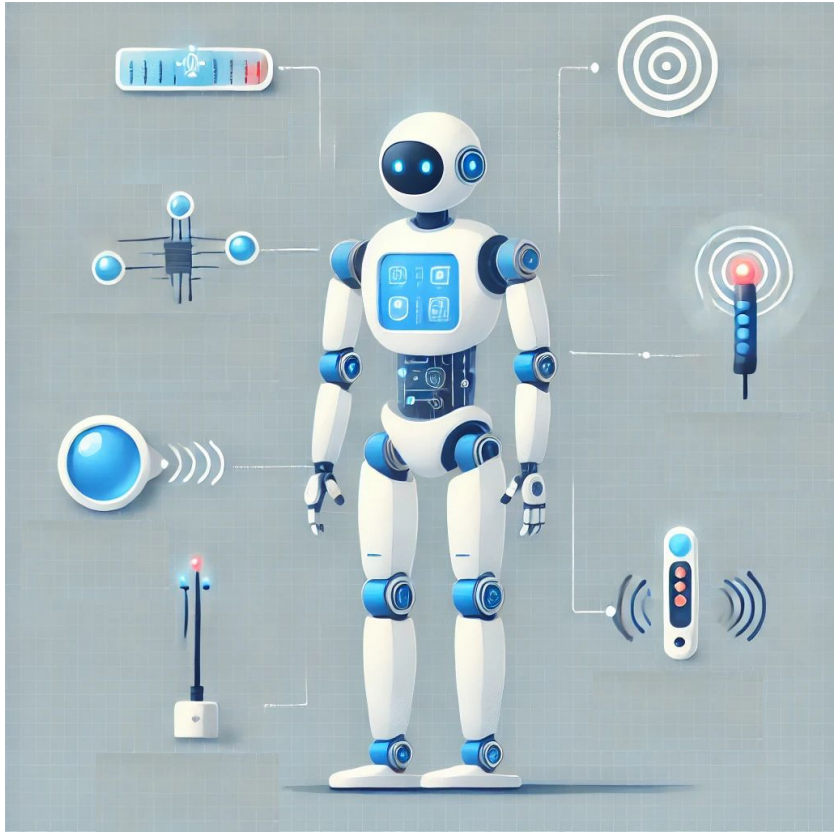
Motors

7/10/2025

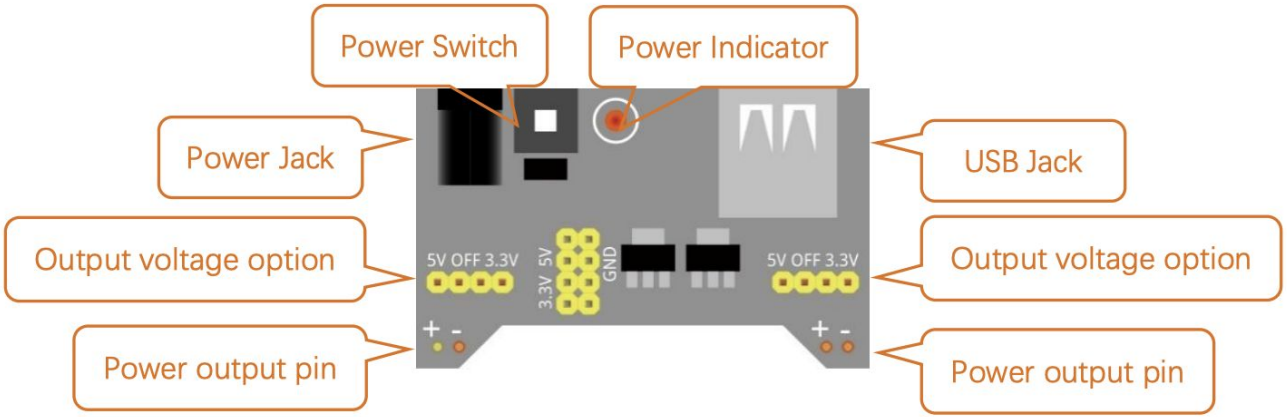
MAYFLOWER
A.S.T.E.M.
ACADEMY



Power Supply

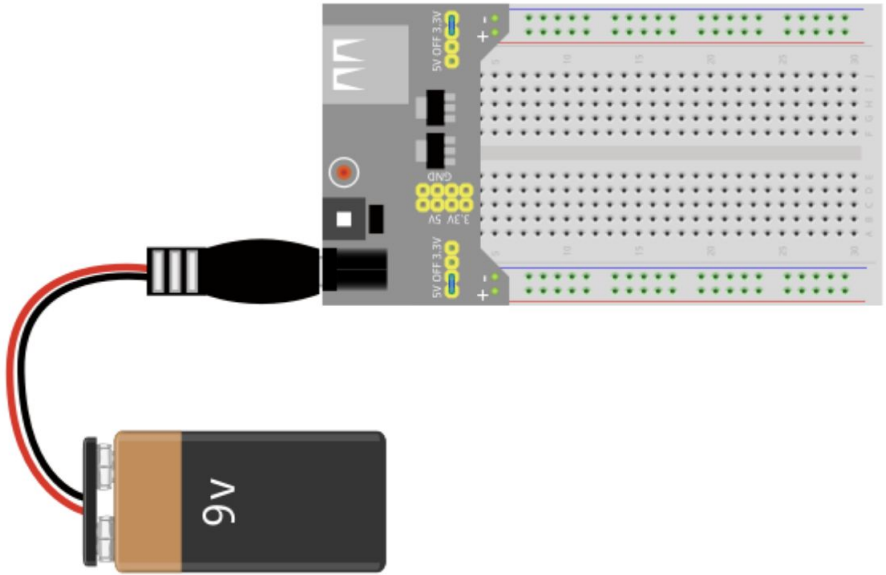
Power supply module for breadboard

The following is the power supply module for breadboard. This module can provide the breadboard with two-channel power supply separately, and each can be configured to 3.3 V or 5 V separately through a jumper.



Power Supply

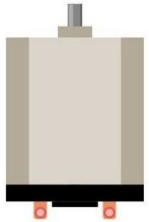
We can build a circuit conveniently by using this module. You only need to provide power supply for this module, and then insert it on the breadboard.



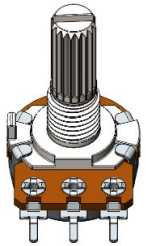
DC Motor & Potentiometer Components

- ADC Module * 1
- Jumper wires
- DC motor * 1
- Rotary potentiometer * 1
- L293D IC Chip * 1

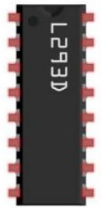
DC Motor x1



Rotary Potentiometer x1

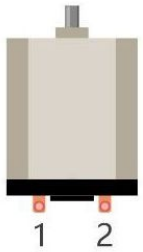


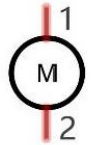
L293D IC Chip



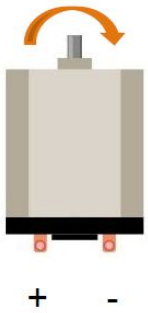
DC Motor

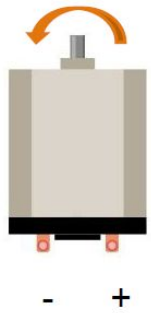
DC Motor is a device that converts electrical energy into mechanical energy. DC Motors consist of two major parts, a Stator and the Rotor. The stationary part of a DC Motor is the Stator and the part that Rotates is the Rotor.





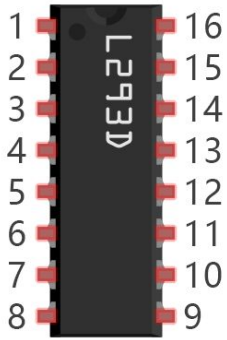
When a DC Motor is connected to a power supply, it will rotate in one direction. If you reverse the polarity of the power supply, the DC Motor will rotate in opposite direction.

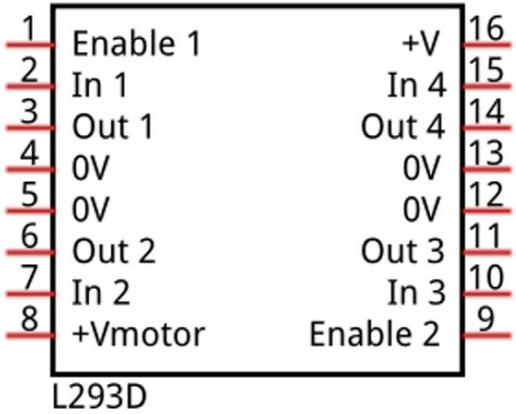




L293D

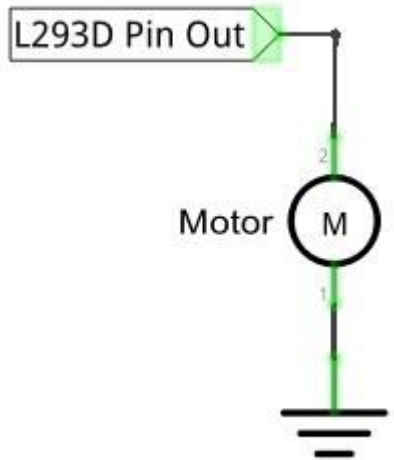
L293D is an IC Chip (Integrated Circuit Chip) with a 4 channel motor drive. You can drive a Unidirectional DC Motor with 4 ports or a Bi Directional DC Motor with 2 ports or a Stepper Motor (Stepper Motors are covered later in this Tutorial).





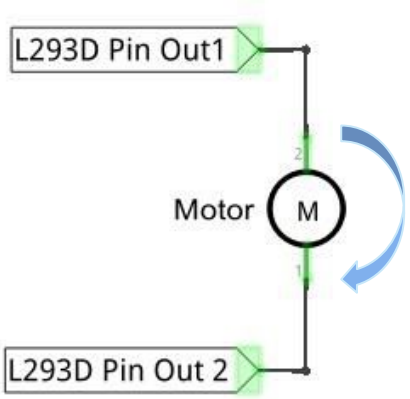
L293D

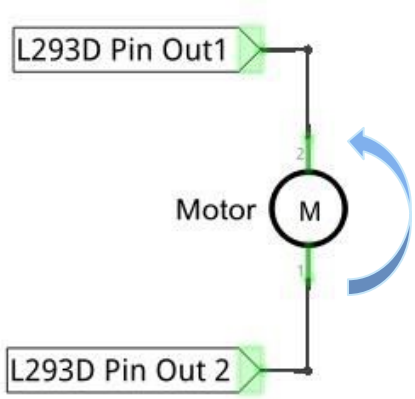
When using the L293D to drive a DC Motor, there are usually two connection options. The following connection option uses one channel of the L239D, which can control motor speed through the PWM, However the motor then can only rotate in one direction.



L293D

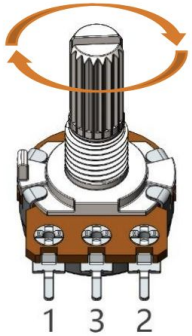
The following connection uses two channels of the L239D: one channel outputs the PWM wave, and the other channel connects to GND. Therefore, you can control the speed of the motor. When these two channel signals are exchanged, not only controls the speed of motor, but also can control the direction of the motor.

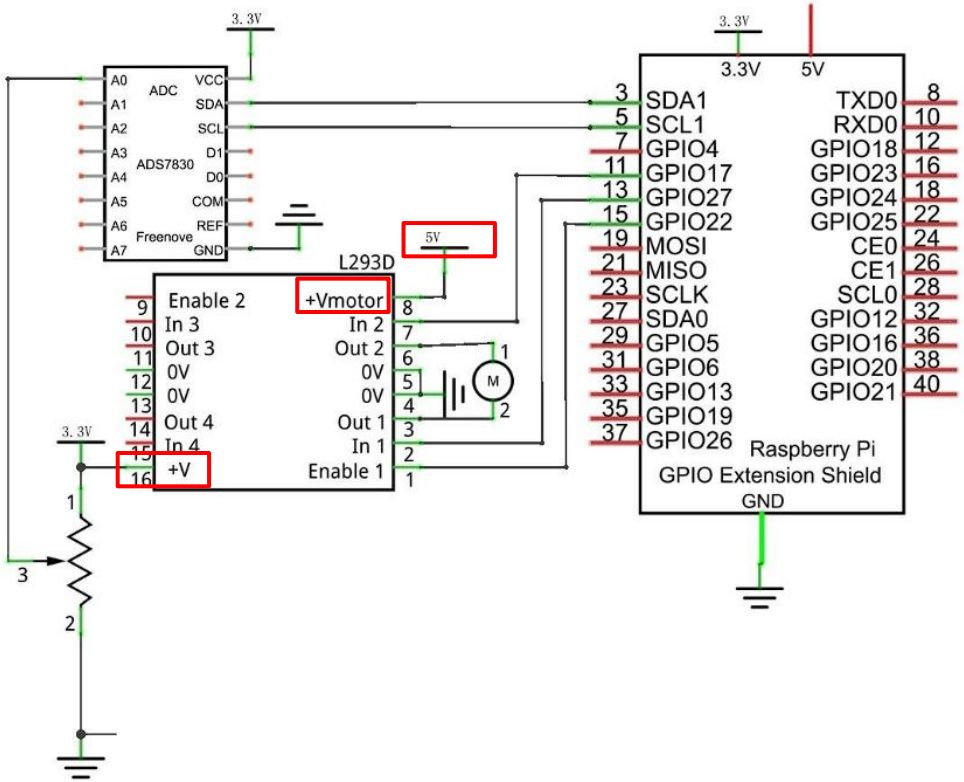


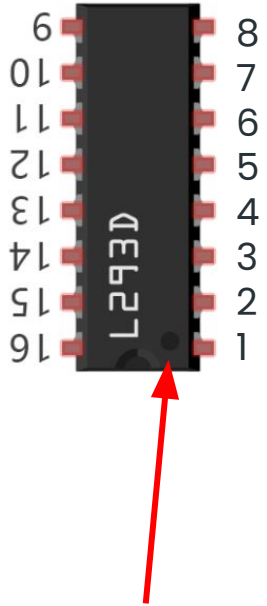


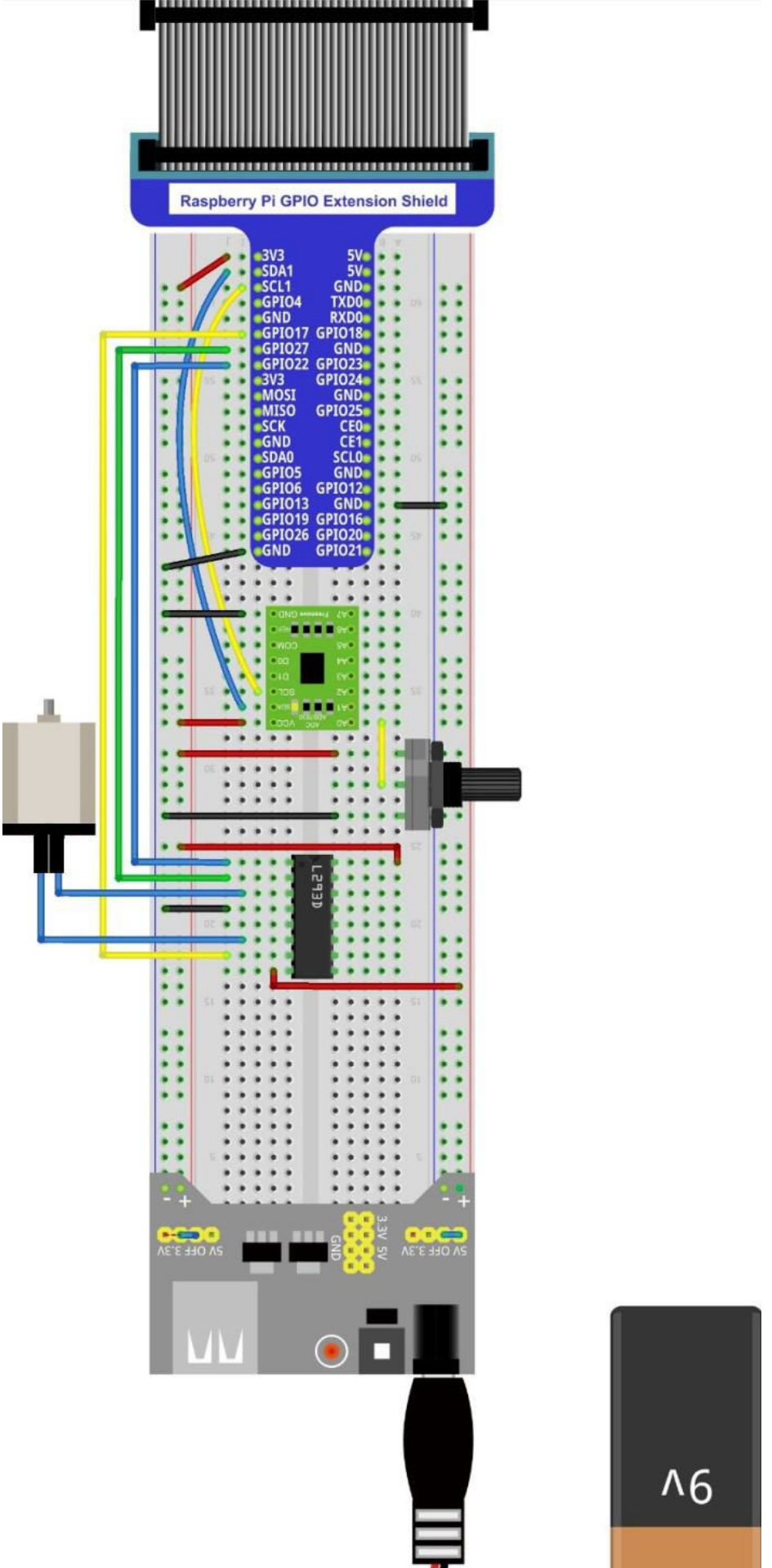
https://github.com/jjia131/ASTEAM-2025-Lab-Resources

DC Motor – Schematic diagram



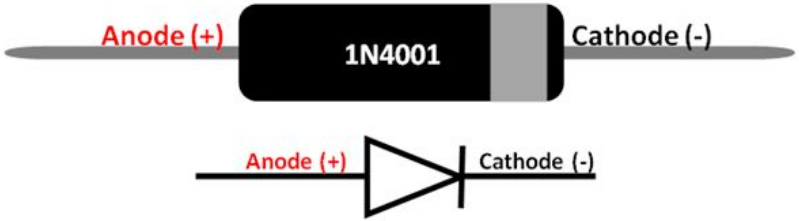





Raspberry Pi GPIO Extension Shield
3V3 5V
SDA1 5V
SCL1 GND
GPIO4 TXD0
GND RXD0
GPIO17 GPIO18
GPIO27 GND
GPIO22 GPIO23
3V3 GPIO24
MOSI GND
MISO GPIO25
SCK CE0
GND CE1
SDA0 SCL0
GPIO5 GND
GPIO6 GPIO12
GPIO13 GND
GPIO19 GPIO16
GPIO26 GPIO20
GND GPIO21
L293D
5V OFF 3.3V
GND
3.3V 5V
5V OFF 3.3V
9V

Relay & Motor Component

- Jumper wire
- Resistor 1kΩ * 1
- NPN transistor (S8050) * 1
- Relay * 1
- Motor * 1
- Push Button * 1
- Diode * 1

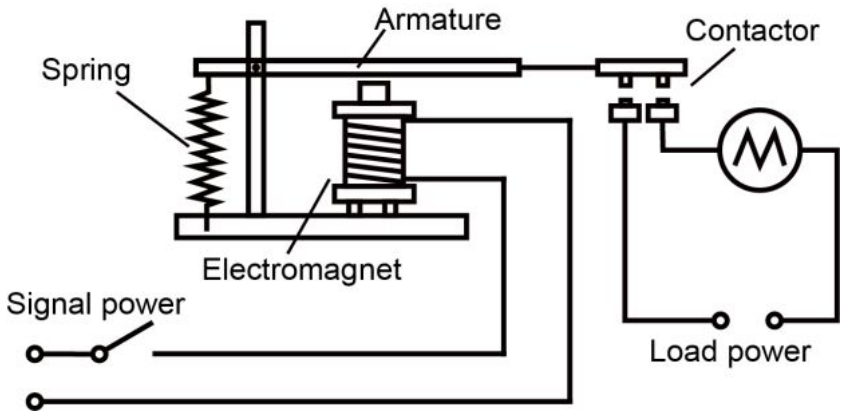


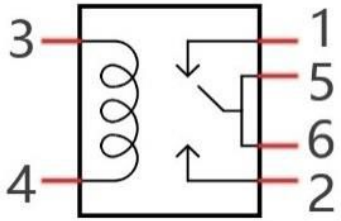
Relay x1

NPN transistor x1

Relay

Relays are electronic switches that open and close circuits using an electromagnet. When energized, the electromagnet attracts internal contacts to complete the circuit. Relays allow a low-powered circuit to control a larger, more powerful one. They are often used in automobiles, such as in the ignition system to control the starter motor.



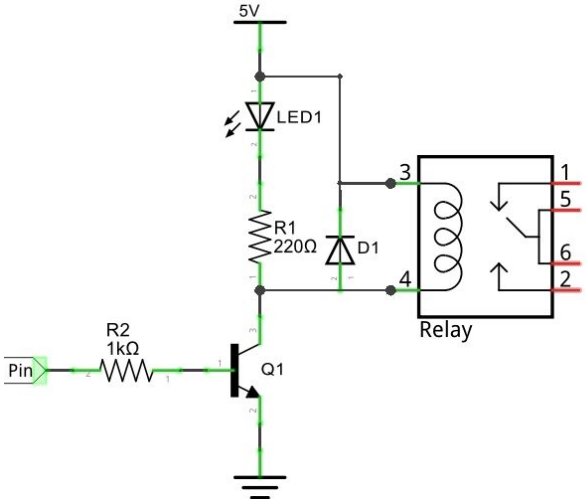


Inductance and Inductors

The symbol for inductance is "L", and the unit is the Henry (H)

Inductor Function: An inductor is a passive device that stores energy in its magnetic field and releases it back into the circuit when needed. It consists of a cylindrical core with many turns of conducting wire, usually copper.

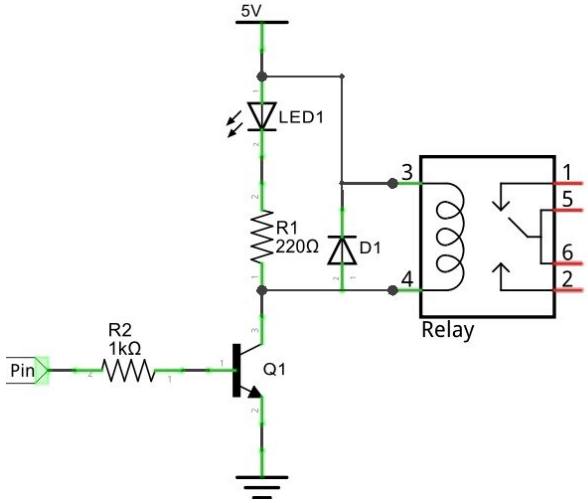
Behavior with Current: Inductors resist changes in current. When the current increases, the inductor opposes the increase. When the current decreases, it opposes the decrease.



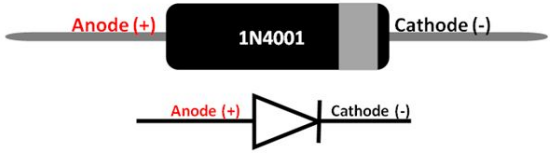
Inductance and Inductors

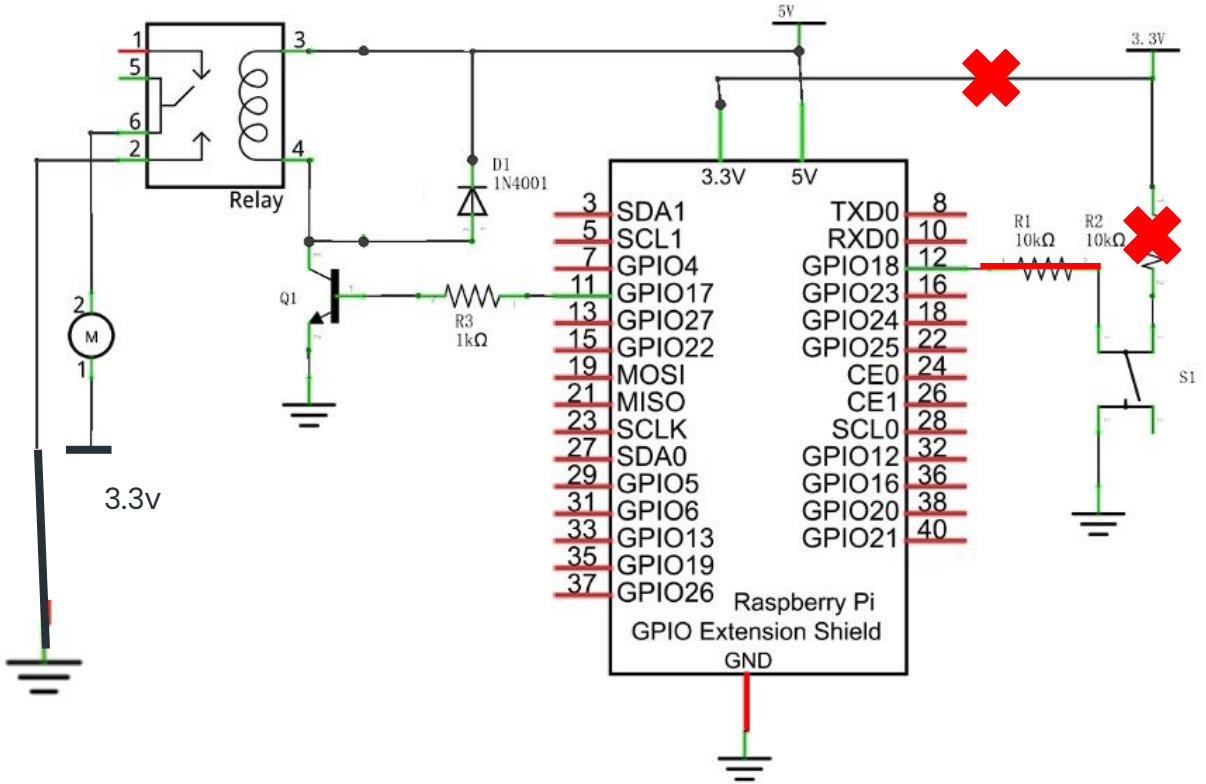
Relay Coil: The coil of a relay functions similarly to an inductor. When a transistor in the coil circuit disconnects power, the current in the relay coil doesn't stop immediately, which can negatively impact the power supply.

Diodes for Protection: To mitigate this issue, diodes are placed in parallel across the relay coil pins in opposite polar directions. This allows the current to pass through the diodes, preventing adverse effects on the power supply.

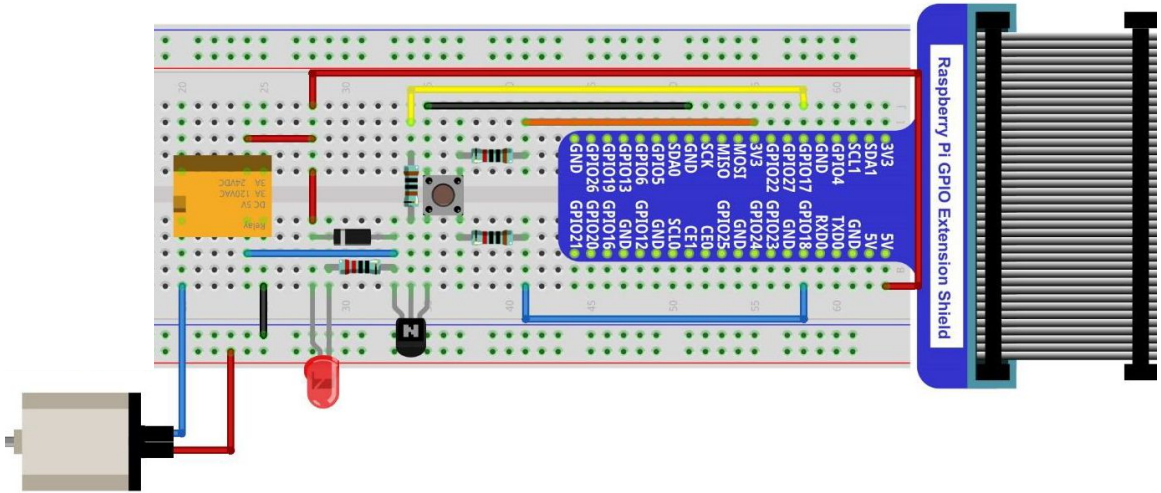


Relay & Motor – Schematic diagram



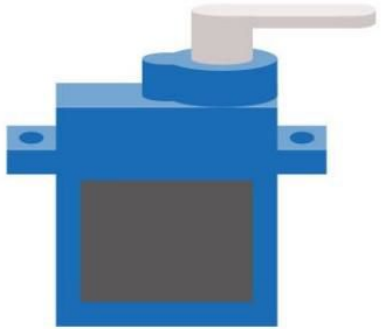


Relay & Motor Connection



Servo Components

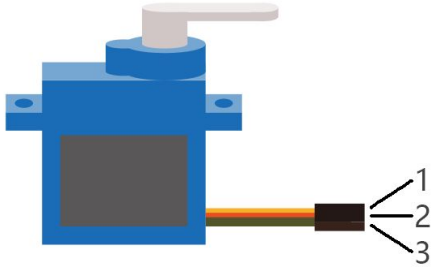
- Servo * 1
- Jumper wires



Servo

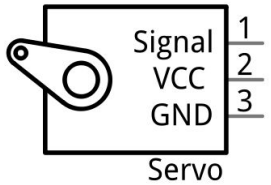
A servo motor is a compact unit consisting of:

- DC Motor
- Reduction gears for increased torque
- Sensor
- Control circuit board



Servos typically have three wires ending in a 3-pin plug:

- Positive (VCC, Red wire)
- Negative (GND, Brown wire)
- Signal (Signal, Orange wire)



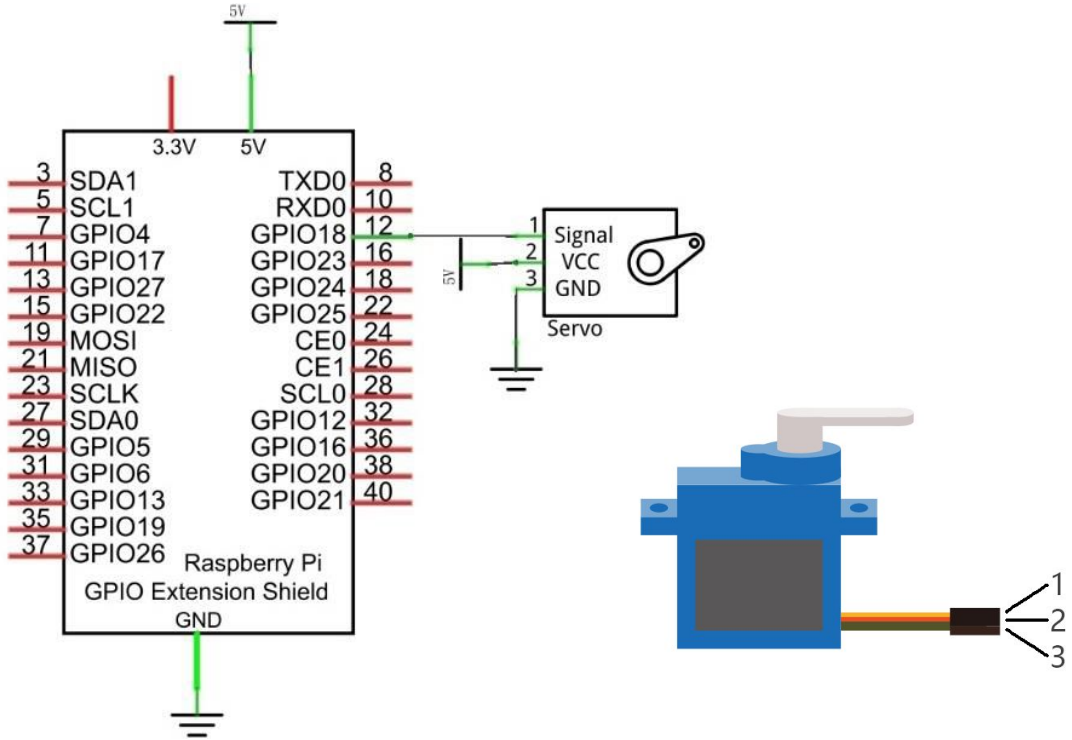
Servo Control Signal

PWM Signal: Use a 50Hz PWM signal with a specific duty cycle to drive the servo.

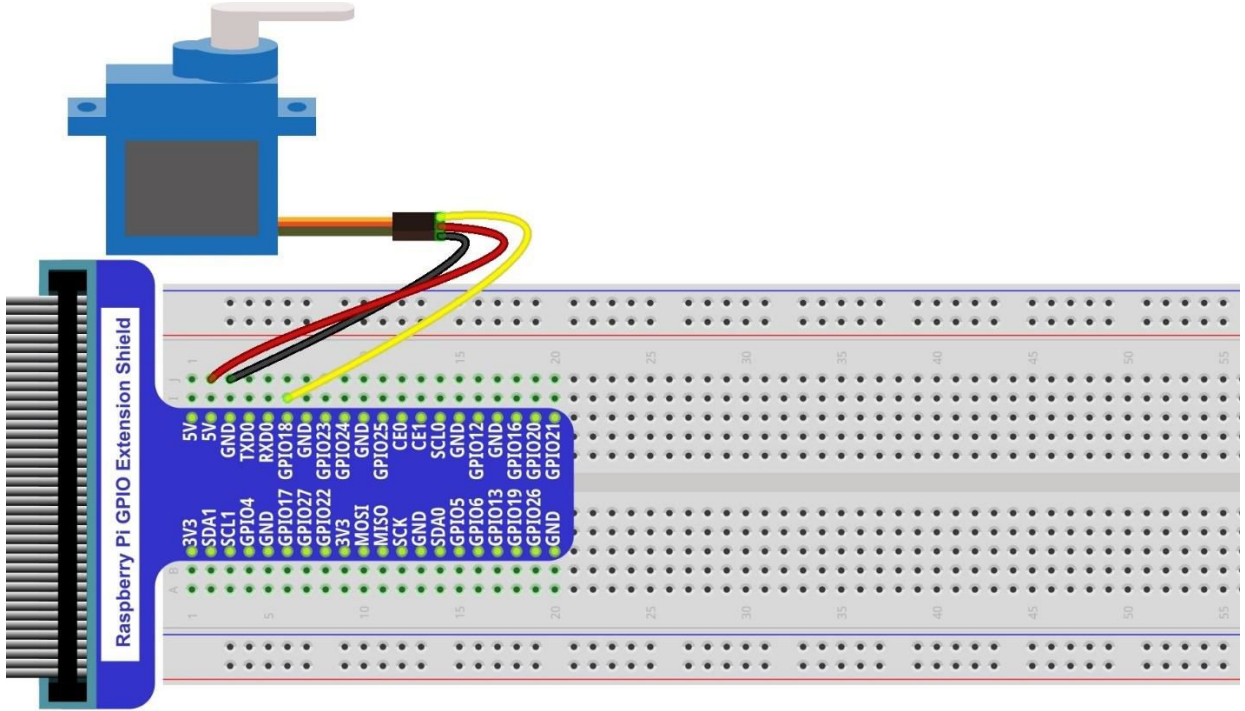
Pulse Duration:

High Level time	Servo Angle
0.5 ms	0 degree
1 ms	45 degree
1.5 ms	90 degree
2 ms	135 degree
2.5 ms	180 degree

Servo Schematic Diagram

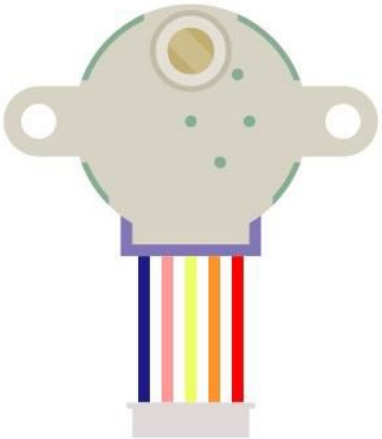


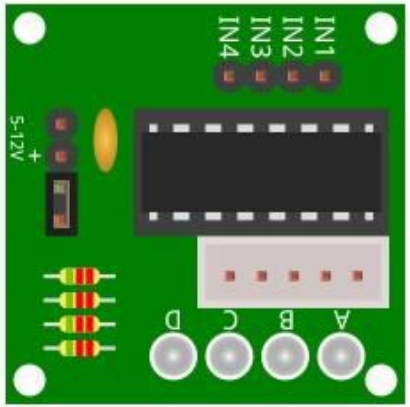
Servo Hardware Connection



Stepper Motor Component

- Jumper wires
- Stepper motor * 1
- ULN2003 Stepper Motor Driver * 1



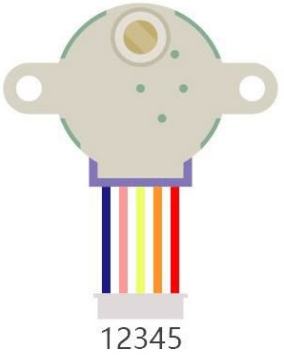


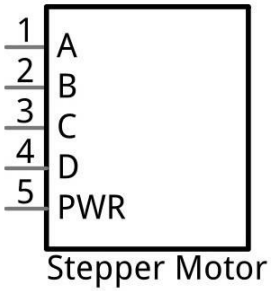
Stepper Motor

A stepper motor is an open-loop control device that converts electronic pulse signals into angular or linear displacement.

Control: The speed and position of the motor depend solely on the pulse signal frequency and number of pulses, unaffected by load changes, unlike a DC motor.

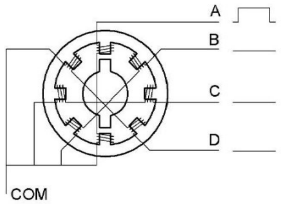
Operation: In non-overload conditions, the motor's performance remains consistent based on the input signals.

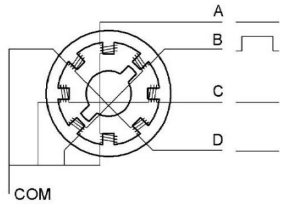


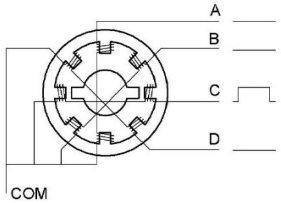


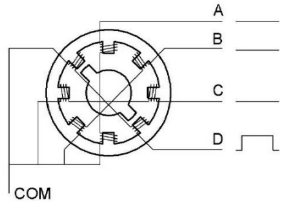
Stepper Motor

- Step Control: The rotation angle is controlled by the number of steps.
- Speed Control: The time interval between steps determines the rotation speed.
- Clockwise Rotation: Powering the coils in the sequence A → B → C → D → A, the rotor rotates step by step in four steps.
- Counterclockwise Rotation: Reversing the sequence to D → C → B → A → D causes counterclockwise rotation.





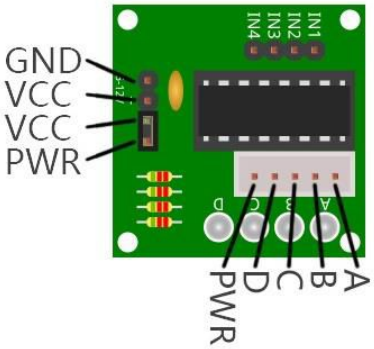


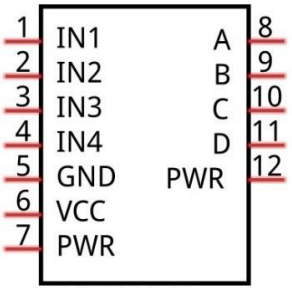


ULN2003 Stepper Motor driver

Converts weak signals into powerful control signals to drive a stepper motor.

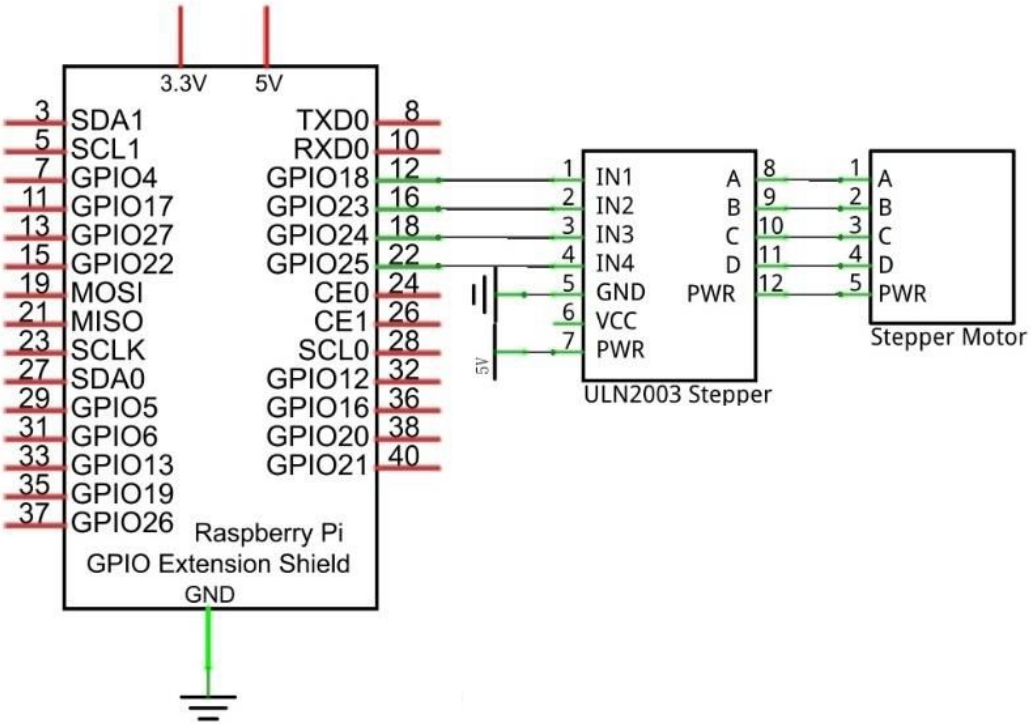
- Input Signals: IN1 to IN4 correspond to the output signals A to D.
- LED Indicators: The board includes 4 LEDs to indicate the state of these signals.
- Power Interface (PWR): Used as a power supply for the stepper motor.
- Default Connection: By default, PWR and VCC are connected.

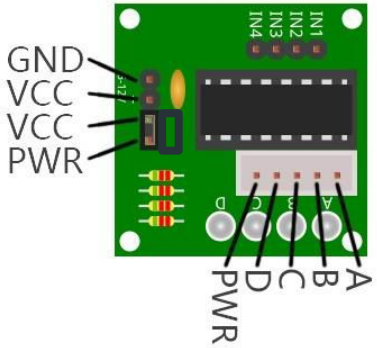


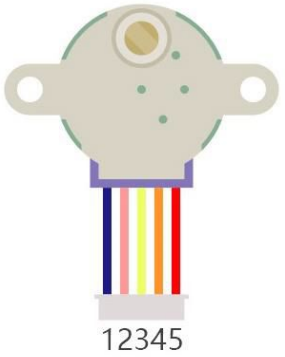


ULN2003 Stepper Motor Driver

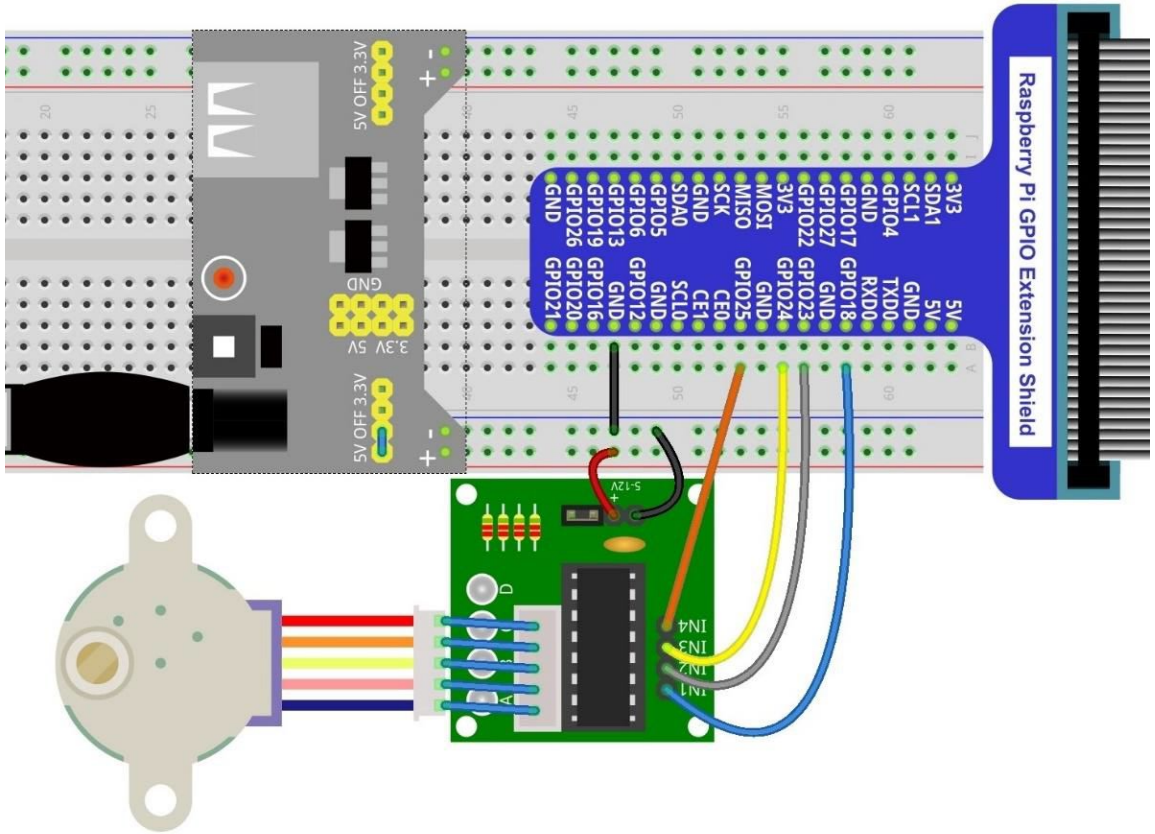
Stepper Motor Schematic Diagram





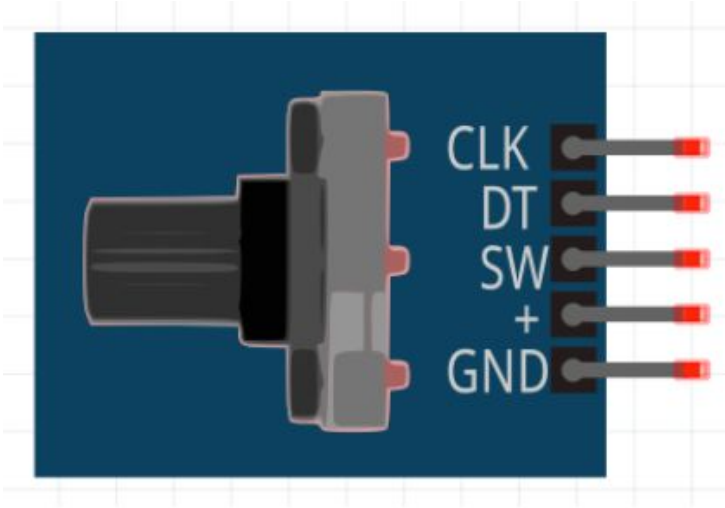


Stepper Motor Hardware Connection



Rotary Encoder – Components

- Rotary Encoder * 1
- Jumper Wires



Rotary Encoder

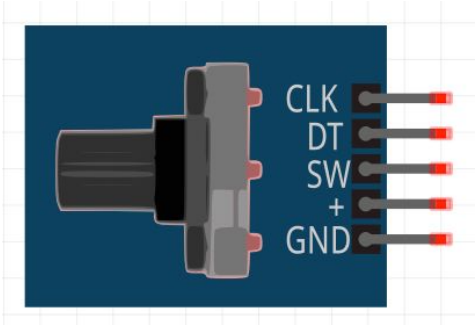
A rotary encoder is a sensor that converts rotational displacement into a periodic electrical signal, which is then converted into count pulses to indicate the magnitude of the rotational displacement.

- **Knob Rotation:** The rotation of the knob drives an internal grating disc.
- **Grating Disc:** The disc has many preset slits.
- **Light Source:** As the grating disc rotates, light passes through the slits, creating pulse changes.
- **Pulse Signal:** These changes are processed by the subsequent circuit to produce a pulse signal.
- **Output:** The rotational displacement of the knob is obtained from the signal pin's output

Rotary Encoder

Pulses per Revolution: 20

Working Voltage: 5V

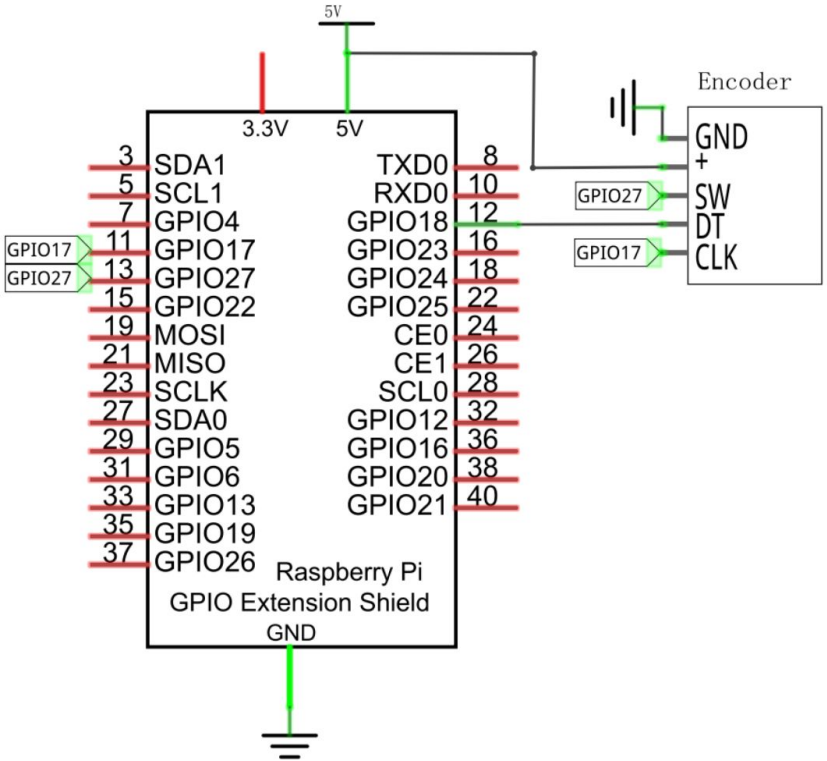


- SW: Input signal pin
- CLK: Rotation signal pin
- DT: Direction signal pin
- VCC: Power supply positive pin
- GND: Power supply negative pin

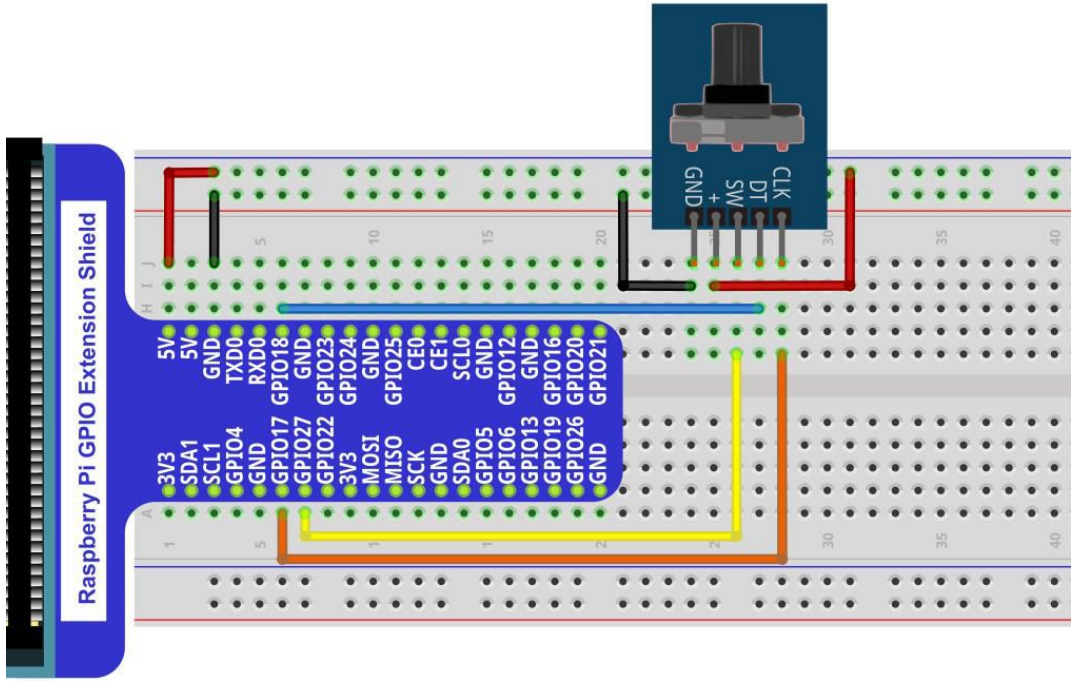
Clockwise Rotation: CLK outputs low level, DT changes from high to low.

Counterclockwise Rotation: CLK outputs low level, DT changes from low to high

Rotary Encoder – Schematic diagram

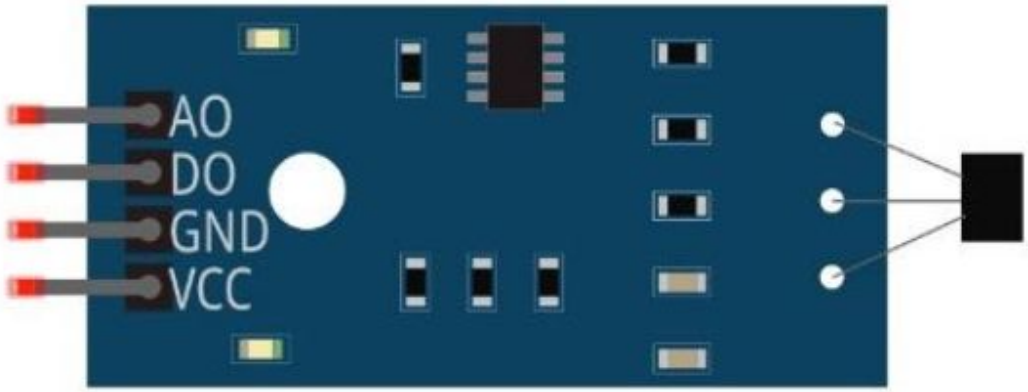


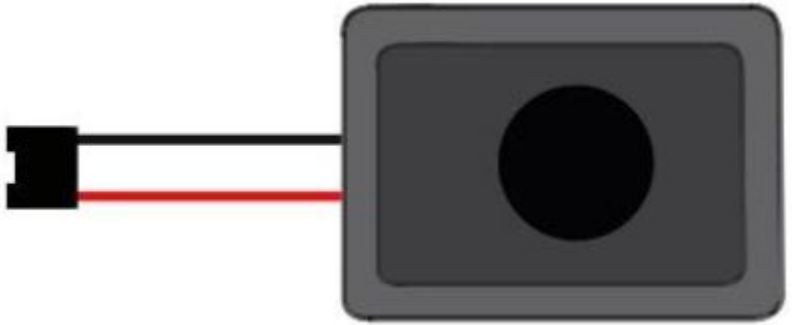
Rotary Encoder – Hardware Connection



Hall Sensor - Components

- Hall Sensor * 1
- Led * 1
- Resistor 220 Ω * 1
- Speaker * 1
- Jumper Wires





Hall Sensor - Schematic diagram