

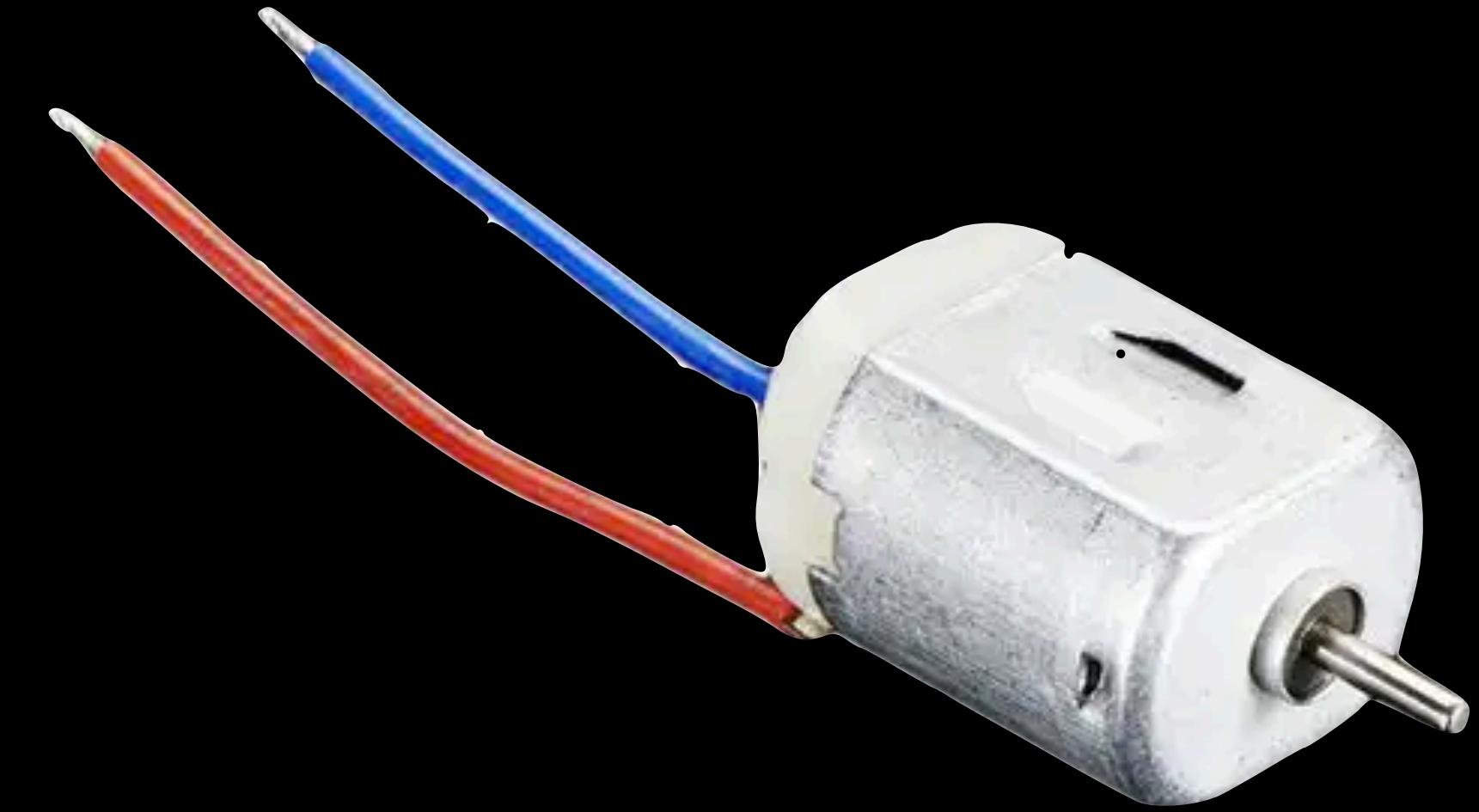
DC Motor



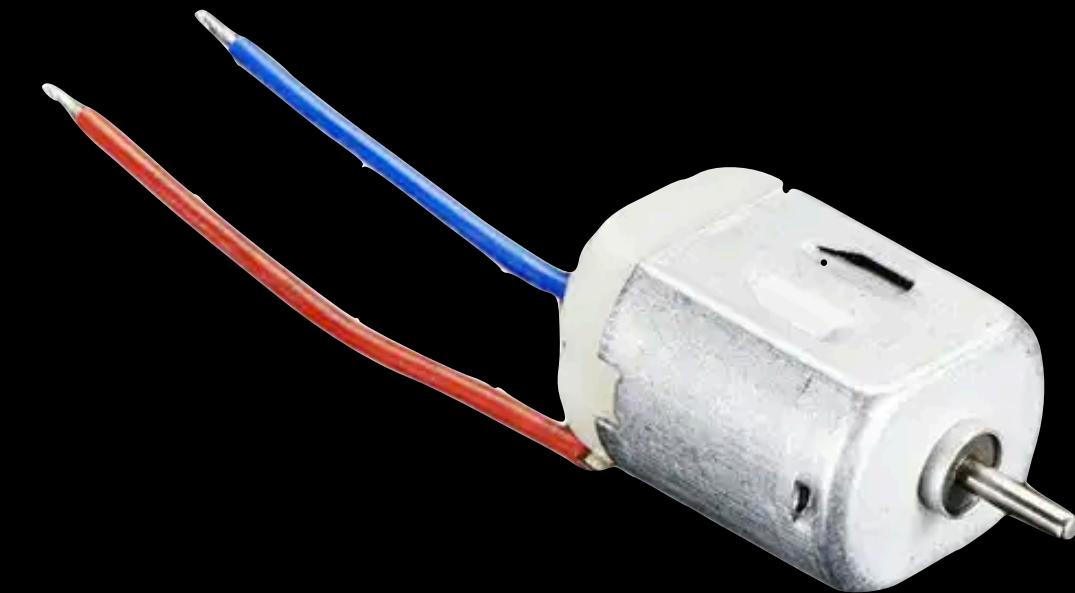
Servo Motor



Stepper Motor

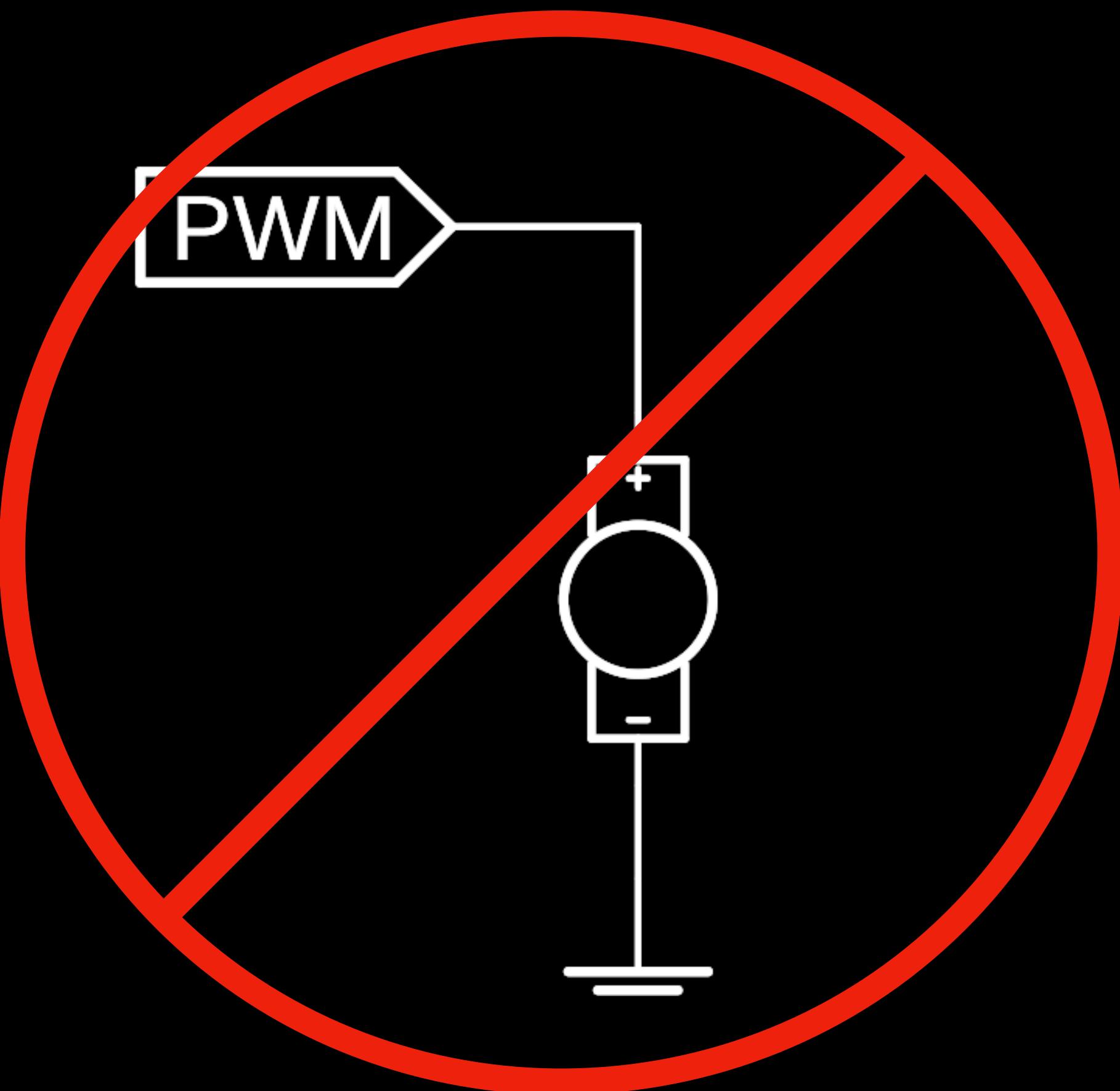


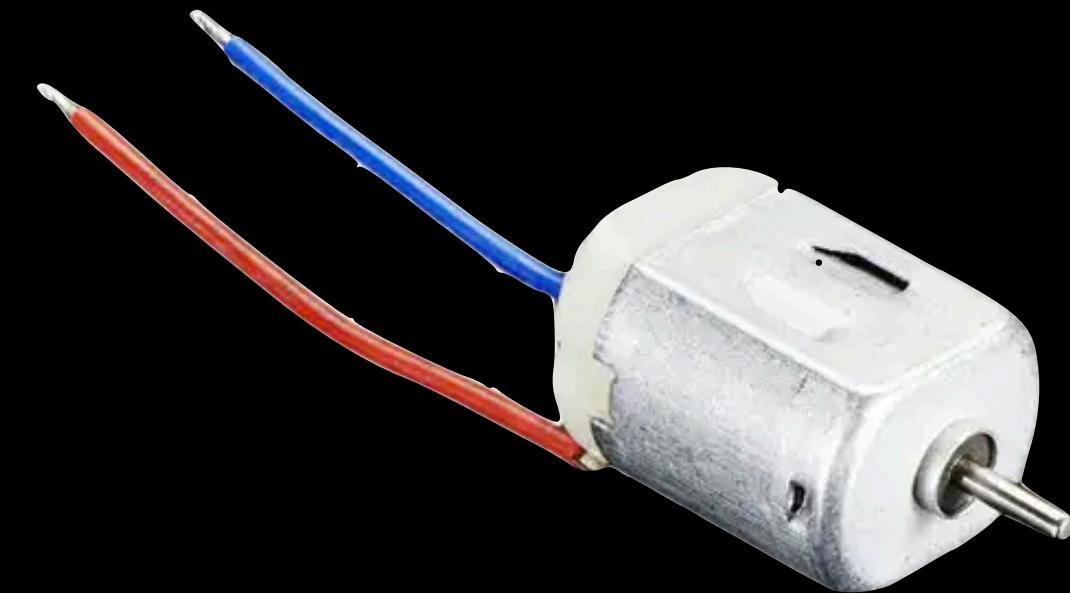
DC Motor



(Brushed) DC Motor

- Control **speed** via PWM



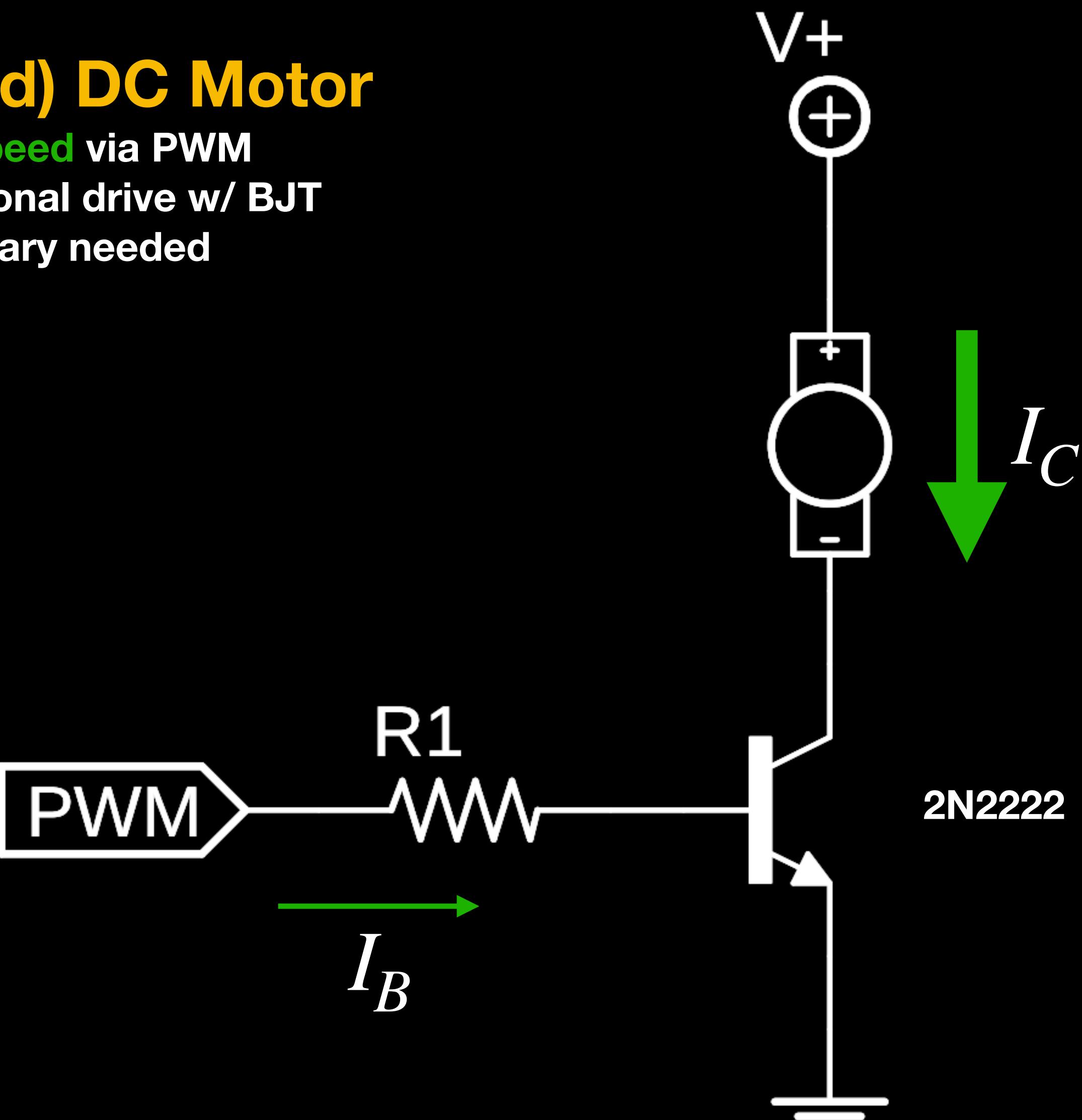


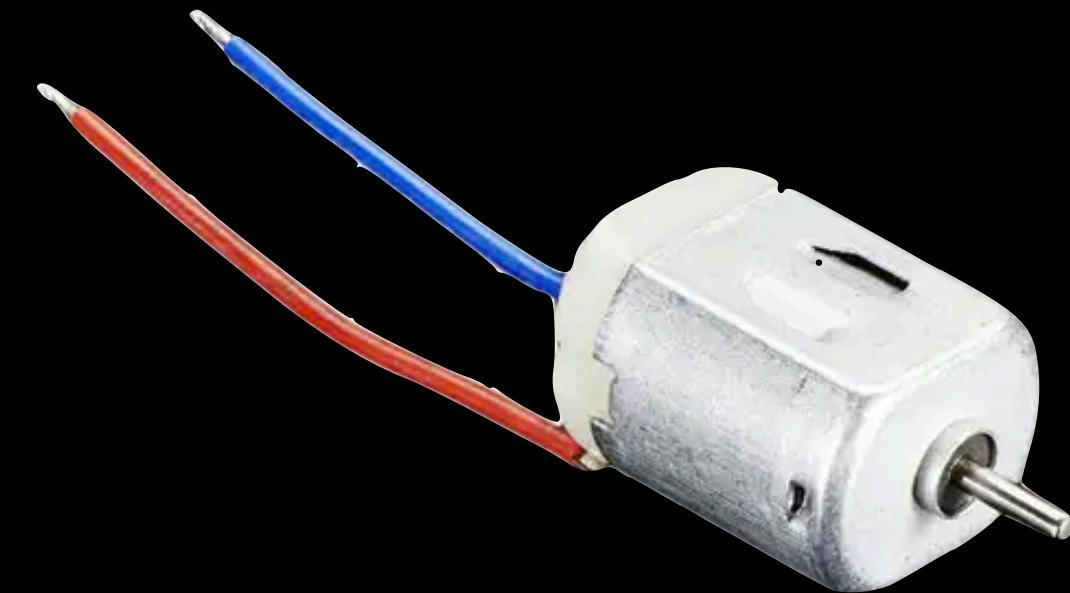
(Brushed) DC Motor

- Control **speed** via PWM
- Unidirectional drive w/ BJT
 - No library needed

Maximum Ratings

Characteristic	Symbol	Value	Unit
Collector – Emitter Voltage	V_{CEO}	40	Vdc
Collector – Base Voltage	V_{CBO}	75	Vdc
Emitter – Base Voltage	V_{EBO}	6.0	Vdc
Collector Current – Continuous	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625 5.0	mW $\text{mW}/^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.5 12	W $\text{mW}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C



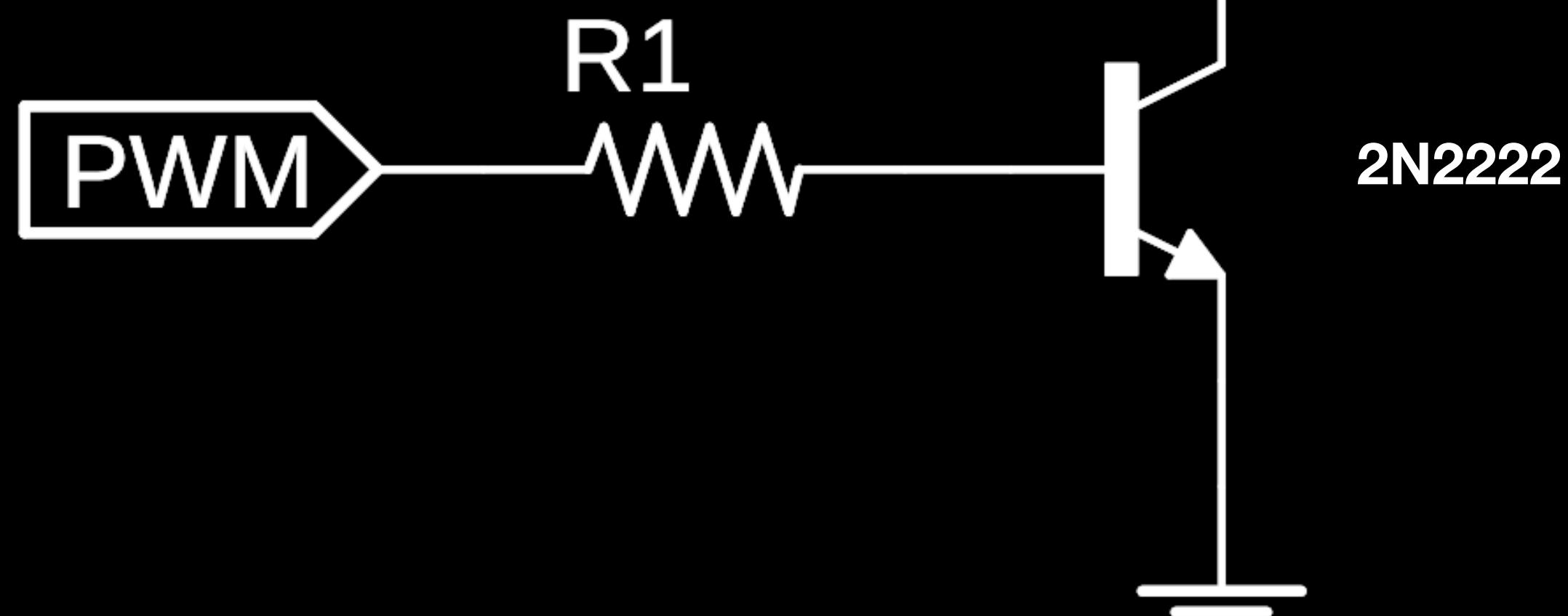


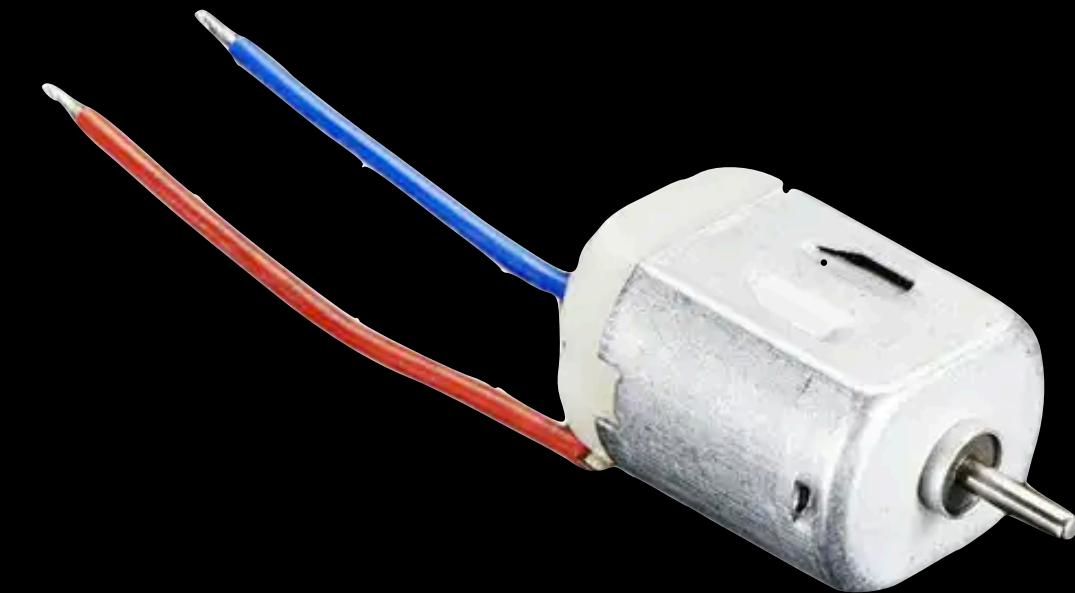
(Brushed) DC Motor

- Control **speed** via PWM
- Unidirectional drive w/ BJT
 - No library needed

“Flyback”

- Large voltage transients occurring on the falling edge of a switched inductor's current



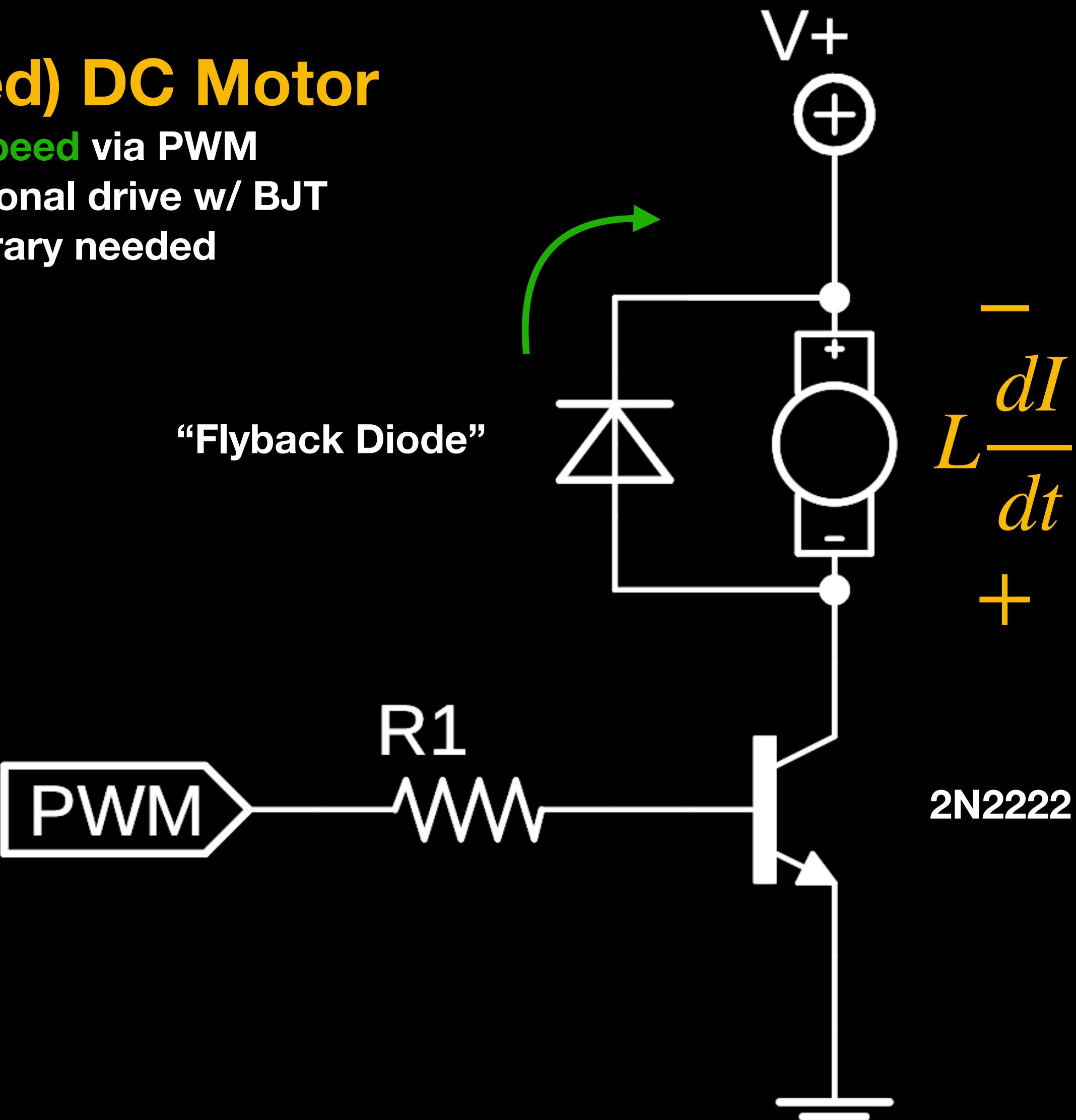


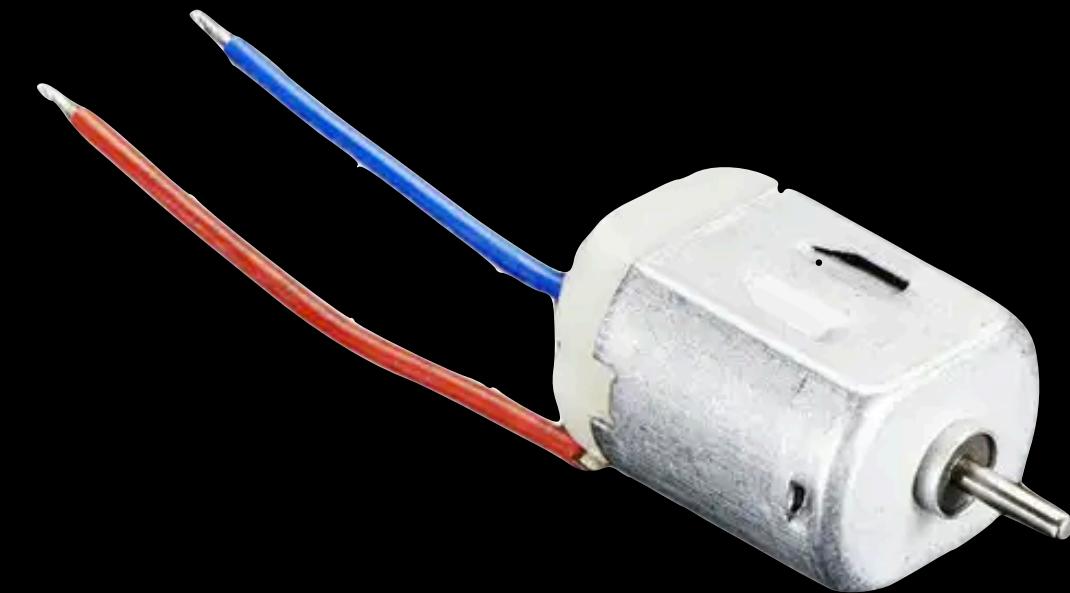
(Brushed) DC Motor

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“Flyback”

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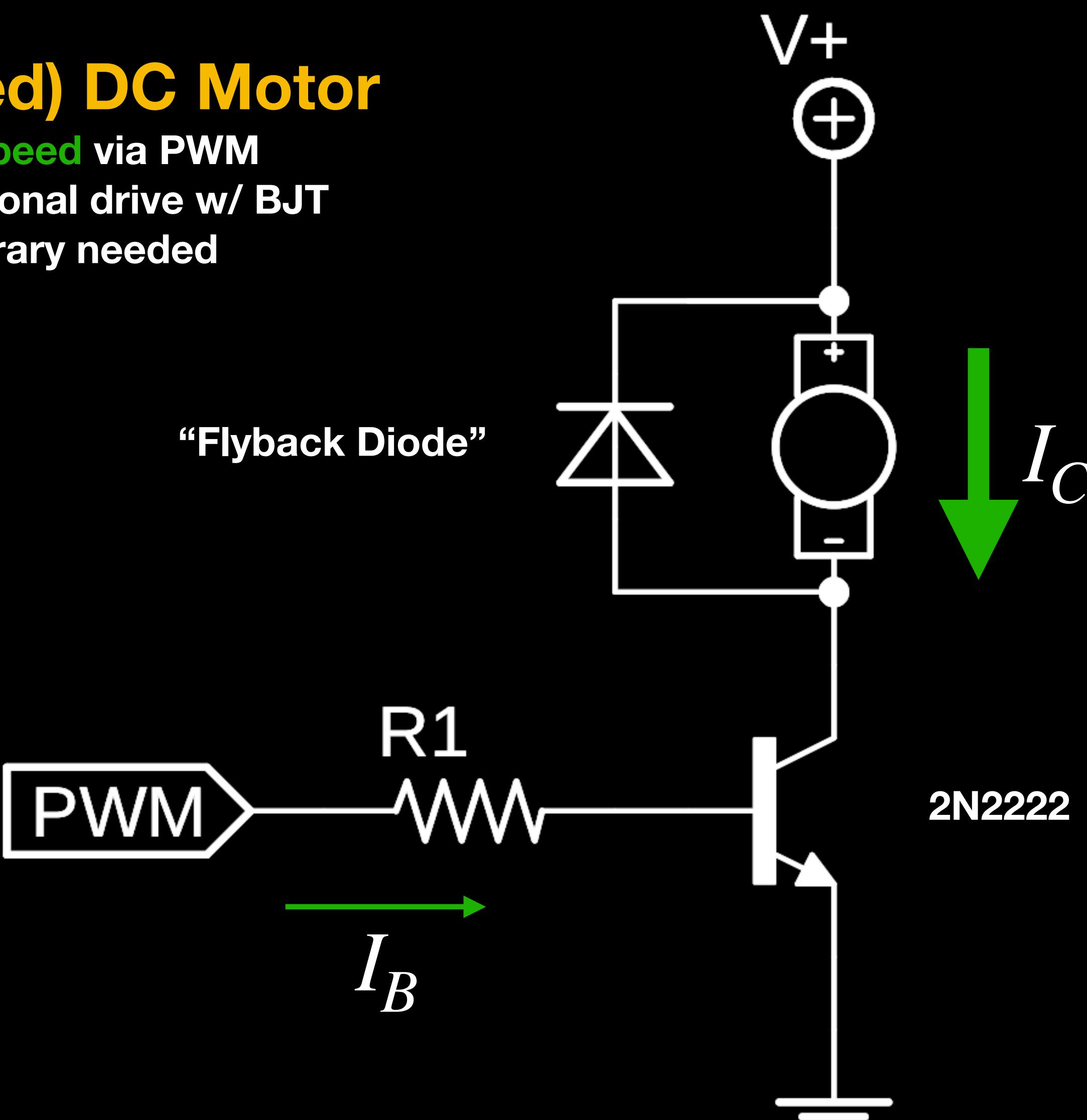


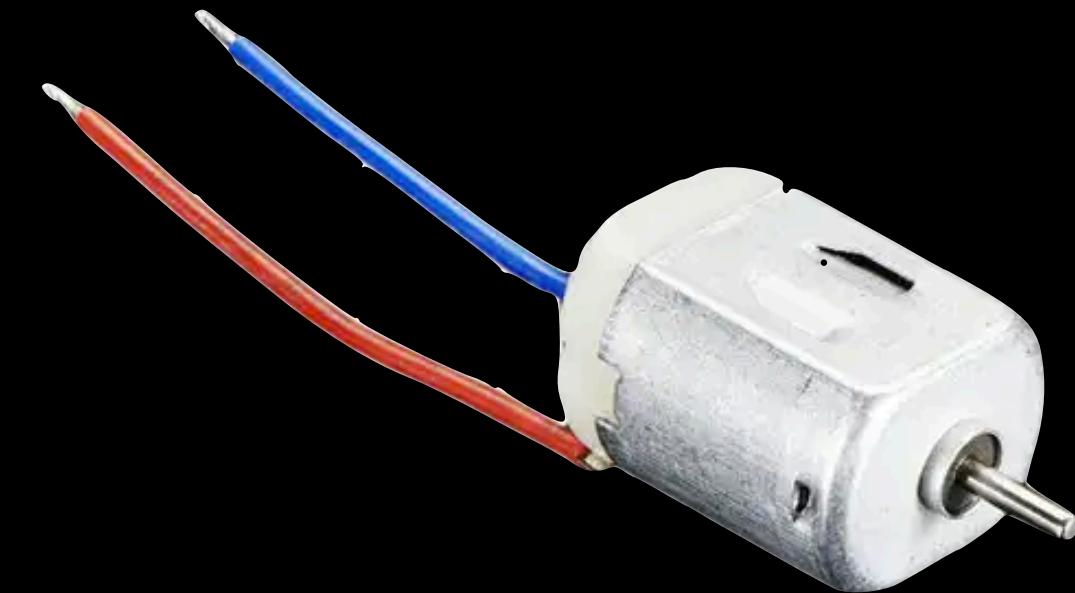
(Brushed) DC Motor

- Control **speed** via PWM
- Unidirectional drive w/ BJT
 - No library needed

“Flyback”

- Large voltage transients occurring on the falling edge of a switched inductor’s current



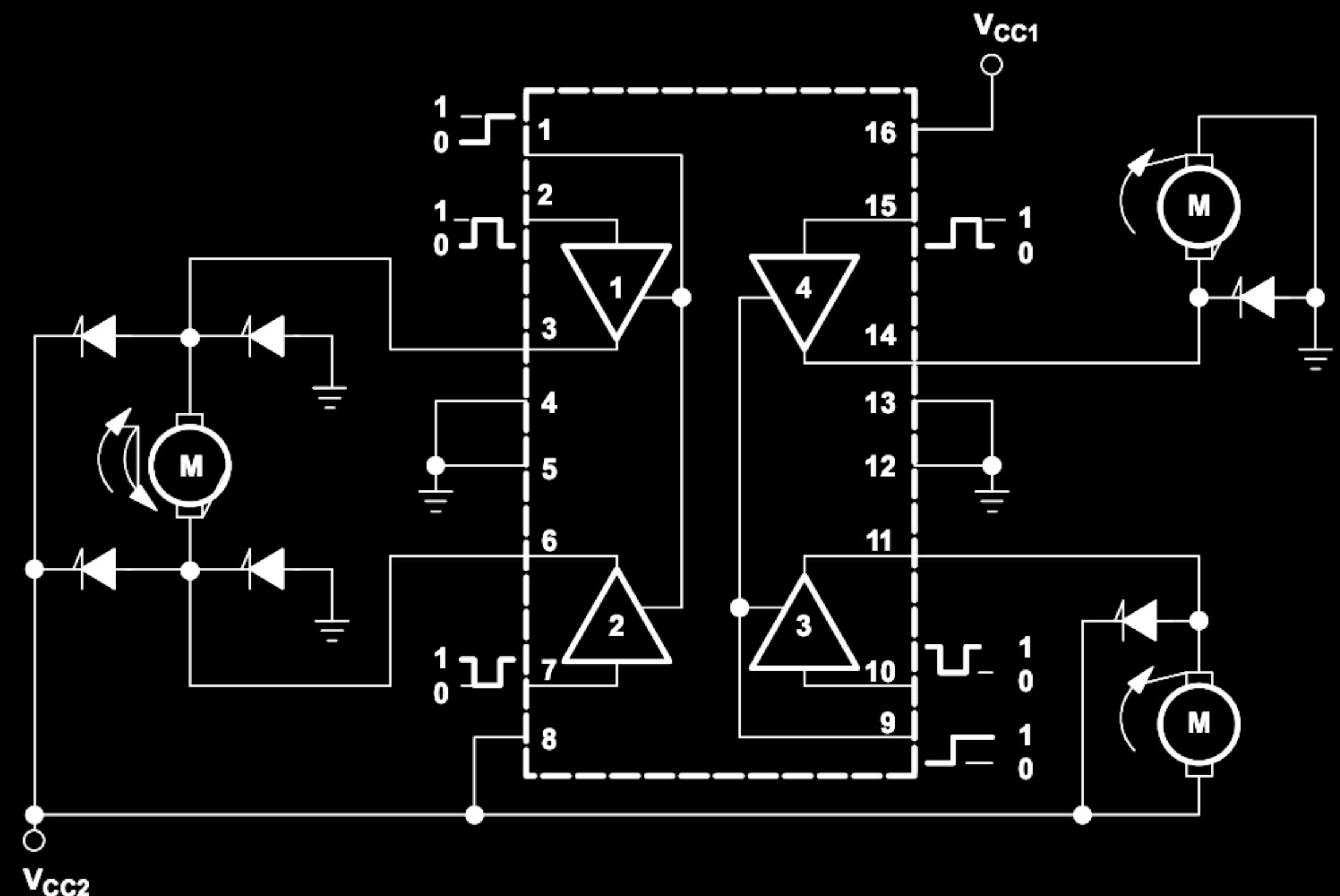
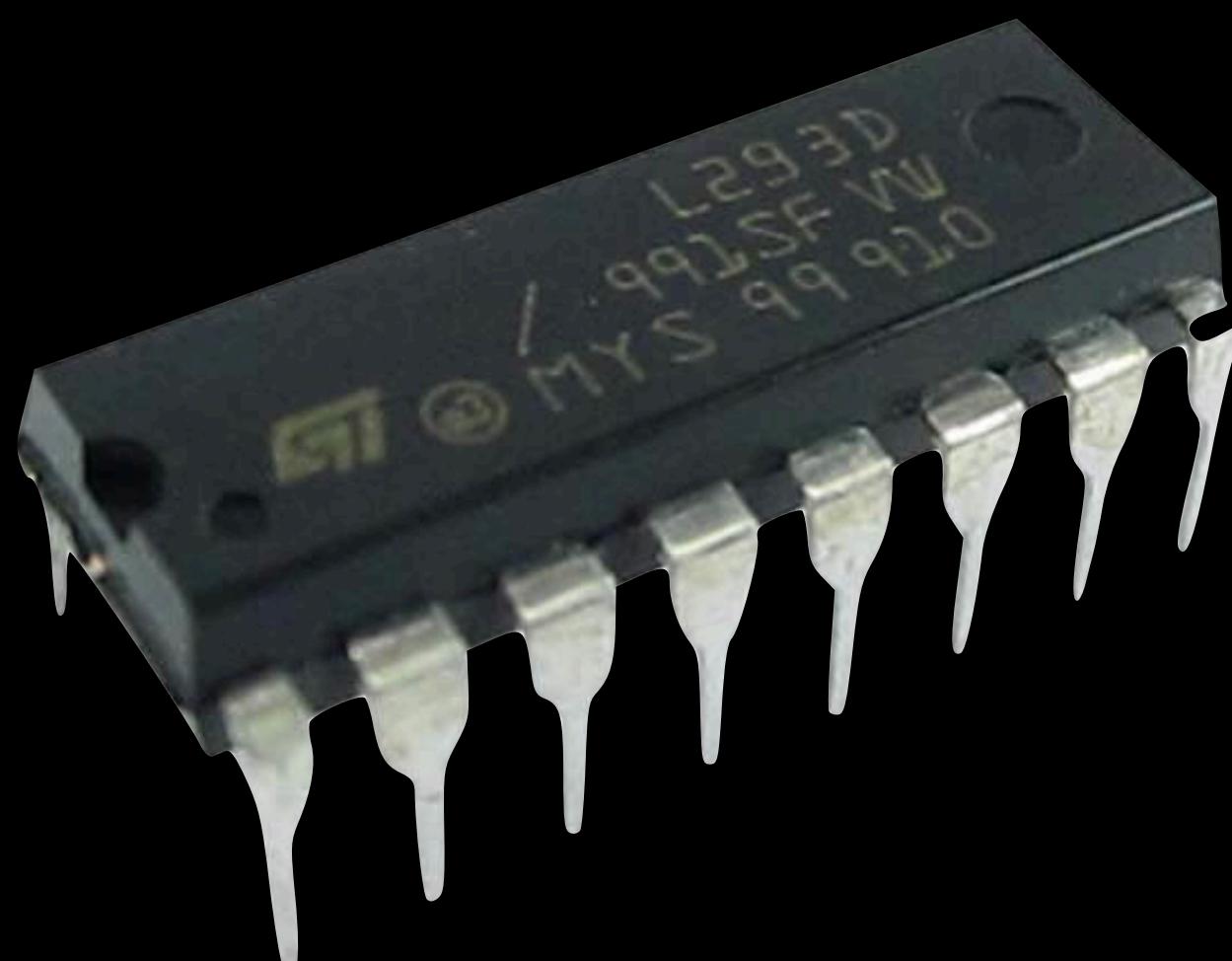


(Brushed) DC Motor

- Control **speed** via PWM
- Unidirectional drive w/ BJT
- Bidirectional drive w/ H-Bridge
 - Still no library needed

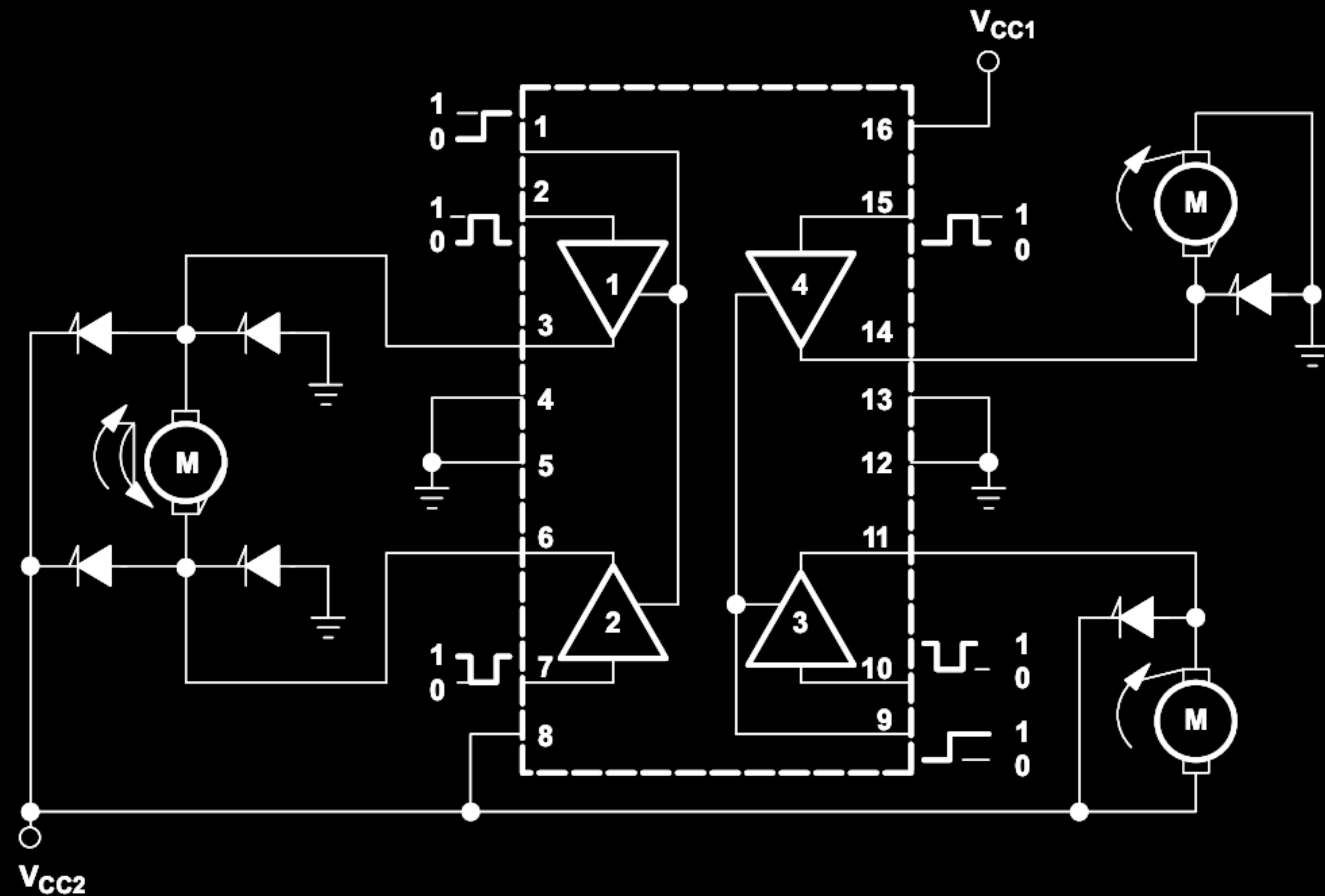
LD293D Quad Half-H Driver

- Use pairs of channels for bidirectional drive (Fig 1, left)
- Use individual channels for unidirectional drive (Fig 1, right)



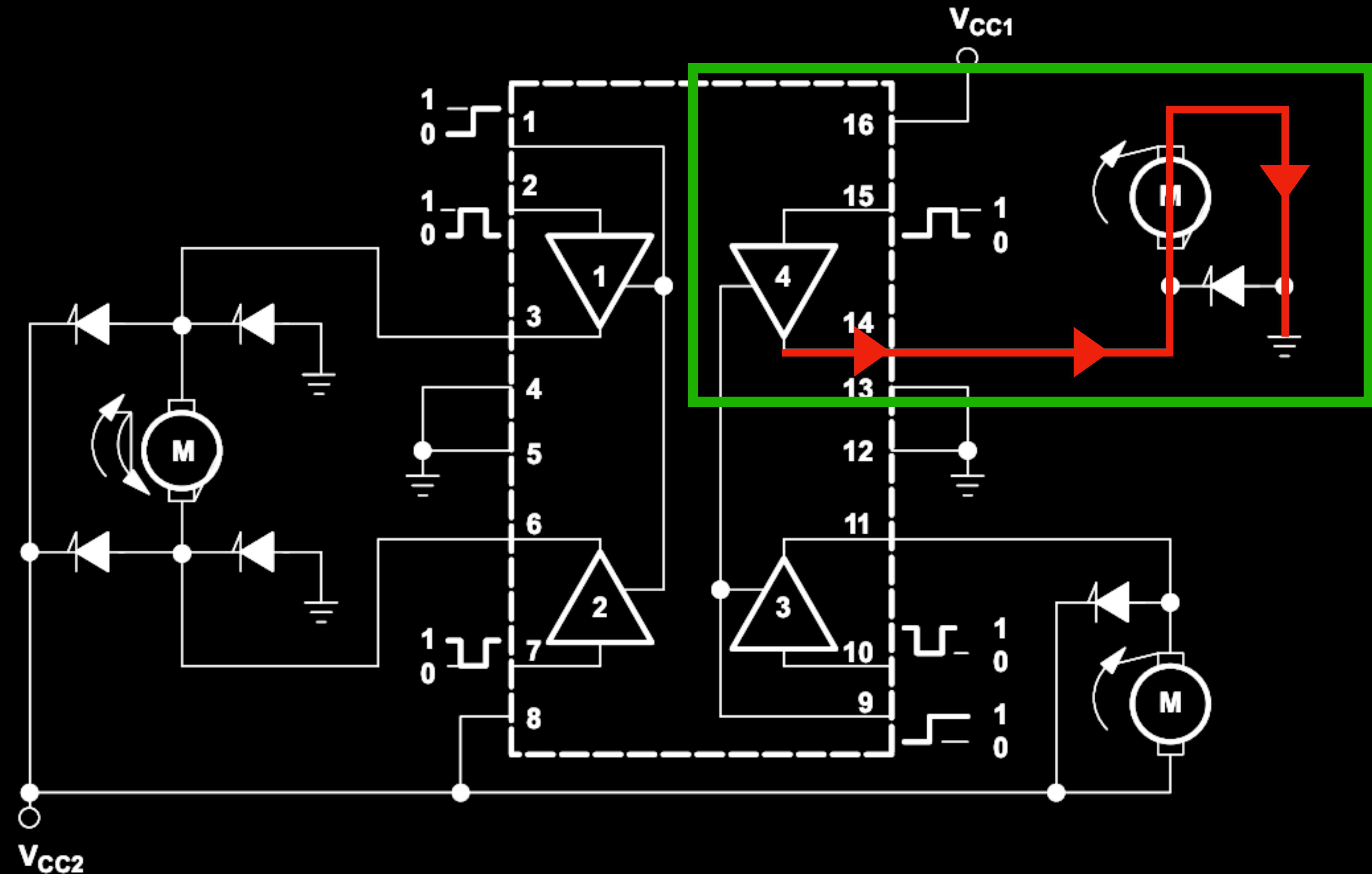
Output diodes are internal in L293D.

Fig 1



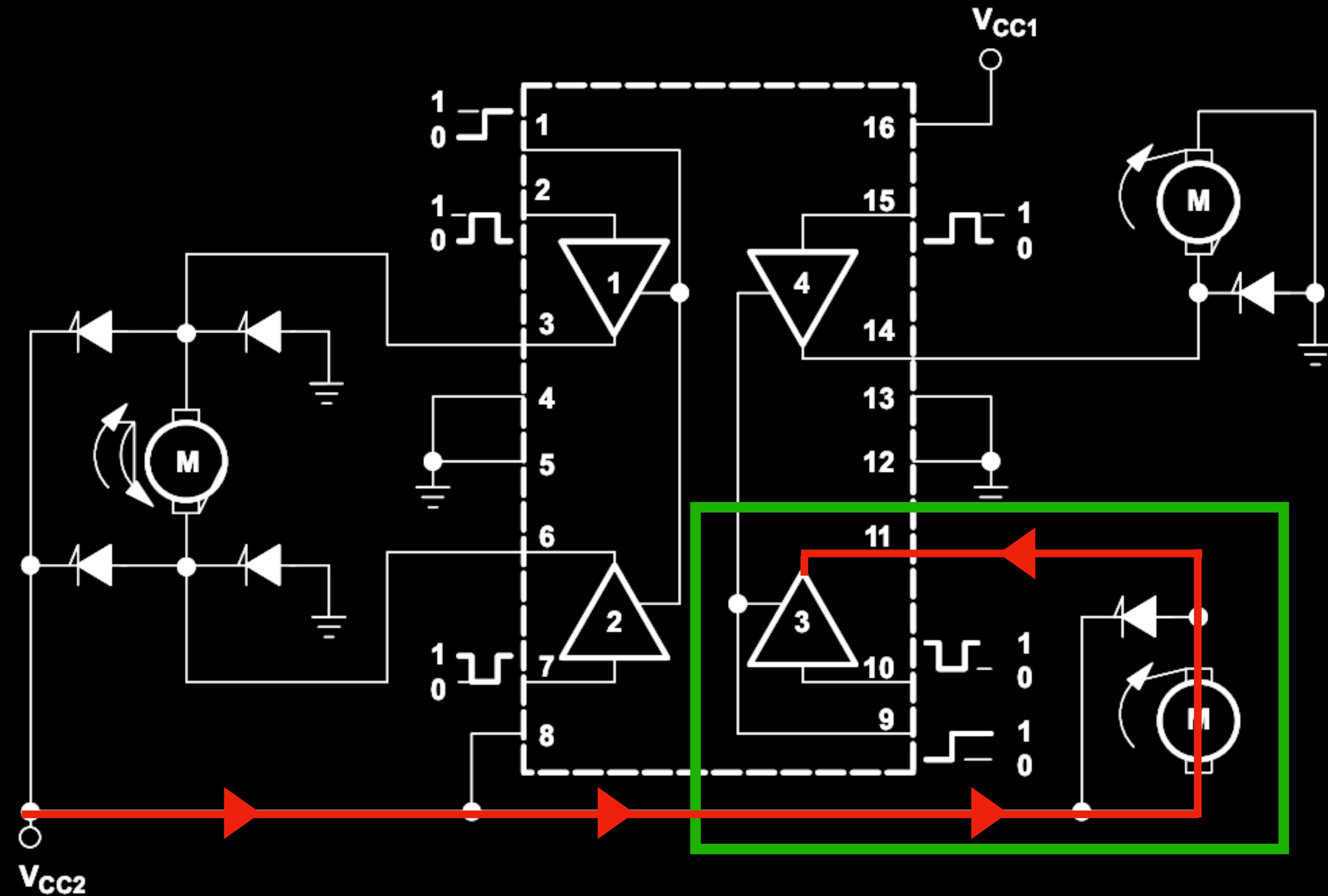
Output diodes are internal in L293D.

Fig 1



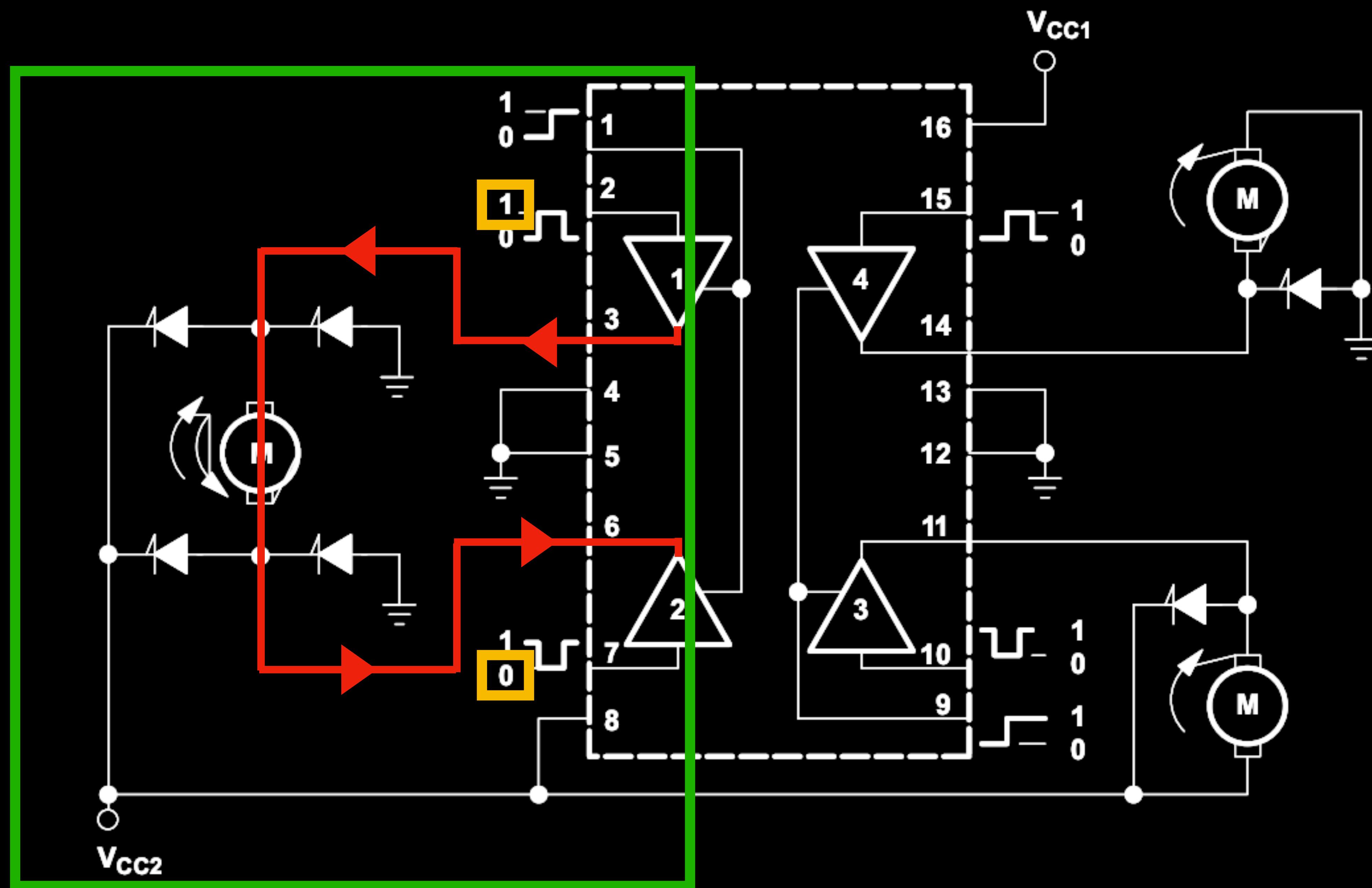
Output diodes are internal in L293D.

Fig 1



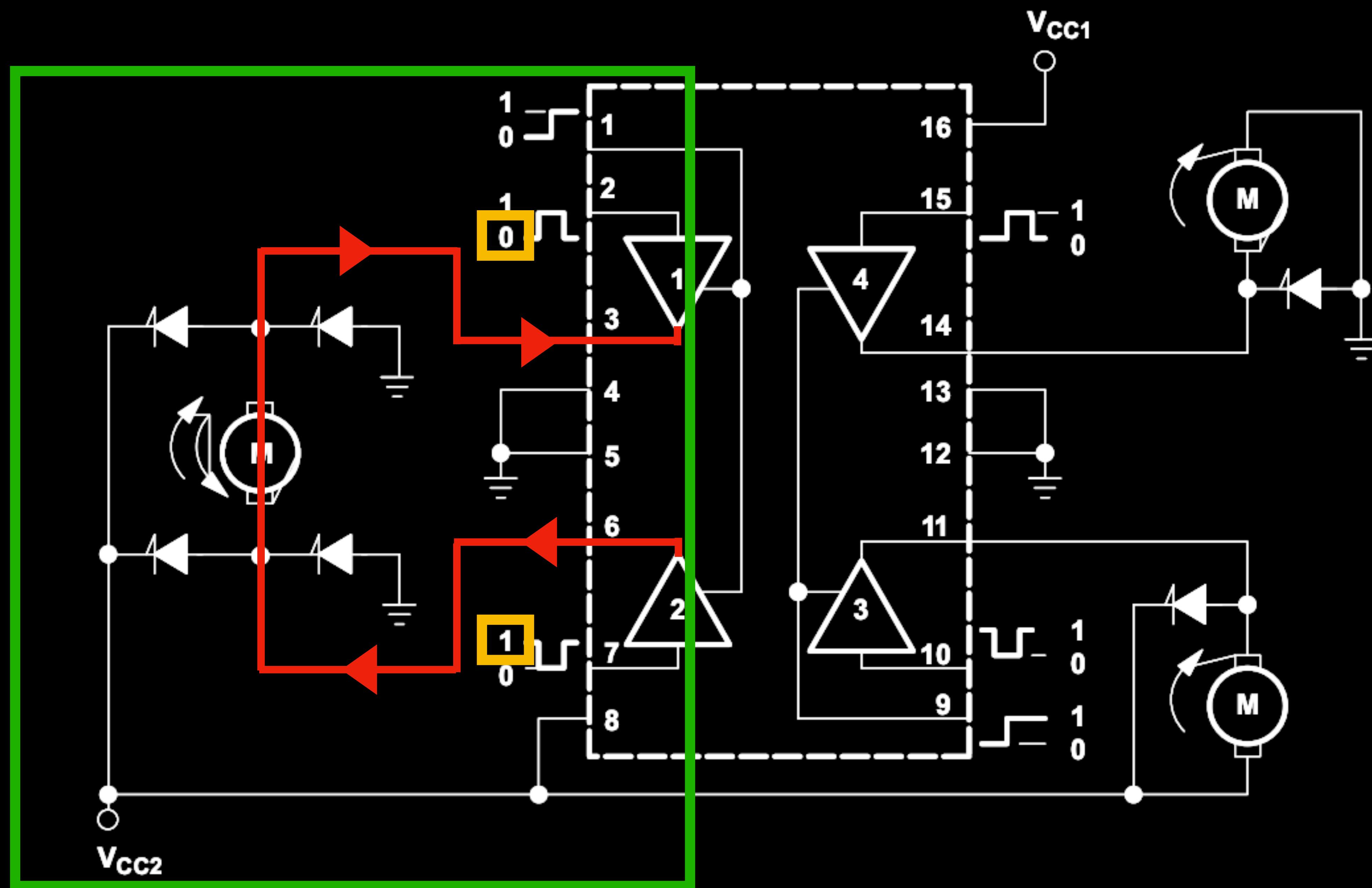
Output diodes are internal in L293D.

Fig 1



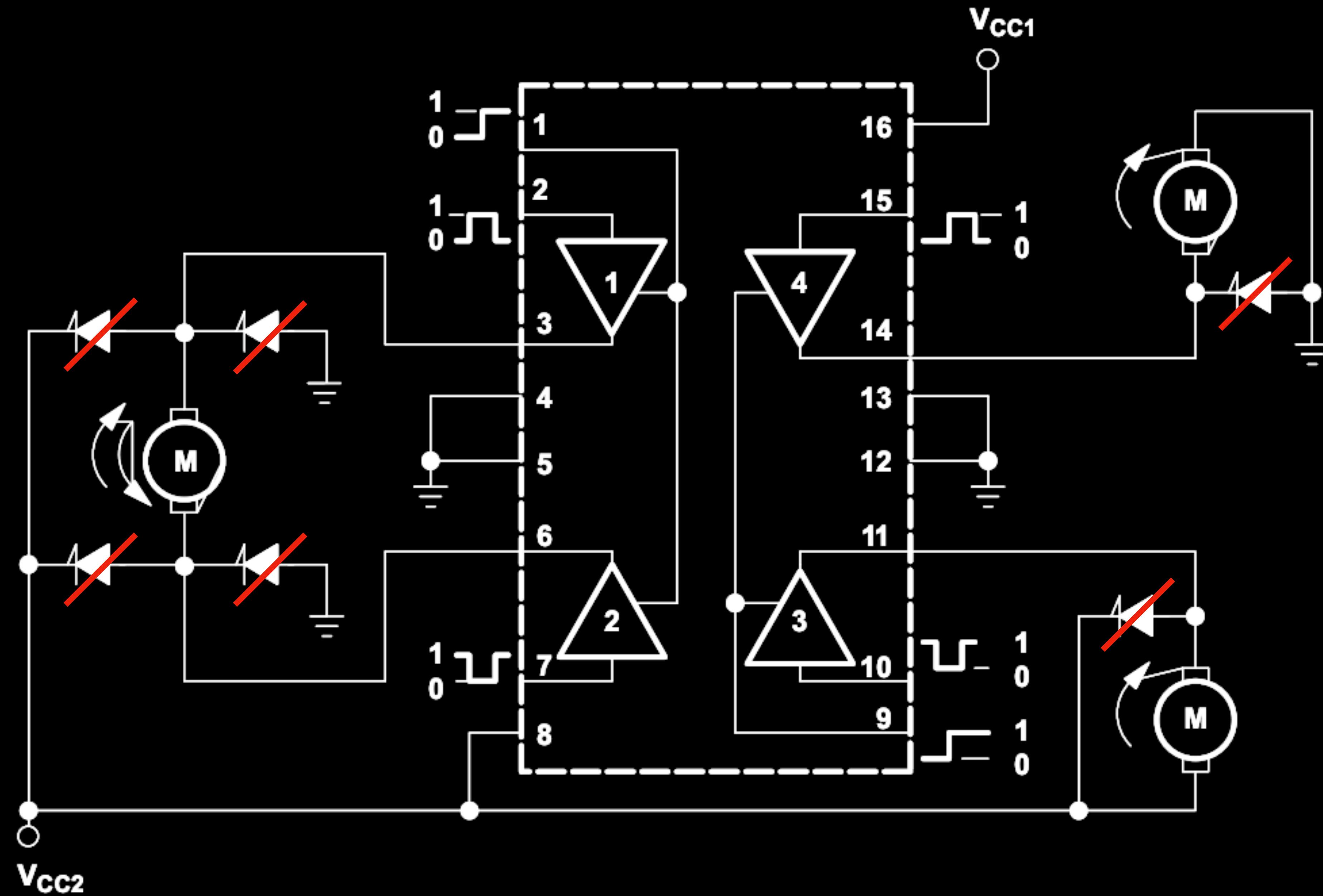
Output diodes are internal in L293D.

Fig 1



Output diodes are internal in L293D.

Fig 1



Output diodes are internal in L293D.

Fig 1



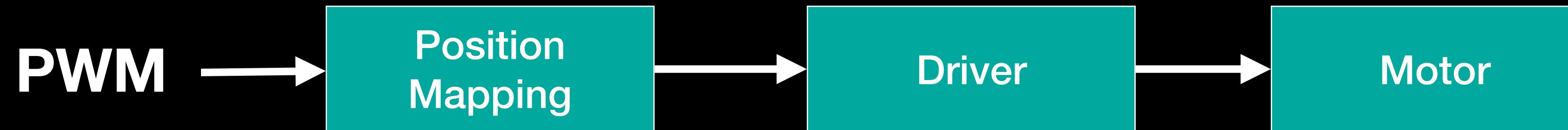
Servo Motor



(Positional Rotation) Servo Motor

- Control **position** via PWM

Open Loop Control

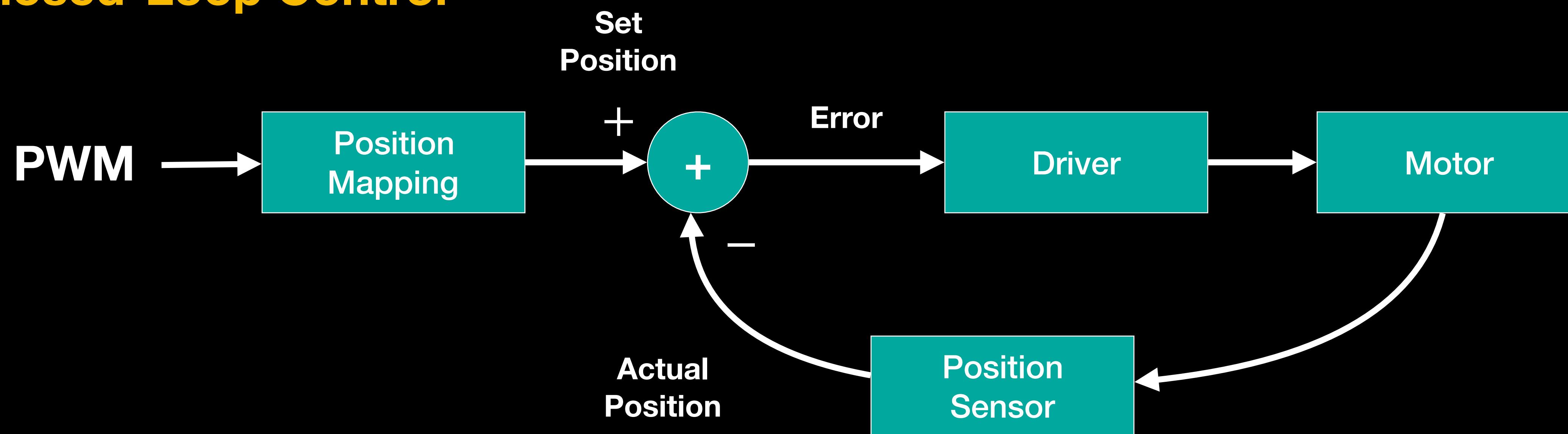




(Positional Rotation) Servo Motor

- Control **position** via PWM
- Consists of a DC motor, driver, and feedback (closed loop) control system
 - No external driver circuit needed

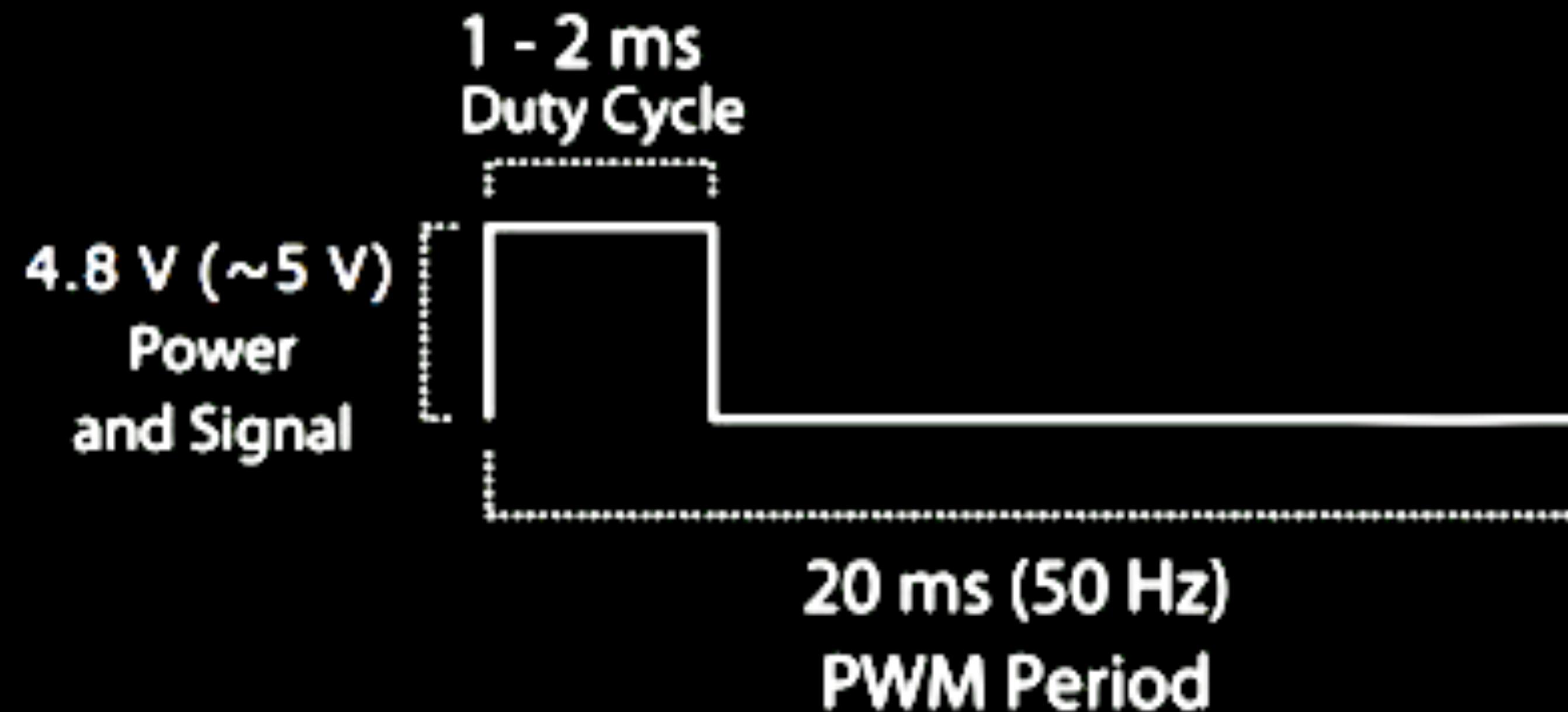
Closed-Loop Control





(Positional Rotation) Servo Motor

- Control **position** via PWM
- Consists of a DC motor, driver, and feedback (closed loop) control system
 - No external driver circuit needed

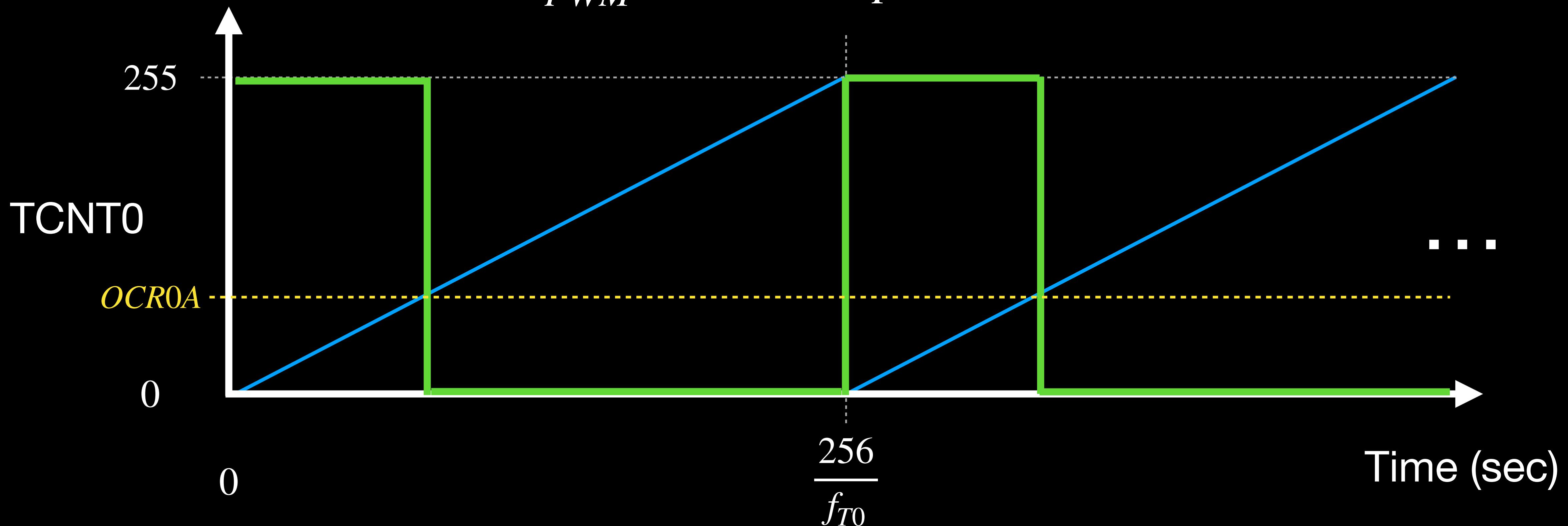




(Positional Rotation) Servo Motor

- Control **position** via PWM
- Need 50Hz PWM

$$F_{PWM} = 16MHz/prescaler/256$$

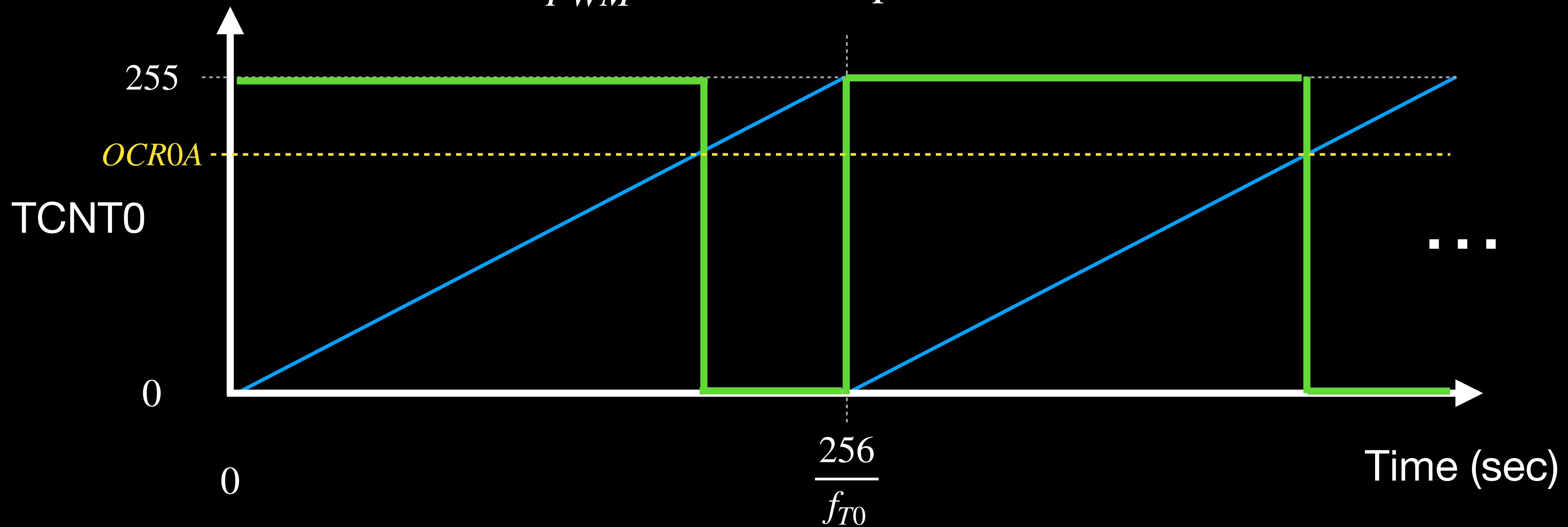




(Positional Rotation) Servo Motor

- Control **position** via PWM
- Need 50Hz PWM

$$F_{PWM} = 16MHz/prescaler/256$$

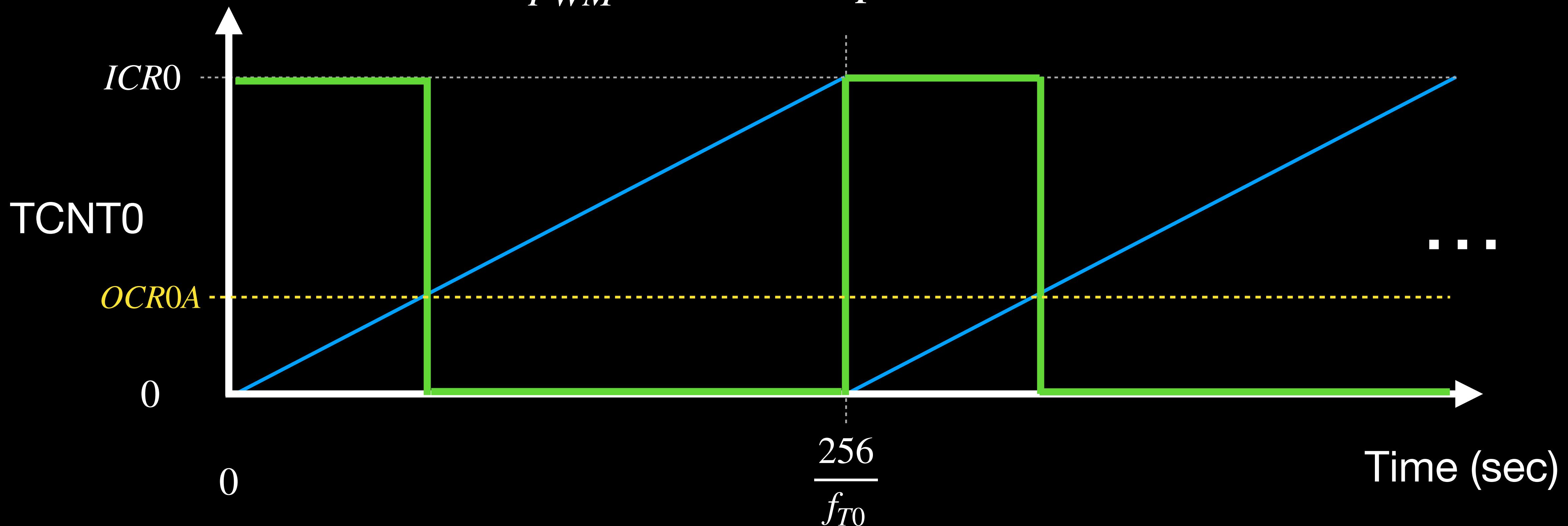




(Positional Rotation) Servo Motor

- Control **position** via PWM
- Need 50Hz PWM

$$F_{PWM} = 16MHz/\text{prescaler}/ICR0$$

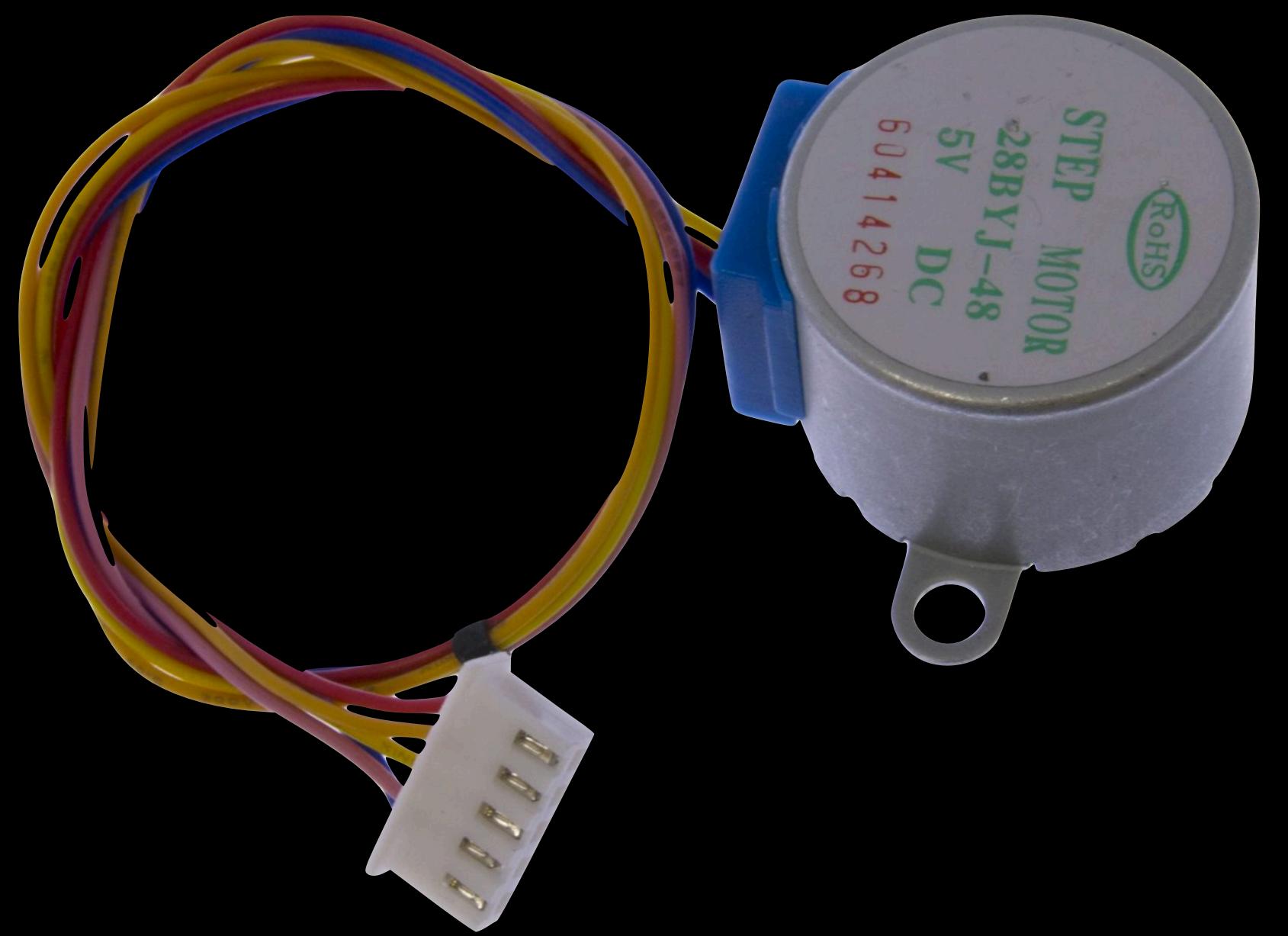




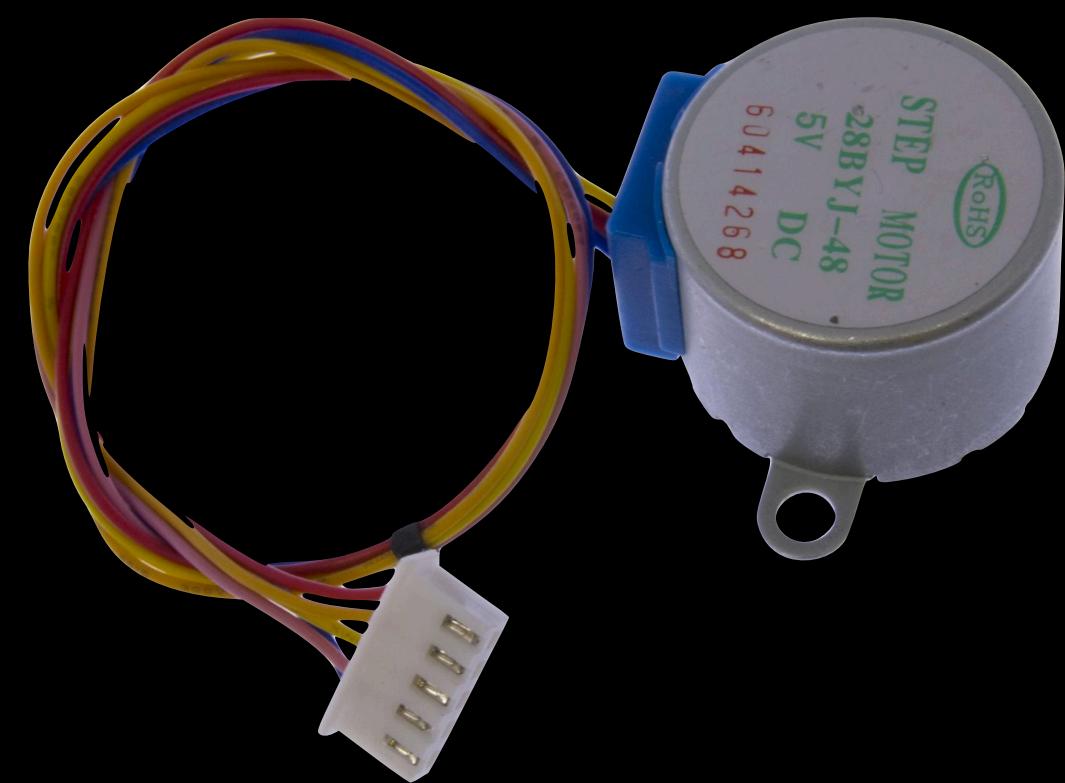
(Positional Rotation) Servo Motor

- Control **position** via PWM
- Consists of a DC motor, driver, and feedback (closed loop) control system
 - No external driver circuit needed
 - Use the Servo library for 50Hz PWM

```
#include <Servo.h>
```



Stepper Motor

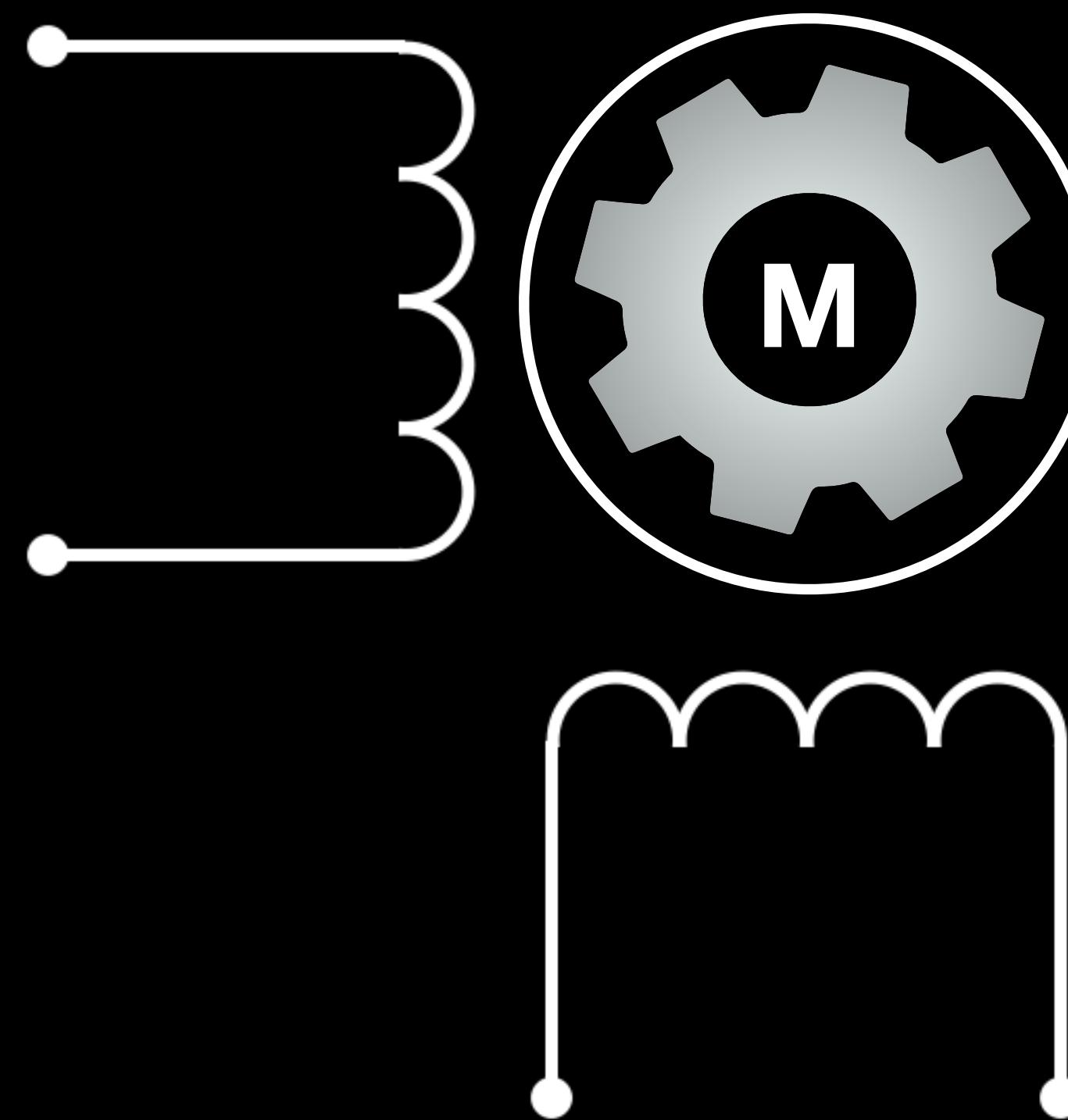
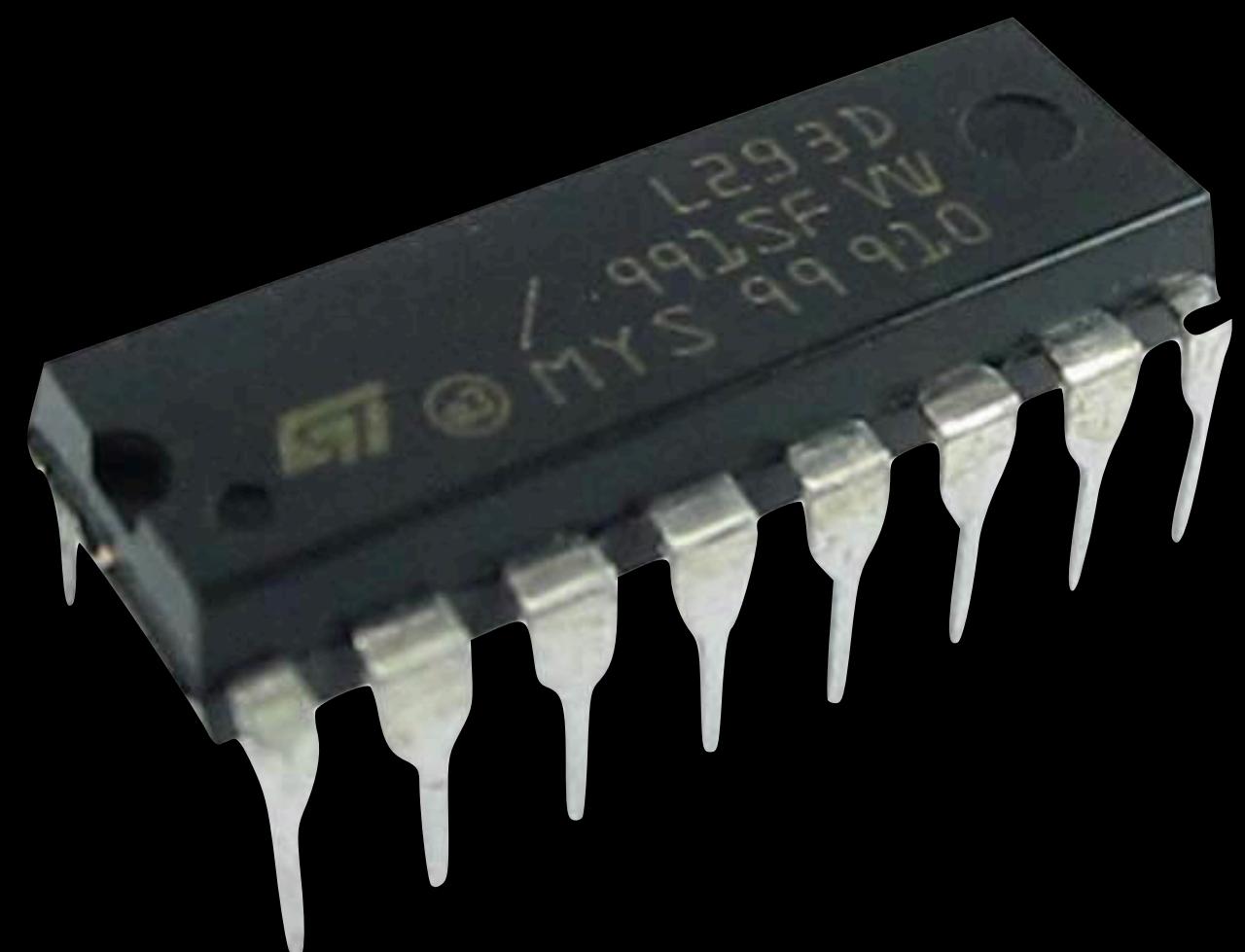


(Unipolar) Stepper Motor

- Windings can be unipolar or bipolar

Bipolar Winding

- Four possible combinations of current direction through 2 coils
- Requires H-Bridge driver like L293

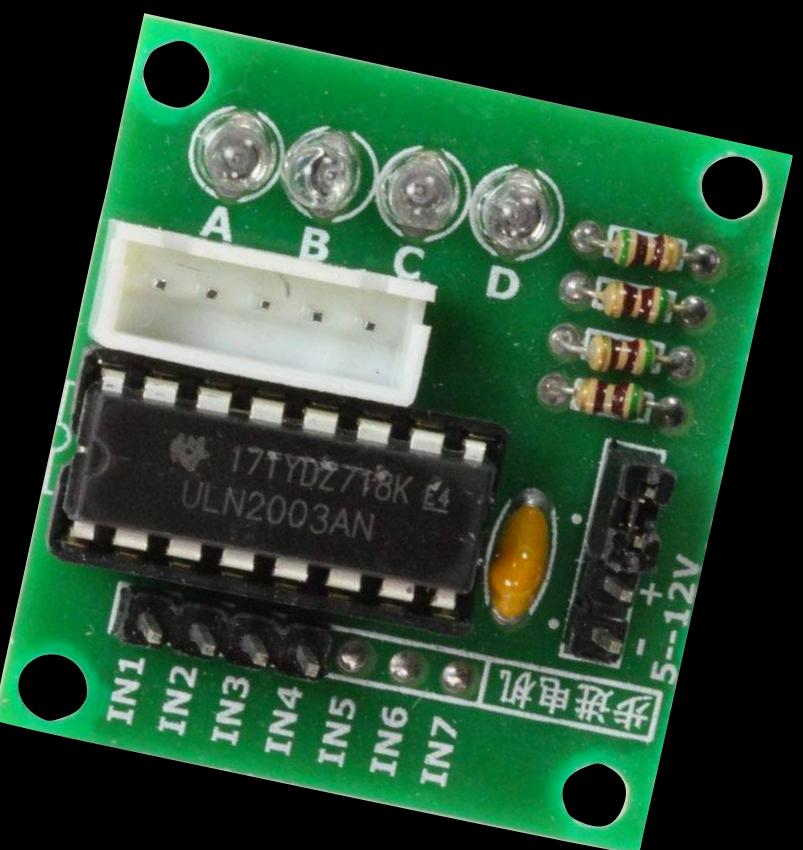




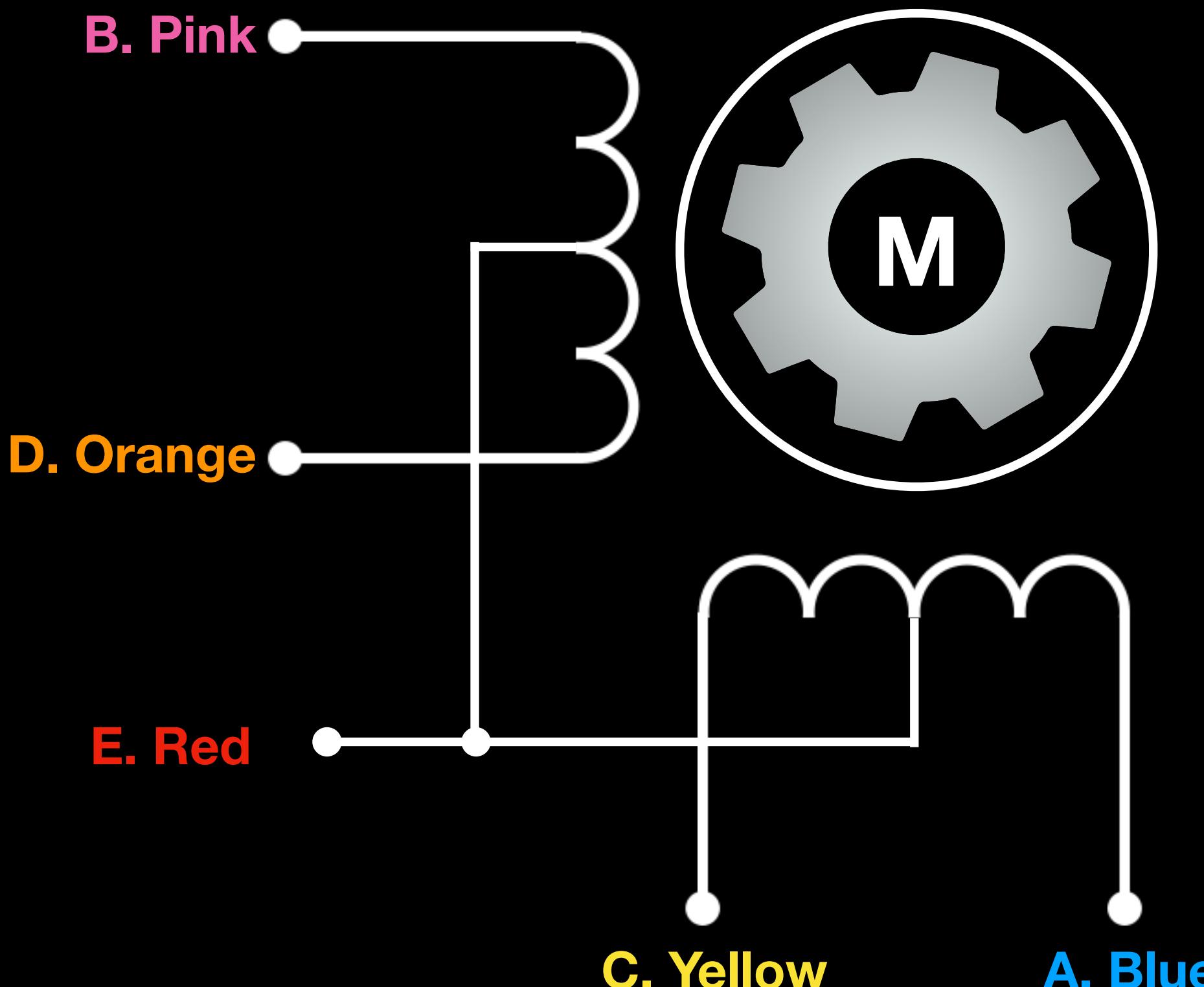
(Unipolar) Stepper Motor

- Windings can be unipolar or bipolar

- Common winding (red) is held HIGH
 - Phases A-D are set LOW to energize
 - Can be driven with four transistors
 - Kit includes ULN2003 darlington array



Unipolar Winding



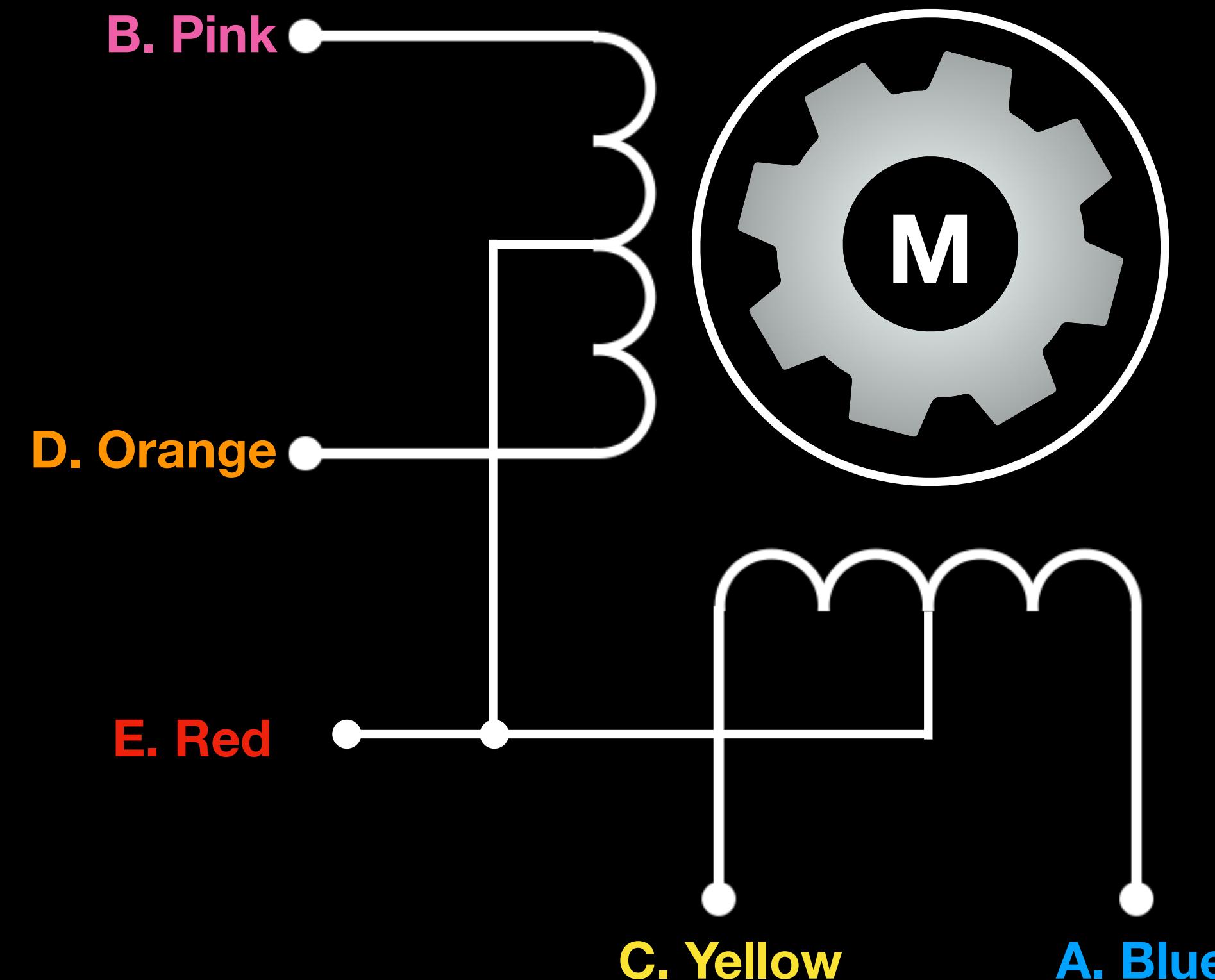


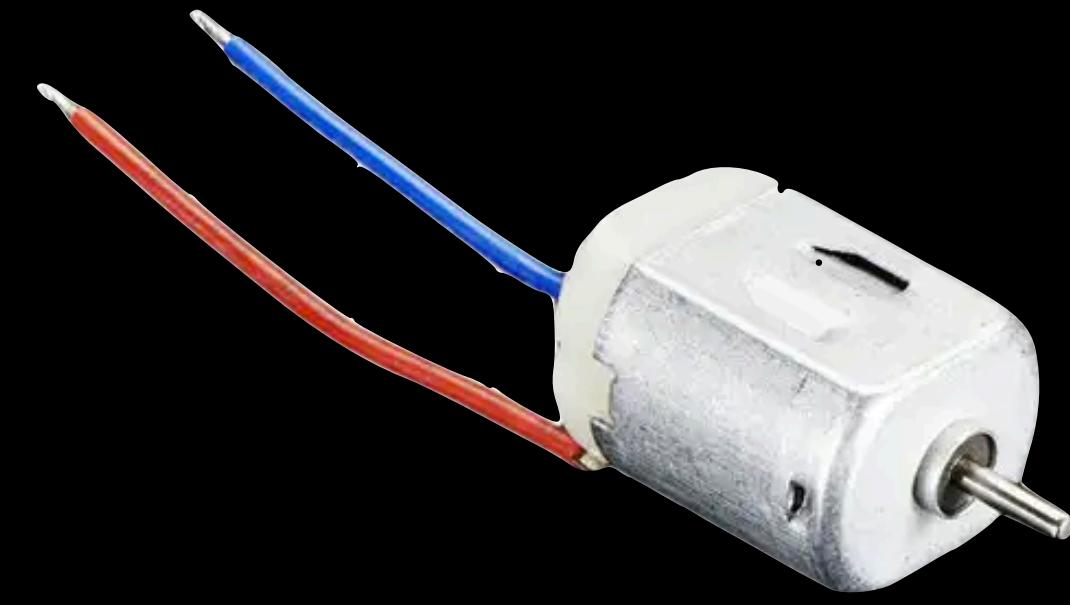
(Unipolar) Stepper Motor

- Windings can be unipolar or bipolar
- Step sequence controls both position and speed

Unipolar Winding

Step	A	B	C	D
0	HIGH	LOW	LOW	HIGH
1	HIGH	HIGH	LOW	LOW
2	LOW	HIGH	HIGH	LOW
3	LOW	LOW	HIGH	HIGH





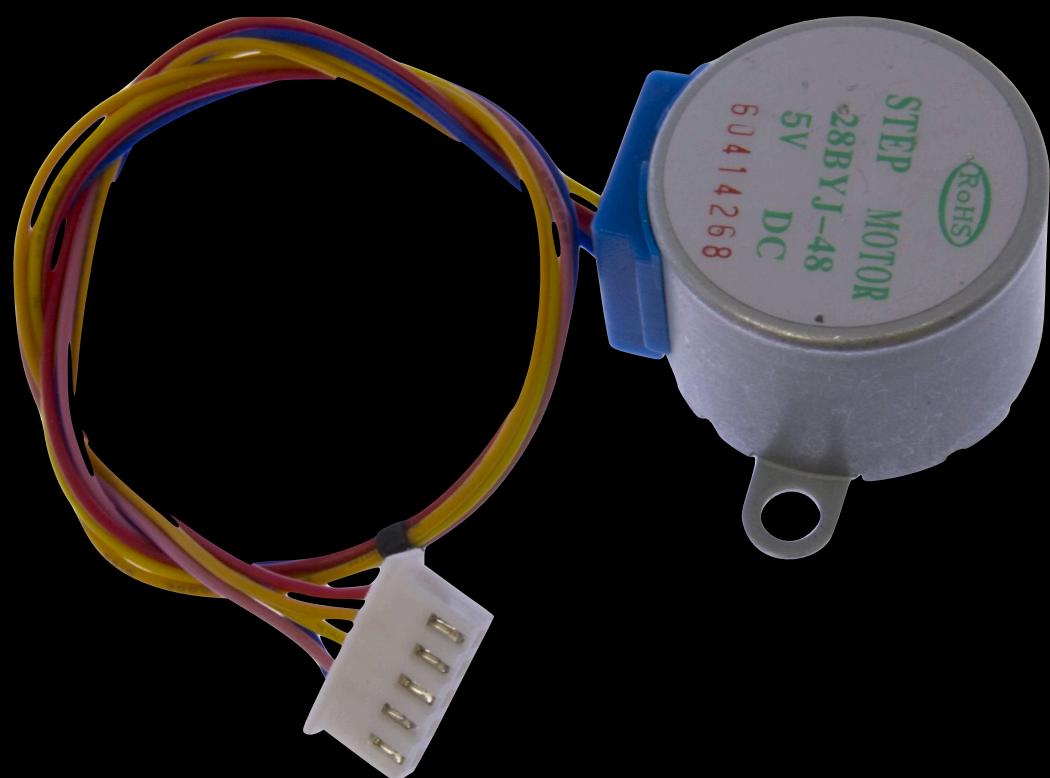
(Brushed) DC Motor

- Control **speed** via PWM
- Use transistor driver for unidirectional operation
- Use H-bridge driver for bidirectional operation
 - No library needed



(Positional Rotation) Servo Motor

- DC Motor + feedback control system
- Control **position** via PWM (*at specific rate and pulse width range*)
 - No external driver circuit needed
 - **#include <Servo.h>**

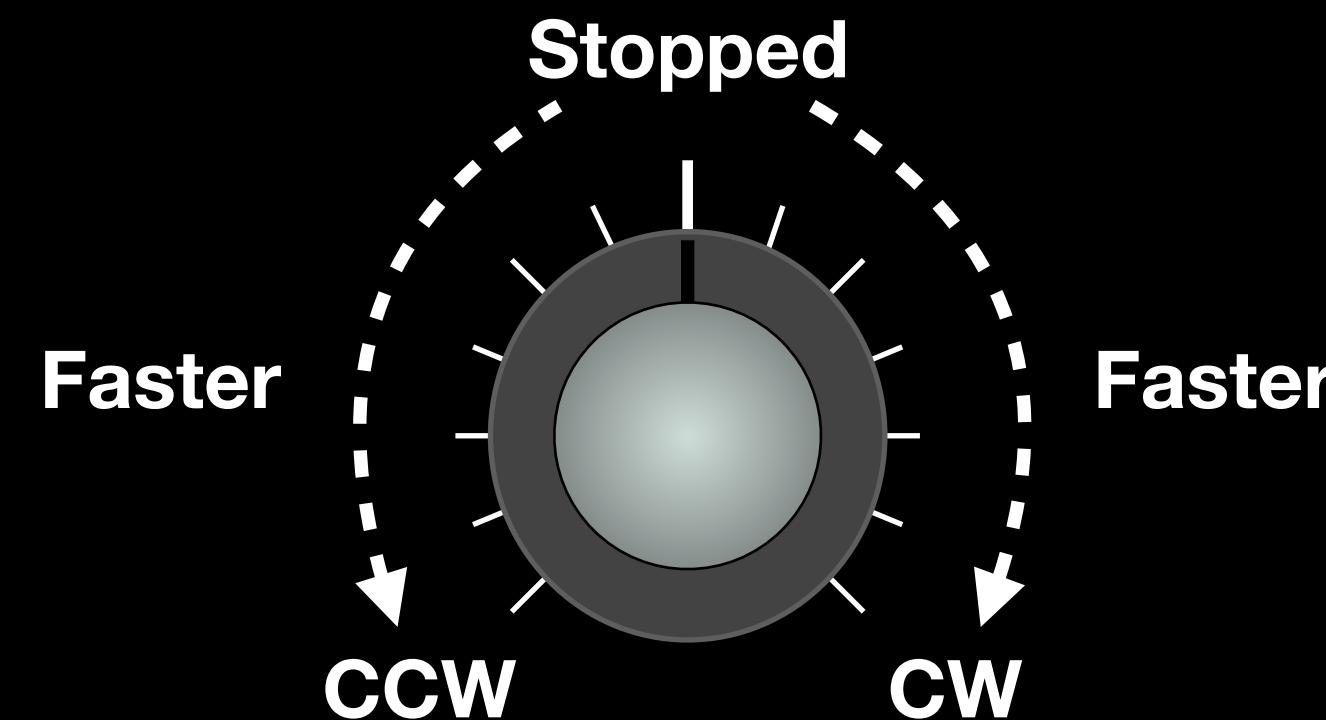


(Unipolar) Stepper Motor

- Increment/decrement **position** in discrete steps by energizing the motor's coils in the correct sequence
 - Use transistor array driver
 - **#include <Stepper.h>**

Week 5 Deliverables

1. DC motor control with variable speed and direction
 - Read from a potentiometer using the ADC
 - Map left side of potentiometer to variable-speed counter clockwise rotation
 - Map right side of potentiometer to variable-speed clockwise rotation



Hint: PWM signals are easily inverted e.g:

```
void analogWriteInverse(int pin, byte outval) {  
    analogWrite(pin, 255 - outval);  
}
```

Week 5 Deliverables

2(a). Servo motor control with variable position over 180°

- Read from a potentiometer using the ADC
- Map full range of the potentiometer to servo position over 180° of rotation

OR

2(b). Stepper motor control with variable direction

- Step the motor clockwise at a constant rate
- If a button is pressed, reverse the direction of the motor

Week 5 Deliverables

3. A short video demonstrating deliverables 1 and either 2(a) or 2(b)
4. An example application for each motor. Justify your decisions.
 - 2-4 sentences is fine