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DesignNews

DC Motor Controls with the RP2040 Pico

DAY 5: RP2040 Pico and H-Bridge DC Motor Controls

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Webinar Logistics

- Turn on your system sound to hear the streaming presentation.
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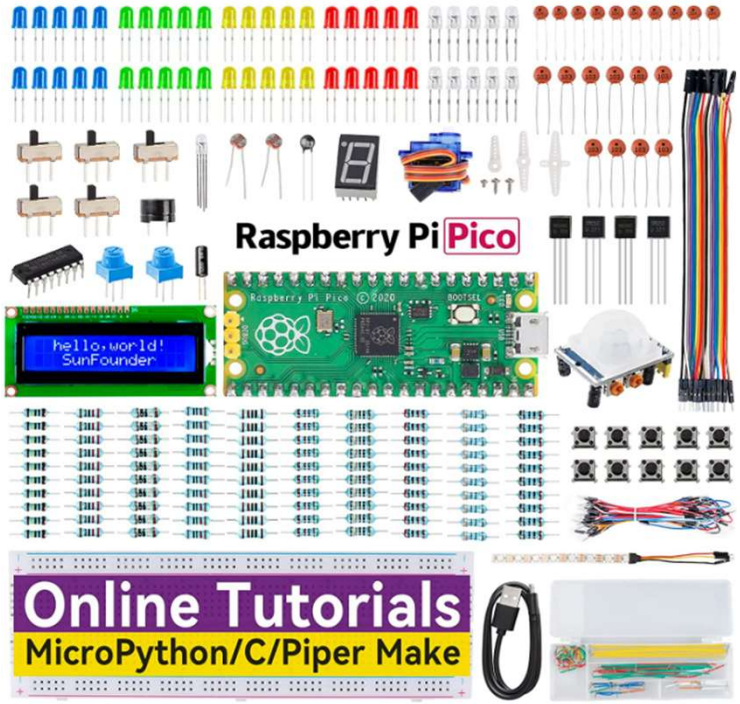
Dr. Don Wilcher

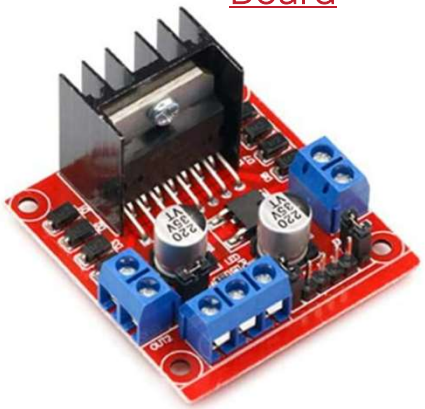
Visit ‘Lecturer Profile’ in your console for more details.

Course Kit and Materials

SunFounder Raspberry Pi Pico Starter Kit



L298N Motor Drive Controller Board



1 Channel Relay Module

ULN2003 4-Phase Stepper Motor with 5V Drive Board

1-5V – 6VDC Motor

Agenda:

- Basic DC Motor Control Concept
- H-Bridge Motor Control Basics
- Lab: H-Bridge DC Motor Controller

Raspberry Pi RP2040 :

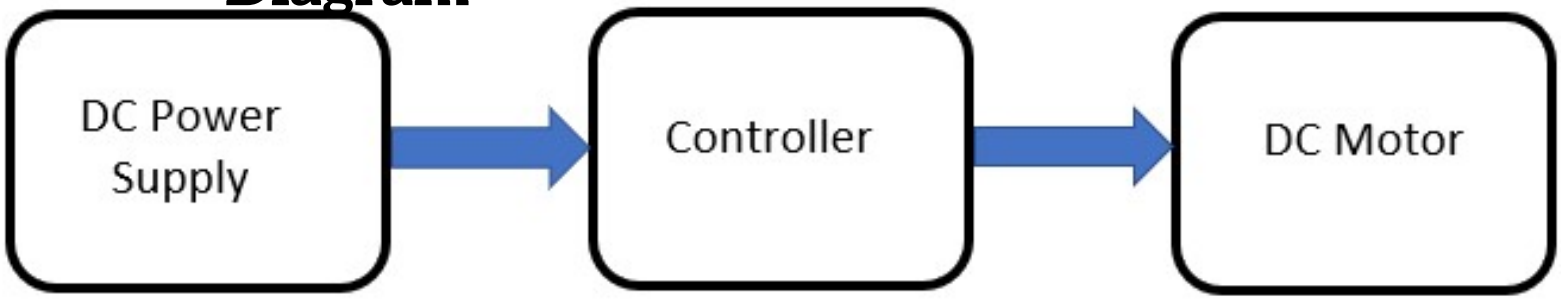
"Raspberry Pi RP2040 SoC, a surprisingly powerful yet radically low-cost microcontroller packing dual Arm Cortex-M0+ processors, the most energy-efficient Arm processor available" (Adams, 2021).

Basic DC Motor Control Concept

A Basic DC Motor Control consists of

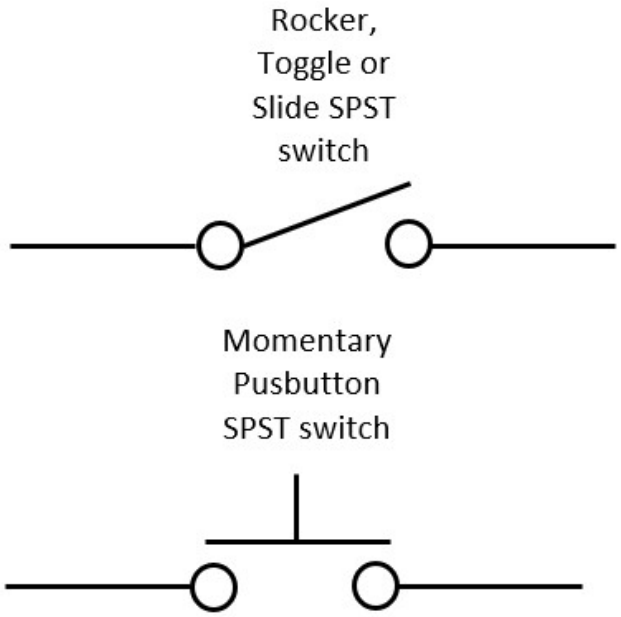
- DC power supply.
- A controller
- A DC motor

Basic DC Motor Control Block Diagram



Basic DC Motor Control Concept…

A simple controller for operating a typical dc motor is a Single Pole-Single Throw switch (SPST).



Typical Switches which can be used as a simple controller

Basic DC Motor Control Concept…

Typical Switches which can be used as a simple controller

Slide SPST Switch

Rocker SPST Switch

Toggle SPST Switch

Question 1

Identify the switch based on the electrical symbol shown in Figure 1.

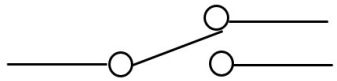
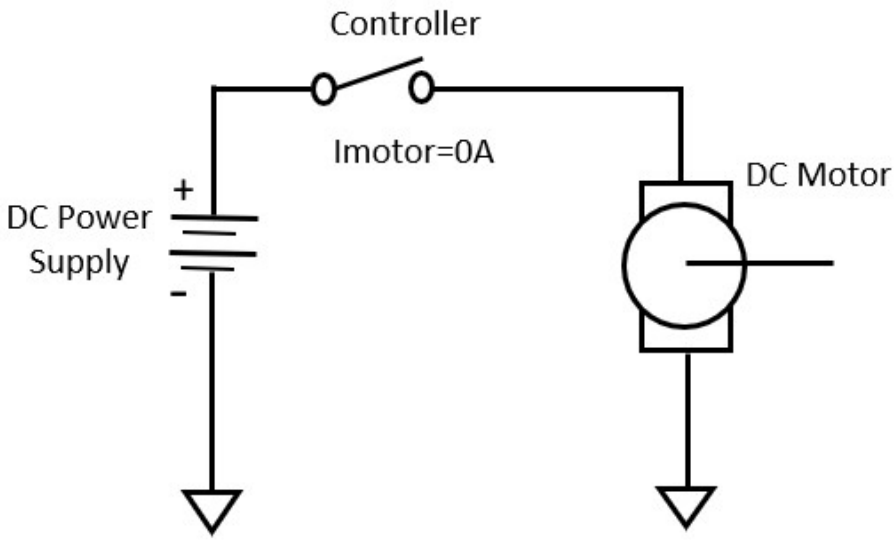


Figure 1.

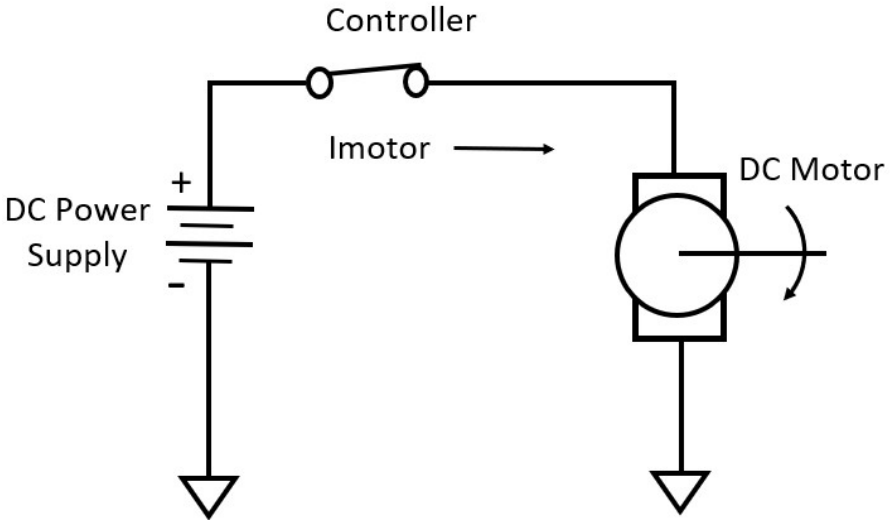
a) Single Pole Single Throw (SPST) switch
b) Single Pole Double Pole (SPDT) switch
c) Double Pole Double Throw (DPDT) switch
d) none of the above

Basic DC Motor Control Concept…

A typical circuit schematic diagram of Basic DC Motor Controller



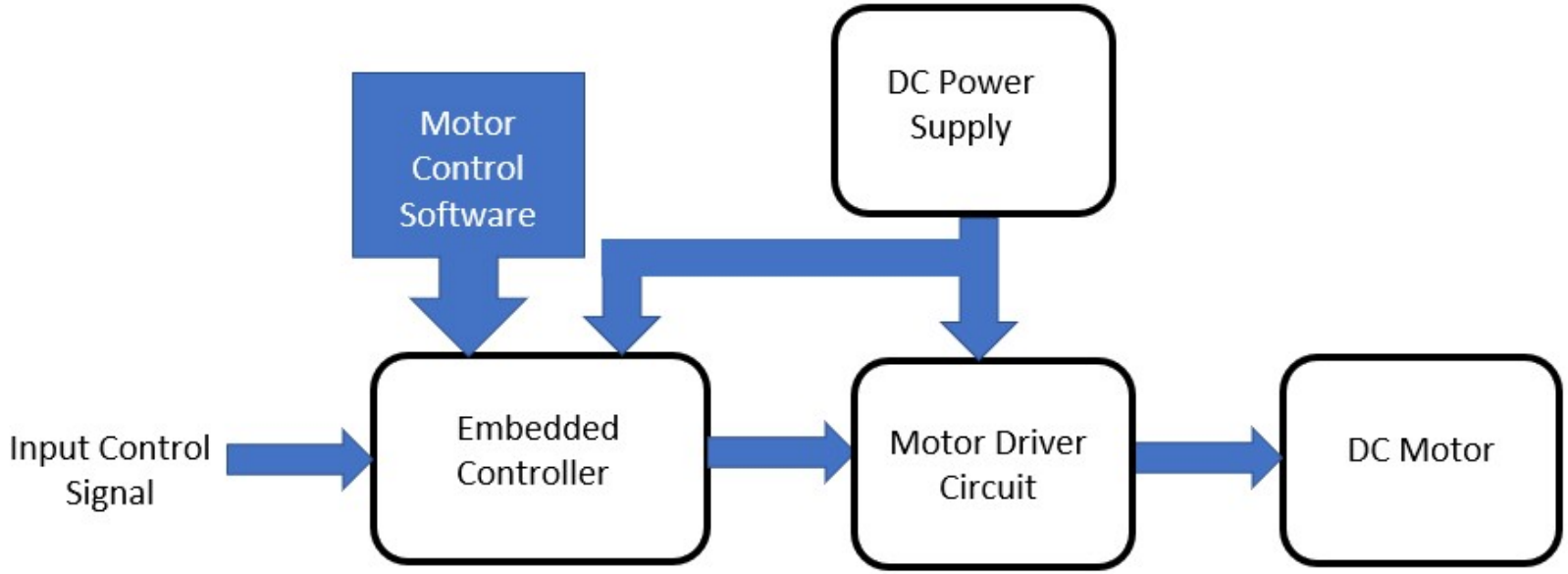
Motor OFF



Motor ON

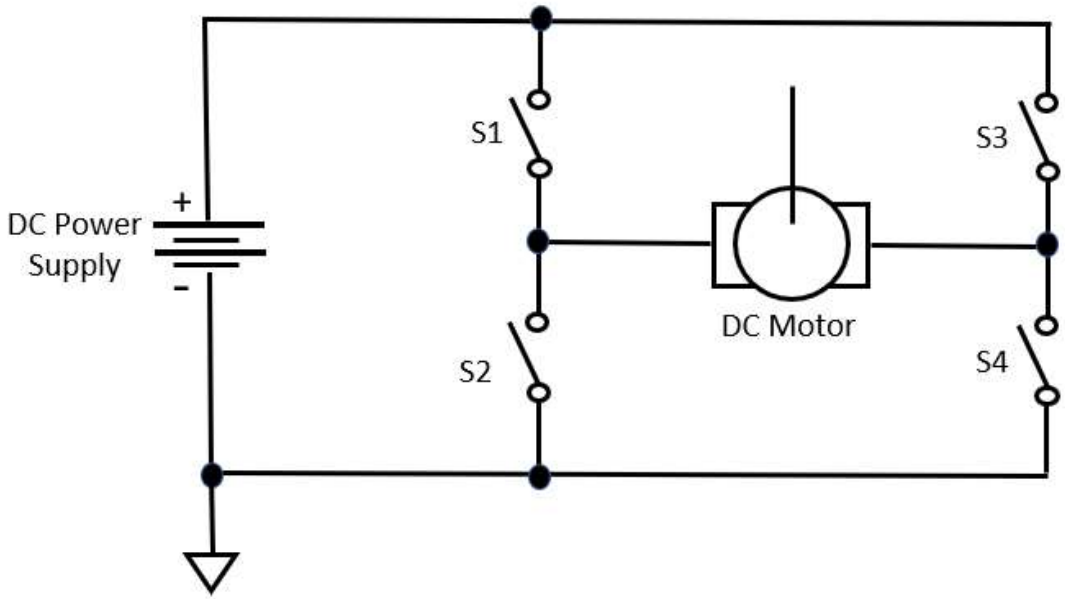
Basic DC Motor Control Concept…

To make a controller that is less manual dependent, a desirable automation-based solution can be conceptualized.



H-Bridge Driver Basics

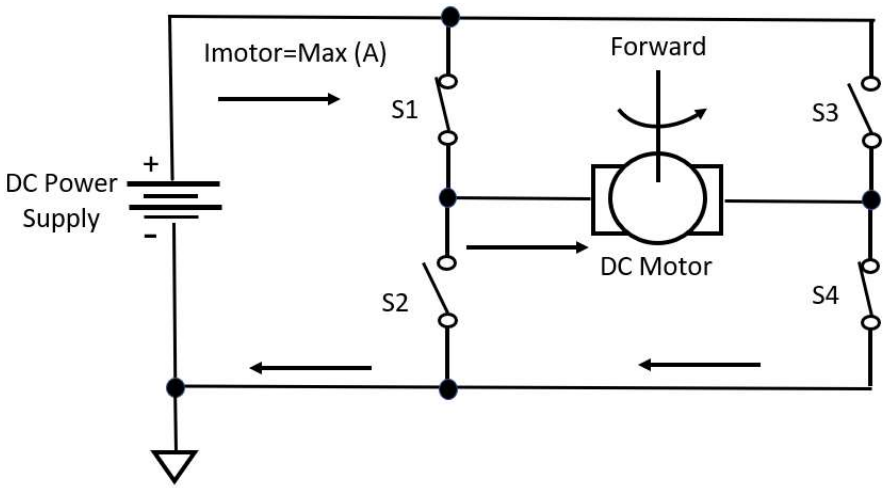
An electronic circuit capable of switch polarity across electromechanical load. A basic method of illustrating the concept of a H-Bridge Driver circuit is using four SPST switches.



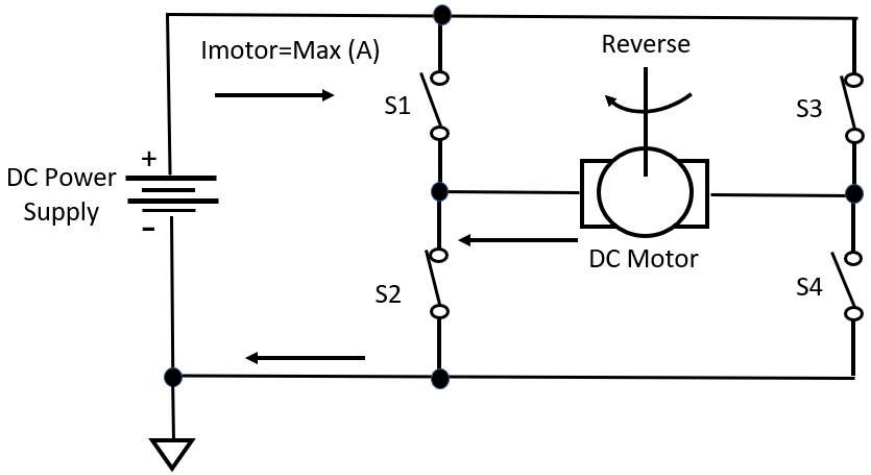
H-Bridge Driver Basics. . .

By closing the correct switch combinations, the H-Bridge Driver can control the direction of the DC motor.

S1S4 = Forward Direction

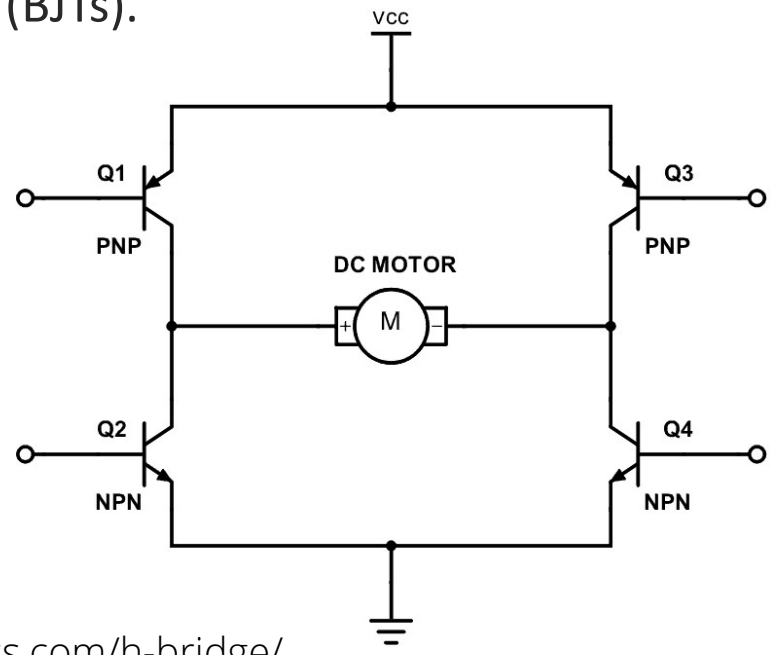


S2S3 = Reverse Direction



H-Bridge Driver Basics. . .

A solid- state (SS) version can be implemented using Complementary Pairs of PNP and NPN bipolar junction transistors (BJTs).

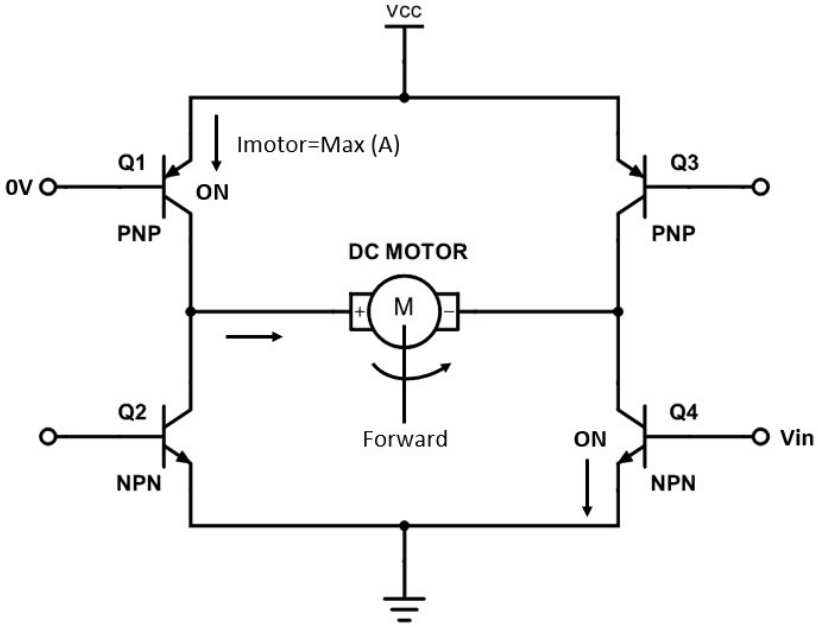


Source:
https://www.build-electronic-circuits.com/h-bridge/

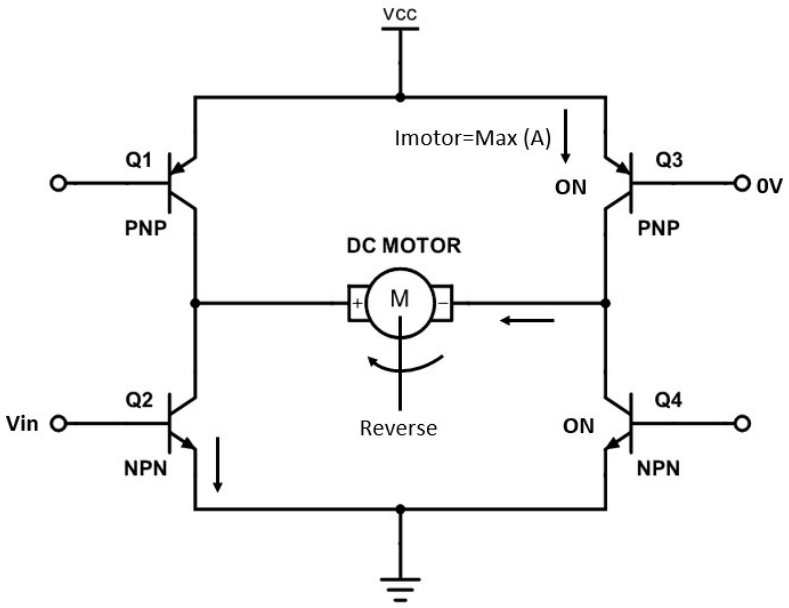
H-Bridge Driver Basics. . .

The direction of the DC Motor is controlled by turning on the correct complementary pair of BJTs.

Q1Q4 = Forward Direction



Q2Q3 = Reverse Direction



H-Bridge Driver Basics

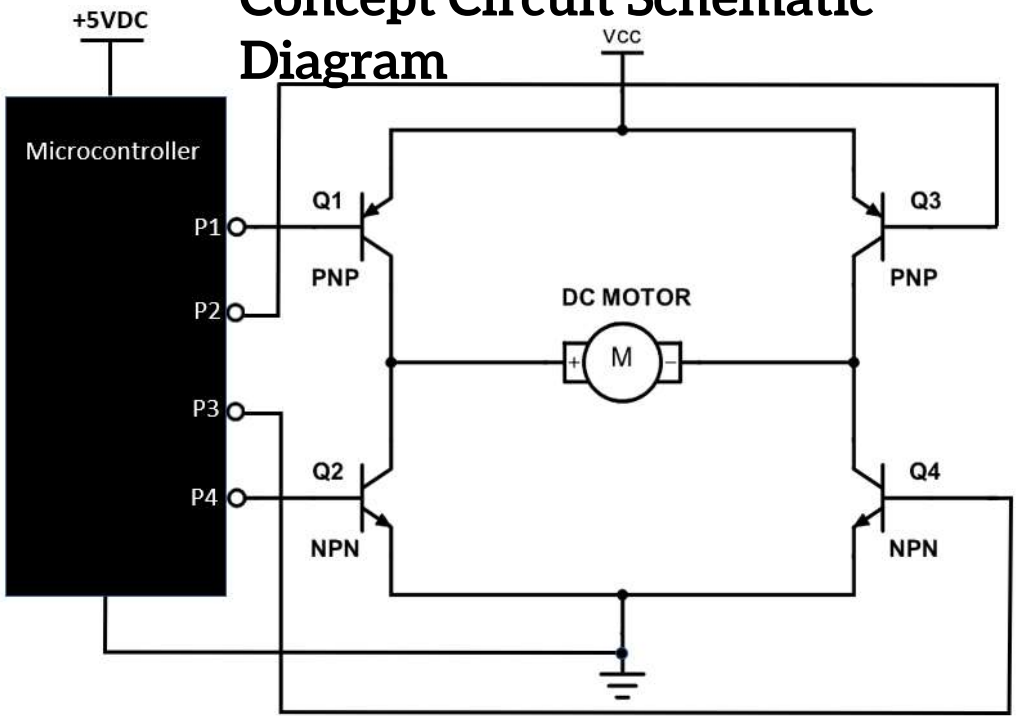
The advantage to using a SS H-Bridge Driver is the ability to control speed and direction of the DC Motor with a microcontroller.

Pulse Width Modulating (PWM) the microcontroller's digital port pins (P1-P4) will provide speed control for the DC Motor.

P1P3 = Forward Direction
P2P4 = Reverse Direction

Note: Each BJT transistor will have a base resistor (Rb) to limit current flowing through the semiconductor component.

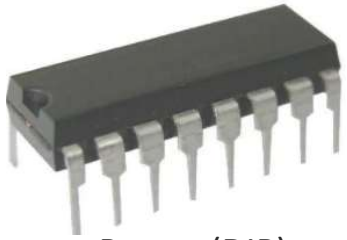
Concept Circuit Schematic Diagram



The L293 H-Bridge IC

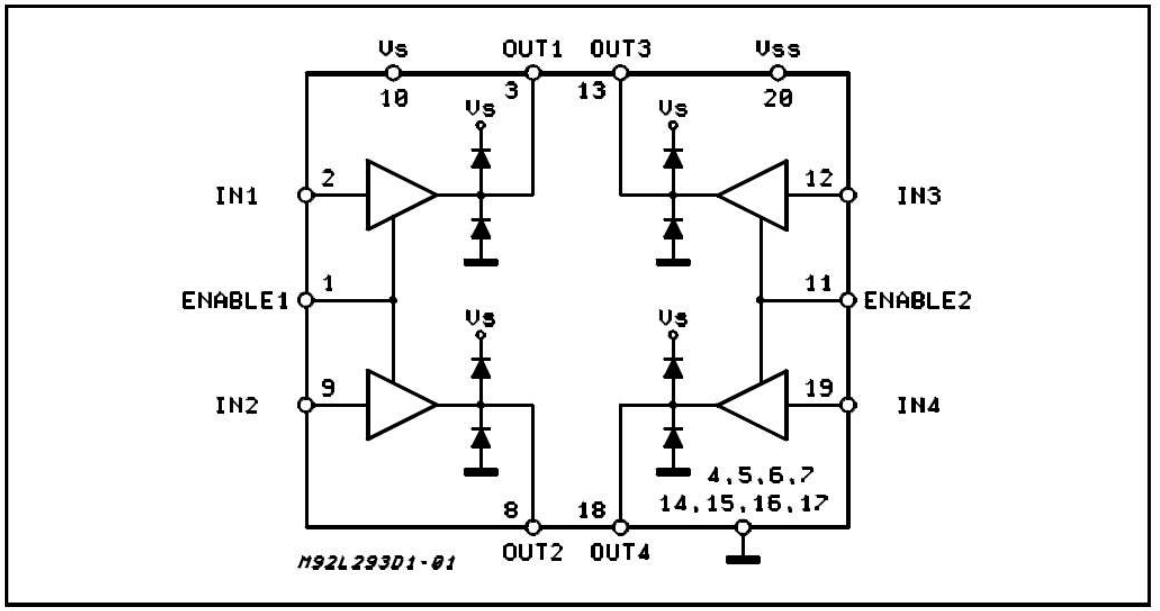
The L293 H-Bridge IC has four SS drivers integrated within its package.

Small Outline (SO)



Power (DIP)

BLOCK DIAGRAM

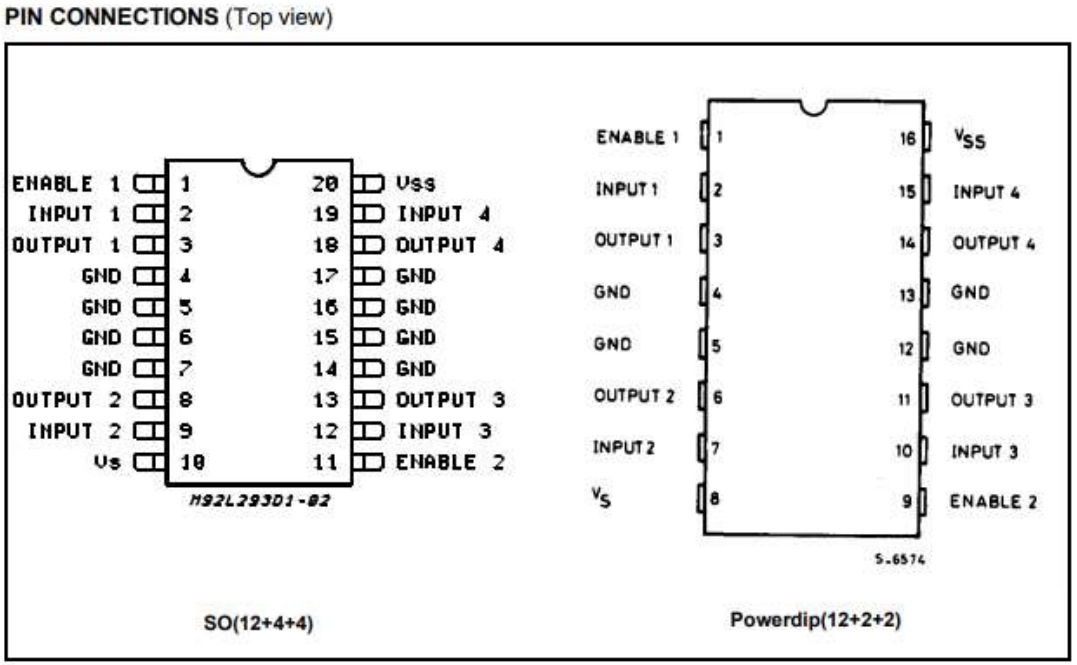


Source:

https://www.mouser.com/datasheet/2/389/cd00000059-1795435.pdf

The L293 H-Bridge IC…

The L293 H-Bridge IC pinout for small outline (SO) and plastic Dual-Inline-Package (DIP) components



Source:

https://www.mouser.com/datasheet/2/389/cd00000059-1795435.pdf

The L293 H-Bridge IC…

The L293 H-Bridge IC electrical specifications.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	Supply Voltage	36	V
V_{SS}	Logic Supply Voltage	36	V
V_i	Input Voltage	7	V
V_{en}	Enable Voltage	7	V
I_o	Peak Output Current (100 µs non repetitive)	1.2	A
P_{tot}	Total Power Dissipation at T_{pins} = 90 °C	4	W
T_{stg}, T_j	Storage and Junction Temperature	– 40 to 150	°C

Source:

https://www.mouser.com/datasheet/2/389/cd00000059-1795435.pdf

Question 2

Identify the electrical circuit shown in Figure 2.

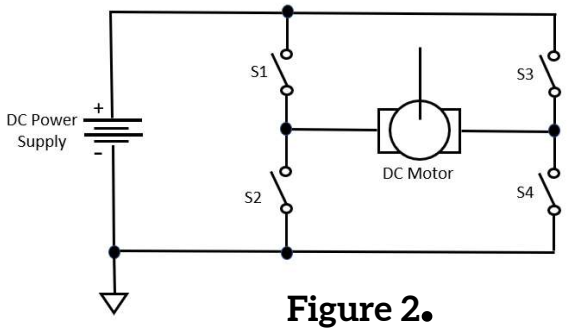
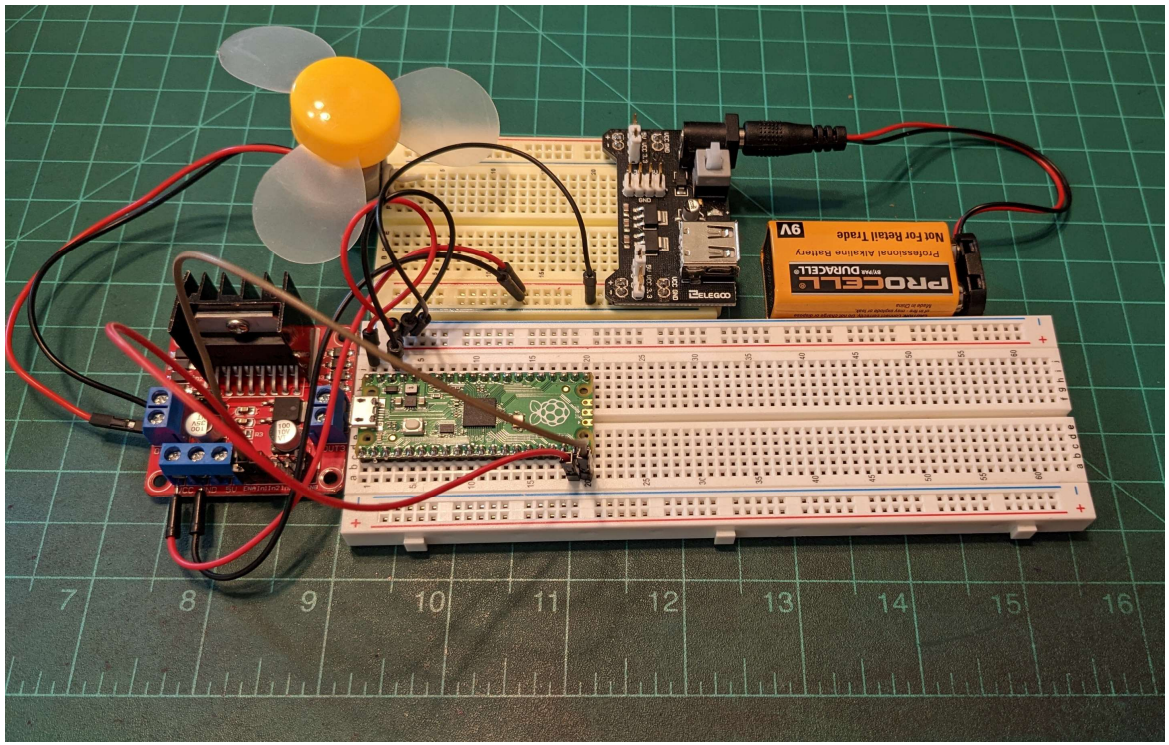


Figure 2.

a) Half bridge DC motor driver circuit
b) DC motor driver circuit
c) H-Bridge DC motor driver circuit
d) none of the above

Lab: H – Bridge DC Motor Controller



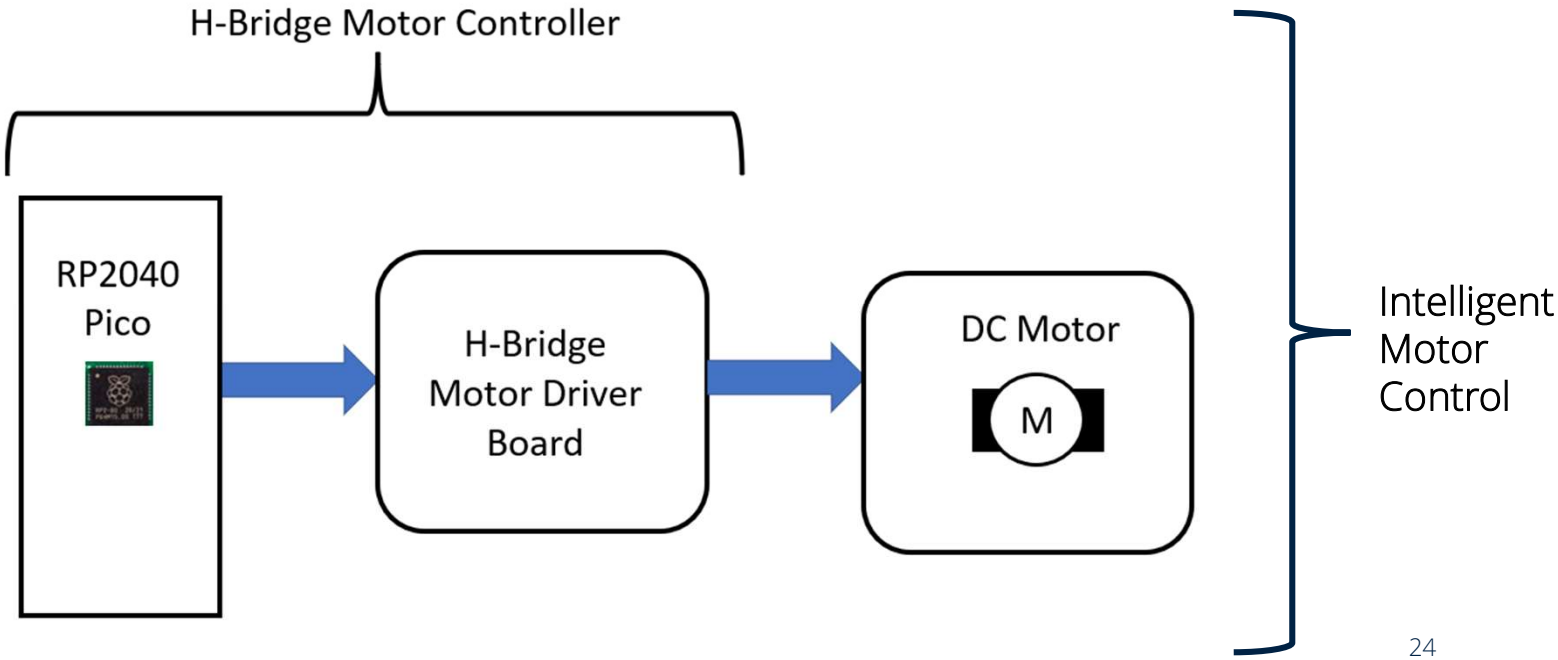
Lab: H – Bridge DC Motor Controller. . .

Big IDEAS (Learning Objectives):

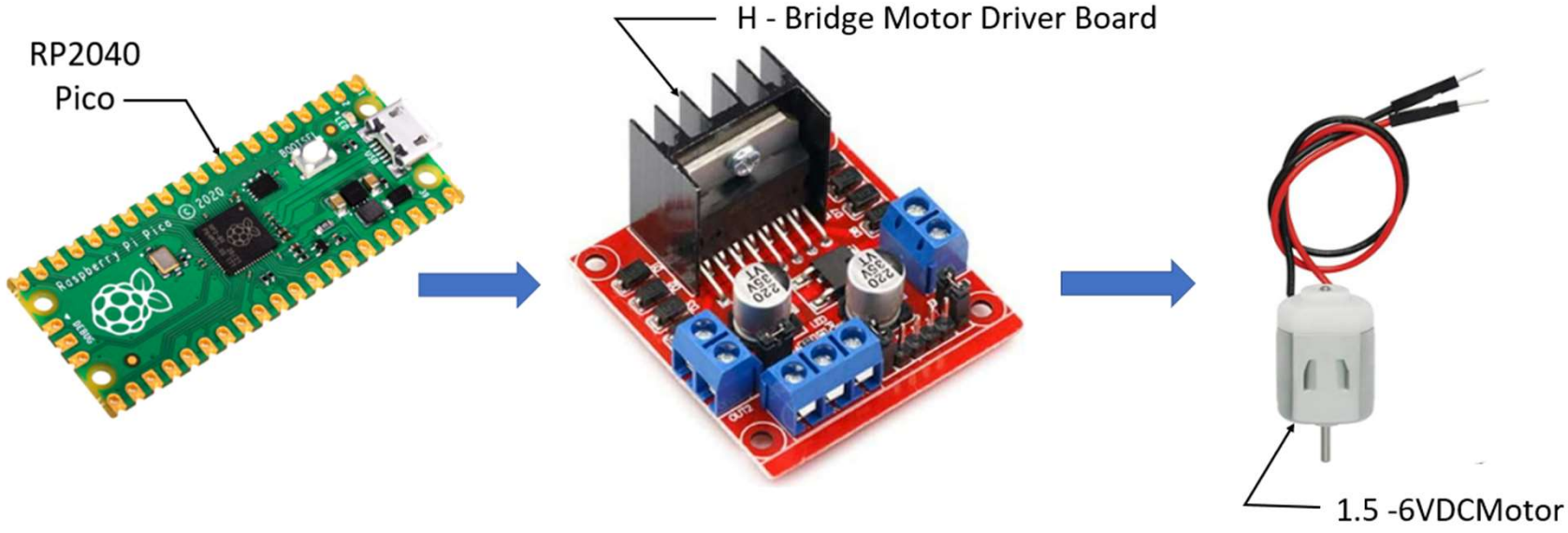
1. The participant will be able to wire a DC motor to an H-Bridge DC motor driver board.
2. The participant will be able to wire an H-Bridge DC motor driver board to an RP2040 microcontroller
3. The participant will be able to create an H-Bridge DC motor controller code using MicroPython.
4. The participant will be able to test a H-Bridge DC motor driver controller using MicroPython and the RP2040.

Lab: H – Bridge DC Motor Controller. . .

The RP2040 microcontroller easily controls a DC motor by providing the appropriate control signals to an H – Bridge motor driver board. Th



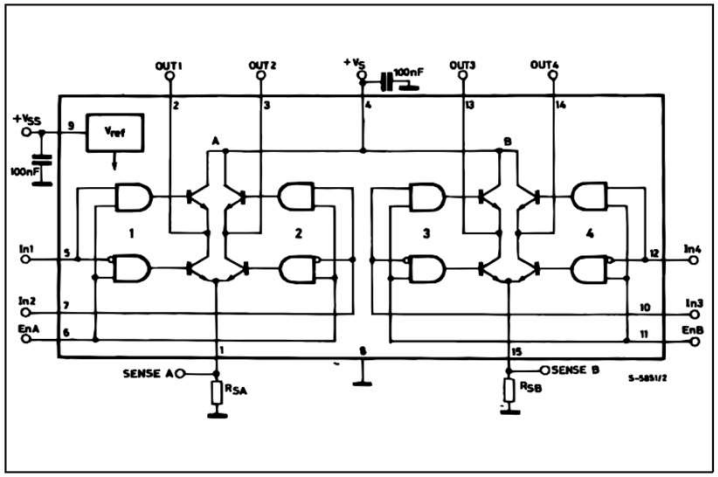
Lab: H – Bridge DC Motor Controller. . .



Lab: H – Bridge DC Motor Controller. . .

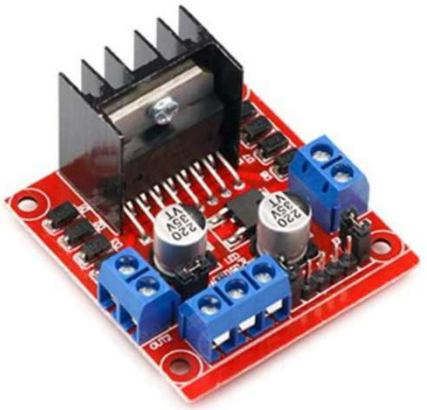
L298 Full Bridge IC on Board

BLOCK DIAGRAM



Milliwatt15 or PowerSO20 packages

H-Bridge Motor Driver Board



Question 3

What IC is on board an H-Bridge Motor driver board?

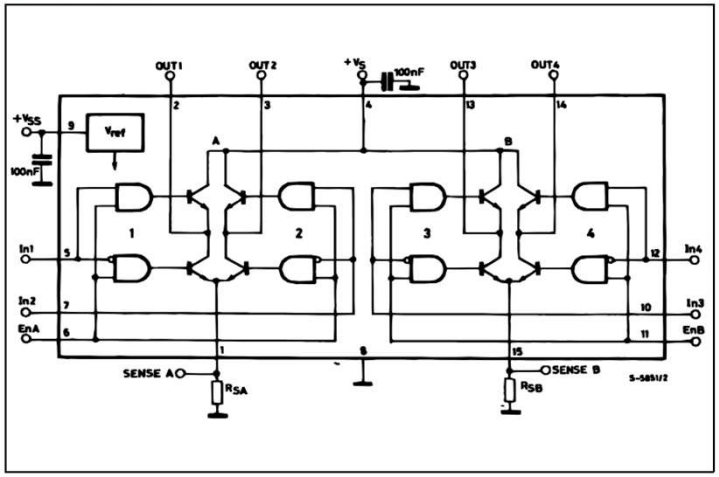
a) L293
b) L294
c) L298
d) none of the above

Lab: H – Bridge DC Motor Controller. . .

L298 Full Bridge IC on Board

2 Full Bridge Drivers

BLOCK DIAGRAM

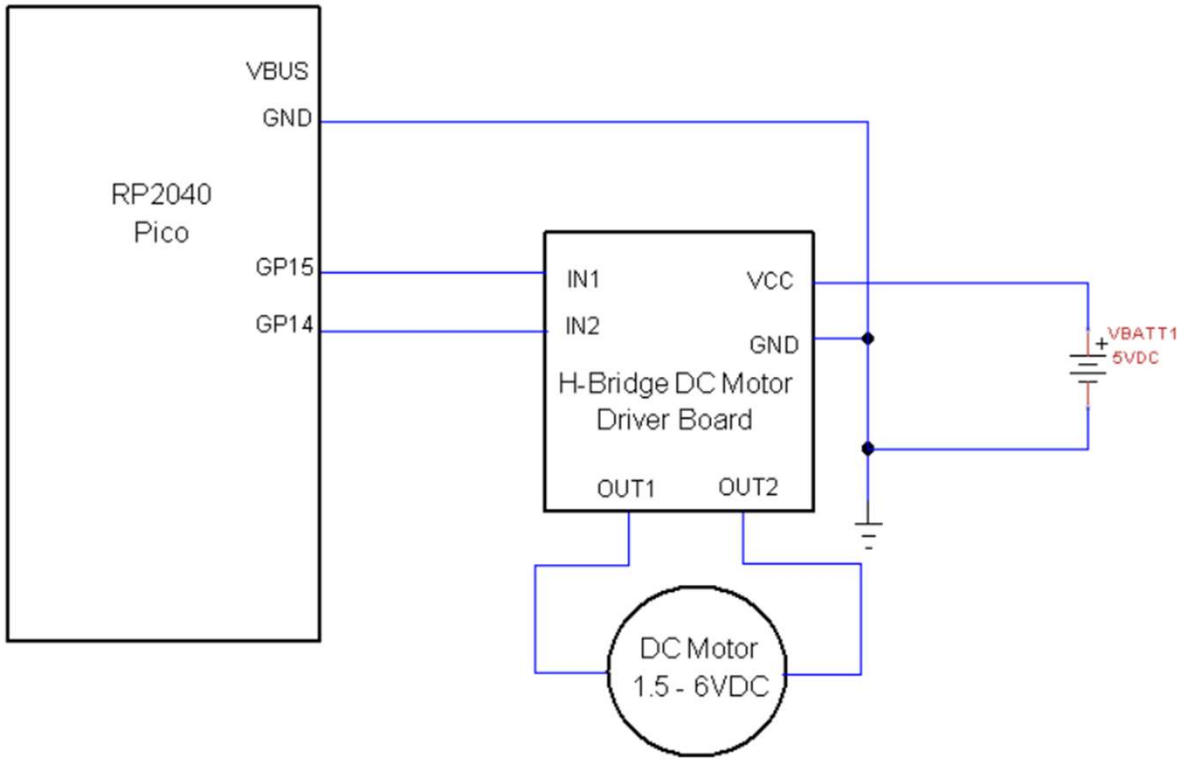


Basic Specifications

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	Power Supply	50	V
V_{SS}	Logic Supply Voltage	7	V
V_I, V_{en}	Input and Enable Voltage	–0.3 to 7	V
I_O	Peak Output Current (each Channel) – Non Repetitive (t = 100µs) –Repetitive (80% on –20% off; t_{on} = 10ms) –DC Operation	 3 2.5 2	 A A A
V_{sens}	Sensing Voltage	–1 to 2.3	V
P_{tot}	Total Power Dissipation (T_{case} = 75°C)	25	W
T_{op}	Junction Operating Temperature	–25 to 130	°C
T_{stg}, T_j	Storage and Junction Temperature	–40 to 150	°C

Lab: H – Bridge DC Motor Controller. . .



H-Bridge DC Motor Controller Circuit Schematic Diagram

Question 4

What is the maximum output current (Io) the 298 IC can source to each channel?

a) 500mA
b) 2.5A
c) 3A
d) none of the above

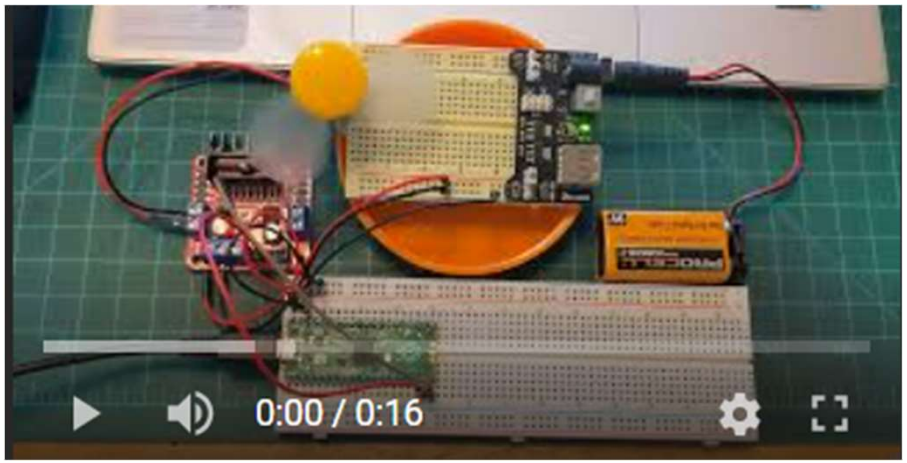
Lab: H – Bridge DC Motor Controller. . .

To run the MicroPython Code, click the Run button

```
from machine import Pin
import utime

In1 = Pin(15, Pin.OUT)
In2 = Pin(14, Pin.OUT)

while True:
    In1.value(0)
    In2.value(0)
    utime.sleep(1)

    In1.value(0)
    In2.value(1)
    utime.sleep(1)

    In1.value(1)
    In2.value(0)
    utime.sleep(1)

    In1.value(1)
    In2.value(1)
    utime.sleep(1)
```

Lab: H – Bridge DC Motor Controller. . .

H- Bridge DC Motor Controller Output



Watch Video Clip → https://youtu.be/s2sDUrZtCME

Question 5

The utime.sleep (1) instruction shown on slide 31 provides what time delay value?

a) 1us
b) 1ms
c) 1s
d) none of the above

Thank you for attending

Please consider the resources below:

Adams, J. (2021, February 1). *Raspberry pi rp2040: Our microcontroller for the masses*. https://www.arm.com/blogs/blueprint/raspberry-pi-rp2040

RP2040 Datasheet. (2022). RP2040 datasheet: A microcontroller by raspberry pi. https://datasheets.raspberrypi.com/rp2040/rp2040-datasheet.pdf

Raspberry Pi Pico Resources: Raspberry Pi Documentation - Raspberry Pi Pico and Pico W

How To Use Your Raspberry Pi Pico with DC Motors: https://www.tomshardware.com/how-to/dc-motors-raspberry-pi-pico

How To Use A DC Motor With The Raspberry Pi Pico: https://www.youngwonks.com/blog/How-to-use-a-DC-motor-with-the-Raspberry-Pi-Pico

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