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DesignNews

Embedded Controls Development with OpenPLC

DAY 3 : OpenPLC ESP32 Hardware Setup

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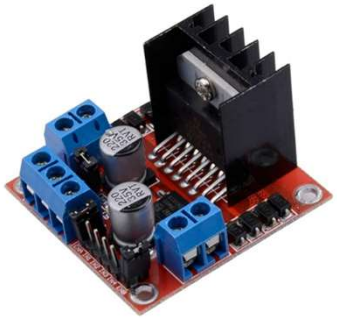
Dr. Don Wilcher

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

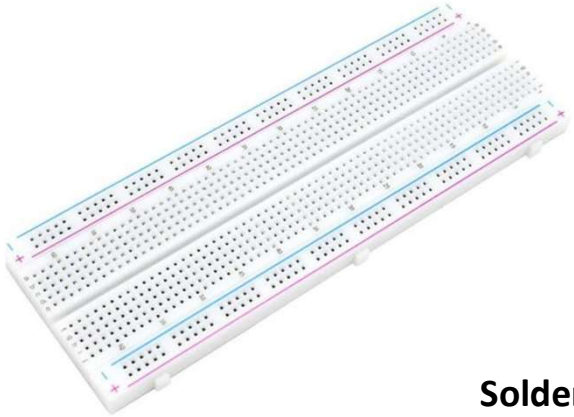
Course Kit and Materials

ESP32 WROOM32D DEVKITC

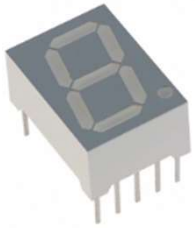
L298N Motor Drive Controller



Solderless Breadboard x2



7 Segment LED Display, Common Cathode



Adafruit Parts Pal Kit

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

Agenda:

- ESP32 Devkit Board Overview
  a) Module Layout
  b) Functional Block Diagram
  c) Pinout
- Electrical Wiring Diagram Review
- Electronic Circuit Schematic Diagram
- Start-Stop Control Circuit Review
- Lab: Build and Test a Start-Stop Control Circuit

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).

ESP32 DevKit Board Overview

ESP32-WROOM-32D and ESP32-WROOM-32U are powerful, generic Wi-Fi + Bluetooth® + Bluetooth LE MCU modules that target a wide variety of applications, ranging from low-power sensor networks to the most demanding tasks, such as voice encoding, music streaming and MP3 decoding.

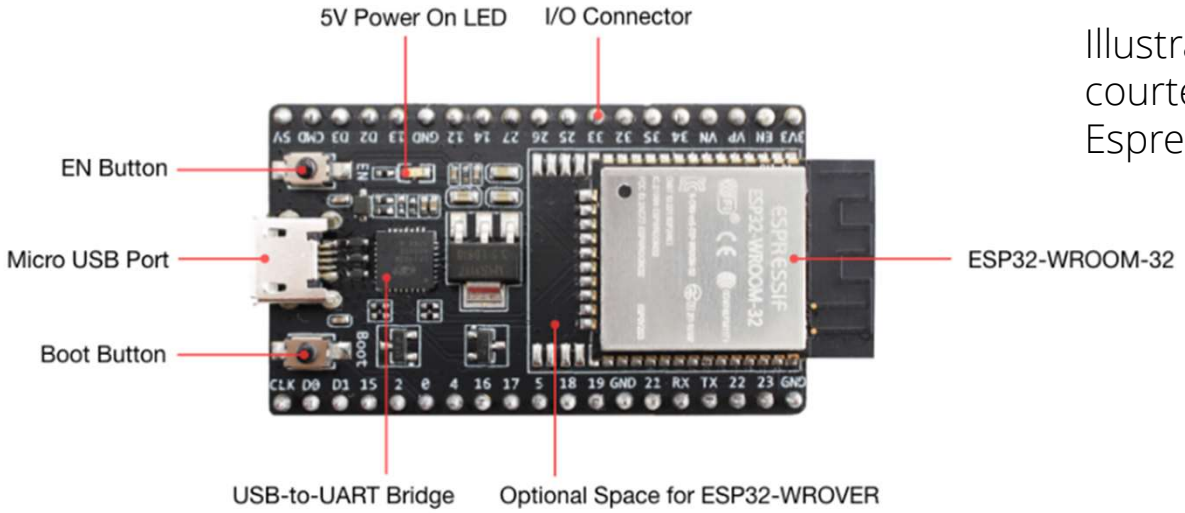


Illustration courtesy of Espressif

Question 1

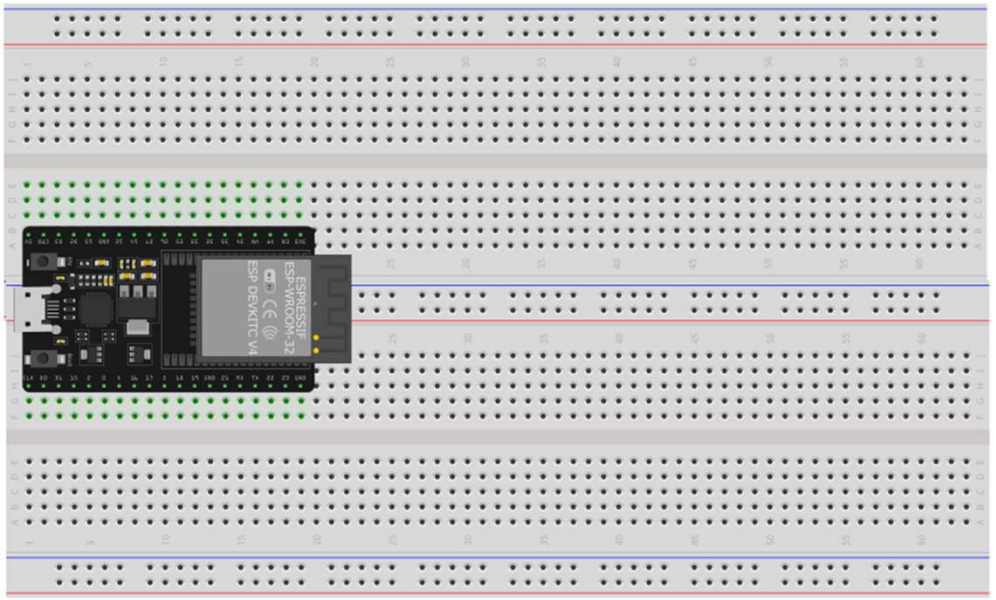
In reviewing slide 7 the optional space on the ESP32 DevKit Board is for what module platform?

a) WROOM
b) WROVER
c) C3
d) S2

ESP32 DevKit Board Overview. . .

Most of the I/O pins are broken out to the pin headers on both sides for easy interfacing. Developers can either connect peripherals with jumper wires or mount ESP32-DevKitC V4 on a solderless breadboard.

Two solderless breadboards are required for mounting the ESP32 DevKit Board for hardware application development.



ESP32 DevKit Board Overview. . .

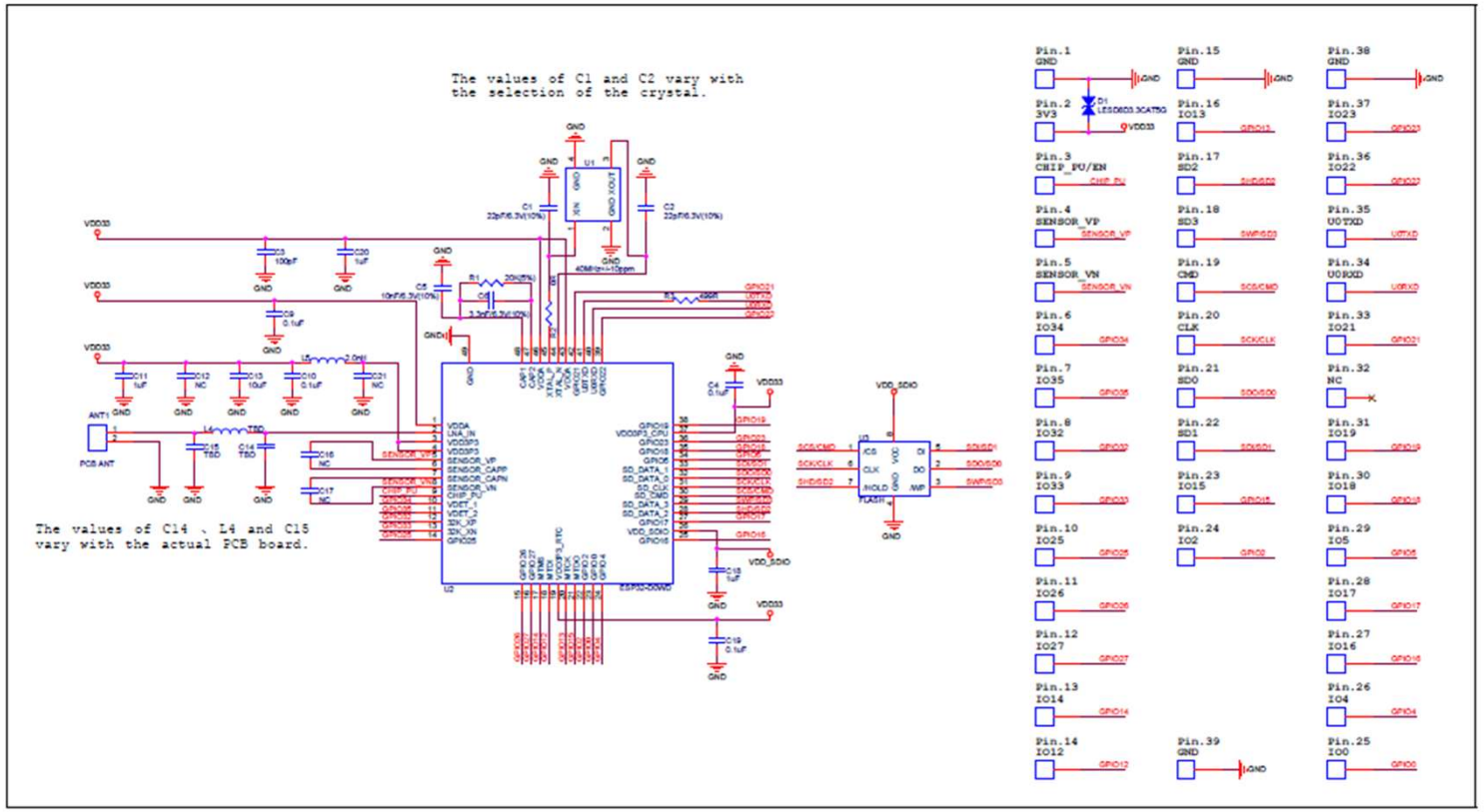
Comparison of ESP32 Devkit Boards

Module	ESP32-WROOM-32D	ESP32-WROOM-32U
Core	ESP32-D0WD	ESP32-D0WD
SPI flash	32 Mbits, 3.3 V	32 Mbits, 3.3 V
Crystal	40 MHz	40 MHz
Antenna	on-board PCB antenna	external antenna connector (which needs to be connected to an external antenna)
Dimensions (Unit: mm)	18 × 25.5 × 3.1 (See Figure 6 for details)	18 × 19.2 × 3.2 (See Figure 7 for details)

ESP32 DevKit Board Overview. . .

Electronic Circuit Schematic Diagram

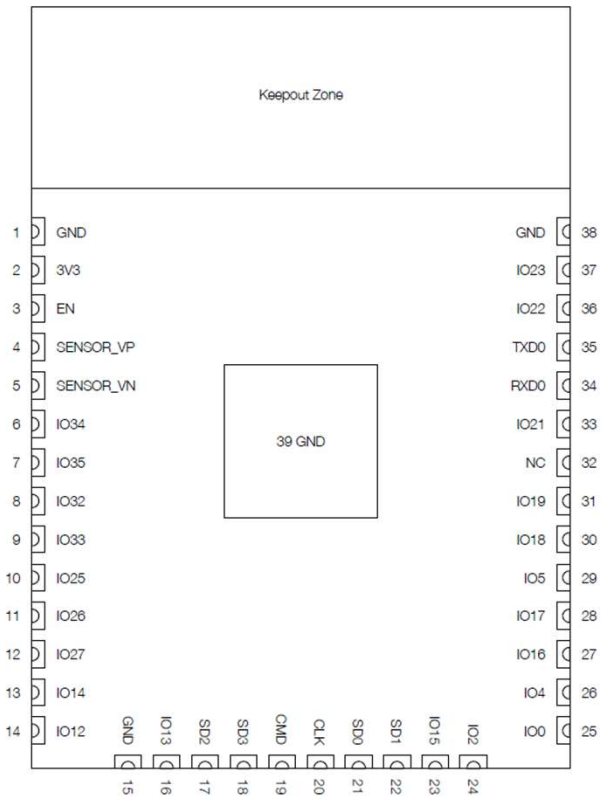
Diagram Courtesy of Espressif



ESP32 DevKit Board Overview. . .

ESP 32 WROOM Module Layout

Illustration and Diagram Courtesy of Espressif



ESP32 DevKit Board Overview. . .

Functional Block Diagram

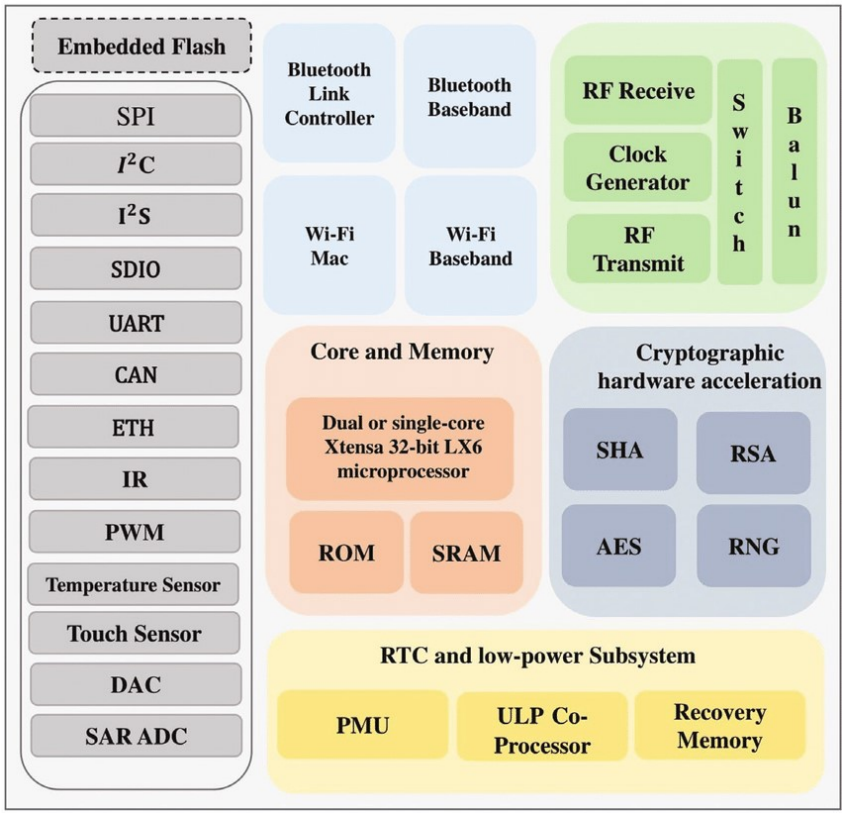
- The ESP32 Module uses a System on a Chip (Soc) architecture to provide various functions like Bluetooth, WiFi, the Advanced Encryption Standard (AES), Inter-Integrated Circuit (I2C), and Infrared (IR).
- With many electronic circuit blocks, a Functional Block diagram allows the developer an in-depth view of the ESP32 Module's inner workings.
- The ESP32 Module's Functional block diagram shows the relationship between the electronic circuit blocks.
- The relationship between these electronic circuit blocks provides a visual view of the internal peripherals available to the hardware and software developer.

ESP32 DevKit Board Overview. . .

Functional Block Diagram

Interaction of the vast electronic circuit blocks is through the electrical connectivity of the external pins of the DevKit board and the software.

Diagram Courtesy of Espressif



ESP32 DevKit Board Overview. . .

ESP32
Pinout

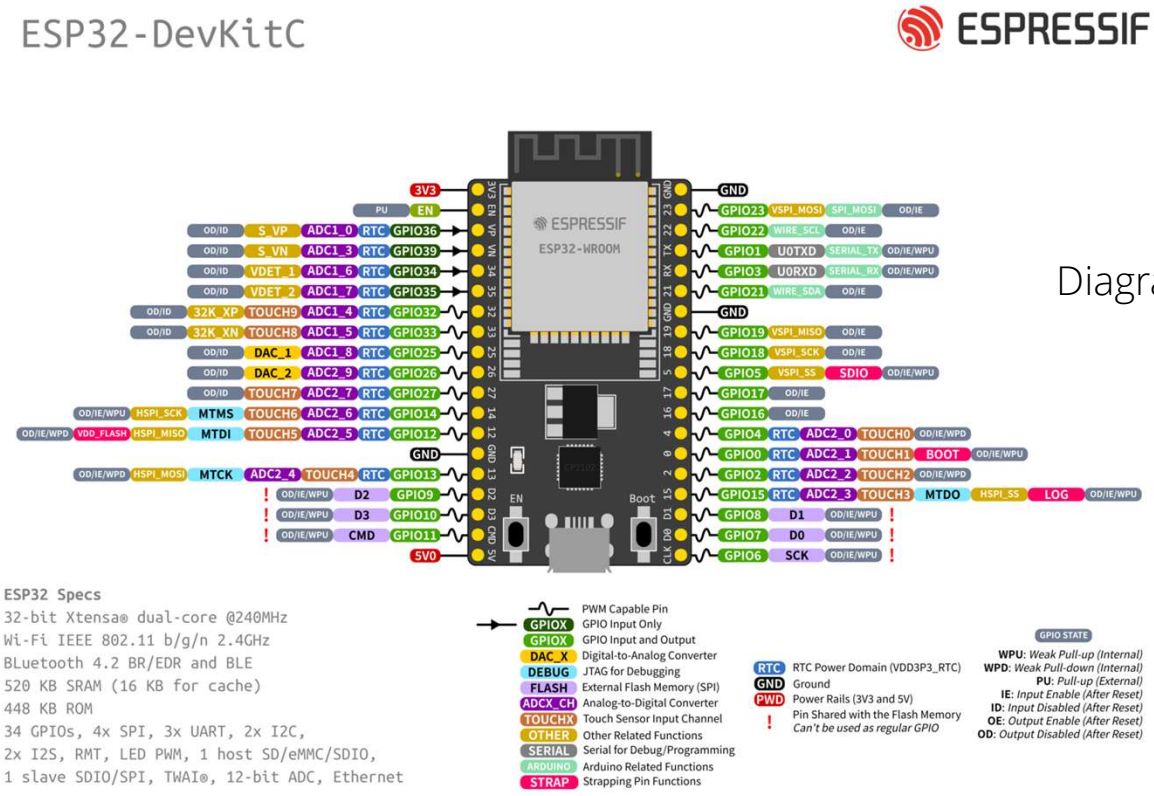
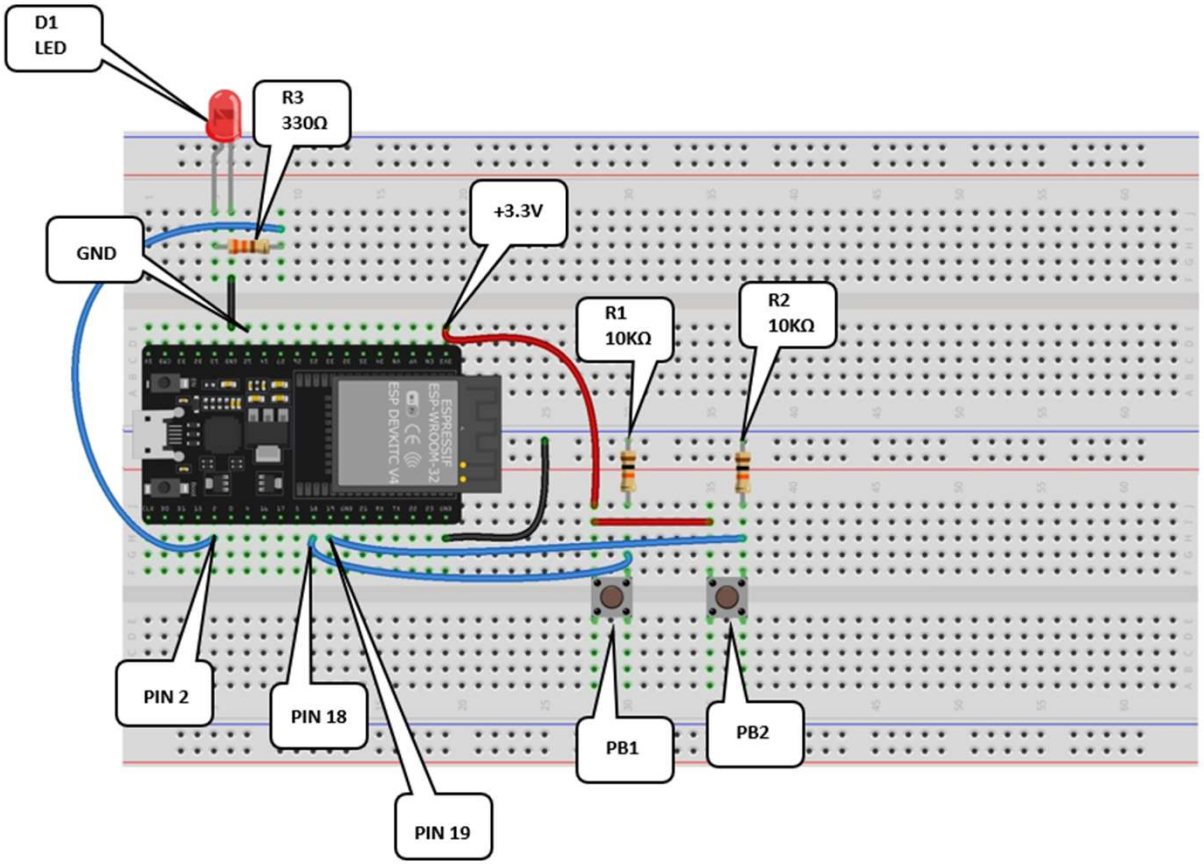


Diagram Courtesy of Espressif

ESP32 DevKit Board Overview. . .

Electrical Wiring Diagram: Solderless Breadboard view



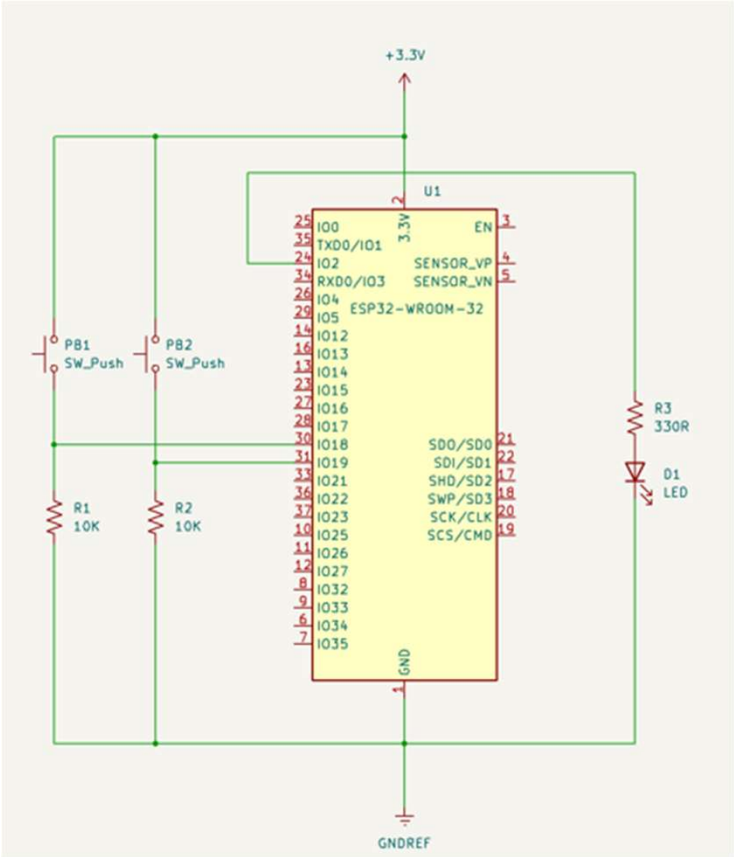
Question 2

In reviewing slide 16, PB1 is wired to which GPIO pin?

a) 19
b) 18
c) 20
d) 2

ESP32 DevKit Board Overview. . .

Electronic Circuit Schematic Diagram



Start-Stop Control Circuit Review

- Developing embedded controls with the OpenPLC platform is as easy as a Start-Stop Control circuit.
- The Start-Stop Control circuit is essentially a circuit that allows turning an electrical–electronic load like an LED ON/OFF with two pushbutton switches.
- One pushbutton switch turns ON the LED (Start).
- One pushbutton switch turns OFF the LED (Stop).
- The Control circuit, therefore, performs a toggle or latching function.
- The basic digital logic function performed by this control circuit is a Memory Circuit.
- A Memory circuit is a Flip-Flop circuit.
- A Flip-Flop circuit stores one binary bit value (1 or 0).

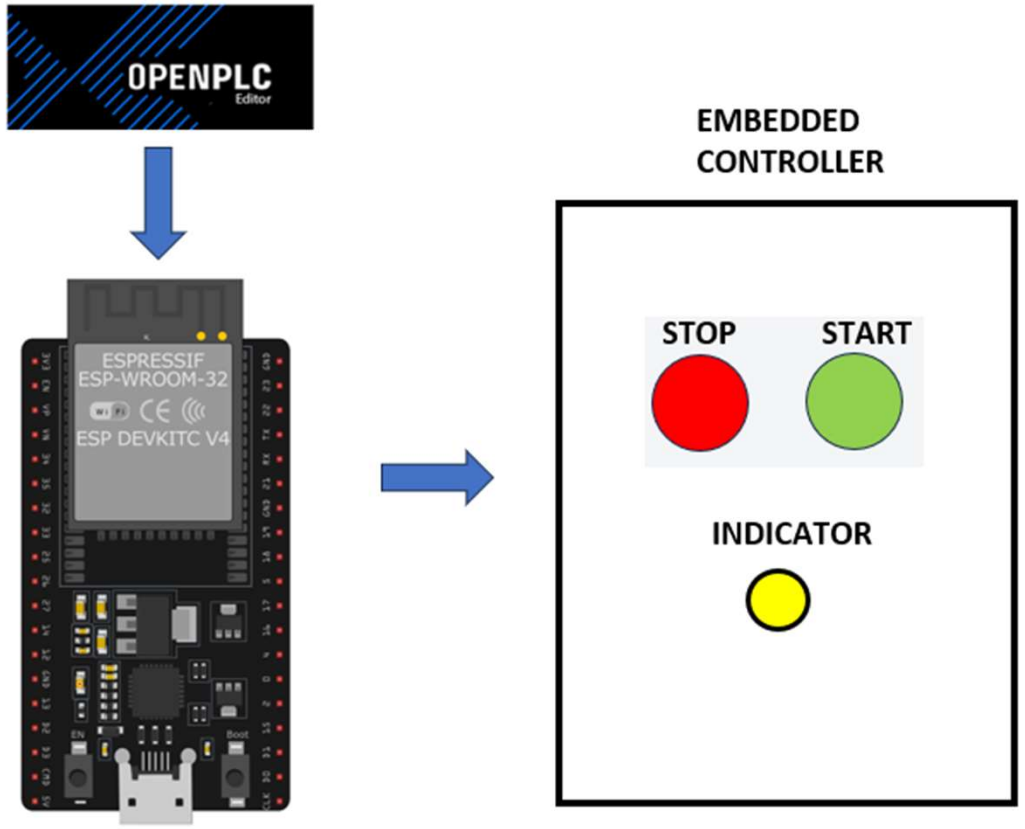
Question 3

Which digital circuit function is performed by a Start-Stop Control Circuit?

a) AND-OR
b) Memory
c) ON/OFF
d) NAND

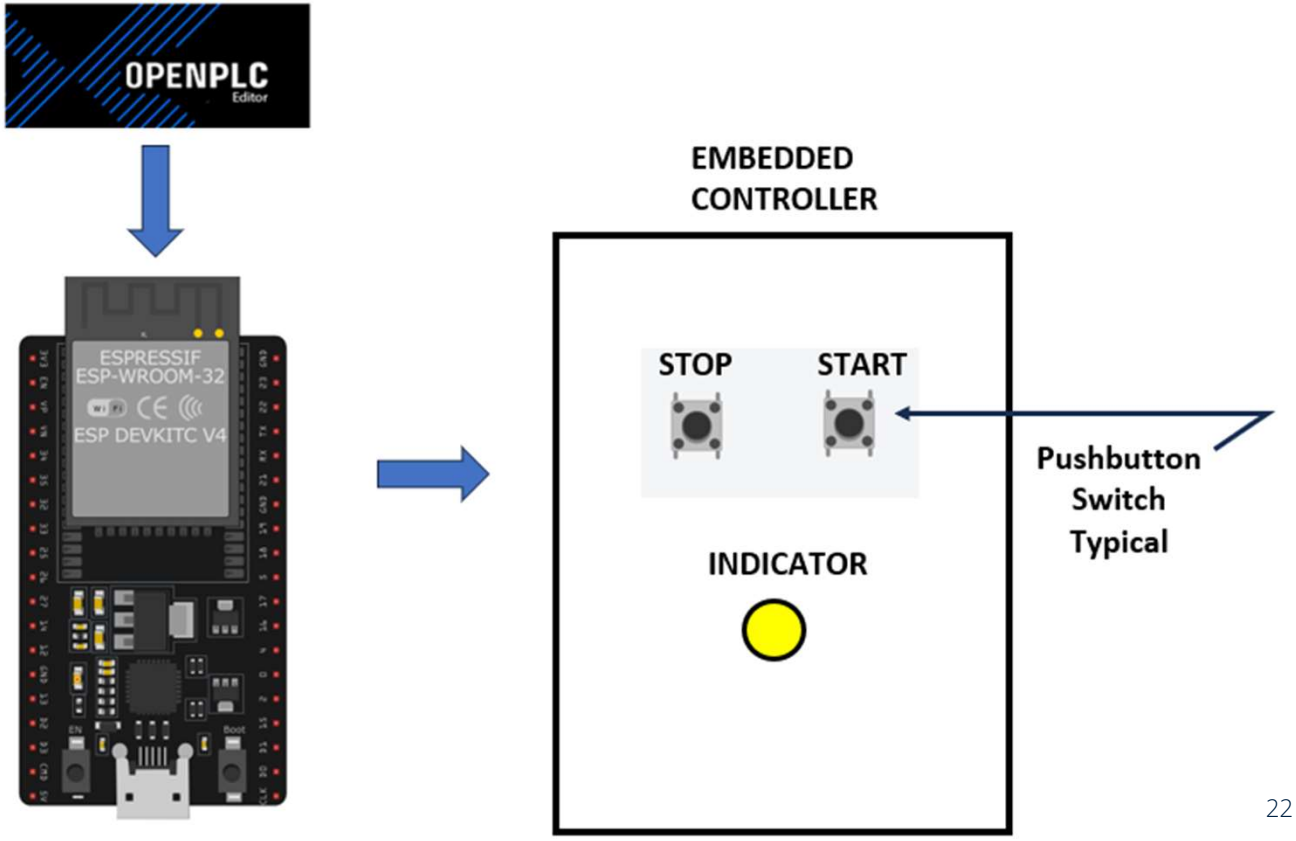
Start-Stop Control Circuit Review. . .

ESP32-based Embedded Controller Concept



Start-Stop Control Circuit Review. . .

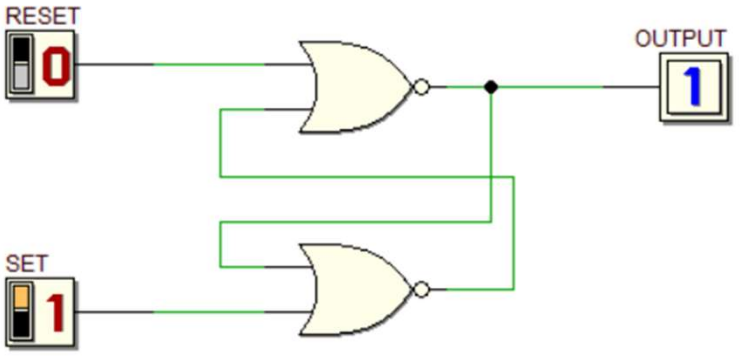
ESP32-based Embedded Controller Concept



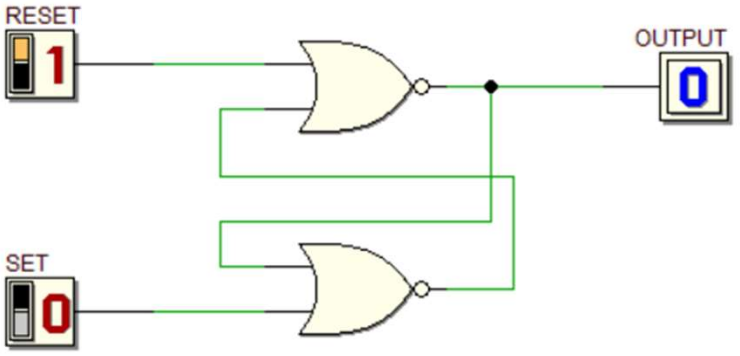
Start-Stop Control Circuit Review. . .

Digital SET-RESET Controller Circuit

The SET-RESET Circuit is also known as a SR Flip-Flop



The SET bit (Binary 1) is latched at the OUTPUT



The RESET bit (Binary 0) is unlatched at the OUTPUT

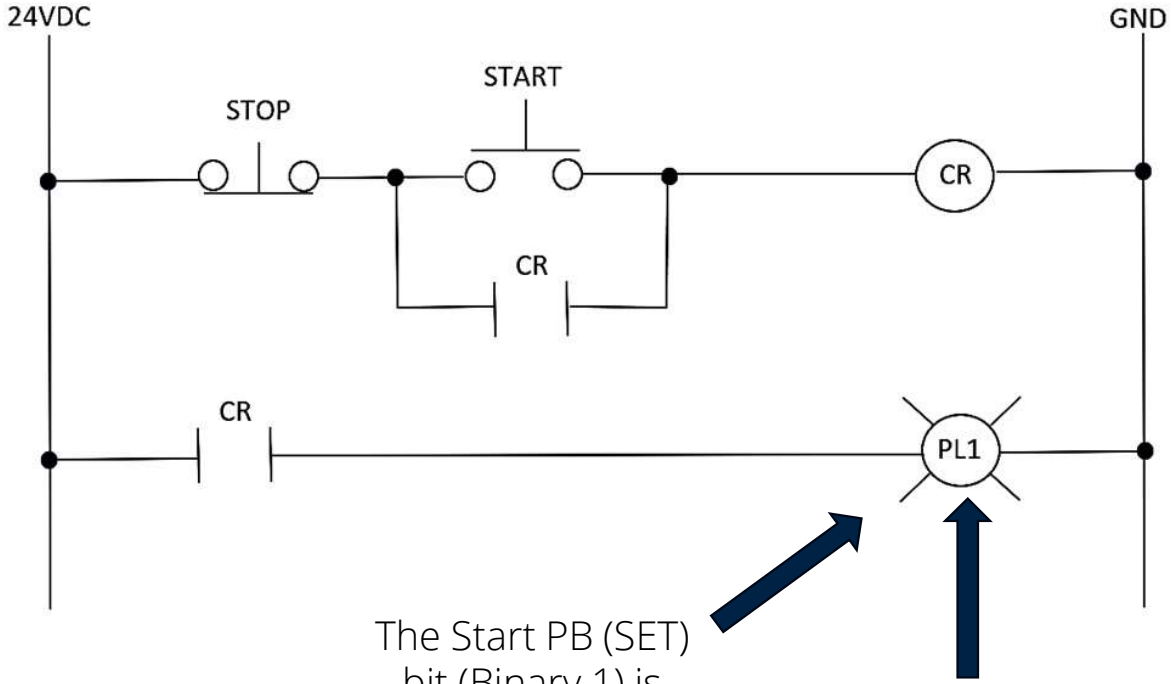
Start-Stop Control Circuit Review. . .

Relay Ladder Logic Controller Circuit

The SET-RESET Circuit is suitable for Start-Stop Control Circuits used in Industrial Control Applications

The Control Relay (CR) coil is energized by pressing the Start Pushbutton switch. The energized state of the coil will close the CR contacts.

A sealed condition exists around the Start Pushbutton Switch. The sealed CR contact allows the operator to release the Start Switch, thereby not affecting the PL1's ON state.



The Start PB (SET) bit (Binary 1) is latched at the OUTPUT: PL1 is ON

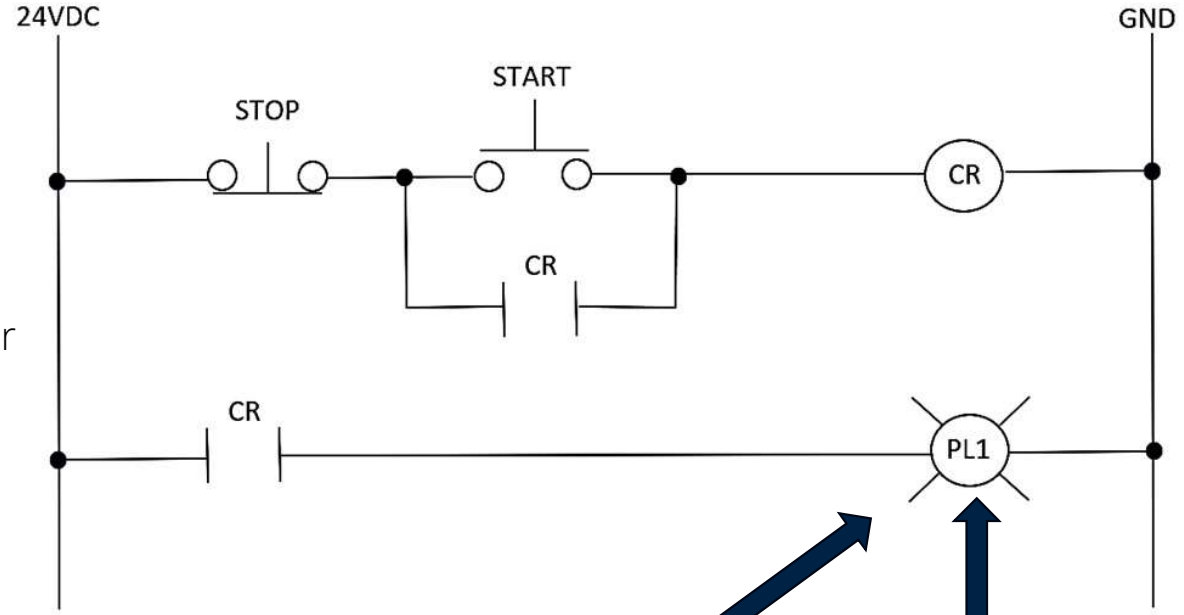
The Stop PB (RESET) bit (Binary 0) is unlatched at the OUTPUT: PL1 is OFF

Start-Stop Control Circuit Review. . .

Relay Ladder Logic Controller Circuit

The SET-RESET Circuit is suitable for Start-Stop Control Circuits used in Industrial Control Applications

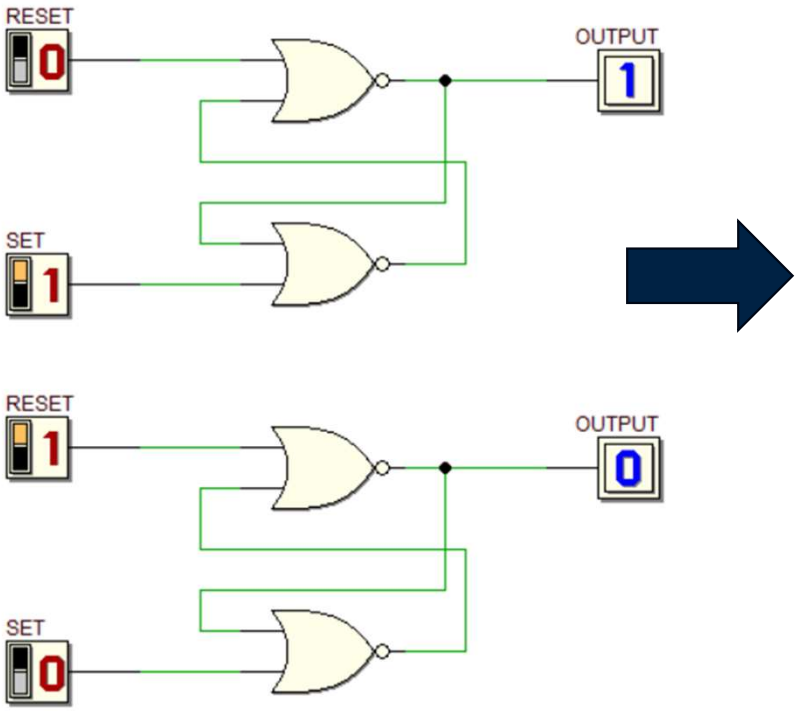
The Stop Pushbutton Switch will de-energize the Control Relay (CR) coil. The CR contacts will open, thereby providing an OFF state for PL1.

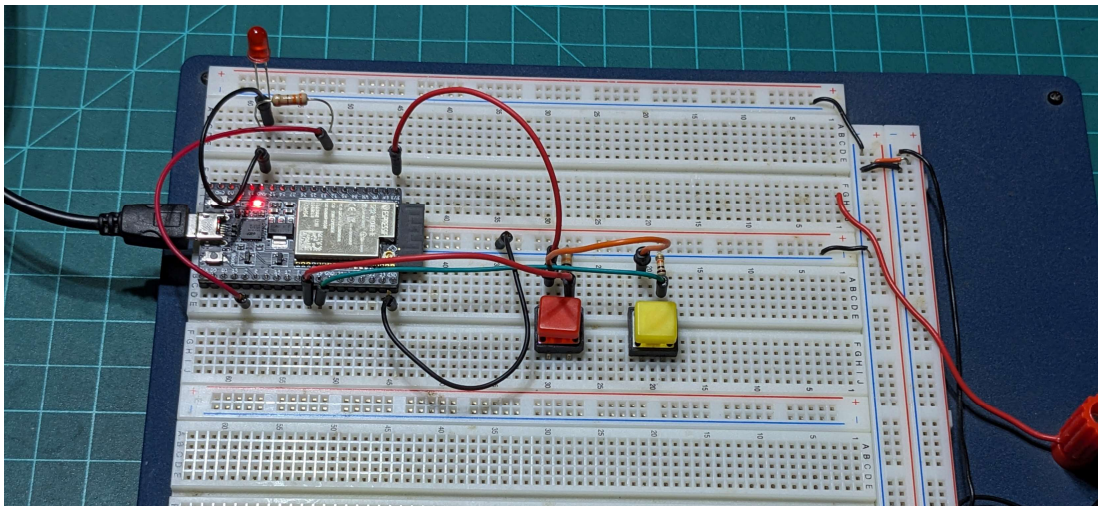


The Start PB (SET) bit (Binary 1) is latched at the OUTPUT: PL1 is ON

The Stop PB (RESET) bit (Binary 0) is unlatched at the OUTPUT: PL1 is OFF

Lab: Build and Test of Start-Stop Control Circuit





Lab: Build and Test of Start-Stop Control Circuit

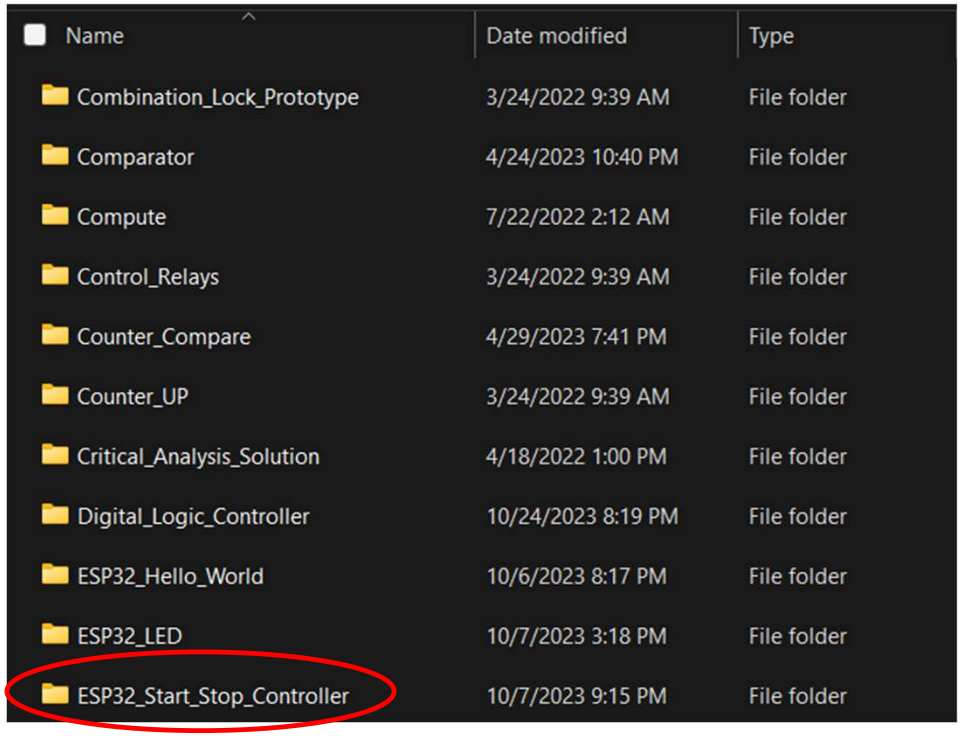
Lab Objectives:

- Participants will learn to Build a Start-Stop Control Circuit using OpenPLC.
- Participants will learn to program the ESP32 microcontroller using OpenPLC.
- Participants will learn to run and test the Start-Stop Control Circuit on an ESP32 microcontroller.

Lab: Build and Test of Start-Stop Control Circuit. . .

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

Create a Main Projects Folder

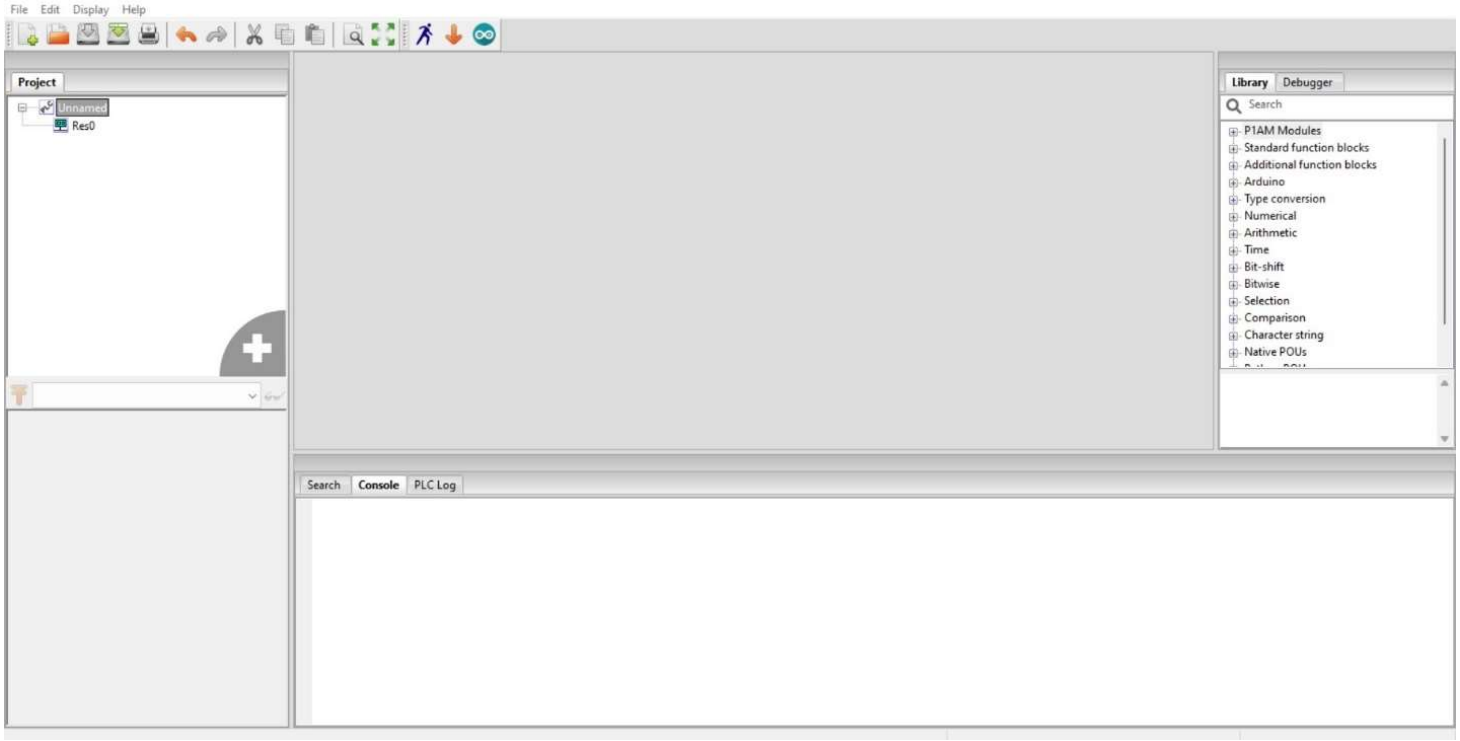


Name of Project Folder

Lab: Build and Test of Start-Stop Control Circuit. . .

Open the OpenPLC editor to start a new LD program.

An open OpenPLC editor

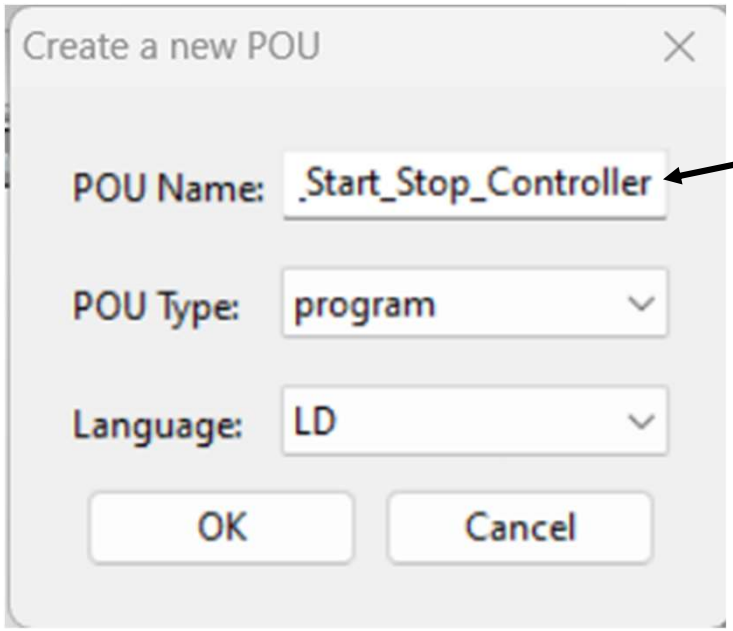


Lab: Build and Test of Start-Stop Control Circuit. . .

OPENPLC Editor

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

Creating a New POU



ESP32_Start_Stop_Controller

Lab: Build and Test of Start-Stop Control Circuit. . .

Create Tags for the Start-Stop Control Circuit.

Creating Tags for the Start-Stop Control Circuit

ESP32_Start_Stop_Controller

Description: Class Filter: All

#	Name	Class	Type	Location	Initial Value	Option	Documentation
1	START	Local	BOOL	%IX0.1			Pin 18 on ESP32 microcontroller
2	STOP	Local	BOOL	%IX0.2			Pin 19 on ESP32 microcontroller
3	CR	Local	BOOL				Internal Memory Bit for OpenPLC
4	LED	Local	BOOL	%QX0.1			Pin 2 on ESP32 microcontroller

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

Question 4

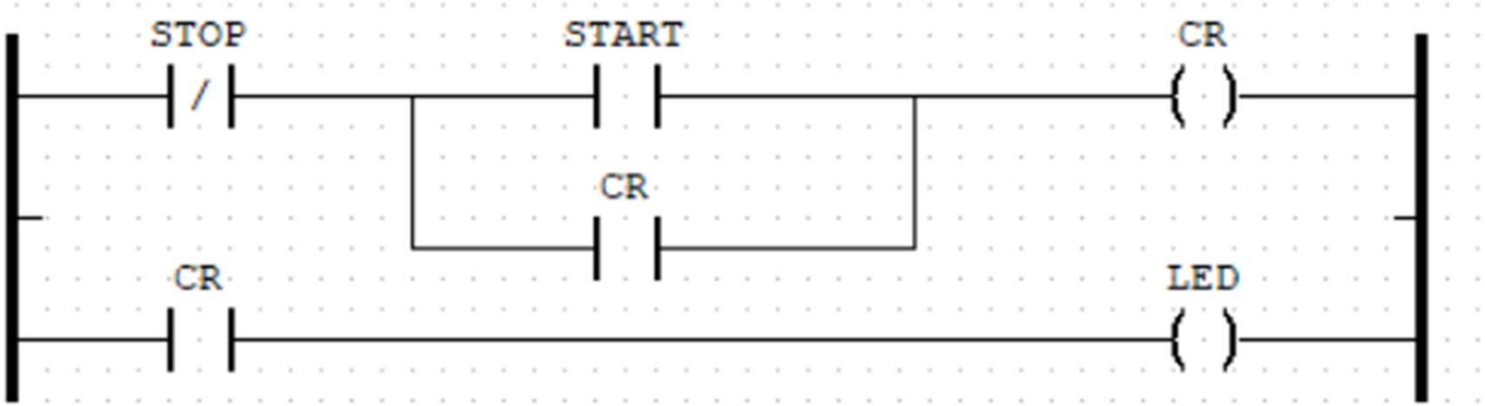
In reviewing slide 31, Pin 2 on the ESP32 microcontroller is linked to memory address location _____.

a) %IX0.1
b) %IX0.2
c) %QX0.2
d) %QX0.0

Lab: Build and Test of Start-Stop Control Circuit. . .

Create Tags for the Start-Stop Control Circuit.

Review Days 1 and 2 steps to build the Start-Stop Control Circuit LD

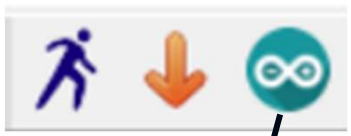


Get Start-Stop Control Circuit LD program below!

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

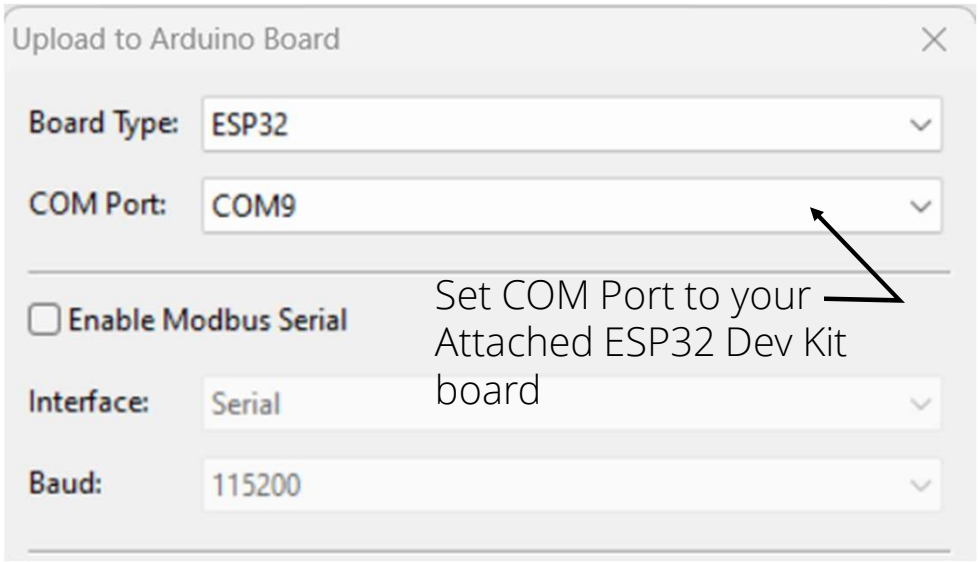
Lab: Build and Test of Start-Stop Control Circuit. . .

OpenPLC Start-Stop Controller Hardware Setup



Opens

Click Arduino Icon

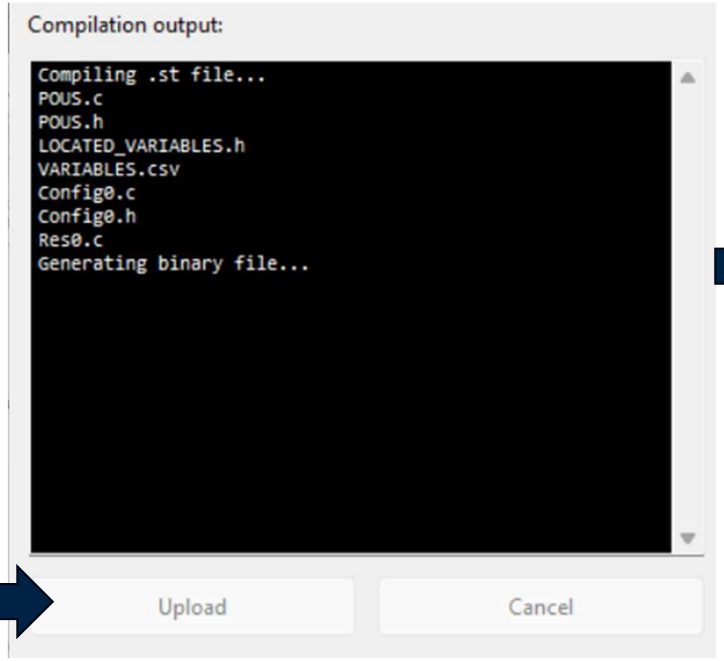


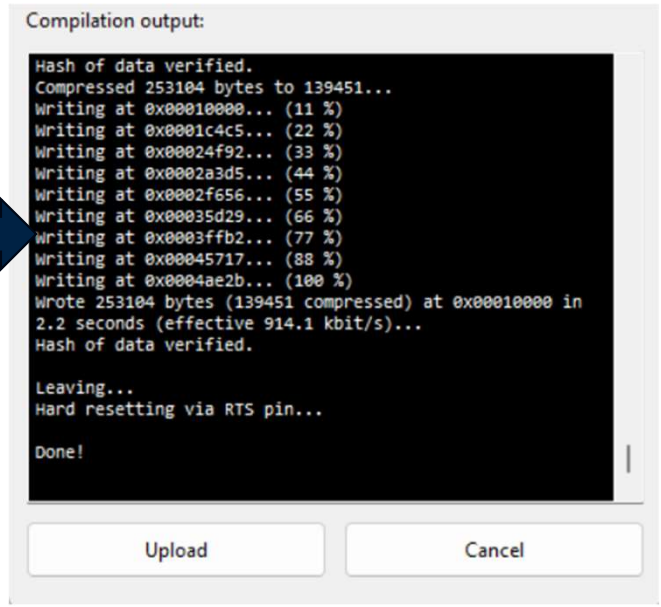
Lab: Build and Test of Start-Stop Control Circuit. . .

OpenPLC Start-Stop Controller Hardware Setup

Upload LD program to the ESP32 Dev Kit Board

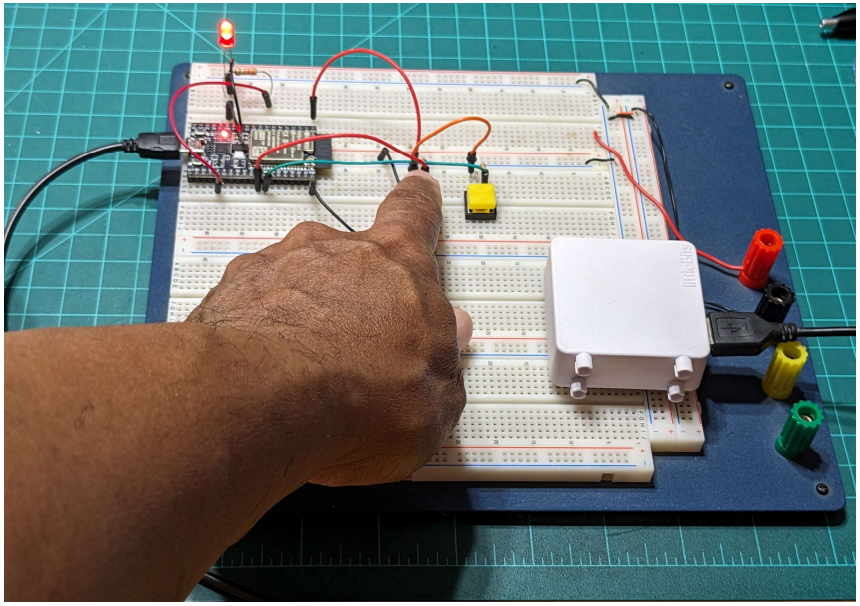
Click Arduino Icon



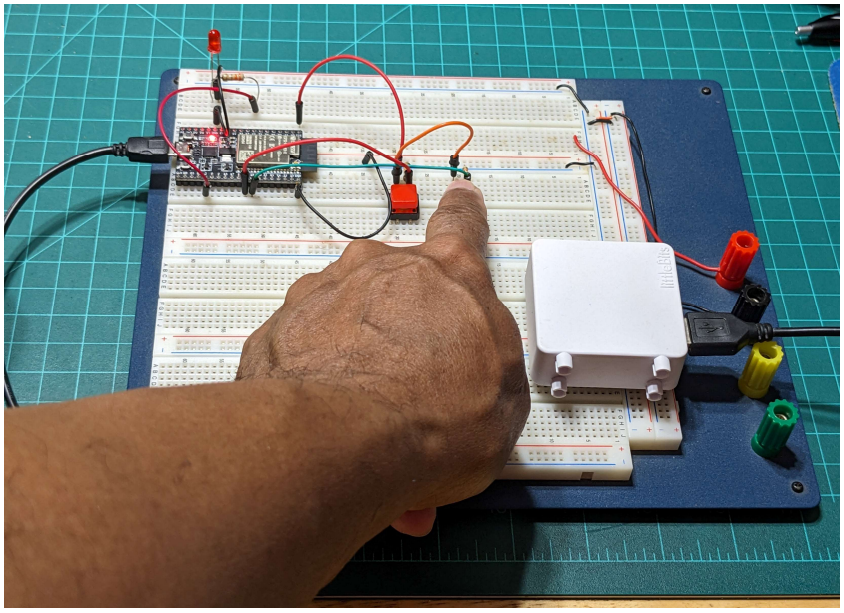


Lab: Build and Test of Start-Stop Control Circuit. . .

Functional ESP Start-Stop Control Circuit



LED Latched (ON)

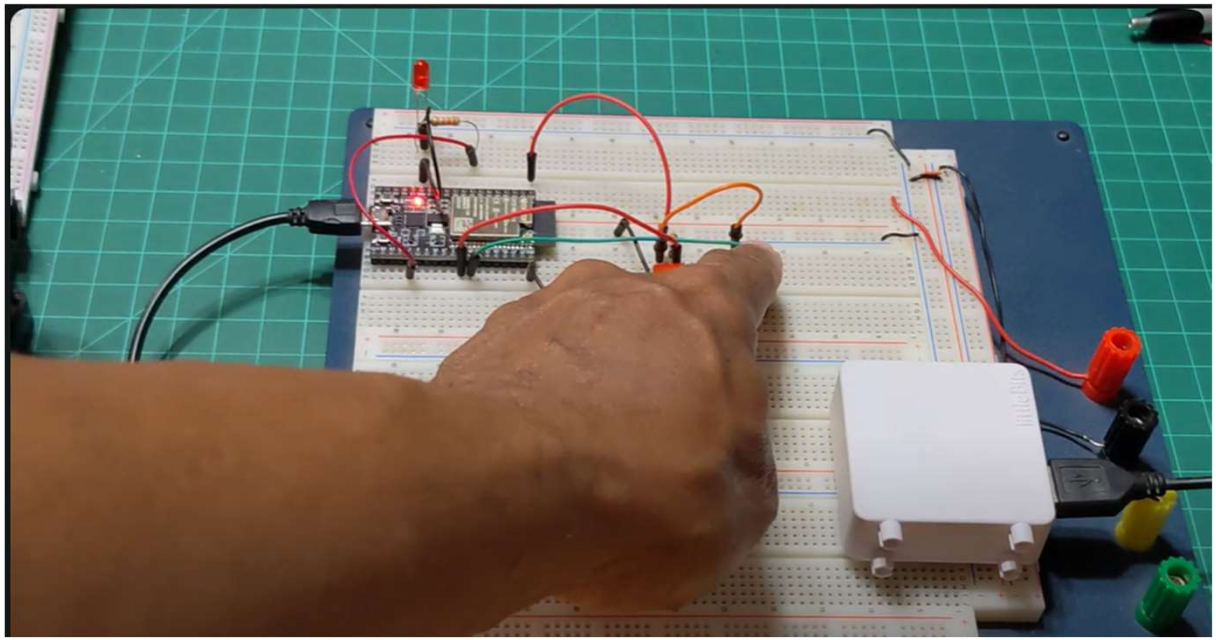


Unlatched (OFF)

Lab: Build and Test of Start-Stop Control Circuit. . .

Functional ESP Start-Stop Control Circuit

YouTube Video



https://youtu.be/WQHfSBPxQps

Question 5

The CR contact shown on slide 33 provides what electrical function for the Start-Stop Control Circuit?

a) Sealed-In
b) parallel
c) Wired OR
d) Sealed-Out

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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