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DesignNews

Raspberry Pi 4 Automation

DAY 4 : DC Motor Controls

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Don Wilcher

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Agenda:

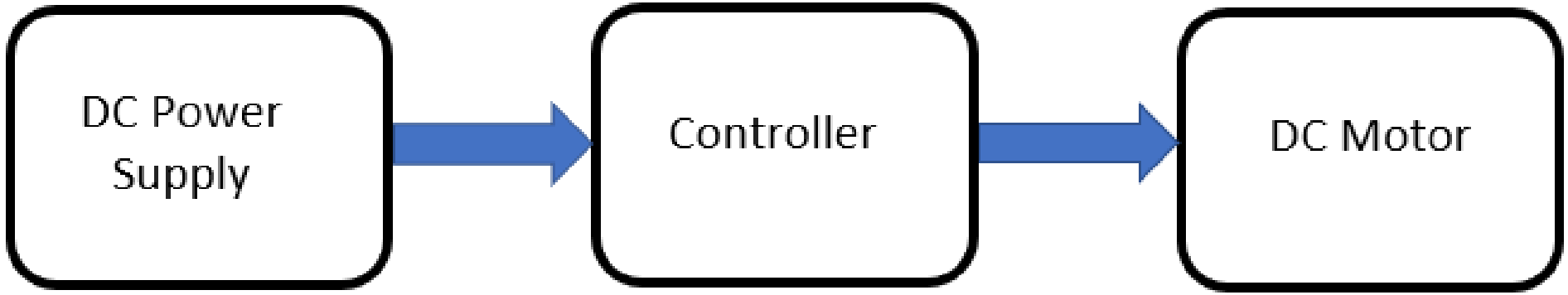
- Basic DC Motor Control Concept
- What is a H-Bridge Driver?
- The L293 H-Bridge IC
- Lab: A DC Motor Controller

Basic DC Motor Control Concept

A Basic DC Motor Control consists of

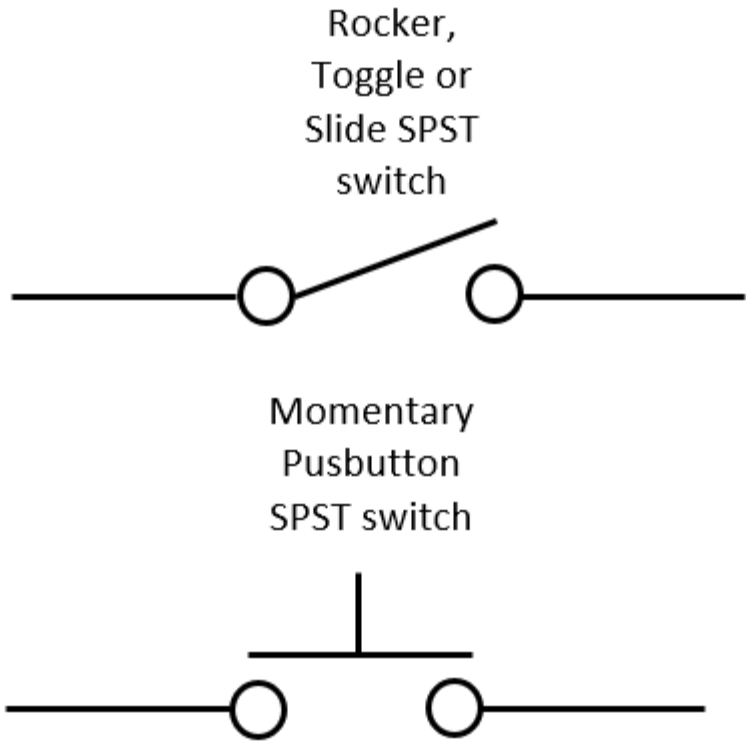
- DC power supply.
- A controller
- A DC motor

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.

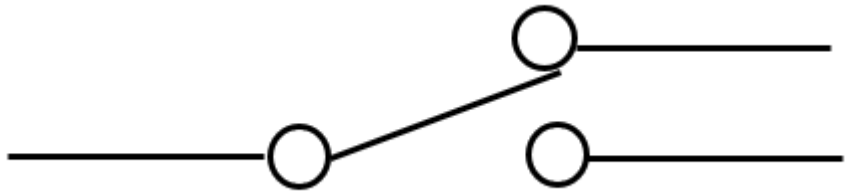
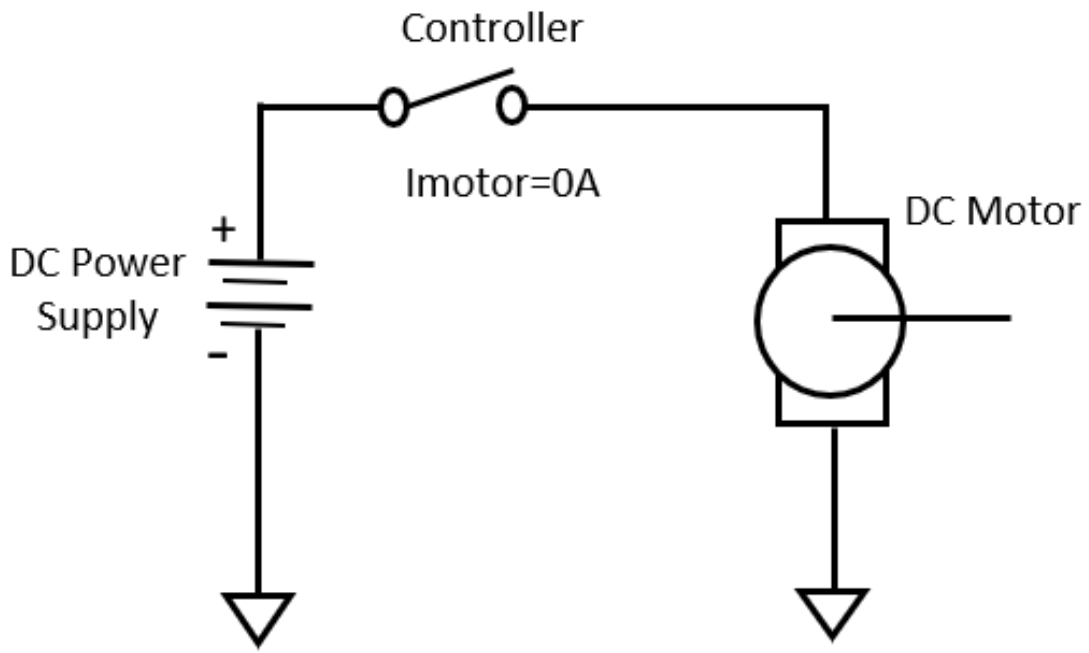


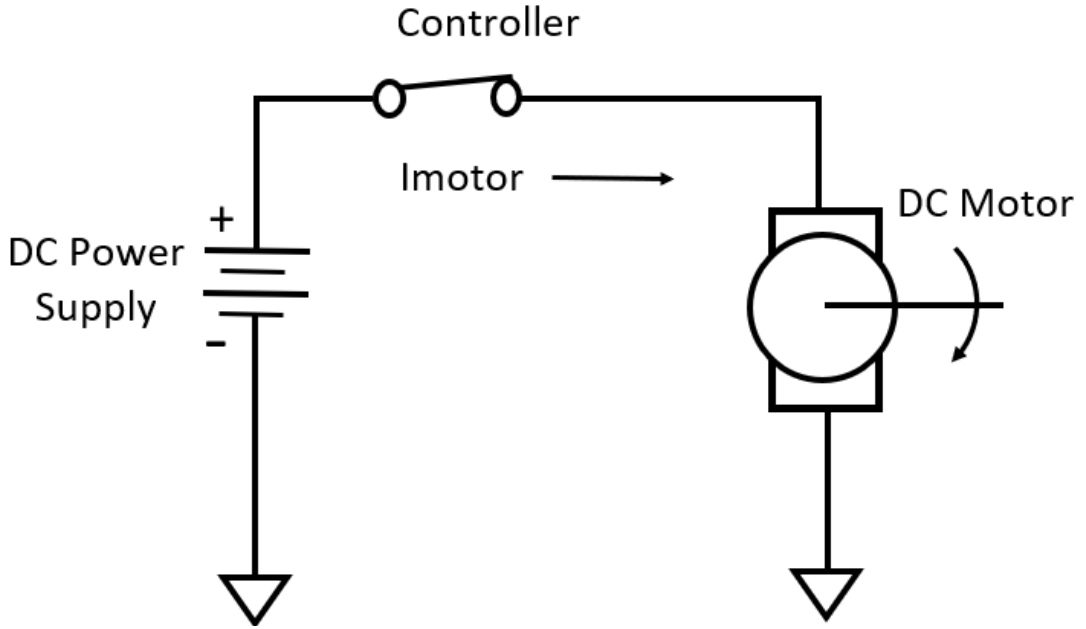
Figure 1.

Basic DC Motor Control Concept…

A typical circuit schematic diagram of Basic DC Motor Controller



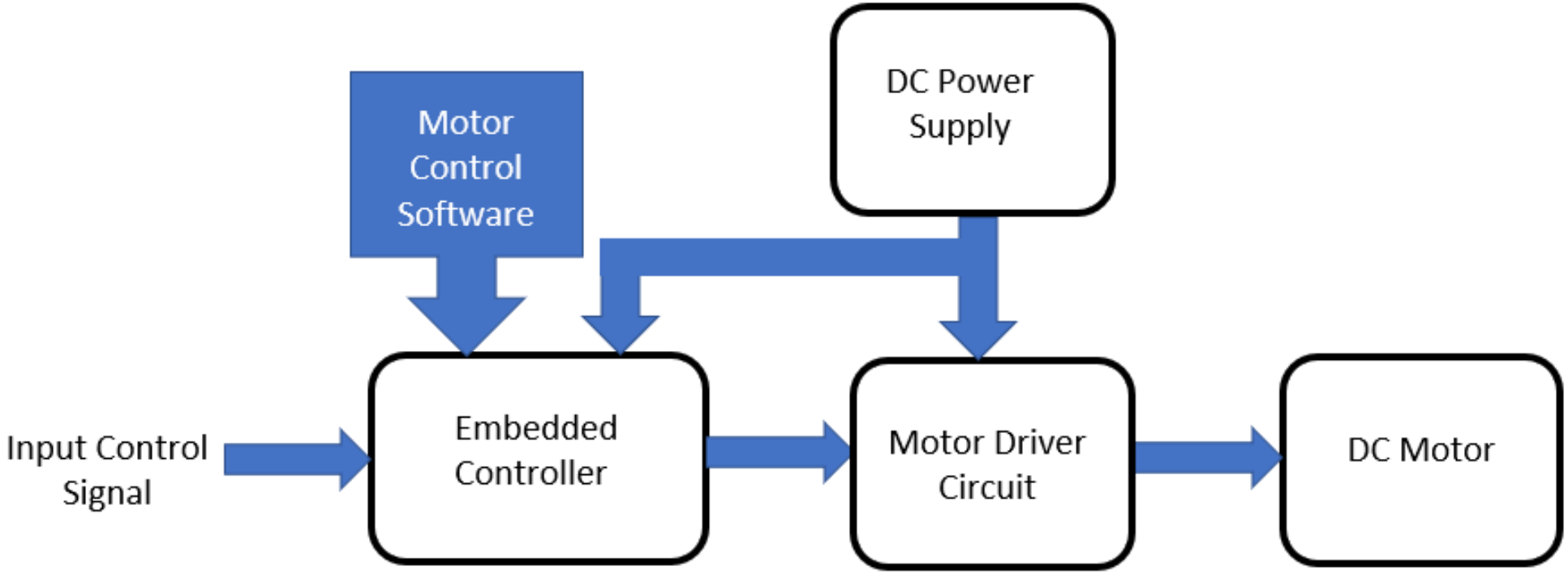
Motor OFF



Motor ON

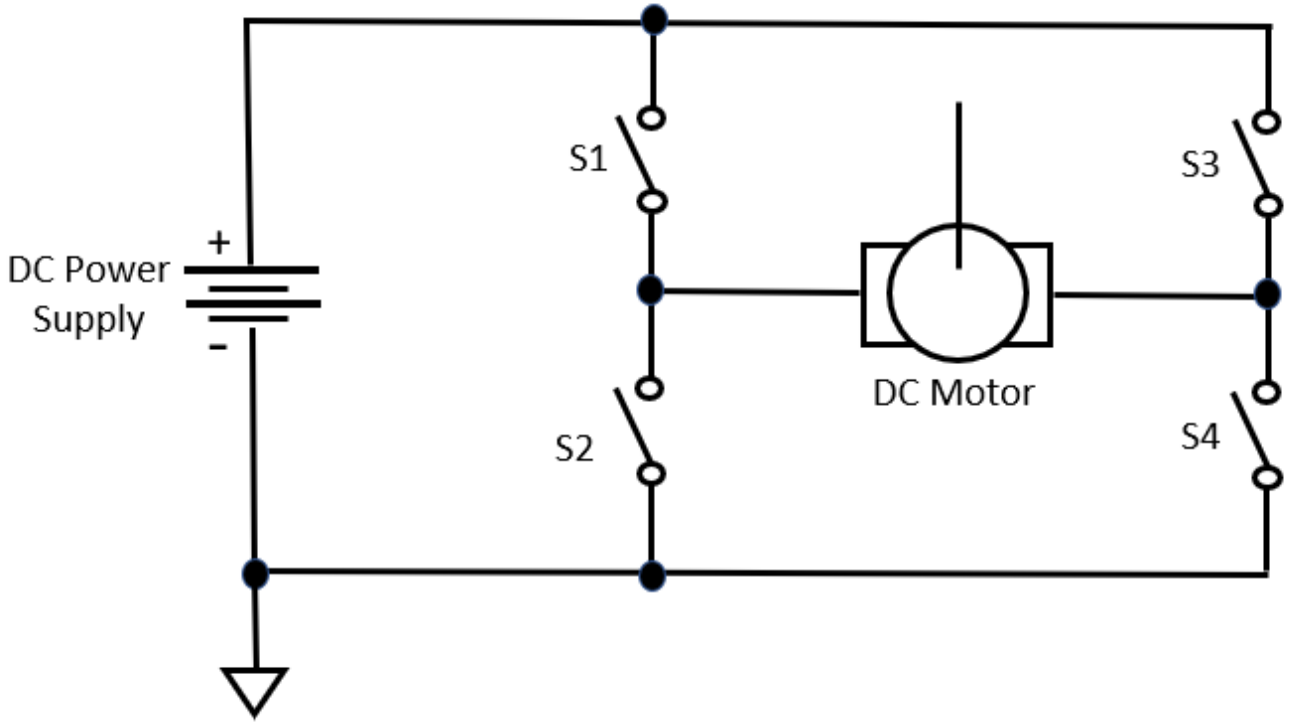
Basic DC Motor Control Concept…

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



What is a H-Bridge Driver?

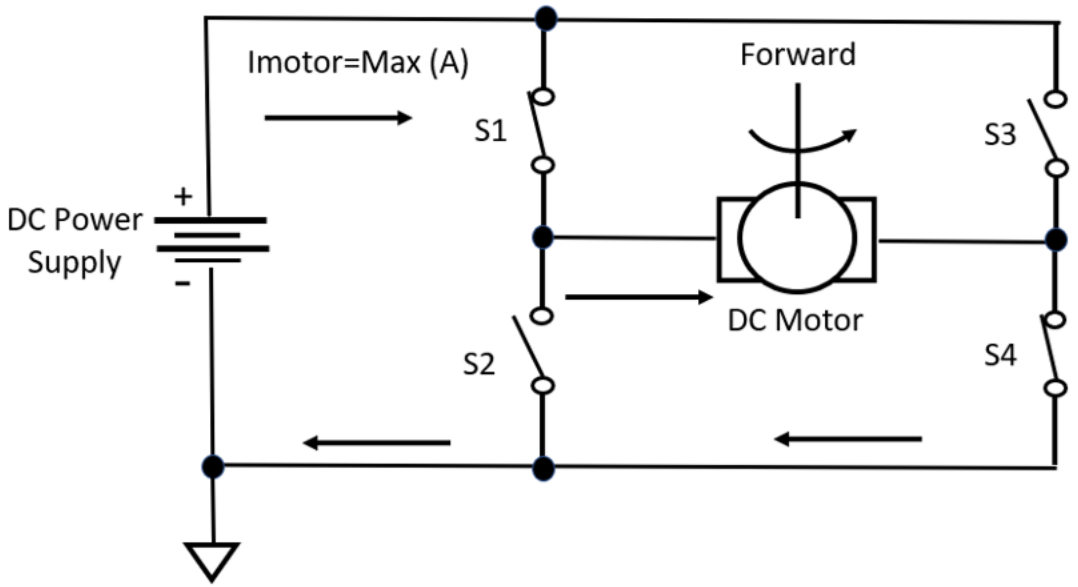
An electronic circuit capable of switch polarity across electromechanical load. A basic method of illustrating the concept of a H-Bridge Driver circuit is using four SPST switches.



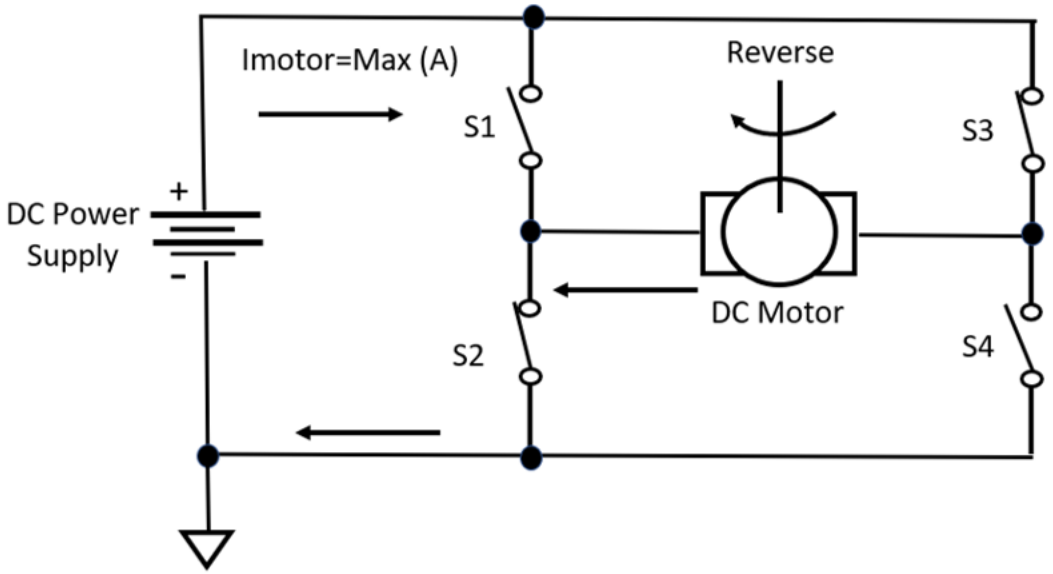
What is a H-Bridge Driver?...

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

S1S4 = Forward Direction

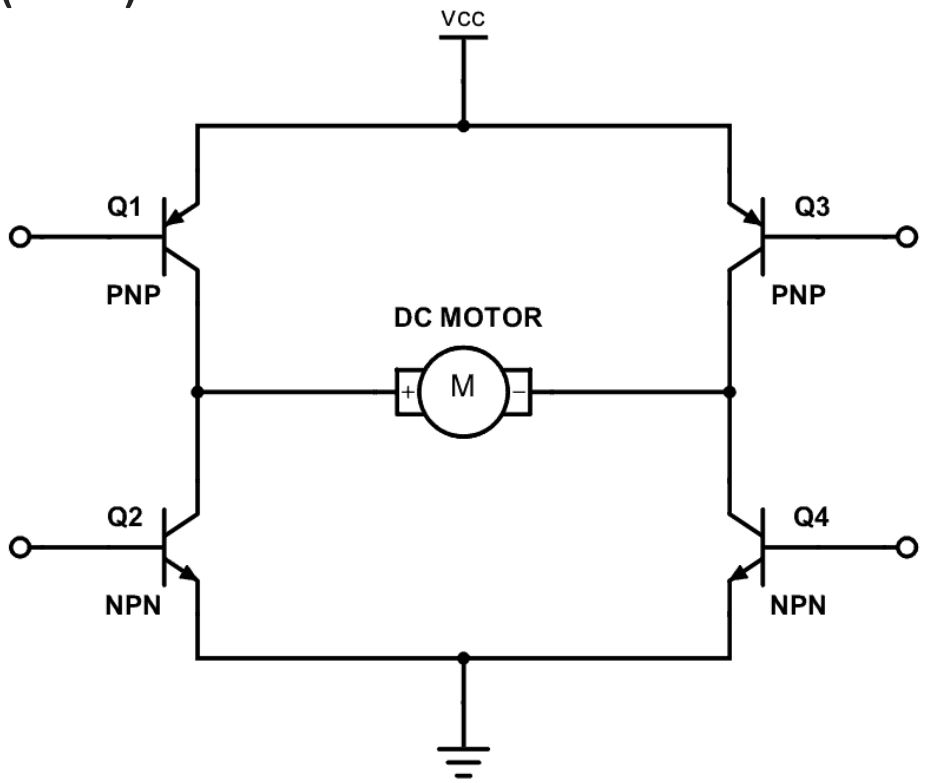


S2S3 = Reverse Direction



What is a H-Bridge Driver?...

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

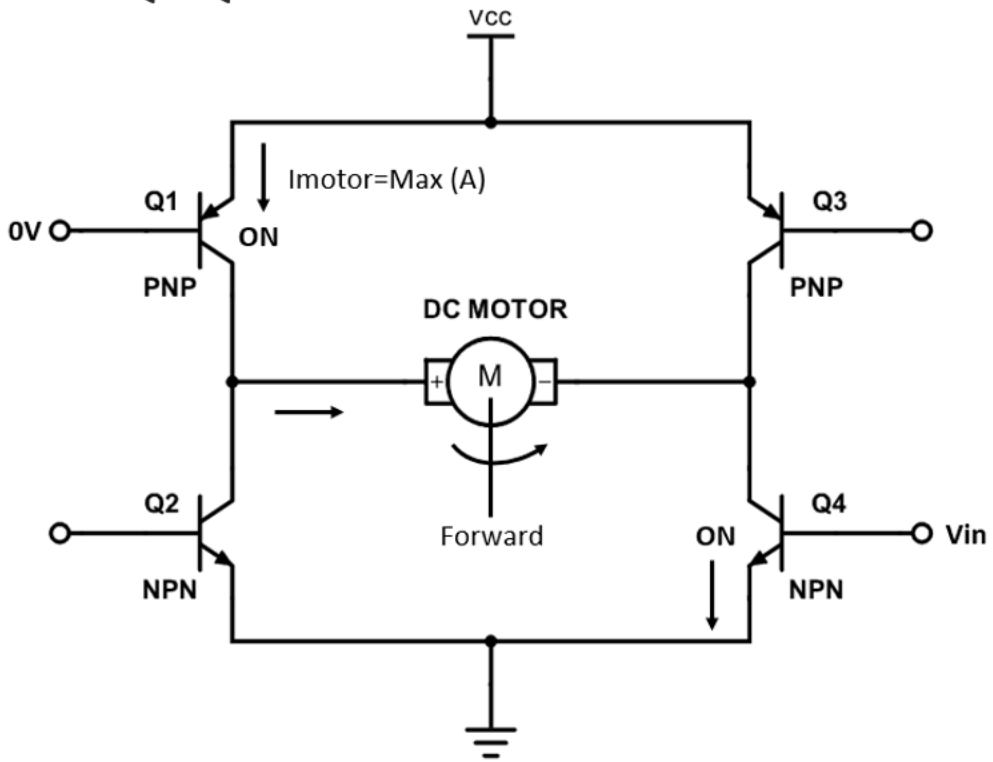


Source:
https://www.build-electronic-circuits.com/h-bridge/

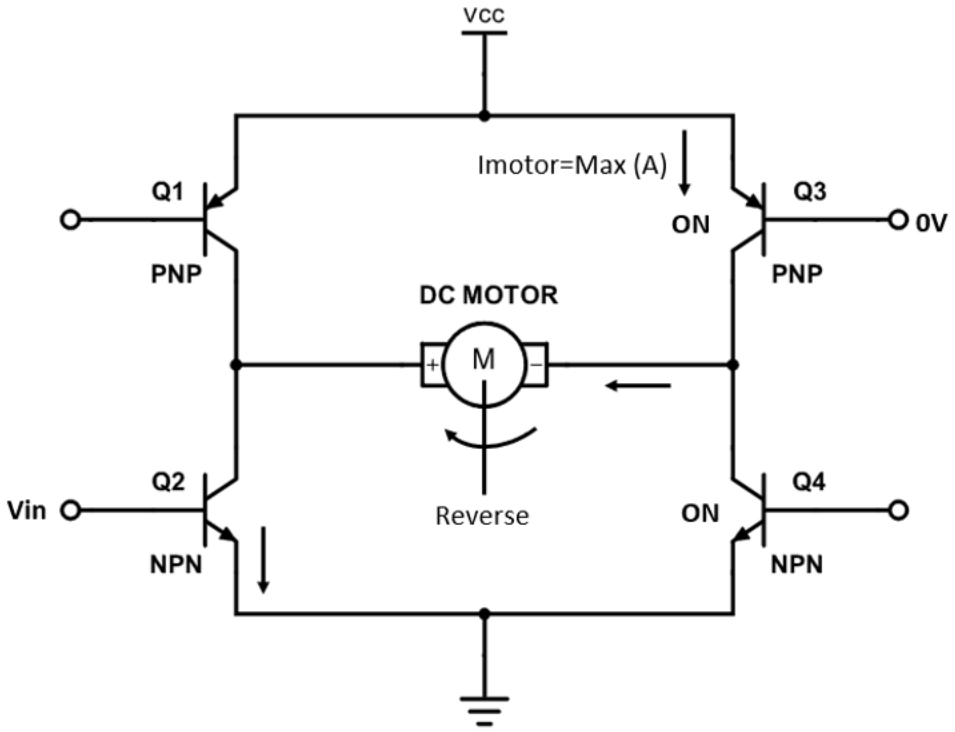
What is a H-Bridge Driver?...

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

Q1Q4 = Forward Direction



Q2Q3 = Reverse Direction



What is a H-Bridge Driver?...

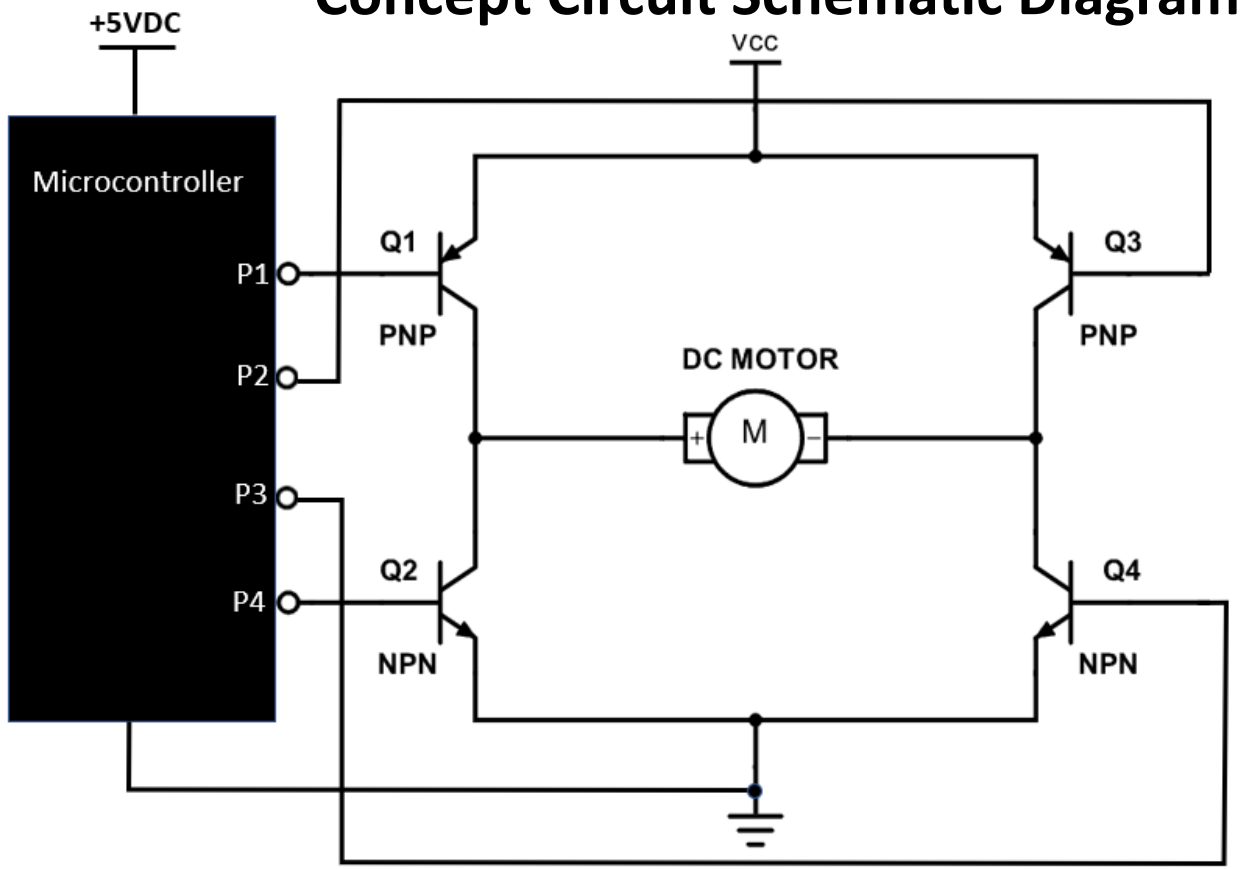
The advantage to using a SS H-Bridge Driver is the ability to control speed and direction of the DC Motor with a microcontroller.

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.

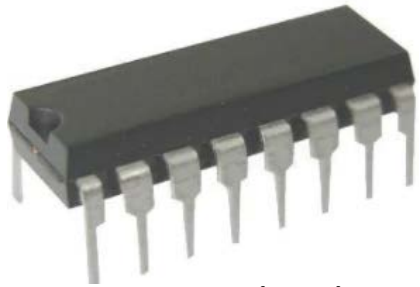
Concept Circuit Schematic Diagram



The L293 H-Bridge IC

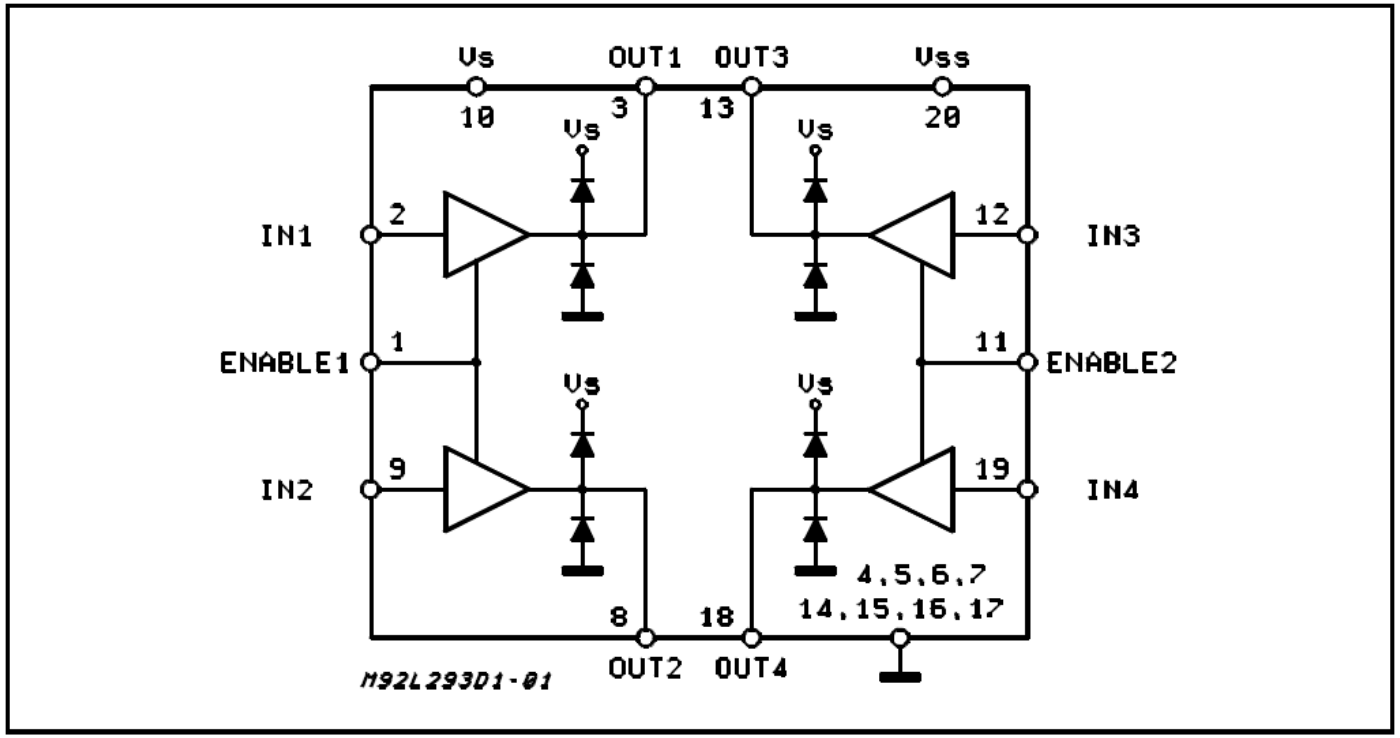
The L293 H-Bridge IC has four SS drivers integrated within its package.

Small Outline (SO)



Power (DIP)

BLOCK DIAGRAM

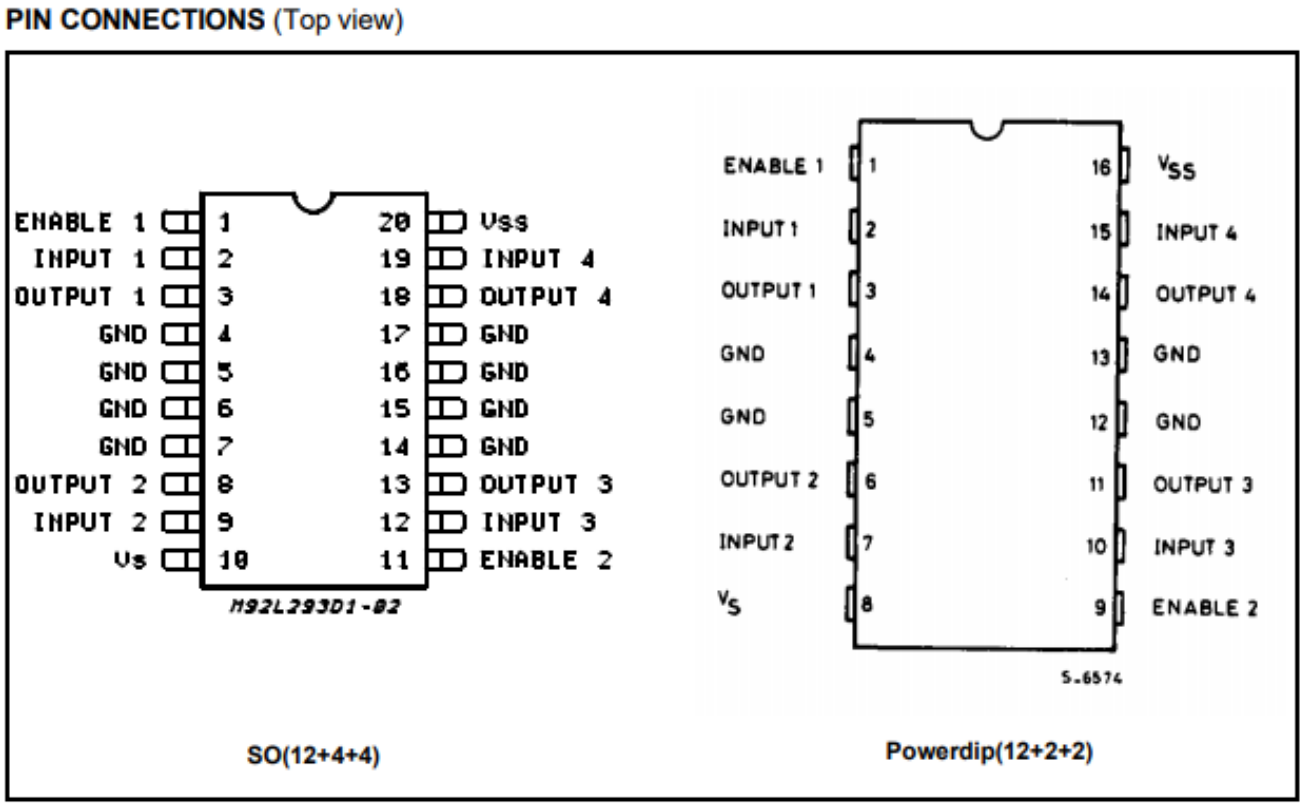


Source:

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

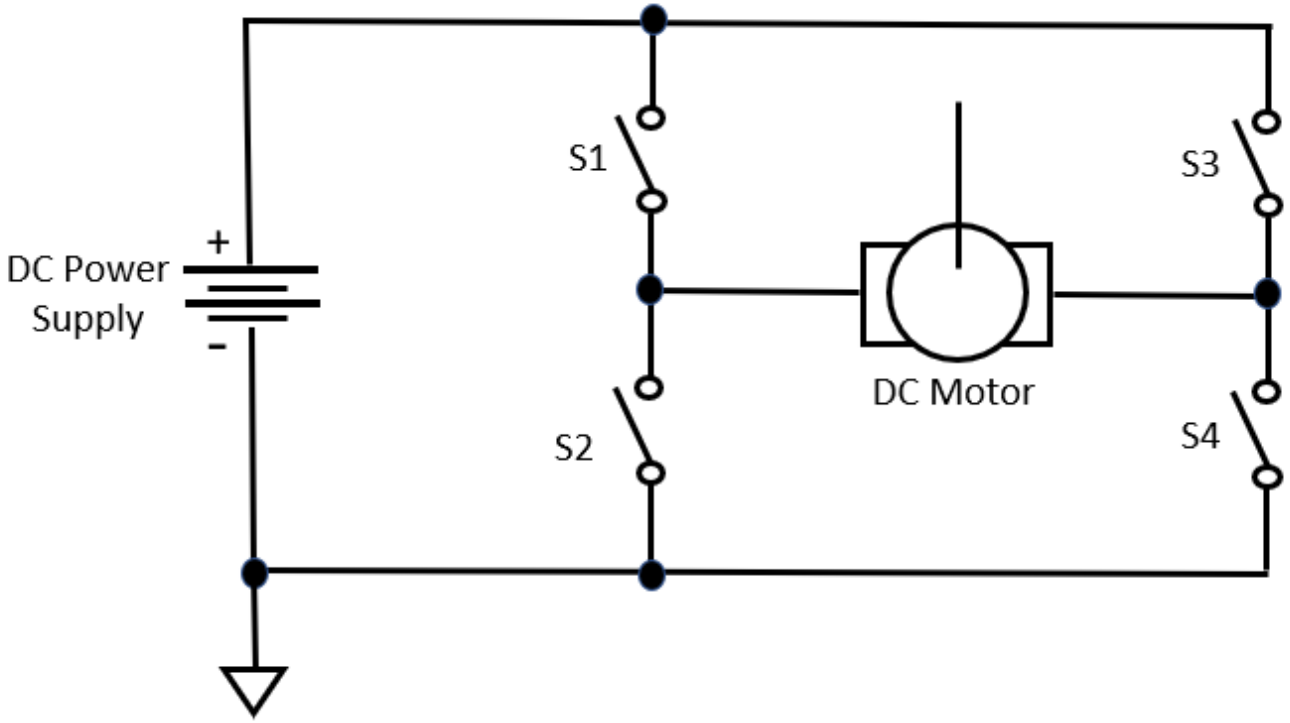
Symbol	Parameter	Value	Unit
V_S	Supply Voltage	36	V
V_{SS}	Logic Supply Voltage	36	V
V_i	Input Voltage	7	V
V_{en}	Enable Voltage	7	V
I_o	Peak Output Current (100 µs non repetitive)	1.2	A
P_{tot}	Total Power Dissipation at T_{pins} = 90 °C	4	W
T_{stg}, T_j	Storage and Junction Temperature	– 40 to 150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

Source:

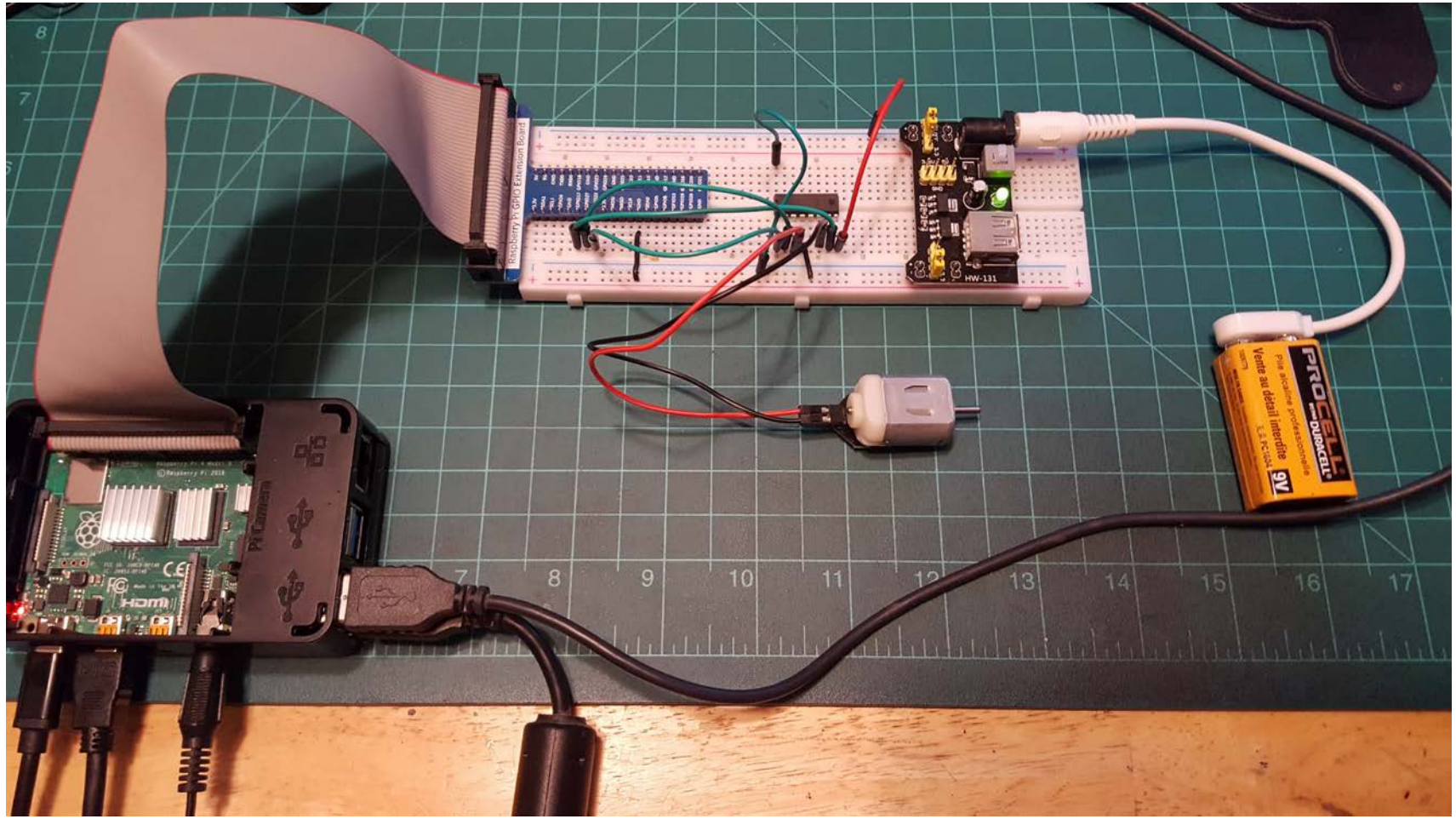
https://www.mouser.com/datasheet/2/389/cd00000059-1795435.pdf

Question 2

Identify the electronic circuit shown in Figure 2.



Lab Project: A DC Motor Controller



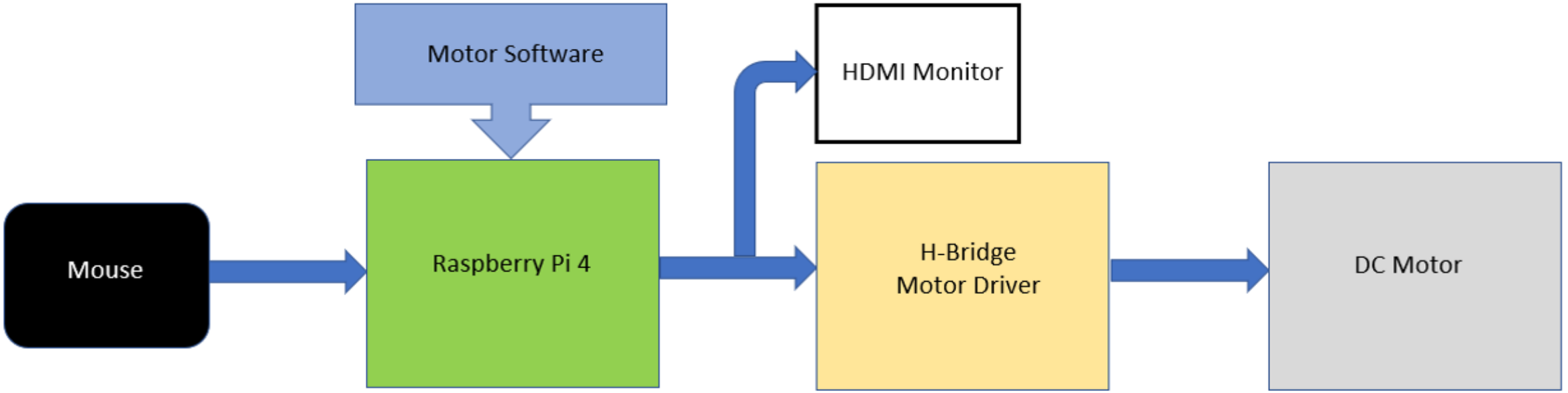
Lab Project: A DC Motor Controller

Big IDEAS:

1. Learners will be able to wire an electronic controller using a few off the shelf components .
2. Learners will be able to build a motor speed control device using Physical Computing concepts.
3. Learners will be able to make small changes to the code for personalization.

Lab Project: A DC Motor Controller…

A DC Motor Controller Block Diagram

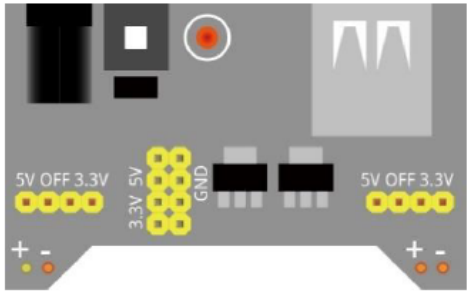
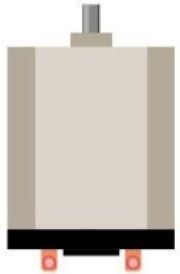
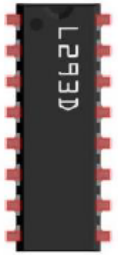
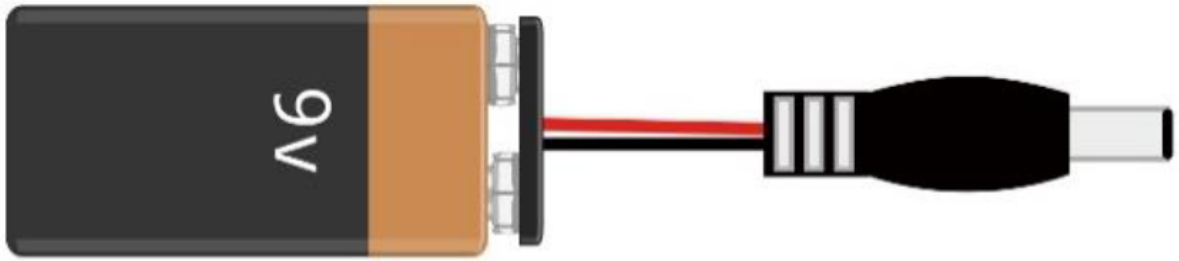


Question 3

In reviewing the DC Motor Controller Block Diagram, what is the name of the IC that performs the H-Bridge Motor Driver function?

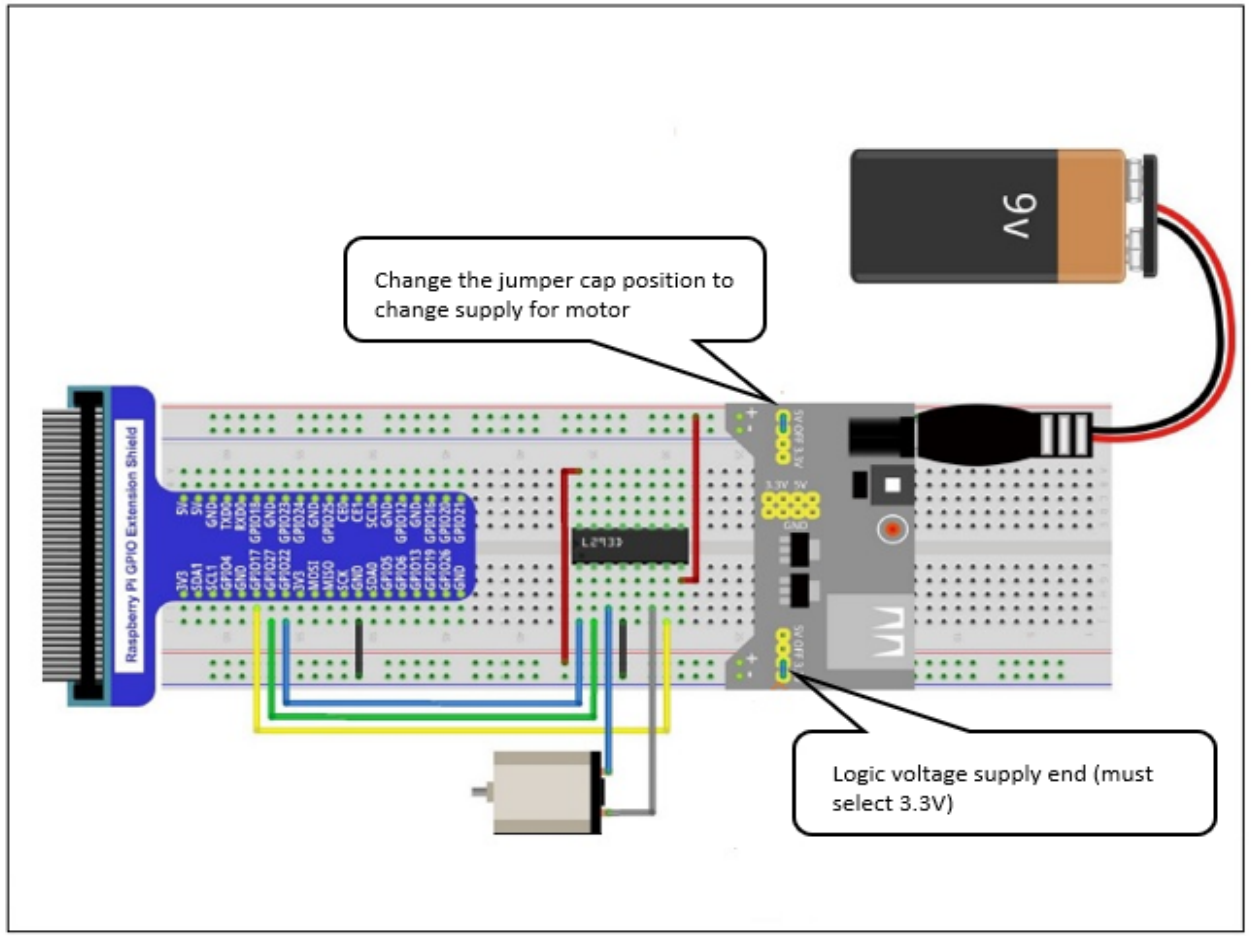
Lab Project: A DC Motor Controller…

Major Components

Raspberry Pi x1 GPIO Extension Board & Wire x1 BreadBoard x1	Jumper M/M x22 	
Breadboard power module x1 	Motor x1 	L293D 
9V Battery (provided by yourself) & battery cable 		

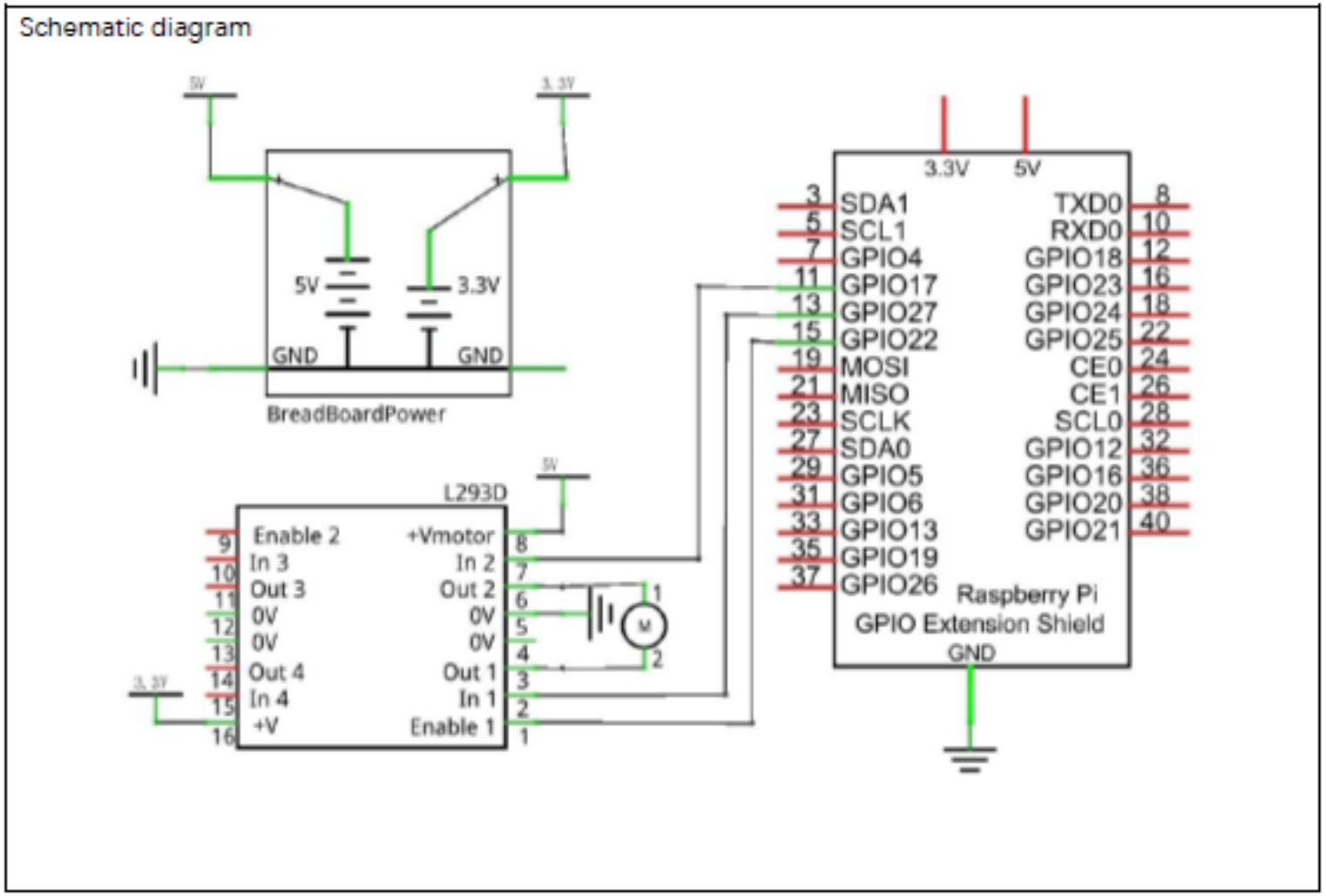
Lab Project: A DC Motor Controller…

Electrical Wiring Diagram



Lab Project: A DC Motor Controller…

Electronic Circuit Schematic Diagram

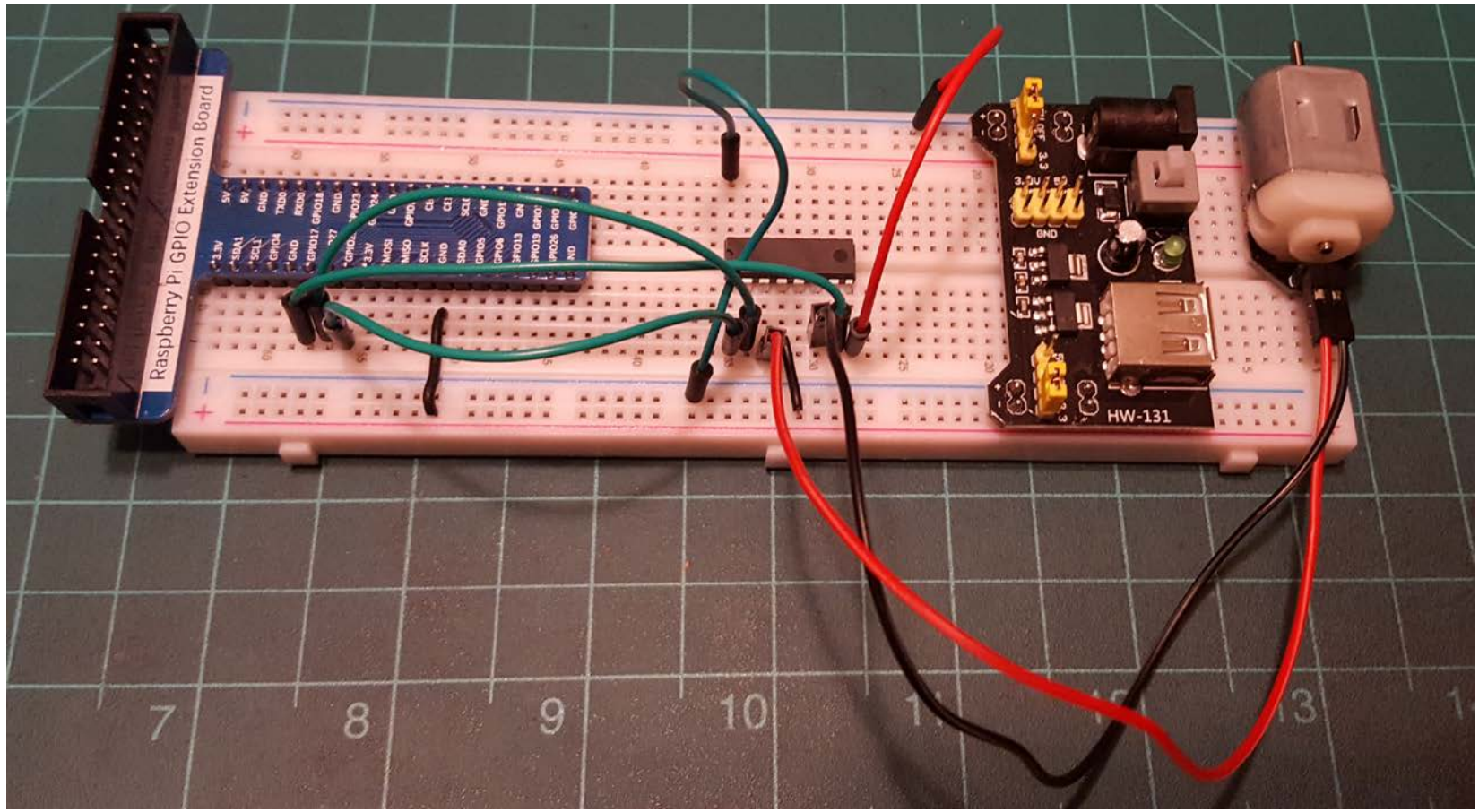


Question 4

In reviewing the electronic circuit schematic diagram shown on slide 26, which GPIO pin on the GPIO Expansion Shield is responsible for enabling the driver circuit wired to the DC motor?

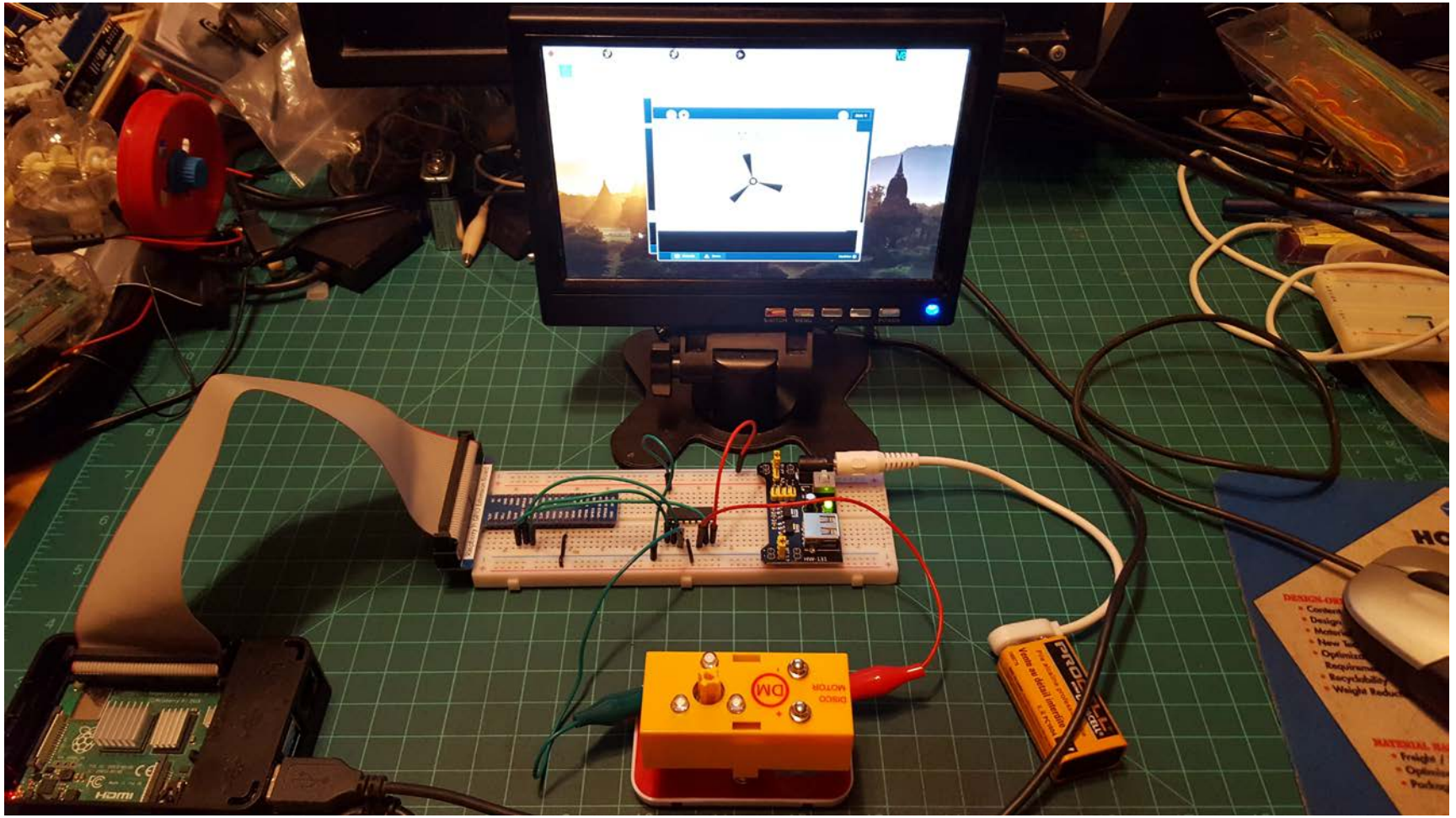
Lab Project: A DC Motor Controller…

Circuit Breadboard Complete



Lab Project: A DC Motor Controller…

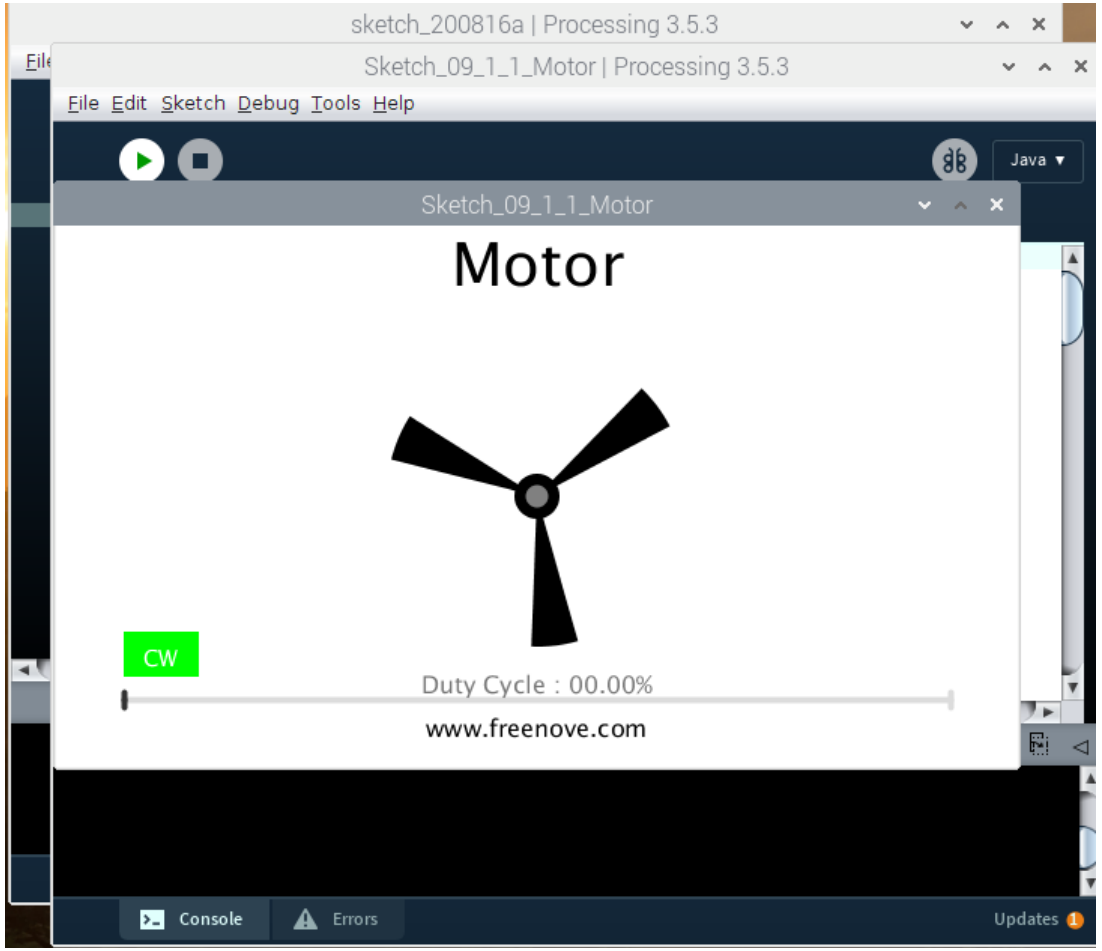
Demo



https://youtu.be/9fopAQj8cP0

Lab Project: A DC Motor Controller…

Processing Code



Lab Project: A DC Motor Controller…

Processing Code…

```
1  import processing.io.*;
2
3  int motorPin1 = 17;    //connect to the L293D
4  int motorPin2 = 27;
5  int enablePin = 22;
6  final int borderSize = 45;    //border size
7  //MOTOR Object
8  MOTOR motor = new MOTOR(motorPin1, motorPin2, enablePin);
9  ProgressBar mBar;    //ProgressBar Object
10 boolean mMouse = false;    //determined whether a mouse click the ProgressBar
11 BUTTON btn;    //BUTTON Object, For controlling the direction of motor
12 int motorDir = motor.CW;    //motor direction
13 float rotaSpeed = 0, rotaPosition = 0;  //motor speed
14 void setup() {
15   size(640, 360);
16   mBar = new ProgressBar(borderSize, height-borderSize, width-borderSize*2);
17   mBar.setTitle("Duty Cycle");    //set the ProgressBar's title
18   btn = new BUTTON(45, height - 90, 50, 30);    //define the button
19   btn.setBgColor(0, 255, 0);  //set button color
20   btn.setText("CW");        //set button text
21 }
```

Lab Project: A DC Motor Controller…

Processing Code…

```
23  void draw() {
24    background(255);
25    titleAndSiteInfo();  //title and site information
26    strokeWeight(4);     //border weight
27    mBar.create();       //create the ProgressBar
28    motor.start(motorDir, (int)(mBar.progress*100));  //control the motor starts to rotate
29    btn.create();       //create the button
30    rotaSpeed = mBar.progress * 0.02 * PI;  //virtual fan's rotating speed
31    if (motorDir == motor.CW) {
32      rotaPosition += rotaSpeed;
33      if (rotaPosition >= 2*PI) {
34        rotaPosition = 0;
35      }
36    } else {
37      rotaPosition -= rotaSpeed;
38      if (rotaPosition <= -2*PI) {
39        rotaPosition = 0;
40      }
41    }
42    drawFan(rotaPosition);    //show the virtual fan in Display window
43  }
```

Lab Project: A DC Motor Controller…

Processing Code…

```
44  //Draw a clover fan according to the stating angle
45  void drawFan(float angle) {
46    constrain(angle, 0, 2*PI);
47    fill(0);
48    for (int i=0; i<3; i++) {
49      arc(width/2, height/2, 200, 200, 2*i*PI/3+angle, (2*i+0.3)*PI/3+angle, PIE);
50    }
51    fill(0);
52    ellipse(width/2, height/2, 30, 30);
53    fill(128);
54    ellipse(width/2, height/2, 15, 15);
55  }
```

Lab Project: A DC Motor Controller…

```
57  void mousePressed() {
58    if ( (mouseY< mBar.y+5) && (mouseY>mBar.y-5) ) {
59      mMouse = true;     //the mouse click the progressBar
60    } else if ((mouseY< btn.y+btn.h) && (mouseY>btn.y)
61      && (mouseX< btn.x+btn.w) && (mouseX>btn.x)) { // the mouse click the button
62      if (motorDir == motor.CW) {    //change the direction of rotation of motor
63        motorDir = motor.CCW;
64        btn.setBgColor(255, 0, 0);
65        btn.setText("CCW");
66      } else if (motorDir == motor.CCW) {
67        motorDir = motor.CW;
68        btn.setBgColor(0, 255, 0);
69        btn.setText("CW");
70      }
71    }
72  }
```

Processing Code…

Lab Project: A DC Motor Controller…

Processing Code…

```
73  void mouseReleased() {
74    mMouse  = false;
75  }
76  void mouseDragged() {
77    int a = constrain(mouseX, borderSize, width - borderSize);
78    float t = map(a, borderSize, width - borderSize, 0.0, 1.0);
79    if (mMouse) {
80      mBar.setProgress(t);
81    }
82  }
83  void titleAndSiteInfo() {
84    fill(0);
85    textAlign(CENTER);    //set the text centered
86    textSize(40);        //set text size
87    text("Motor", width / 2, 40);    //title
```

Lab Project: A DC Motor Controller…

Processing Code…

```
88      textSize(16);
89      text("www.freenove.com", width / 2, height - 20);    //site
90  }
```

Question 5

Identify the Processing Code line number that displays the developer's website on the virtual simulator control panel.

Thank you for attending

Please consider the resources below:

- The L239 H-Bridge Motor Driver IC Datasheet
  https://www.mouser.com/datasheet/2/389/cd00000059-1795435.pdf
- Physical Computing
  O'Sullivan, D., & Igoe, T. (2004). *Physical computing: Sensing and controlling the physical world with computers*. Boston, MA: Thompson.
- Freenove Ultimate Starter Kit for Raspberry Pi
  http://www.freenove.com/tutorial.html
- H-Bridge Driver Circuit
  https://www.build-electronic-circuits.com/h-bridge/

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