the right side of the board is the current potentiometer. This potentiometer limits the current output to the motor. When the potentiometer is all the way to the right, you can get up to 2A max. Note that the higher currents will heat up both the motor driver and stepper, so you may need to add heatsinking to the chip.

Terminal Block Bipolar Stepper Motor Connections

- **1A** and **1B** - The first set of motor control outputs connected to DMOS bridge 1.
- **2A** and **2B** - The second set of motor control outputs connected to DMOS bridge 2.

Stepper Control Pins

- **DIR** - This is the direction control pin. You can set this pin high or low to set the spin orientation. Pulling it high turns the motor clockwise. Pulling it low turns it counterclockwise.
- **STEP** - This is the microstep control pin. Toggle this pin to take one step or microstep at a time. By default, the driver is set to 1/8 microstep mode.

Microstep Selection Pins

There are two pins (**MS1**, and **MS2**) that can be pulled high to change the default 1/8 microstep mode where both pins are open/low. The table below shows the pin combinations to change to the different modes. For example, if you wanted to use 1/16 microstep mode, you would tie both **MS1** and **MS2** high.

STEP	MS1	MS2
1/8	L	L
1/16	H	H
1/32	H	L
1/64	L	H

TMC2209 Control Pins

- **DIAG** - This is the diagnostic pin. It's driven high if there is a problem causing the motor driver to not be able to work properly.
- **INDEX** - This is the index pin. It's driven high when the microstep counter is in it's zero position. This can be helpful for precise homing. It signals every 4 full steps, so in the default 1/8 microstep mode, this pin will go high once every 32 microsteps.
- **UART** - This is the UART interface control pin. It is a single-pin serial port with auto-baud detection that allows more precise communication, diagnostics and control. This requires a microcontroller library and is not needed for basic driver control.
- **EN** - This is the enable pin. Pull this pin high to disable the output to the motors.

LEDs

- Green LED - The green LED is tied to the DIR pin. It is labeled **F** on the board silk. It is lit when the motor is being driven counterclockwise when the DIR pin is low.
- Red LED - The red LED is tied to the DIR pin. It is labeled **B** on the board silk. It is lit when the motor is being driven clockwise when the DIR pin is high.
- Yellow LED - The yellow LED is tied to the STEP pin. It is labeled **S** on the board silk. It is lit when the motor driver is being moved.

SPREAD Jumper

On the front of the board there is a jumper labeled **SPRD** for the SPREAD pin on the controller. This pin selects between the two available chopper modes for the motor driver.

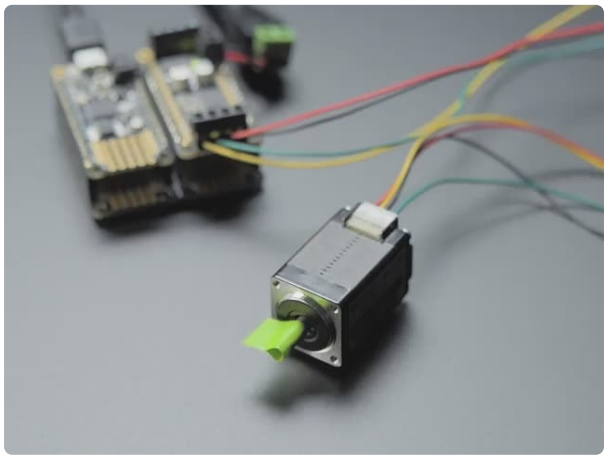
By default, with the **jumper open** the **SPRD** pin is unconnected. This selects the StealthChop mode, which is optimized for the least amount of noise and vibration.

If you solder the **jumper closed** the **SPRD** pin is tied to **VDD**. This selects the SpreadCycle mode, which is optimized for highest dynamic movements.

CircuitPython and Python

It's easy to use the **TMC2209 Stepper Motor Driver** with CircuitPython and the digitalio (https://adafru.it/19ID) core module. This module allows you to easily write Python code to access input and outputs on GPIO pins.

You can use the example code with any CircuitPython microcontroller board or with a computer that has GPIO and Python thanks to Adafruit_Blinka, our CircuitPython-for-Python compatibility library (https://adafru.it/BSN).



Mini Stepper Motor - 200 Steps - 20x30mm NEMA-8 Size
This tiny stepper motor is the same quality and step-size as the big NEMA-17's we stock, but so cute so it will work with compact CNC builds. This 4-wire bipolar stepper has...
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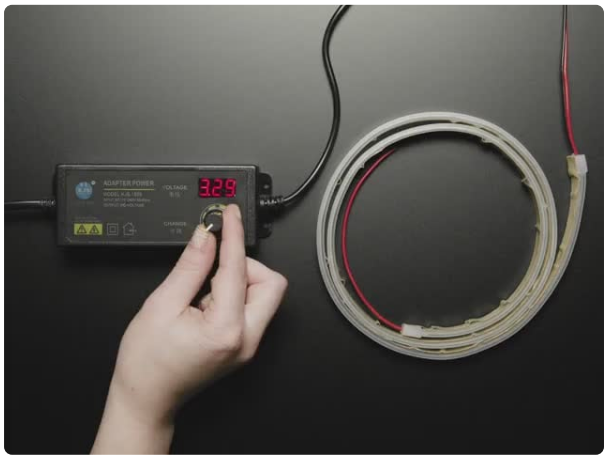

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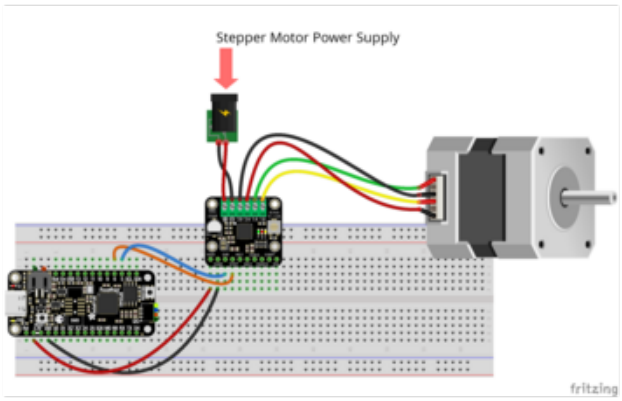
CircuitPython Microcontroller Wiring

Here is how you'll wire the breakout to a Feather RP2040 and stepper motor:

Check your stepper motor wiring - your motor may have different wire colors or wire order.



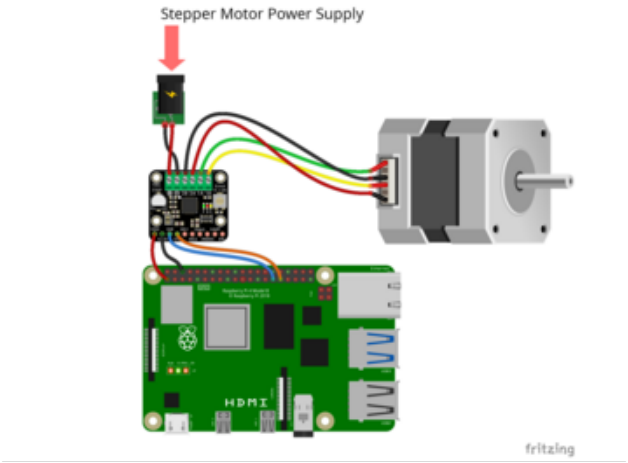
Stepper motor power supply positive to **breakout terminal block + (red wire)**
Stepper motor power supply negative to **breakout terminal block - (black wire)**
Breakout VDD to **Feather 3.3V (red wire)**
Breakout GND to **Feather GND (black wire)**
Breakout DIR to **Feather pin 5 (blue wire)**
Breakout STEP to **Feather pin 6 (orange wire)**
Breakout 1A to **stepper motor coil 1 positive (green wire)**
Breakout 1B to **stepper motor coil 1 negative (yellow wire)**
Breakout 2A to **stepper motor coil 2 positive (red wire)**
Breakout 2B to **stepper motor coil 2 negative (black wire)**

Python Computer Wiring

Since there are dozens of Linux computers/boards you can use, we will show wiring for Raspberry Pi. For other platforms, [please visit the guide for CircuitPython on Linux to see whether your platform is supported](https://adafru.it/BSN) (https://adafru.it/BSN).

Here's the Raspberry Pi wired to the breakout and a stepper motor:

Check your stepper motor wiring - your motor may have different wire colors or wire order.



Stepper motor power supply positive to **breakout terminal block + (red wire)**
Stepper motor power supply negative to **breakout terminal block - (black wire)**
Breakout VDD to **Pi 3.3V (red wire)**
Breakout GND to **Pi GND (black wire)**
Breakout DIR to **Pi GPIO 5 (blue wire)**
Breakout STEP to **Pi GPIO 6 (orange wire)**
Breakout 1A to **stepper motor coil 1 positive (green wire)**
Breakout 1B to **stepper motor coil 1 negative (yellow wire)**
Breakout 2A to **stepper motor coil 2 positive (red wire)**
Breakout 2B to **stepper motor coil 2 negative (black wire)**

Python Blinka Setup

You'll need to install the **Adafruit_Blinka** library that provides the CircuitPython support in Python. This may also require enabling I2C on your platform and verifying you are running Python 3. Since each platform is a little different, and Linux changes often, please visit the CircuitPython on Linux guide to get your computer ready (https://adafru.it/BSN)!

CircuitPython Usage

To use with CircuitPython, you need to update **code.py** with the example script.

In the example below, click the **Download Project Bundle** button below to download the **code.py** file in a zip file. Extract the contents of the zip file, and copy the **code.py** file to your **CIRCUITPY** drive.

There are no additional libraries needed for this example. It uses core modules that are included when you install CircuitPython on your board.

Python Usage

Once you have the library `pip3` installed on your computer, copy or download the following example to your computer, and run the following, replacing **code.py** with whatever you named the file:

```
python3 code.py
```

Example Code

If running CircuitPython: Once everything is saved to the **CIRCUITPY** drive, connect to the serial console (https://adafru.it/Bec) to see the data printed out!

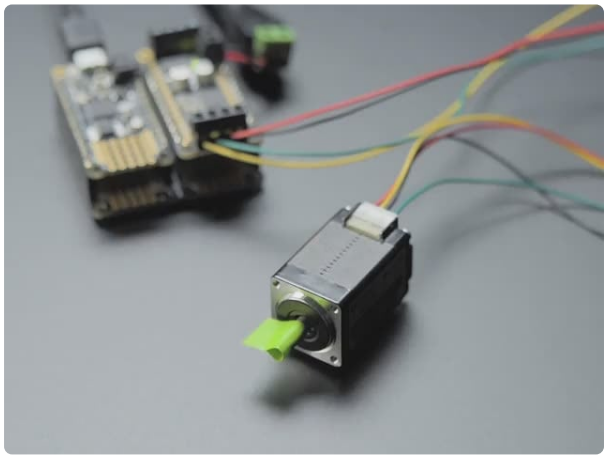
If running Python: The console output will appear wherever you are running Python.

```
# SPDX-FileCopyrightText: 2025 Liz Clark for Adafruit Industries
#
# SPDX-License-Identifier: MIT

import time
import board
from digitalio import DigitalInOut, Direction

# direction and step pins as outputs
DIR = DigitalInOut(board.D5)
DIR.direction = Direction.OUTPUT
STEP = DigitalInOut(board.D6)
STEP.direction = Direction.OUTPUT

# microstep mode, default is 1/8 so 8
# another ex: 1/16 microstep would be 16
microMode = 8
# full rotation multiplied by the microstep divider
steps = 200 * microMode

while True:
    # change direction every loop
    DIR.value = not DIR.value
    # toggle STEP pin to move the motor
    for i in range(steps):
        STEP.value = True
        time.sleep(0.001)
        STEP.value = False
        time.sleep(0.001)
    print("rotated! now reverse")
    # 1 second delay before starting again
    time.sleep(1)
```

The code starts by setting up the direction and step pins as outputs. In the loop, the direction pin will toggle once every loop to change directions. The step pin toggles in a `for` loop to step the motor. As the code runs, you'll see your attached stepper motor turn clockwise and then reverse and turn counterclockwise.

Arduino

Using the TMC2209 breakout with Arduino involves wiring up the breakout with a stepper motor to your Arduino-compatible microcontroller and running the provided example code.



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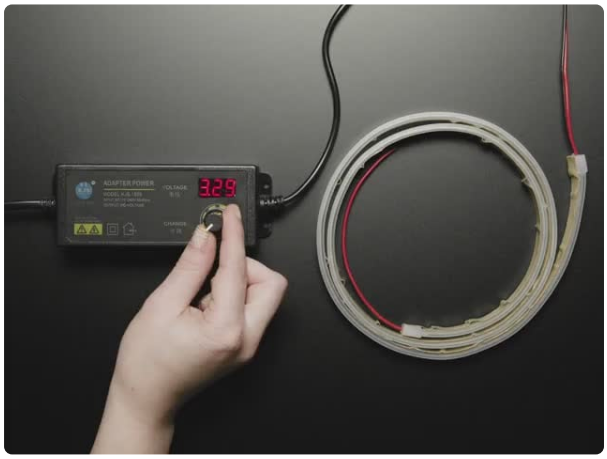

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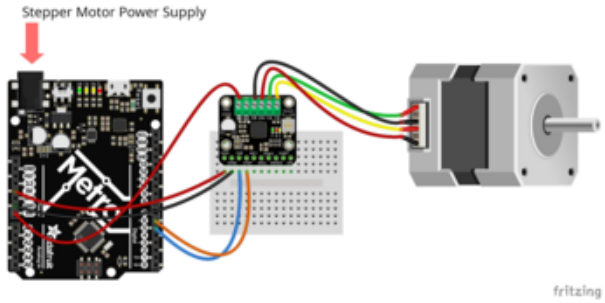
Wiring

Wire as shown for a **5V** board like an Uno. If you are using a **3V** board, like an Adafruit Feather, wire the board's 3V pin to the breakout VDD.

Here is an Adafruit Metro wired up to the breakout with a stepper motor. You'll need to connect the stepper motor power supply to the DC jack on the Metro.

Check your stepper motor wiring - your motor may have different wire colors or wire order.



Stepper motor power supply to **Metro DC Jack**
Breakout VDD to **Metro 5V (red wire)**
Breakout GND to **Metro GND (black wire)**
Breakout DIR to **Metro pin 5 (blue wire)**
Breakout STEP to **Metro pin 6 (orange wire)**
Breakout terminal block + to **Metro VIN (red wire)**
Breakout 1A to **stepper motor coil 1 positive (green wire)**
Breakout 1B to **stepper motor coil 1 negative (yellow wire)**
Breakout 2A to **stepper motor coil 2 positive (red wire)**
Breakout 2B to **stepper motor coil 2 negative (black wire)**

Example Code

```
// SPDX-FileCopyrightText: 2025 Liz Clark for Adafruit Industries
//
// SPDX-License-Identifier: MIT

const int DIR = 5;
const int STEP = 6;
const int microMode = 8; // microstep mode, default is 1/8 so 8; ex: 1/16 would be
16
// full rotation * microstep divider
const int steps = 200 * microMode;

void setup()
{
  // setup step and dir pins as outputs
  pinMode(STEP, OUTPUT);
  pinMode(DIR, OUTPUT);
}

void loop()
{
  // change direction every loop
  digitalWrite(DIR, !digitalRead(DIR));
  // toggle STEP to move
  for(int x = 0; x < steps; x++)
  {
    digitalWrite(STEP, HIGH);
    delay(2);
    digitalWrite(STEP, LOW);
    delay(2);
  }
  delay(1000); // 1 second delay
}
```

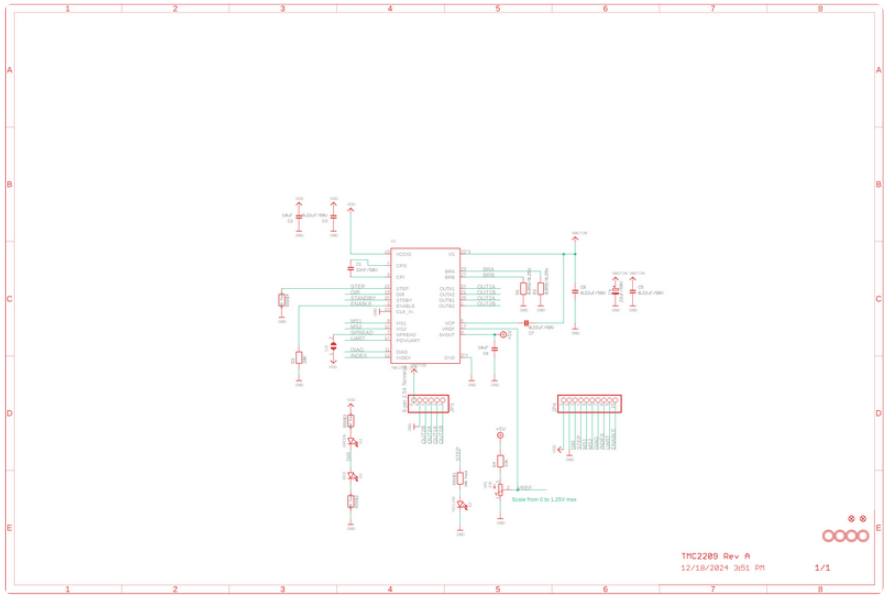
Upload the sketch to your board. You'll see your attached stepper motor turn clockwise and then reverse and turn counterclockwise.

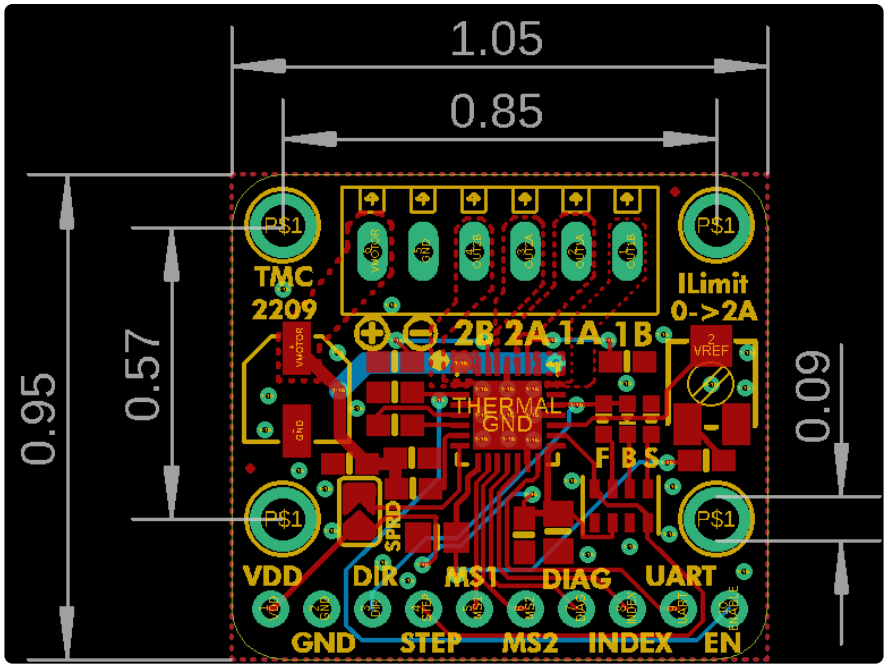
Downloads

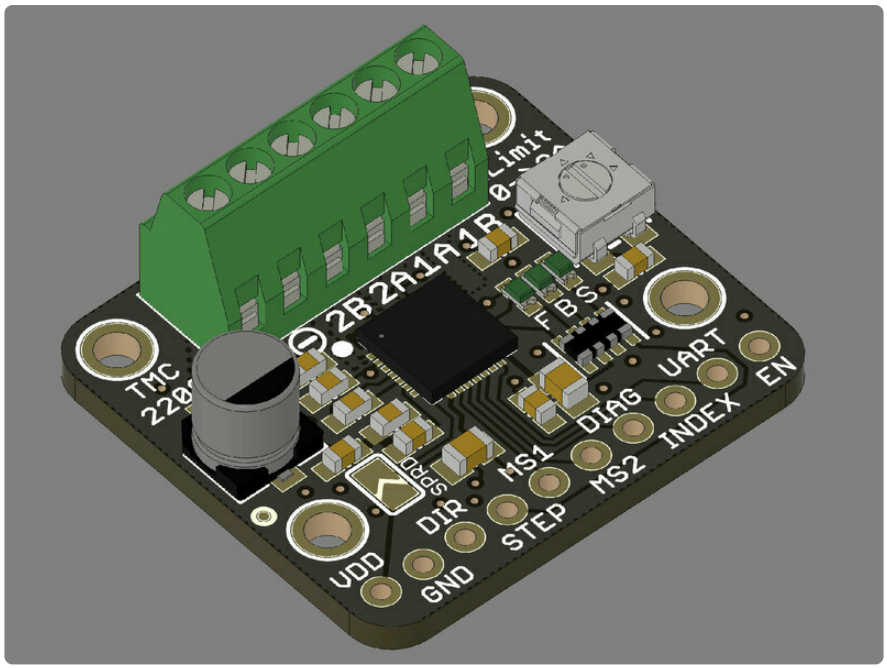
Files

- TMC2209 Datasheet (https://adafru.it/1ac0)
- EagleCAD PCB Files on GitHub (https://adafru.it/1ac1)
- 3D models on GitHub (https://adafru.it/1ac7)
- Fritzing object in the Adafruit Fritzing Library (https://adafru.it/1ac2)

Schematic and Fab Print






2B2A1A1B
F B S
TMC
UART
EN
DIAG
INDEX
MS1
MS2
SPRD
DIR
STEP
VDD
GND