Embedded Controls Development with OpenPLC

DAY 4 : ESP Controlled DC Motor with OpenPLC

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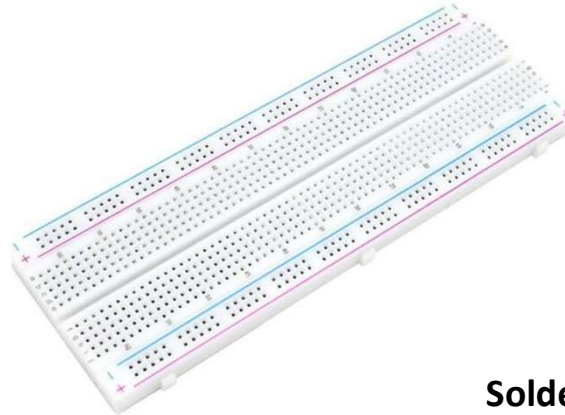
Dr. Don Wilcher

Visit 'Lecturer Profile' in your console for more details.

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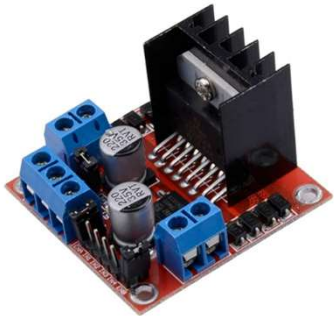# Course Kit and Materials

ESP32 WROOM32D DEVKITC
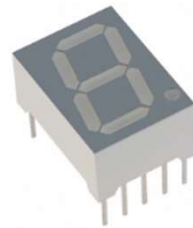
Solderless Breadboard x2

Adafruit Parts Pal Kit

L298N Motor Drive Controller

7 Segment LED Display, Common Cathode

Solderless Breadboard Power Supply Module with 9V Battery Clip Power Cable

Agenda:

- DC Motor Control Basics
  - a) Basic Switch Controls
  - b) H-Bridge driver
  - b) IC driver
- ESP32-OpenPLC Motor driver concept
- Electronic Circuit Schematic Diagram
- Lab: Build and Test an ESP32-OpenPLC Motor Driver controller

Research Perspective

"Embedded electronics is a subfield of electronics that can unite the power of programming with the power of electronics" (Zemmouri et al., 2023).

DC Motor Control Basics...

A Basic DC Motor Control consists of
- DC power supply.
- A controller
- A DC motor
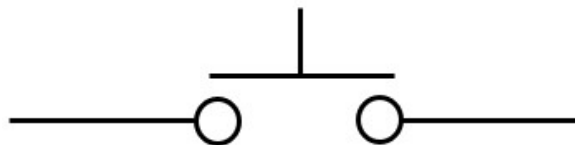
Basic DC Motor Control Block Diagram

DC Motor Control Basics. . .

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

Rocker,
Toggle or
Slide SPST
switch

Momentary
Pusbutton
SPST switch

Typical Switches which can be used as a simple controller

DC Motor Control Basics. . .

Typical Switches which can be used as a simple controller

Slide SPST Switch

Rocker SPST Switch

Toggle SPST Switch

Question 1
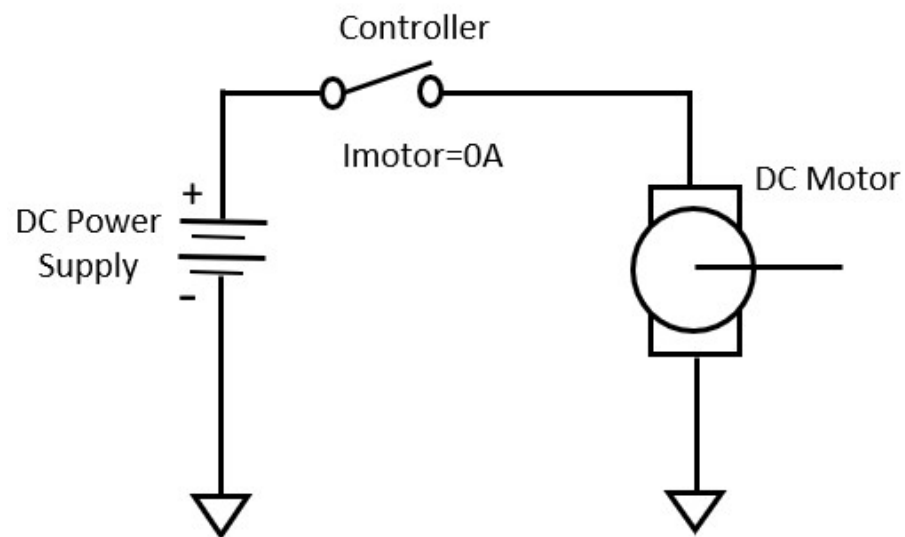
A simple controller for operating a typical DC motor is_____
   a) Double Pole-Double Throw Relay
   b) Double Pole-Double Throw Switch
   c) Single Pole-Single Throw Switch
   d) Single Pole-Double Throw Switch

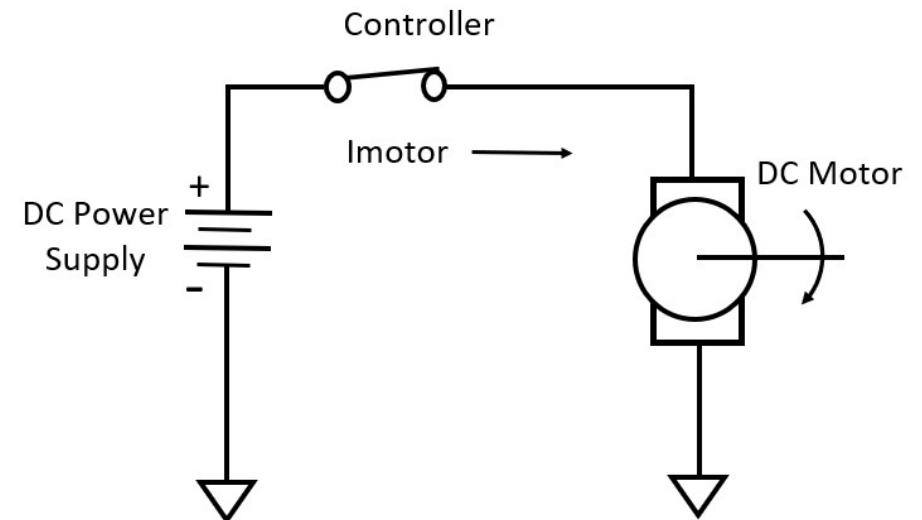# DC Motor Control Basics. . .

OPENPLC

A typical circuit schematic diagram of Basic DC Motor Controller
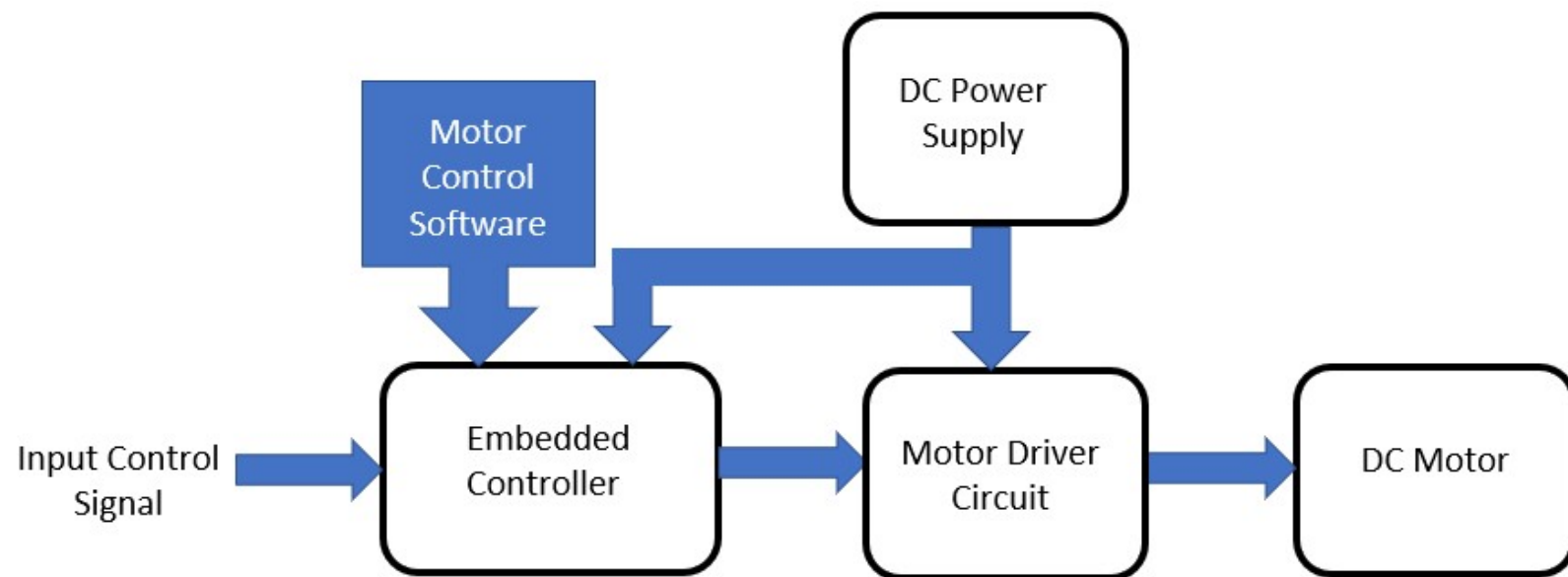

Motor OFF

Motor ON

DC Motor Control Basics. . .

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

H-Bridge Driver

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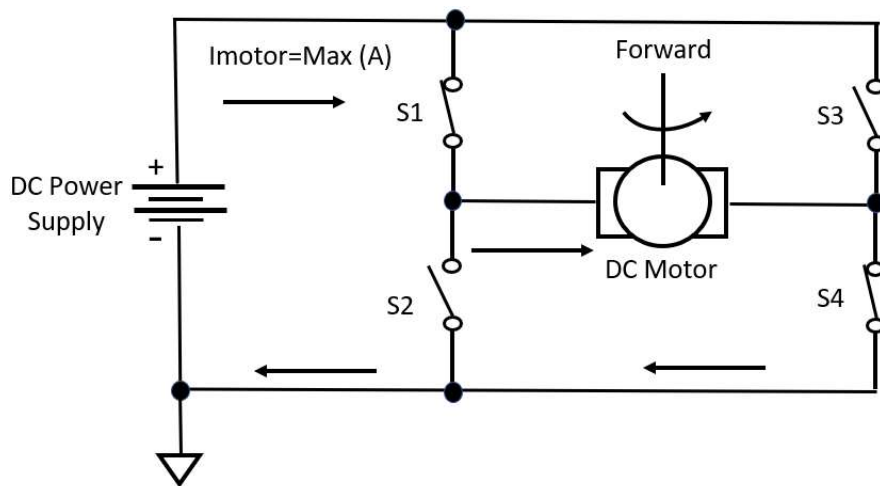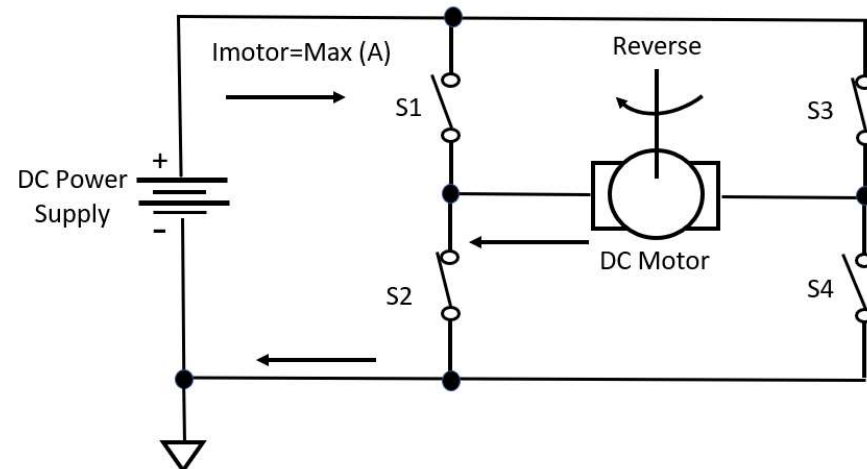
What is an H-Bridge Driver?
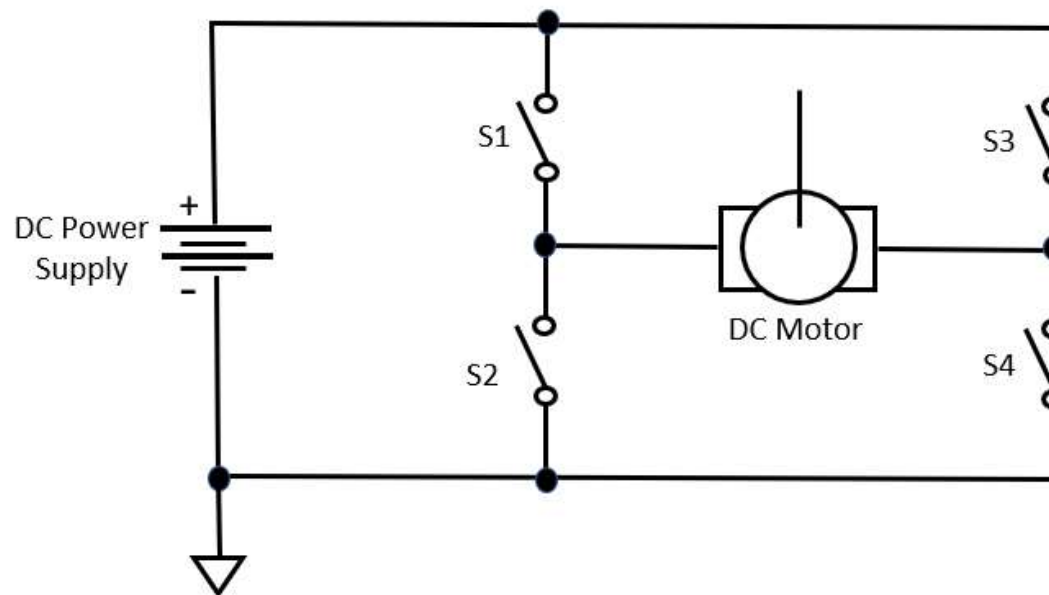
H-Bridge Driver . . .

By closing the correct switch combinations, the H-Bridge Driver can control the direction of the DC motor.
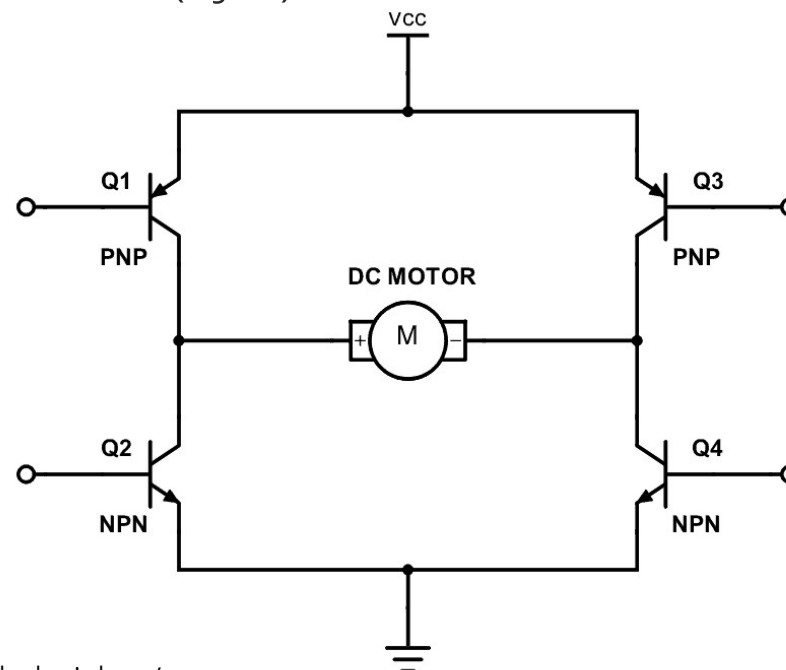
S1S4 = Forward Direction

S2S3 = Reverse Direction

H-Bridge Driver . . .

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

Illustration courtesy of Build Electronic Circuits

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

Question 2

An H-Bridge Driver Circuit uses _____
   a) four DPDTs
   b) four SPDTs
   c) four SPSTs
   d) None of the above

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.
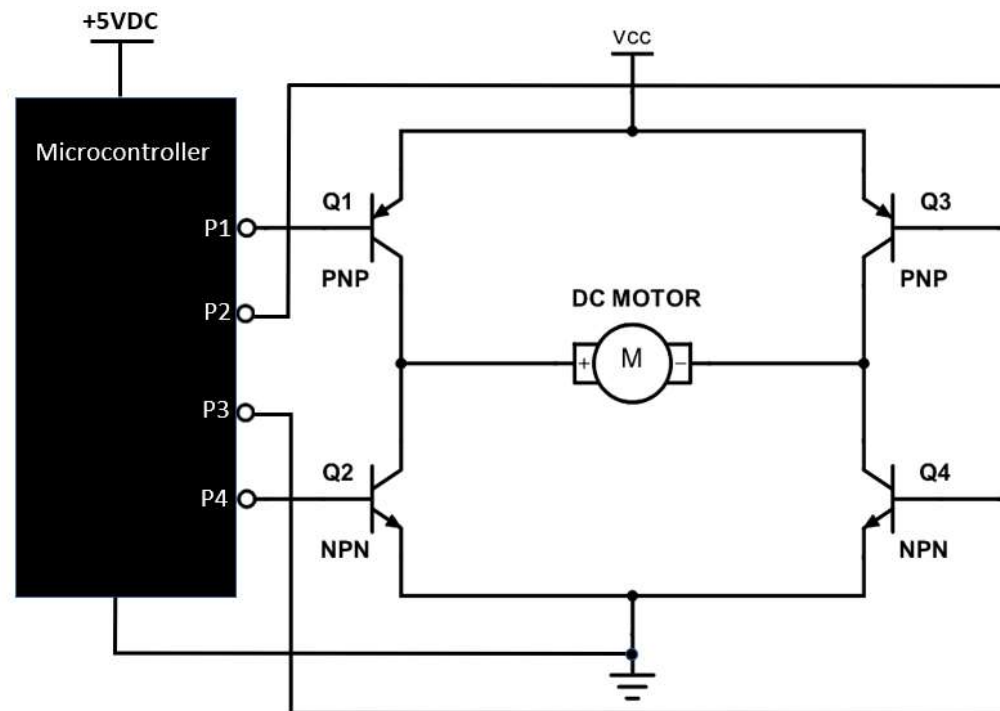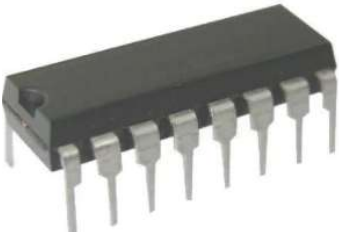

Concept Circuit Schematic Diagram

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IC Driver . . .

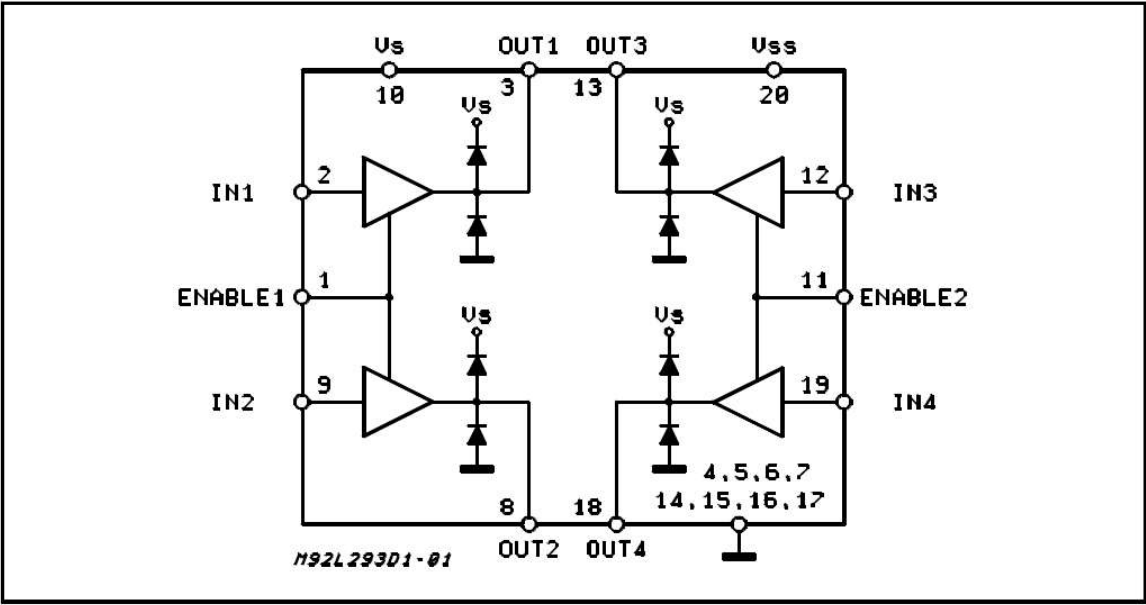The L293 H-Bridge IC has four SS drivers integrated within its package.

BLOCK DIAGRAM

Small Outline (SO)

Power (DIP)

Illustrations courtesy of Mouser Electronics

Source:

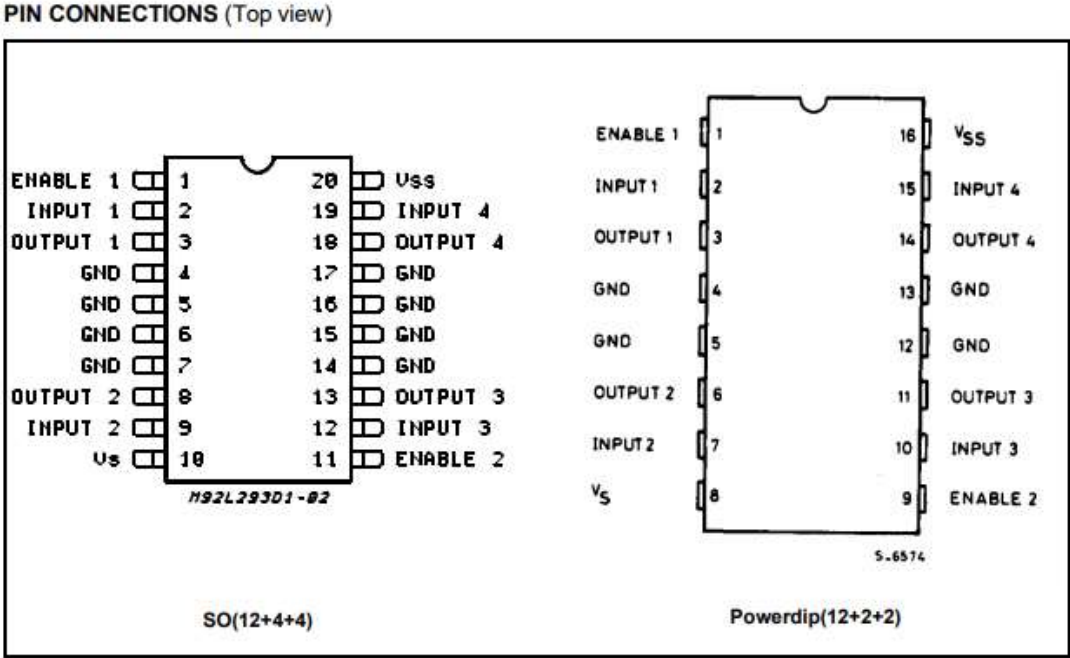https://www.mouser.com/datasheet/2/389/cd00000059-1795435.pdf

IC Driver . . .

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

The L293 H-Bridge IC

Illustrations courtesy of Mouser Electronics

PIN CONNECTIONS (Top view)

ENABLE 1	1	20	Vss
INPUT 1	2	19	INPUT 4
OUTPUT 1	3	18	OUTPUT 4
GND	4	17	GND
GND	5	16	GND
GND	6	15	GND
GND	7	14	GND
OUTPUT 2	8	13	OUTPUT 3
INPUT 2	9	12	INPUT 3
Vs	10	11	ENABLE 2

M92L293D1-02

SO(12+4+4)

ENABLE 1	1	16	Vss
INPUT 1	2	15	INPUT 4
OUTPUT 1	3	14	OUTPUT 4
GND	4	13	GND
GND	5	12	GND
OUTPUT 2	6	11	OUTPUT 3
INPUT 2	7	10	INPUT 3
Vs	8	9	ENABLE 2

S-6574

Powerdip(12+2+2)

Source:

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

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Question 3

There are 5 solid-state drivers in a L293 H-Bridge IC.
   a) True
   b) False

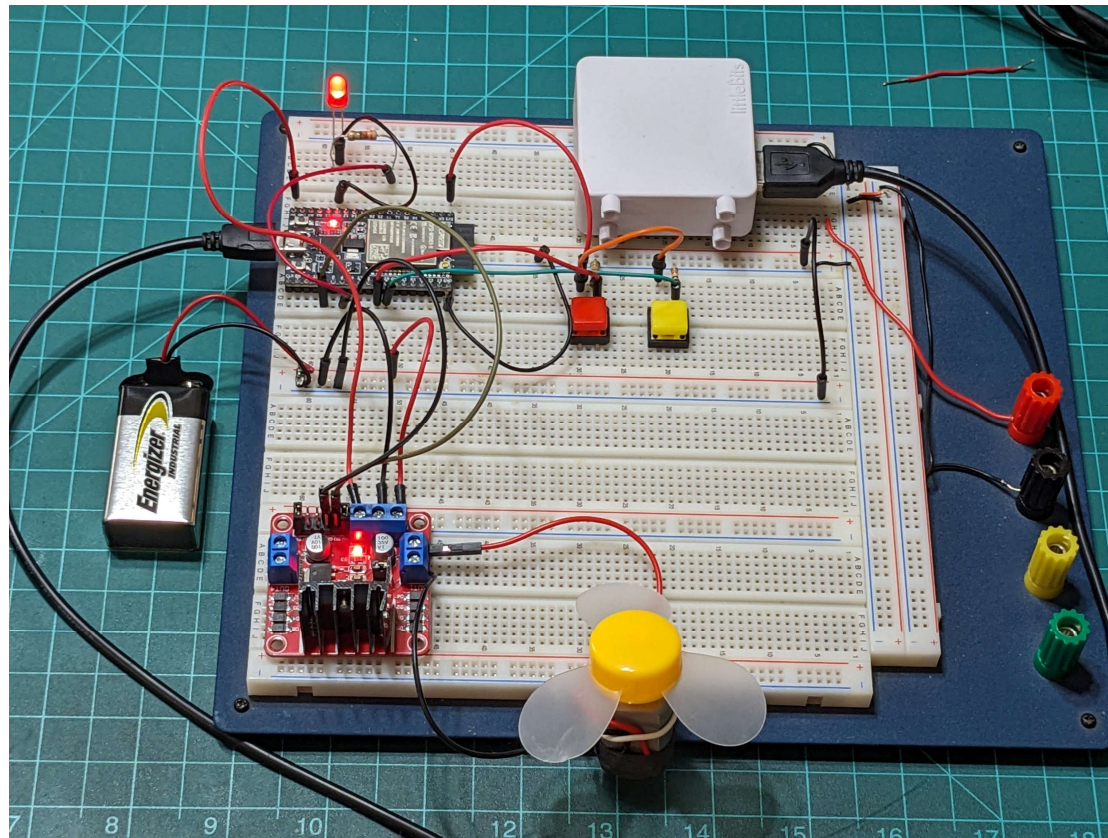# IC Driver . . .

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

Lab: Build and Test an ESP32 OpenPLC Motor Driver Controller

Lab: Build and Test ESP32 OpenPLC Motor Driver Controller...

Lab Objectives:
- Participants will learn to Build an ESP32 Motor Driver Controller.
- Participants will learn to program the ESP32 microcontroller using OpenPLC.
- Participants will learn to run and test the ESP32 Counter UP Motor Controller LD program on an ESP32 microcontroller.
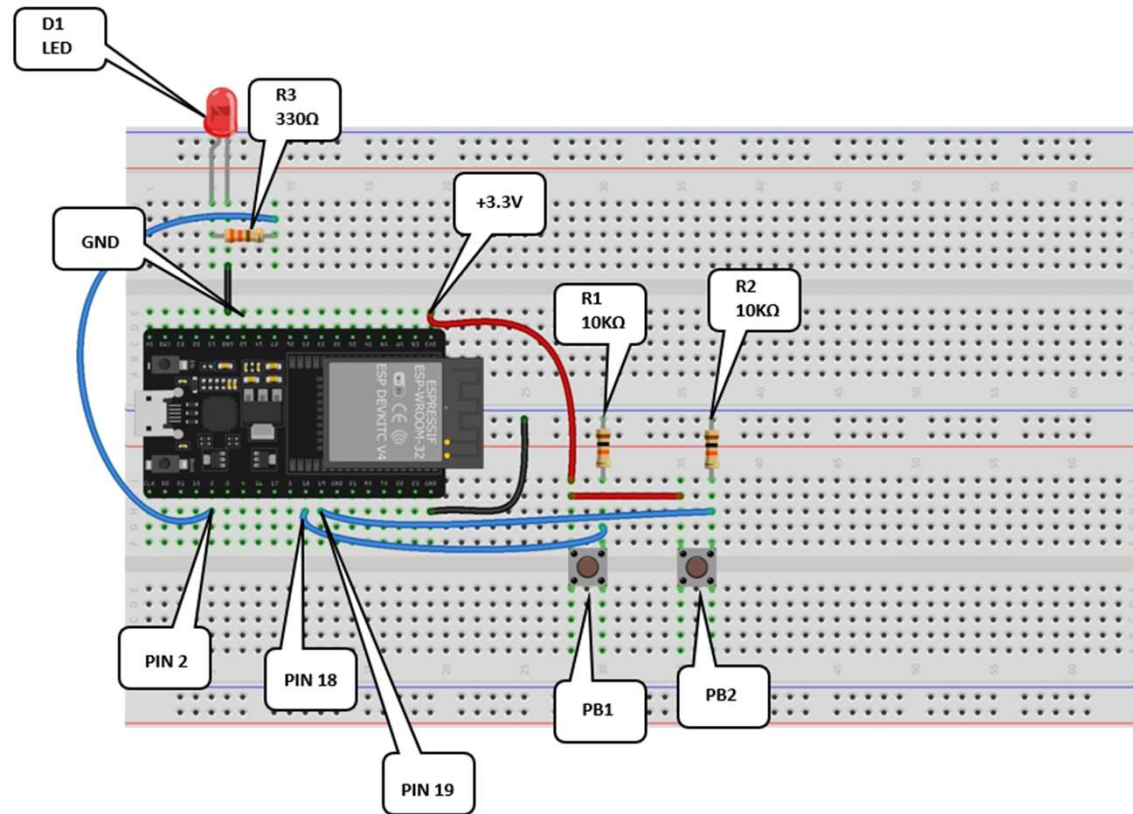
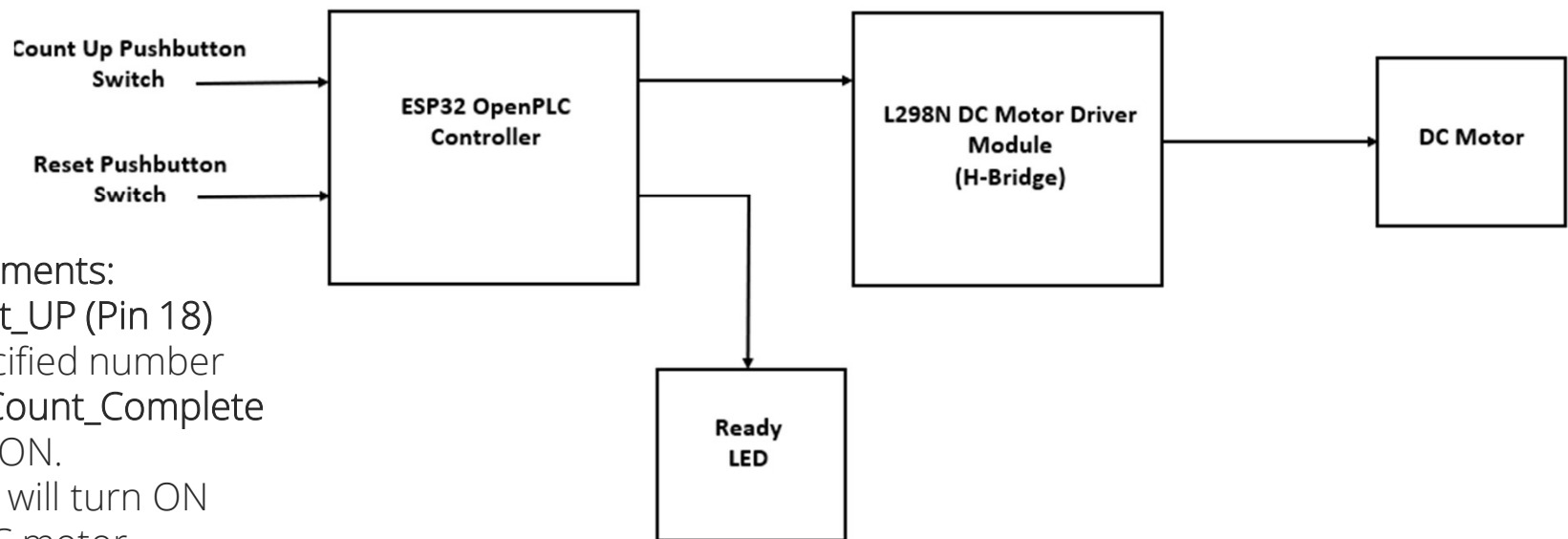# Lab: Build and Test an ESP32 OpenPLC Motor Driver Controller...

Concept Block Diagram
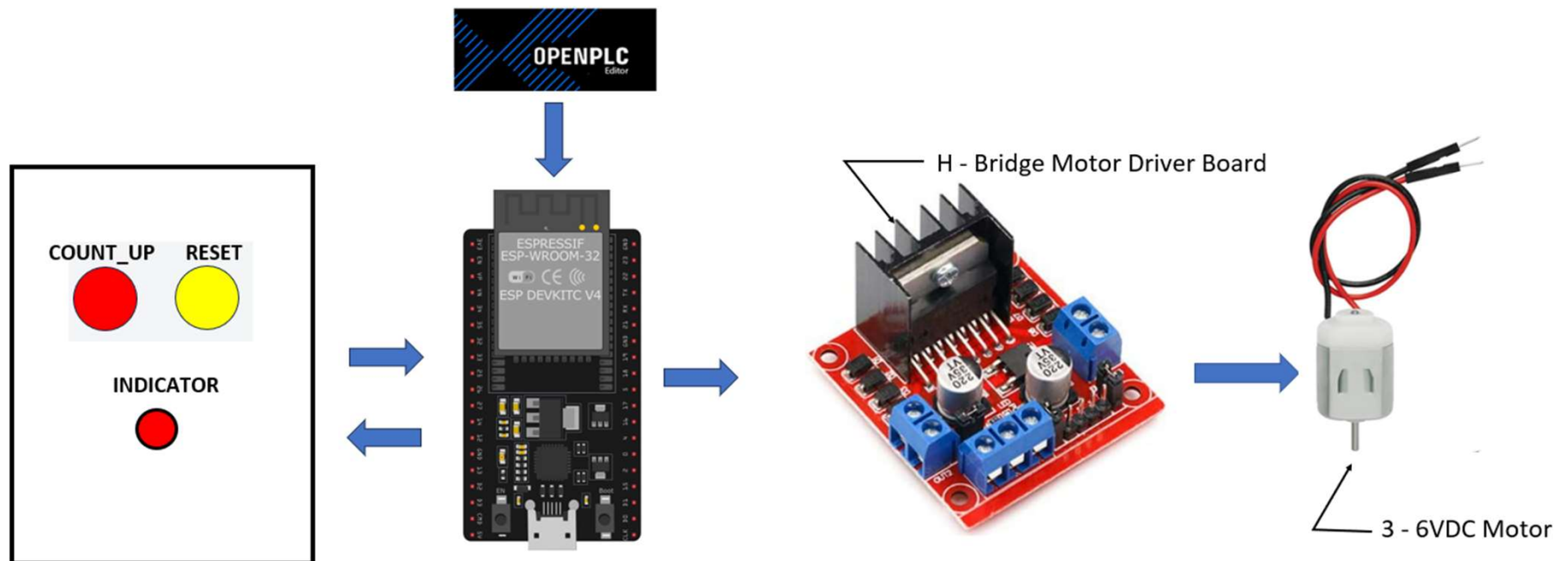
Lab: Build and Test ESP32 OpenPLC Motor Driver Controller...

Existing Electrical Wiring Diagram: Solderless Breadboard view

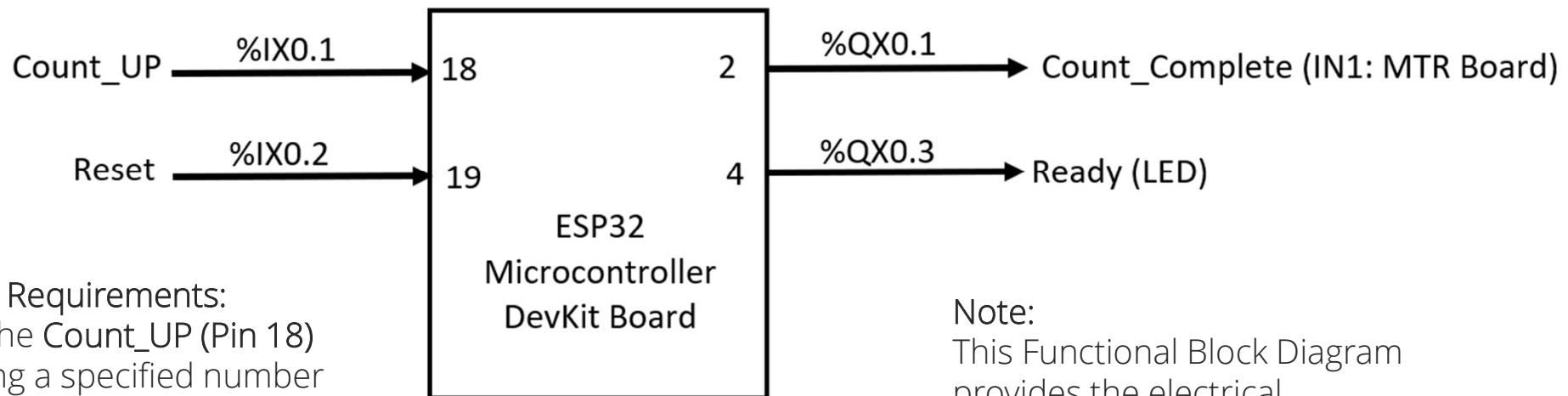# Lab: Build and Test an ESP32 OpenPLC Motor Driver Controller...

System Block Diagram

Functional Requirements:
- Upon the **Count_UP (Pin 18)** receiving a specified number of pulses, **The Count_Complete (Pin 2)** will turn ON.
- The MTR Board will turn ON the attached DC motor.
- The **Reset (Pin 19)** will turn OFF the DC motor.

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Lab: Build and Test an ESP32 OpenPLC Motor Driver Cont

Functional Requirements:
- Upon the **Count_UP (Pin 18)** receiving a specified number of pulses, **The Count_Complete (Pin 2)** will turn ON.
- The MTR Board will turn ON the attached DC motor.
- The **Reset (Pin 19)** will turn OFF the DC motor.

Note:
This Functional Block Diagram provides the electrical modifications from the existing electrical wiring diagram shown on slide 23 for the OpenPLC Motor Driver Controller application.
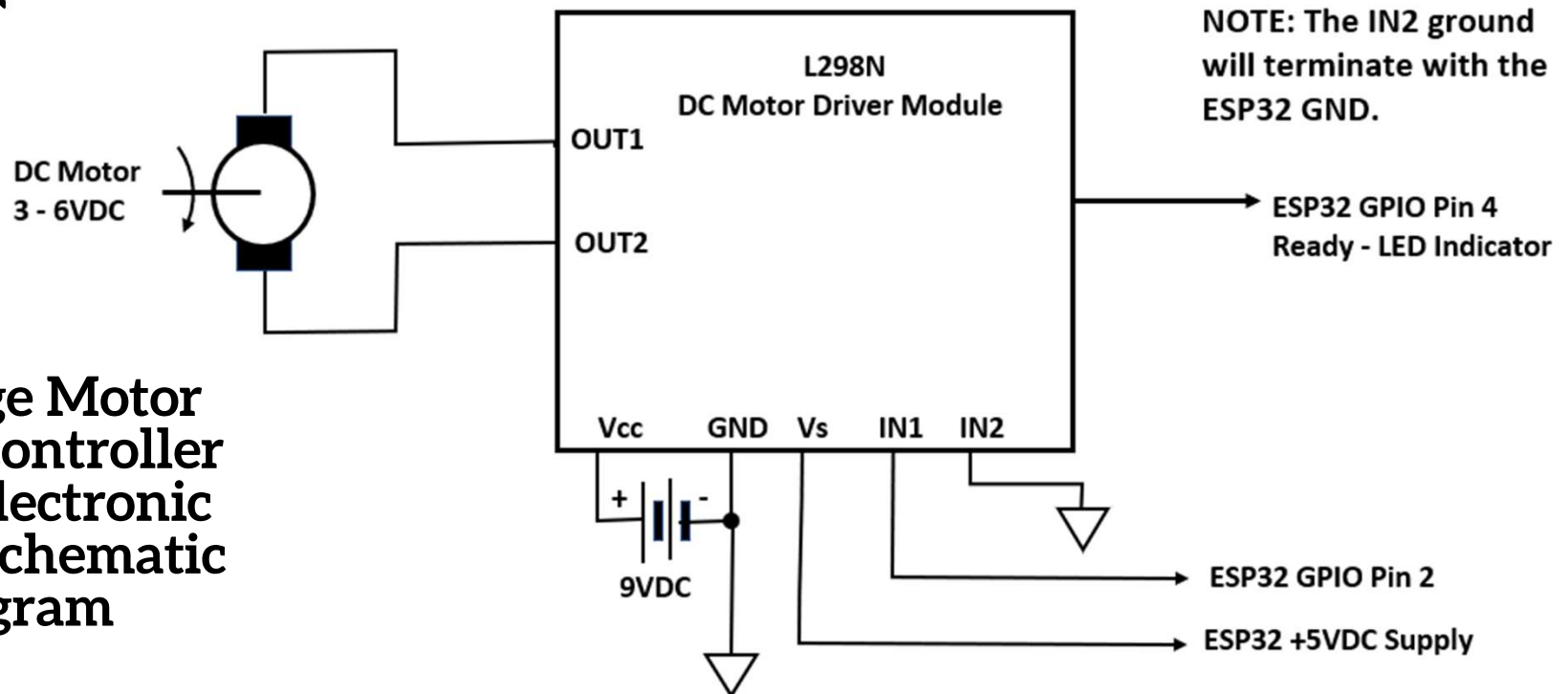
Lab: Build and Test an ESP32 OpenPLC Motor Driver Controller...

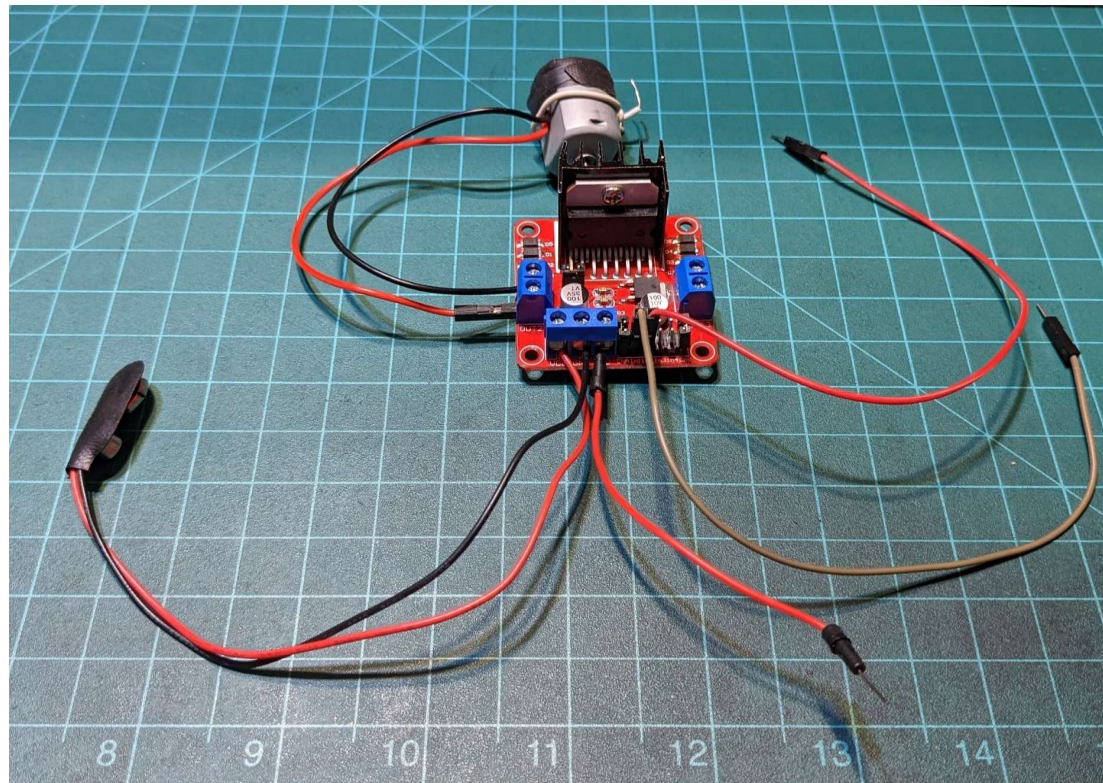### ESP32 OpenPLC Motor Driver Controller Electronic Circuit Schematic Diagram
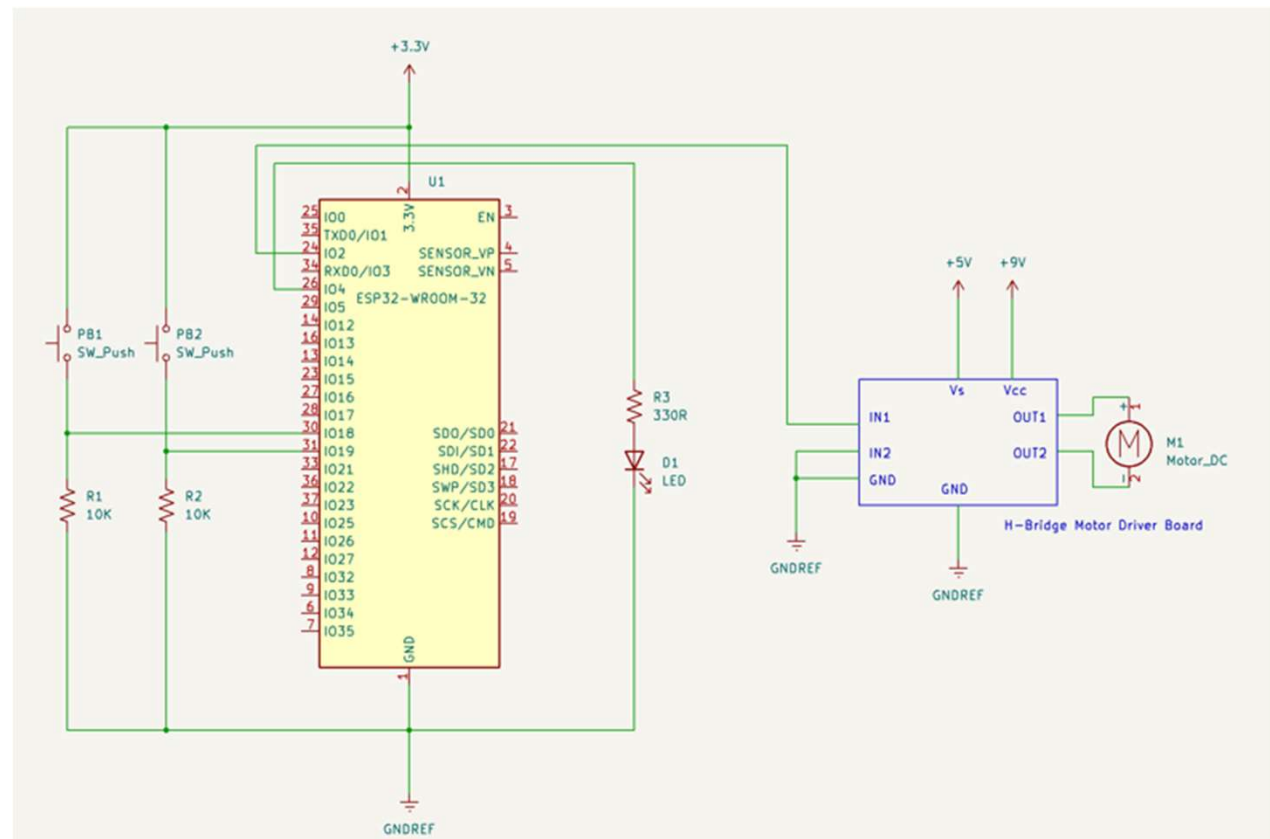
Lab: Build and Test an ESP32 OpenPLC Motor Driver Controller

H-Bridge Motor Driver Controller Board Electronic Circuit Schematic Diagram

L298N DC Motor Driver Module

DC Motor 3 - 6VDC

OUT1

OUT2

Vcc GND Vs IN1 IN2

9VDC

NOTE: The IN2 ground will terminate with the ESP32 GND.

ESP32 GPIO Pin 4 Ready - LED Indicator

ESP32 GPIO Pin 2

ESP32 +5VDC Supply

Lab: Build and Test an ESP32 OpenPLC Motor Driver Controller...

DC motor wired to the H-Bridge Motor Driver Board

Lab: Build and Test an ESP32 OpenPLC Motor Driver Controller...

Select Here!

Obtaining Count Up Function Block

Select Here

Question 4

Which Function Block is used in the ESP32 OpenPLC Motor Driver Controller?
  a) CTD
  b) CTU
  c) SR
  d) RS

Lab: Build and Test an ESP32 OpenPLC Motor Driver Controller...

Before setting up the OpenPLC Simulator, a project folder needs to be created.

Create a Main Projects Folder

Name of Project Folder →

Lab: Build and Test an ESP32 OpenPLC Motor Driver Controller...
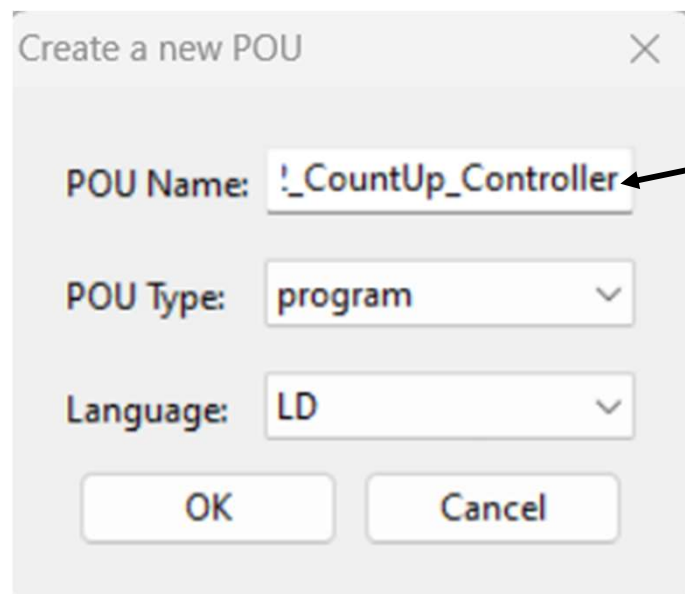
Open the OpenPLC editor to start a new LD program.

An open OpenPLC editor
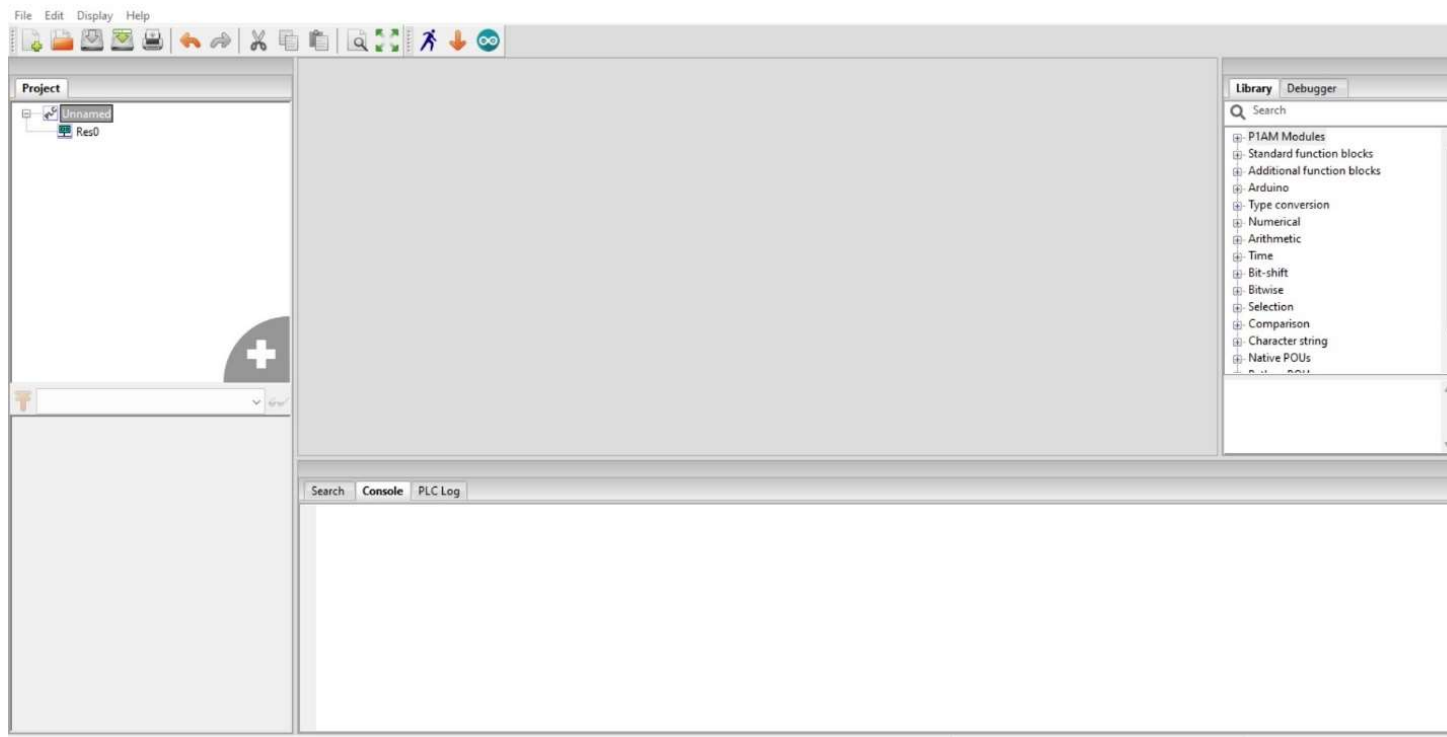
Lab: Build and Test an ESP32 OpenPLC Motor Driver Controller…

Create a Program Organizational Unit (POU) (Name/Type). Select LD for programming language.
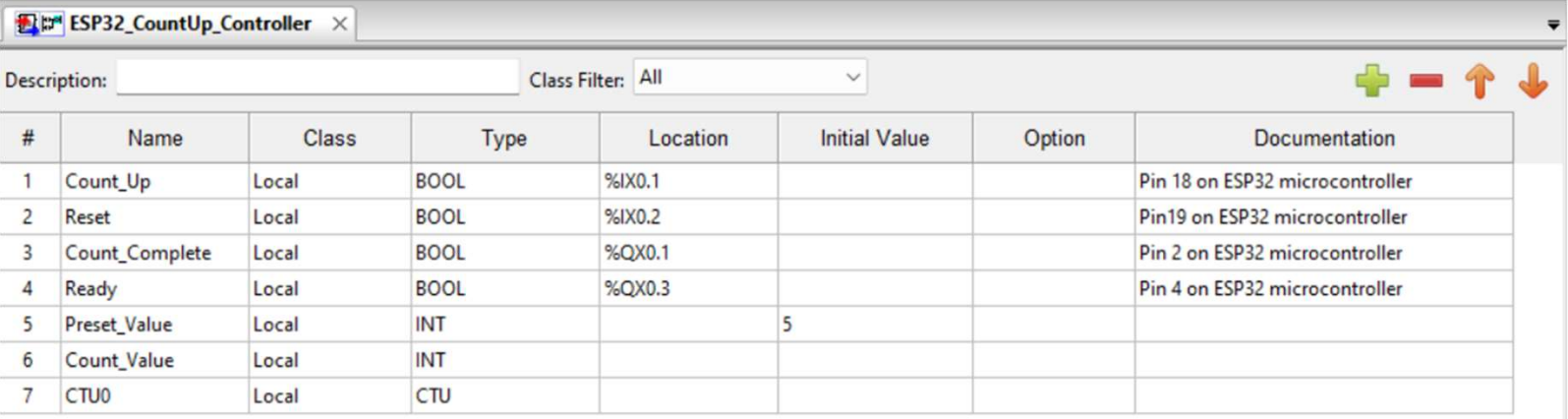
Creating a New POU

ESP32_CountUp_Controller

Lab: Build and Test an ESP32 OpenPLC Motor Driver Controller...

Create Tags for the CountUp Controller.

Creating Tags for the CountUp Controller

The Location on the Tag Listing table is where the addresses for the GPIO pins are included.

Lab: Build and Test an ESP32 OpenPLC Motor Driver Controller...

Create Tags for the CountUp DC Motor Controller

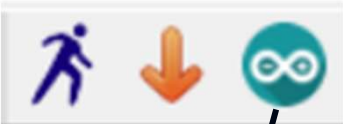**Review Days 1 and 2 steps to build the Start-Stop Control Circuit LD**
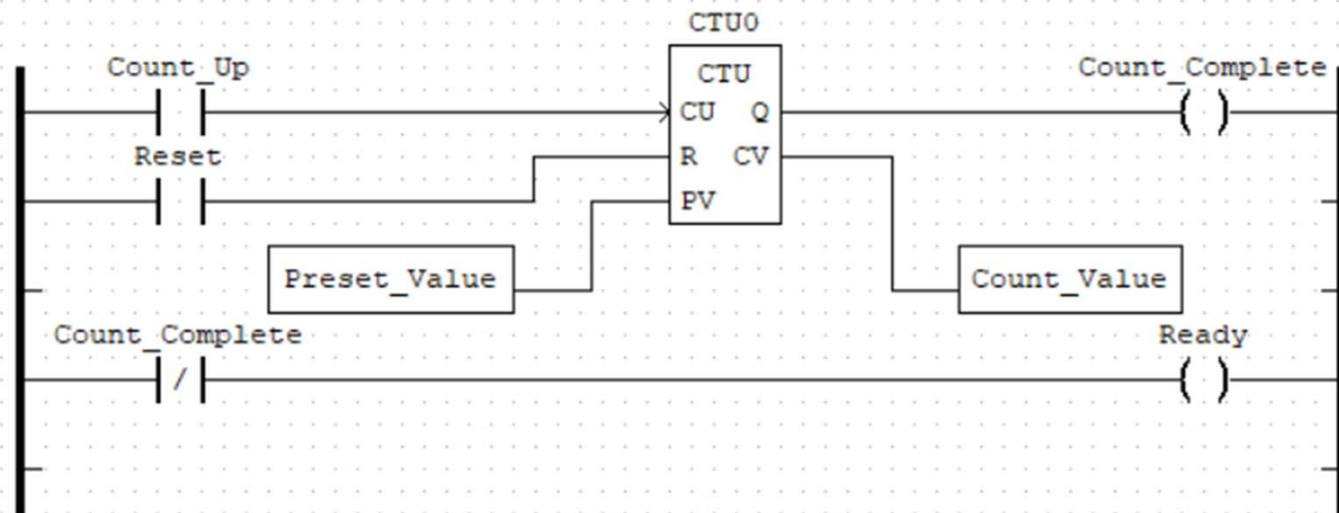
Get ESP32_CountUp_Controller LD program below!

https://github.com/DWilcher/HCI_Electronics/blob/main/Embedded_Controls_Development_Code.zip

Lab: Build and Test an ESP32 OpenPLC Motor Driver Controller...

OpenPLC CountUp DC Motor Controller Hardware Setup

Opens ➡️

Click Arduino Icon

Upload to Arduino Board ✕

Board Type: ESP32

COM Port: COM9

☐ Enable Modbus Serial

Set COM Port to your Attached ESP32 Dev Kit board

Interface: Serial

Baud: 115200

Lab: Build and Test an ESP32 OpenPLC Motor Driver Controller…

OpenPLC CountUp DC Motor Controller Hardware Setup

Upload LD
program to
the ESP32 Dev
Kit Board

Click Arduino
Icon

Lab: Build and Test an ESP32 OpenPLC Motor Driver Controller...

Functional ESP32 CountUp DC Motor Controller

YouTube Video

https://youtu.be/oFdwihapwVE
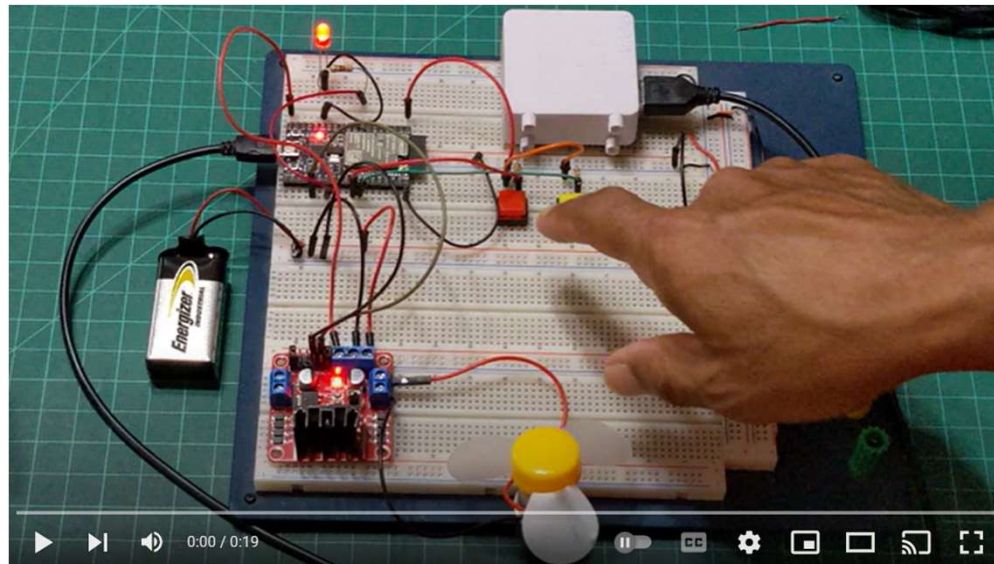
Question 5

In reviewing slide 36, which Tag has an initial value of 5?
   a) Count_Up
   b) Reset
   c) Count_Complete
   d) Preset_Value

Thank you for attending

Please consider the resources below:

International Electrotechnical Commission. (2003). *International standard* (IEC61131-3). https://d1.amobbs.com/bbs_upload782111/files_31/ourdev_569653.pdf

OpenPLC.(2023). Openplc overview. https://autonomylogic.com/docs/openplc-overview/

Wilcher. D. (2023, September 28). *PLC ladder logic on an arduino: Build a start-stop control circuit.* https://control.com/technical-articles/plc-ladder-logic-on-an-arduino-building-a-start-stop-circuit/

Zemmouri, A., Barodt, A., Dahou, H., Alarequi, M., Eigouri, R., Htou, L., & Benbrahim, M. (2023). A microsystem design for controlling a dc motor by pulse width modulation using microblaze soft-core. *International Journal of Electrical and Computer Engineering, 13*(2), 1337-1448. https://www.researchgate.net/publication/365994306_A_microsystem_design_for_controlling_a_DC_motor_by_pulse_width_modulation_using_MicroBlaze_soft-core

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