



**DesignNews**

Understanding Industrial Controls with an ESP32

# Day 5: OpenPLC and ESP32 Industrial Controls-Part 2

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## Webinar Logistics

- Turn on your system sound to hear the streaming presentation.
- If you have technical problems, click “Help” or submit a question asking for assistance.
- Participate in ‘Attendee Chat’ by maximizing the chat widget in your dock.



## Dr. Don Wilcher

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

**ESP32-DEVKITC-V1E**

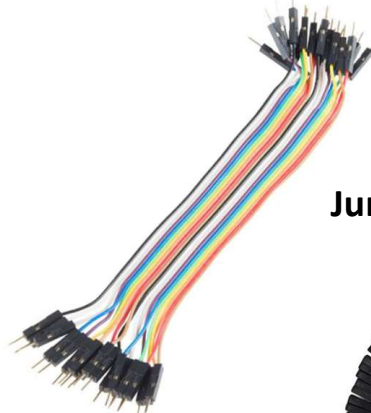


**Course Kit and Materials**

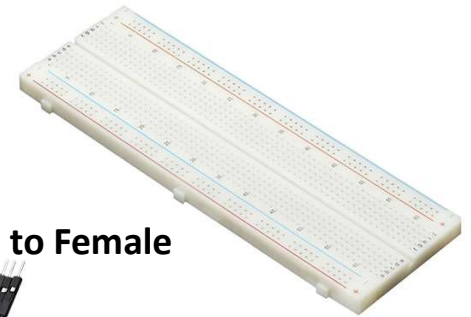
**Adafruit Parts Pal Kit**



**Jumper Wires: Male to Male**



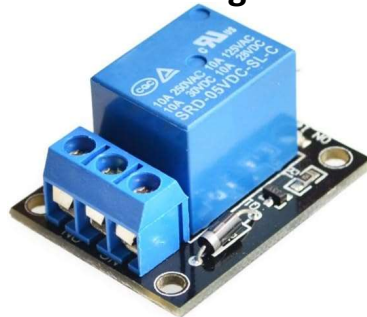
**Solderless Breadboard x2**



**Jumper Wires: Male to Female**



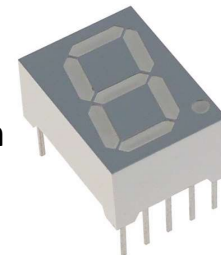
**5V Relay Module, 5V Indicator Light LED**



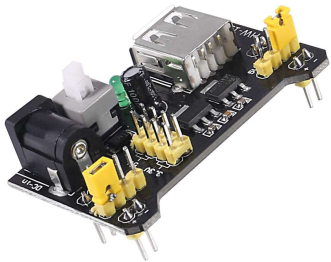
**Standard Motor, 9100 RPM 6VDC**



**7 Segment LED Display, Common Cathode**



**Solderless Breadboard Power Supply**



## Agenda:

- Timers (TON/TOF/TP) Instructions
- Counters (CTU/CTD) Instructions
- OpenPLC Counters and Timers Hands-ON Activities
- Lab: Build An ESP32 OpenPLC Conveyor Simulator



## Research Perspective

“Programmable logic controllers (PLCs) provide an ecosystem of relatively simple software logic, robust and ruggedized hardware, networks with controllable real-time behaviors, and extensive availability of interoperable components such as sensors and actuators” (Sehr et al., 2021).

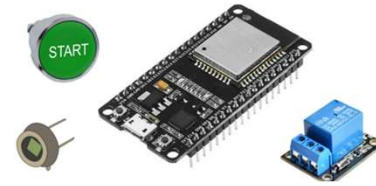
## Course Question

**Can an ESP32 microcontroller contribute to the Industrial Controls field?**



## Timers (TON/TOFF/TP)

- Timers are important devices used in industrial control systems.
- There are three types of timers used in industrial control systems:
  - a) Analog or mechanical timers.
  - b) Digital or solid-state timers.
  - c) PLC timers.





# Timers (TON/TOFF/TP)...

Examples of Timers



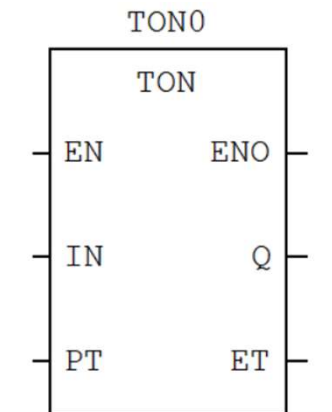
Mechanical – Motor-driven



Digital or Solid-State Timer



PLC Timer (OpenPLC)



## Question 1

**What are the three types of timers used in industrial systems?**

- a) analog/mechanical, digital/solid-state, LR timer**
- b) analog/mechanical, digital/solid-state, PLC timers**
- c) analog/mechanical, digital/solid-state, RC timers**
- d) none of the above**



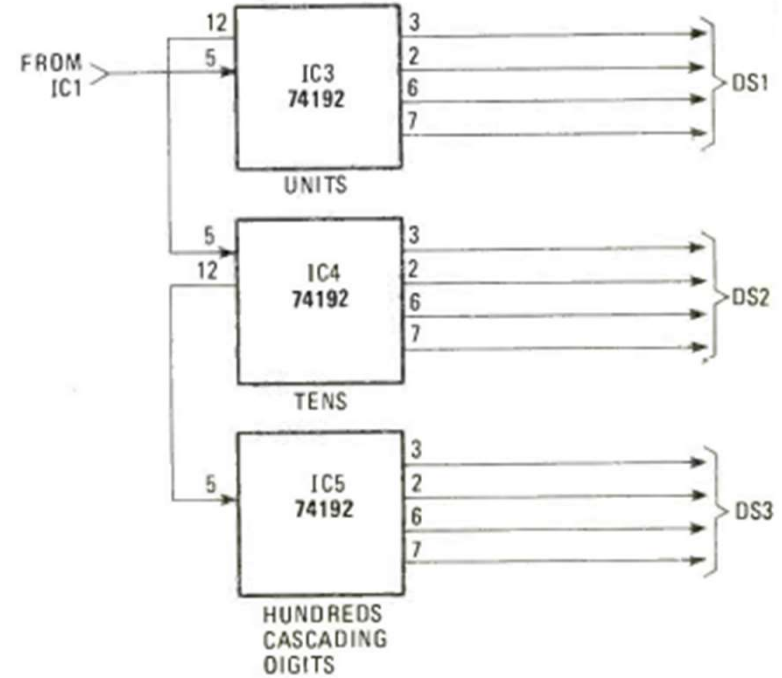
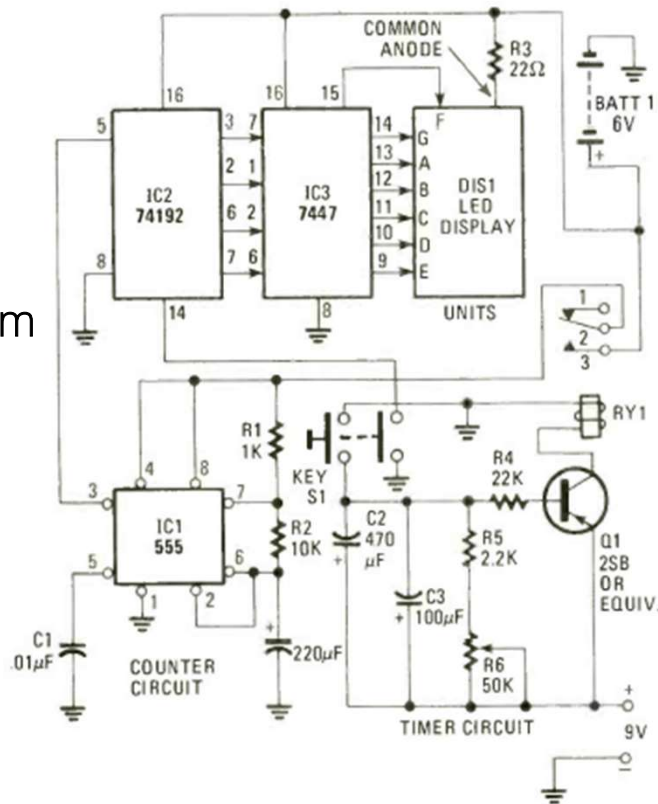
## Timers (TON/TOFF/TP)...

- Analog or mechanical timers are used in older relay logic control systems.
- Connecting a resistor in series with a capacitor creates a basic RC-time constant circuit.
- Wiring this circuit to a transistor relay circuit can create a solid-state timer.
- Adding a n-bit counter to the RC-based transistor relay circuit allows for creating a Digital Electronic Timer.



# Timers (TON/TOFF/TP)...

Digital Electronic Timer Circuit Schematic Diagram



Wilcher (1983)

## Timers (TON/TOFF/TP)...

PLC Timers - (OpenPLC)

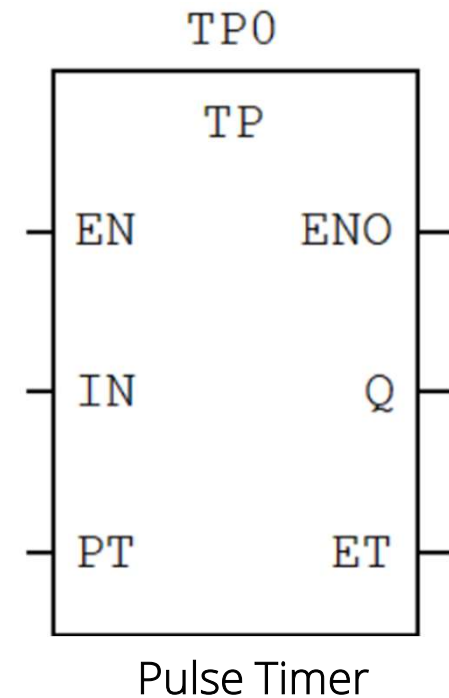
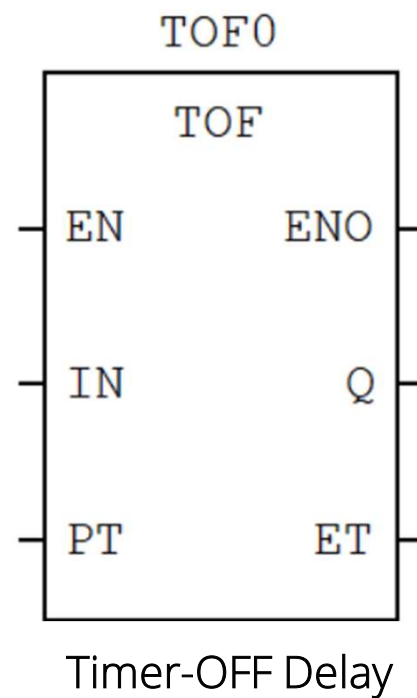
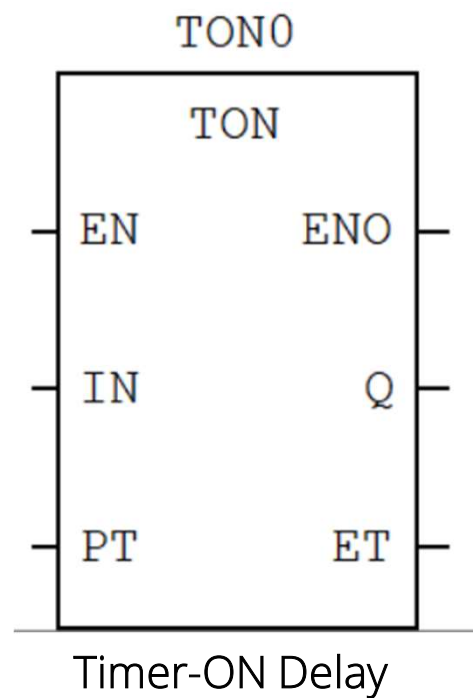
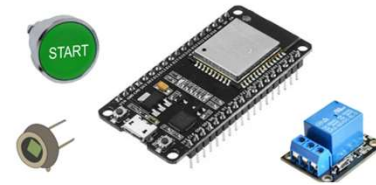
- Timer-ON Delay (TON) Timer: Counts time-based intervals when the instruction is true.
- Timer-OFF (TOF) Timer: Counts time-based intervals when the instruction of false.
- Pulse Timer (TP): Counts short time-based intervals when the instruction is true.



Note:  
The Timers are  
Function Blocks  
(FBs).

## Timers (TON/TOFF/TP)...

Example PLC Timers- (OpenPLC)



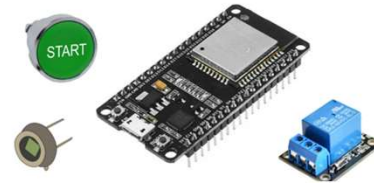


## Counters (CTU/CTD)

- Programmed counters serve the same function as mechanical timers-to receive external count events.
- When a trigger event is applied to the programmed counter, the count increments (Count-Up) or decrements (Count-Down).
- Although the majority of counters used in industrial controls are up-counters, down-counters are used in numerous control and material handling systems. Example: Parts shelf inventory tracking.



## Counters (CTU/CTD)...



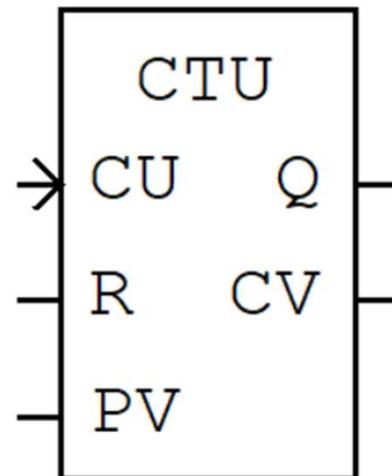
Mechanical Counter



Note:  
The Up and  
Down counters  
are Function  
Blocks (FBs).

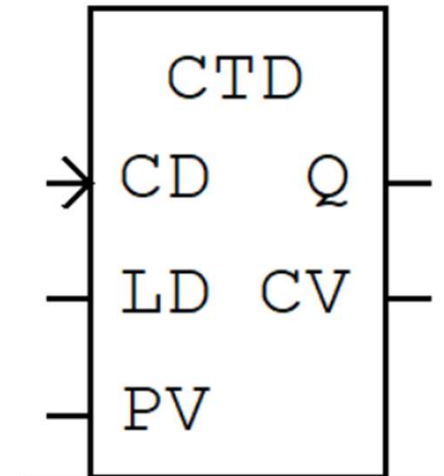
Example PLC Counters- (OpenPLC)

CTU0



Up-Counter

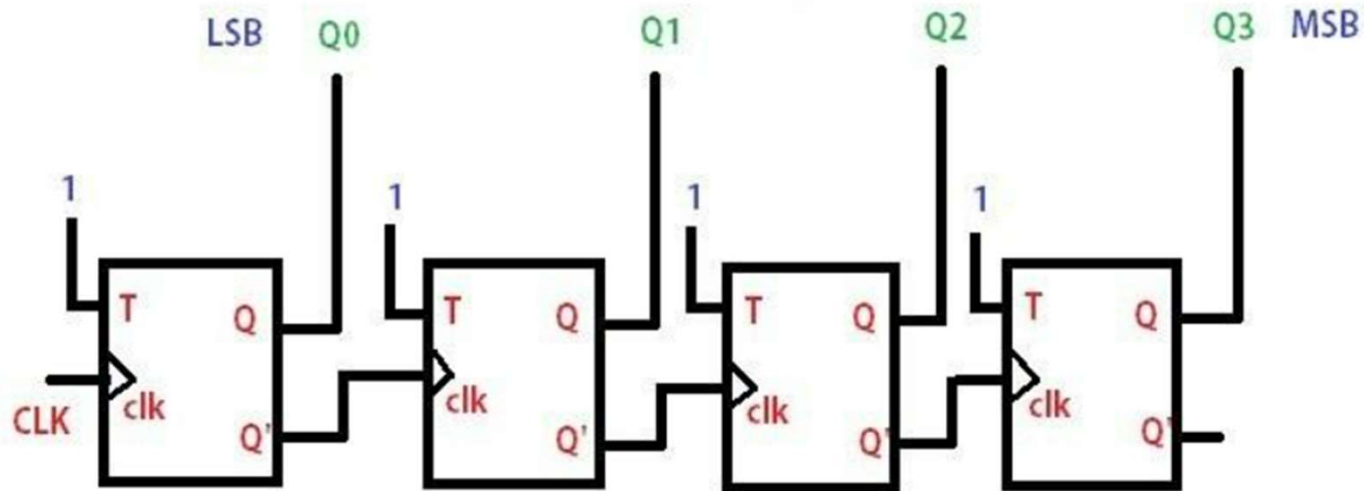
CTD0



Down-Counter

# Counters (CTU/CTD)...

A Digital 4 Bit Binary Counter



Jotrin (2024)

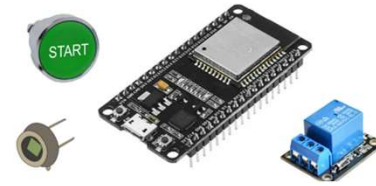
## Question 2

**What function is provided by a programmed counter?**

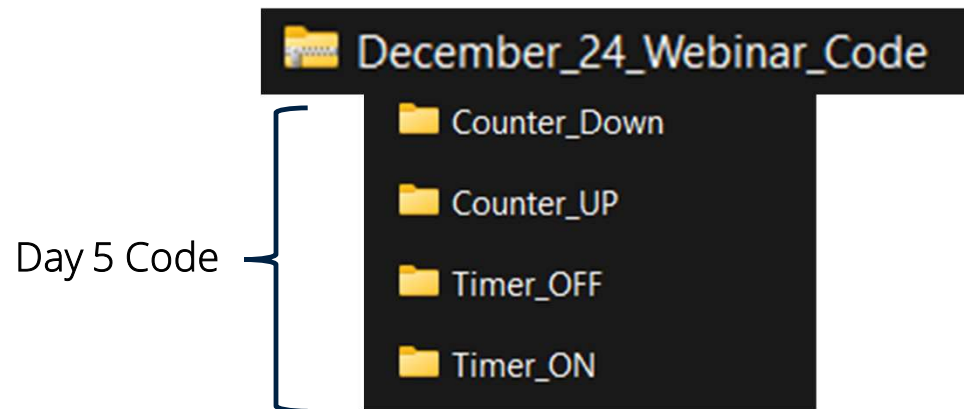
- a) same function as mechanical timers – to receive external count events**
- b) same as RC counters – to receive external count events**
- c) same as digital clocks – to receive external count events**
- d) none of the above**



## OpenPLC Counters and Timers Hands-ON Activities



The hands-on activities will demonstrate the basics of OpenPLC Counters and Timers. The OpenPLC files are located in the Design News webinar code zipped folder.



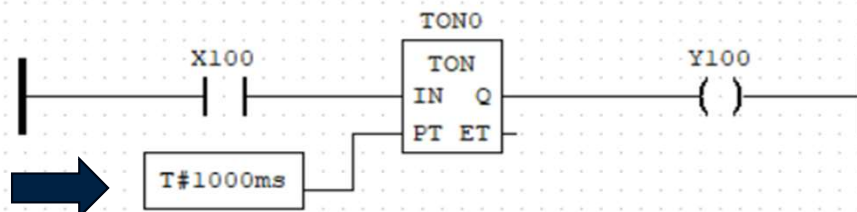
# OpenPLC Counters and Timers Hands-ON Activities...

## Basic Timer ON Control



#	Name	Class	Type	Location	Initial Value	Option	Documentation
1	X100	Local	BOOL	%IX0.1			PB_Switch1 (GPIO18: ESP32)
2	Y100	Local	BOOL	%QX0.0			LED (GPIO2: ESP32)
3	TON0	Local	TON				Timer_ON Delay

Click on T#1000ms  
to change the ON  
delay time!



Pressing PB\_Switch1 for  
1 second will turn on the  
LED and 7-Segment LED  
Display.



## Question 3

**In reviewing slide 20, which tag is associated with the ESP32 GPIO pin 18?**

- a) X100**
- b) Y100**
- c) TON0**
- d) none of the above**

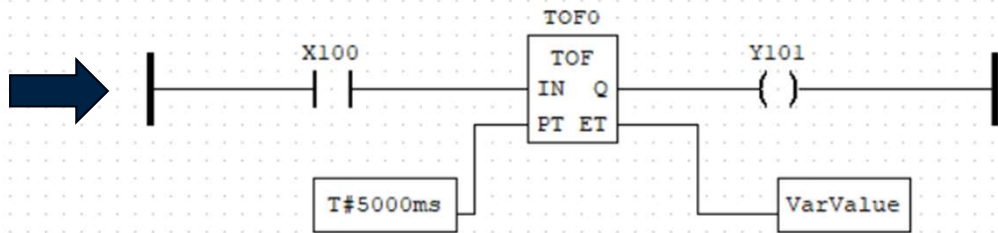


# OpenPLC Counters and Timers Hands-ON Activities...

## Basic Timer OFF Control



#	Name	Class	Type	Location	Initial Value	Option	Documentation
1	X100	Local	BOOL	%IX0.1			PB1_Switch1 (GPIO18: ESP32)
2	Y101	Local	BOOL	%QX0.0			LED (GPIO2: ESP32)
3	TOF0	Local	TOF				
4	VarValue	Local	TIME				

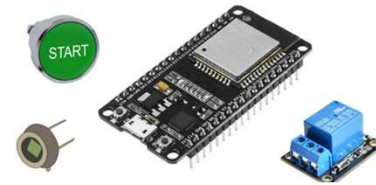


Double-click on the T#5000ms variable to change the ON delay time!

Pressing PB\_Switch1, the LED and 7-Segment LED Display will turn on. The LED and 7-Segment LED Display will stay on for 5 seconds.

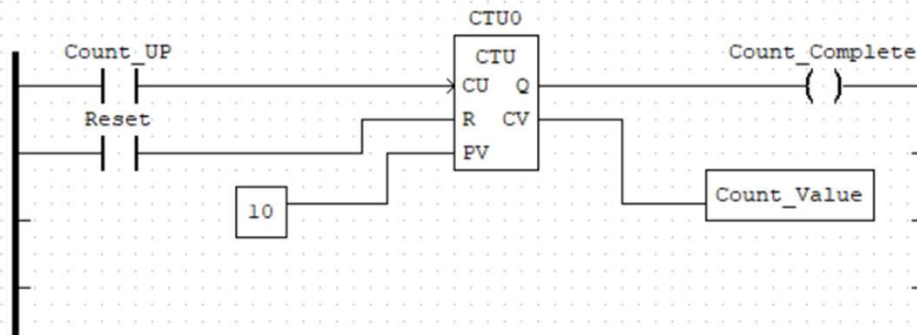
# OpenPLC Counters and Timers Hands-ON Activities...

## Basic Up Counter Control



#	Name	Class	Type	Location	Initial Value	Option	Documentation
1	Count_UP	Local	BOOL	%IX0.1			PB_Switch1 (GPIO18: ESP32)
2	Reset	Local	BOOL	%IX0.2			PB_Switch2 (GPIO19: ESP32)
3	Count_Complete	Local	BOOL	%QX0.0			LED (GPIO2: ESP32)
4	CTU0	Local	CTU				
5	Preset_Value	Local	INT				
6	Count_Value	Local	INT				

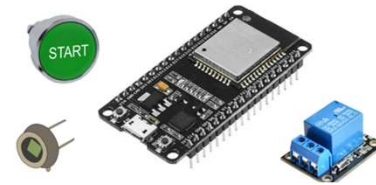
Double-click on the 10 variable to change the count value!



Pressing PB\_Switch1 ten times will turn on the LED and the 7-Segment LED Display. Pressing PB\_Switch2 will turn off the visual indicators. The counter will be reset.

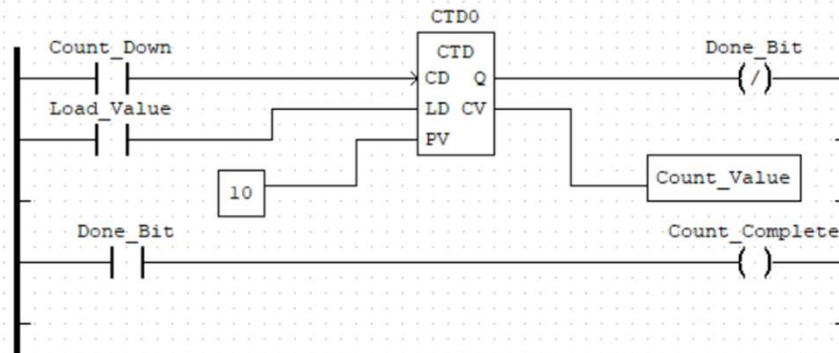
# OpenPLC Counters and Timers Hands-ON Activities...

## Basic Down Counter Control



#	Name	Class	Type	Location	Initial Value	Option	Documentation
1	Count_Down	Local	BOOL	%IX0.1			PB_Switch1 (GPIO18: ESP32)
2	Load_Value	Local	BOOL	%IX0.2			PB_Switch2 (GPIO19: ESP32)
3	Count_Complete	Local	BOOL	%QX0.0			LED (GPIO2: ESP32)
4	Done_Bit	Local	BOOL				
5	CTD0	Local	CTD				
6	Preset_Value	Local	INT				
7	Count_Value	Local	INT				

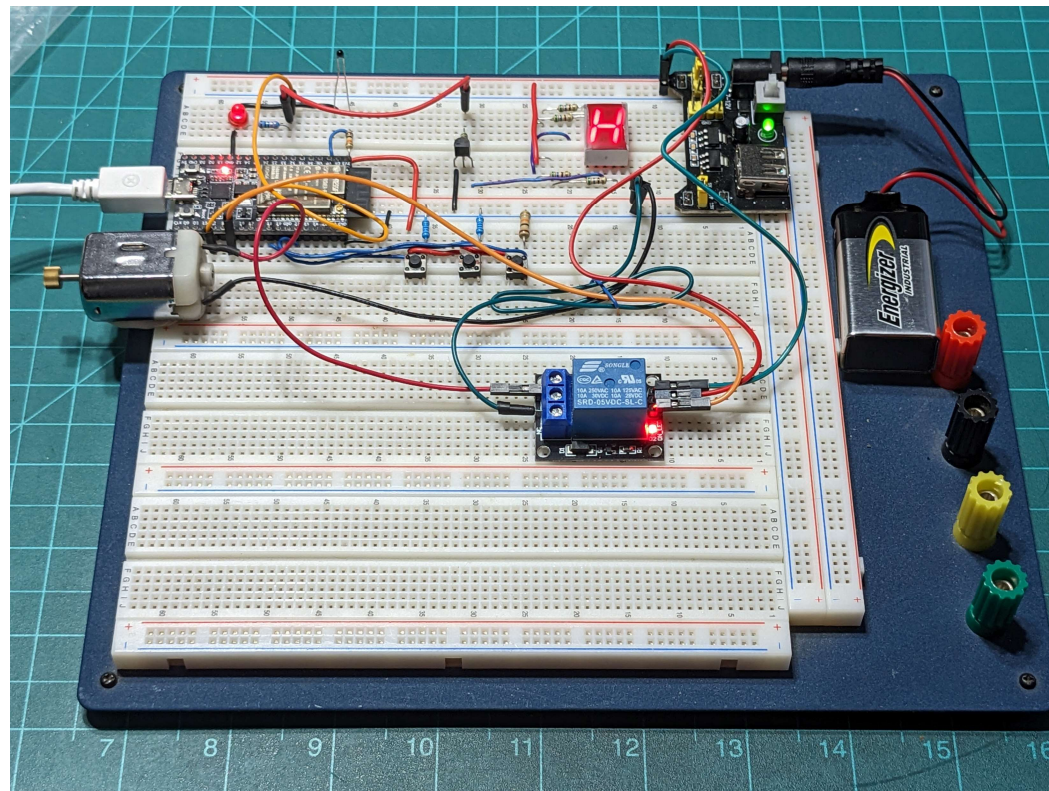
Double-click on the 10 variable to change the count value!



Pressing PB\_Switch2 will load the Down Counter with a Preset value of ten. The LED and 7-Segment LED Display will turn on. Pressing PB\_Switch1 10 times will turn off the LED and the 7-Segment LED Display.



## Lab: Build An ESP32 OpenPLC Conveyor Simulator



## Lab: Build An ESP32 OpenPLC Conveyor Simulator...



### Participant Learning Objectives:

- Participants will learn a practical application for a Down Counter Function Block in implementing a PLC Industrial Controls concept with an ESP32 microcontroller.
- Participants will learn to open an LD file and run a pre-programmed OpenPLC conveyor simulator application.
- Participants will learn to change the count value for the OpenPLC Conveyor Simulator application.



## Lab: Build An ESP32 OpenPLC Conveyor Simulator...

### Conveyor Simulator Concept



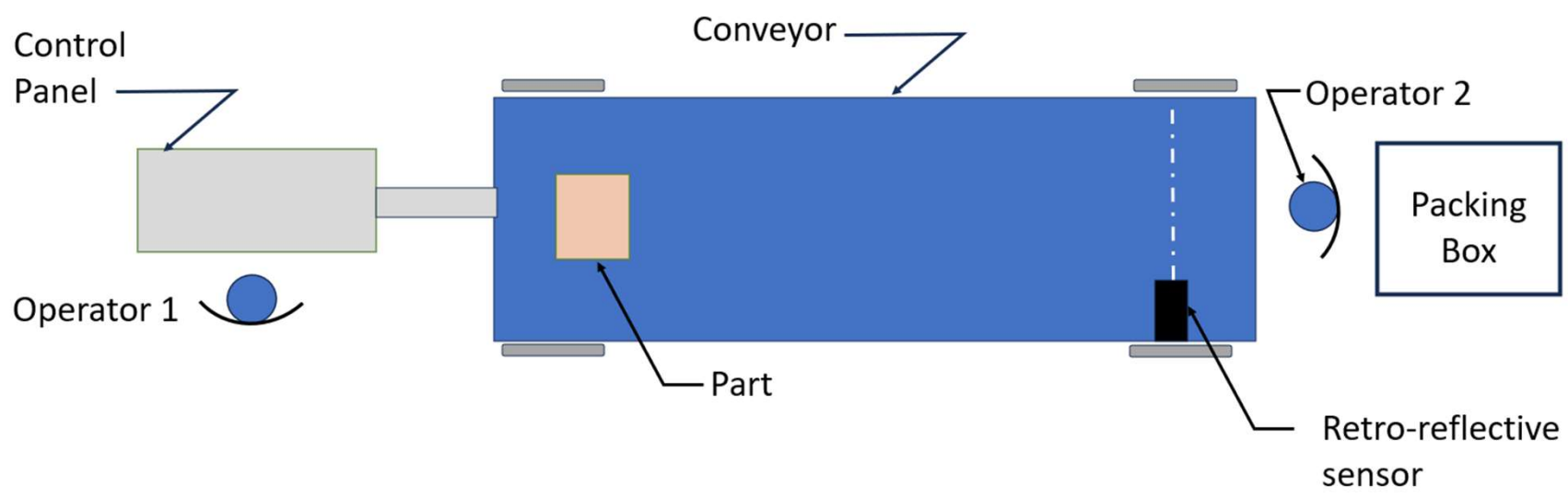
#### Conveyor Sequence of Operation:

1. Operator 1 Loads Preset Count Value.
2. The Control Panel turns ON the Visual Indicators.
3. The Control Panel turns ON the Conveyor Motor.
4. The Conveyor transports the part to Operator 2.
5. The Retro-Reflective Sensor detects the part on the Conveyor.
6. The Control Panel counter is decremented by 1.
7. When the parts counter equals 0, then the Conveyor Motor stops.
8. The Visual Indicators turn OFF.

# Lab: Build An ESP32 OpenPLC Conveyor Simulator...



Concept Diagram:



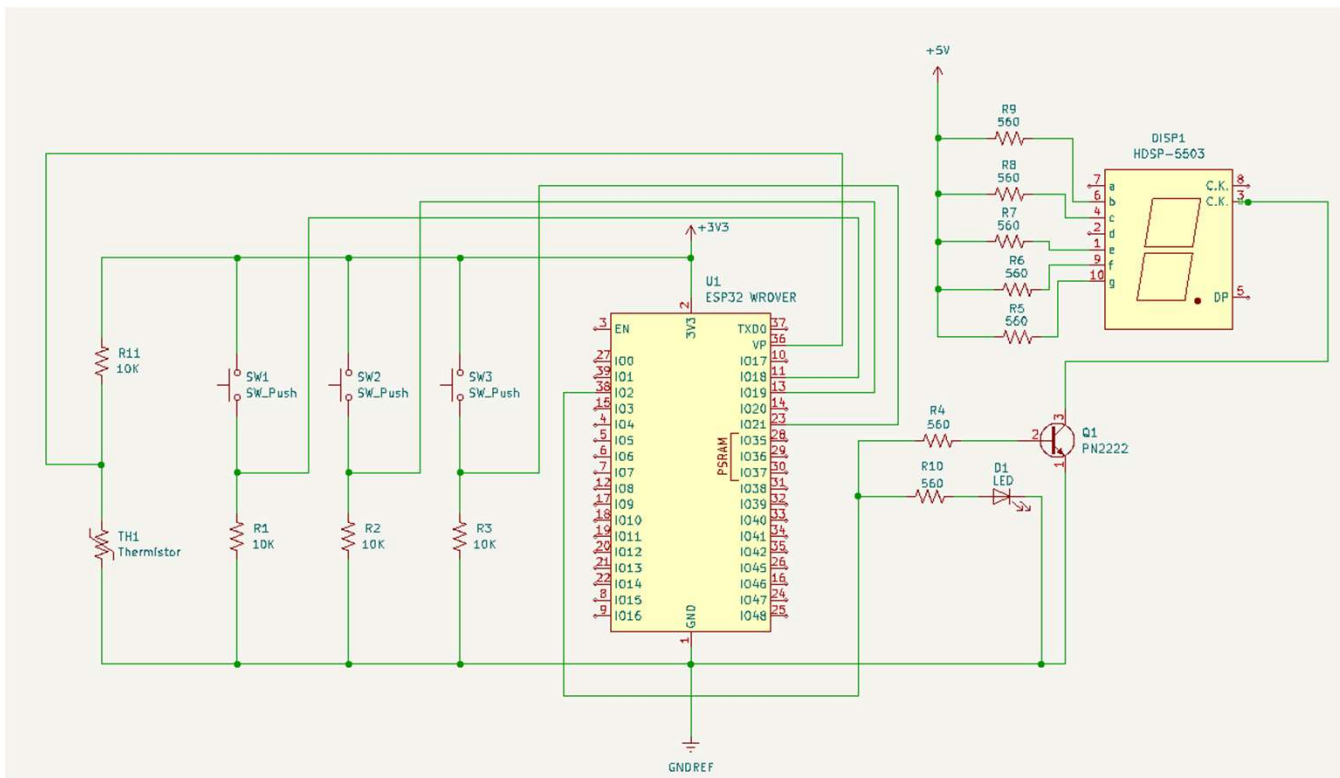
## Question 4

**For the Conveyor Simulator Concept, what sensor detects the part?**

- a) Photocell**
- b) Proximity**
- c) Hall-Effect**
- d) Retro-Reflective**

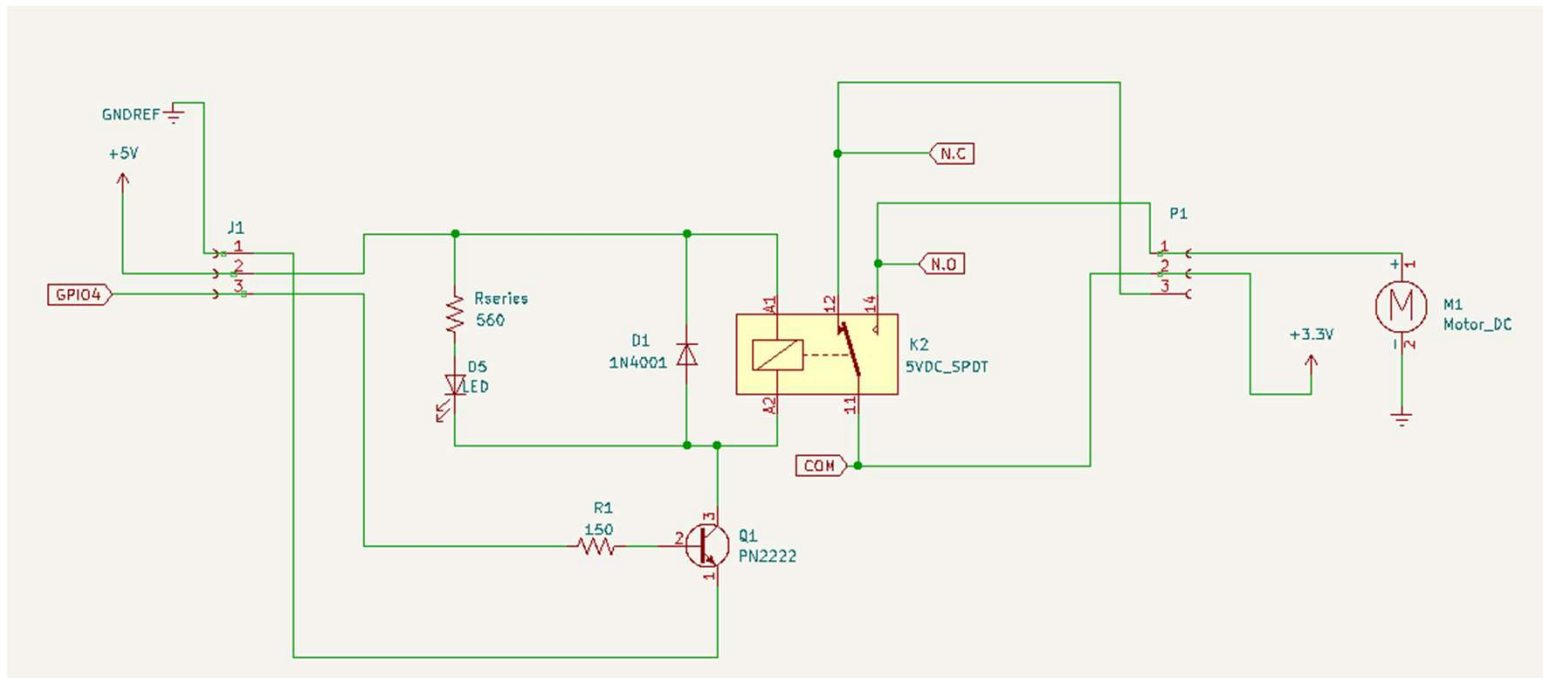


# Lab: Build An ESP32 OpenPLC Conveyor Simulator...



Partial ESP32  
Micro Trainer  
Electronic Circuit  
Schematic  
Diagram

## Lab: Build An ESP32 OpenPLC Conveyor Simulator...



ESP32 Micro  
Trainer Transistor  
Motor Electronic  
Circuit Schematic  
Diagram

## Lab: Build An ESP32 OpenPLC Conveyor Simulator...



The  
Conveyor  
Simulator file  
will be  
executed in  
OpenPLC!



December\_24\_Webinar\_Code

Conveyor\_Simulator

Counter\_Down

Counter\_UP

Timer\_OFF

Timer\_ON

Day 5 Code

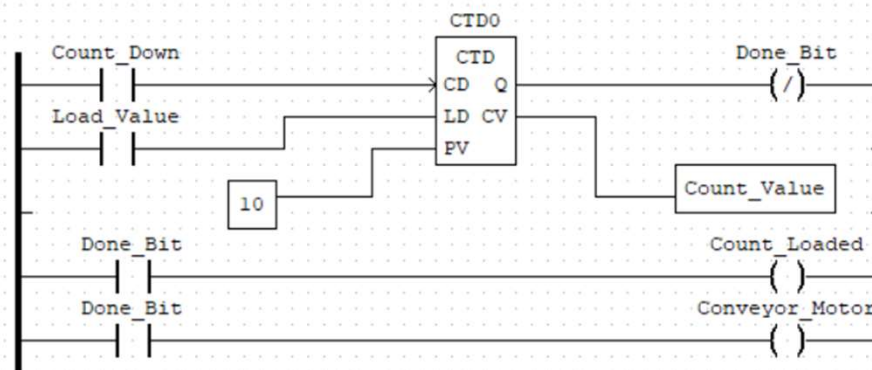


# Lab: Build An ESP32 OpenPLC Conveyor Simulator...

## Conveyor Simulator LD



#	Name	Class	Type	Location	Initial Value	Option	Documentation
1	Count_Down	Local	BOOL	%IX0.1			PB_Switch1 (GPIO18: ESP32)
2	Load_Value	Local	BOOL	%IX0.2			PB_Switch2 (GPIO19: ESP32)
3	Count_Loaded	Local	BOOL	%QX0.0			LED (GPIO2: ESP32)
4	Done_Bit	Local	BOOL				
5	Conveyor_Motor	Local	BOOL	%QX0.1			Motor (GPIO4: ESP32)
6	CTD0	Local	CTD				
7	Preset_Value	Local	INT				
8	Count_Value	Local	INT				



# Lab: Build An ESP32 OpenPLC Conveyor Simulator...

## The ESP32 I/O Pin Configuration




Click here to  
view the  
assigned  
OpenPLC  
ESP32 I/O Pins !





Transfer Program to PLC

Board Type: ESP32 Generic [3.0.7]

COM Port: Silicon Labs CP210x USB to UART Bridge (COM3) (COM3)

 Transfer

 I/O Config

 Communications

This setting will allow you to change the default pin mapping for your board. Please be cautious while editing, as mistakes can lead to compilation errors. Pin numbers should obey the Arduino notation for your board and must be comma-separated.

Digital Inputs  
17, 18, 19, 21, 22, 23, 27, 32, 33

Digital Outputs  
02, 04, 05, 12, 13, 14, 15, 16

Analog Inputs  
34, 35, 36, 39

Analog Outputs  
25, 26

Restore Defaults Save Changes

# Lab: Build An ESP32 OpenPLC Conveyor Simulator...

Transfer Conveyor Simulator LD to the ESP32 microcontroller



Click here to transfer the LD program to the ESP32 microcontroller.



Transfer Program to PLC

Board Type: ESP32 Generic [3.0.7]

COM Port: Silicon Labs CP210x USB to UART Bridge (COM3) (COM3)

This setting will allow you to change the default pin mapping for your board. Please be cautious while editing, as mistakes can lead to compilation errors. Pin numbers should obey the Arduino notation for your board and must be comma-separated.

Digital Inputs: 17, 18, 19, 21, 22, 23, 27, 32, 33

Digital Outputs: 02, 04, 05, 12, 13, 14, 15, 16

Analog Inputs: 34, 35, 36, 39

Analog Outputs: 25, 26

Restore Defaults Save Changes

Transfer

I/O Config

Communications

## Lab: Build An ESP32 OpenPLC Conveyor Simulator...

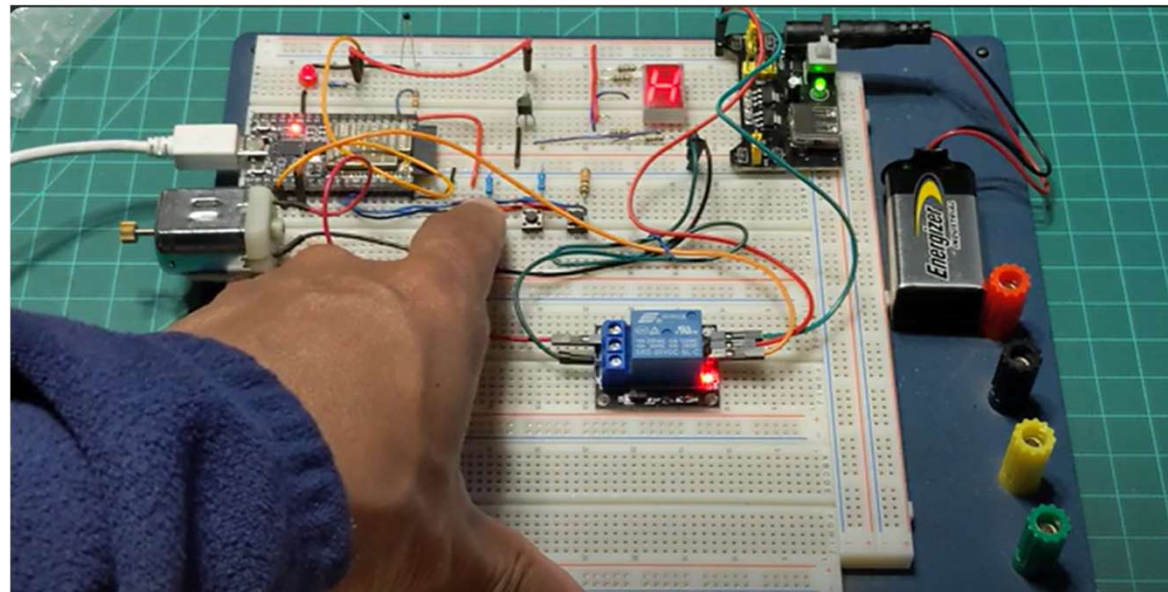
Press the SW2 pushbutton switch to load the preset count value (10). The LED, the 7-Segment LED display (letter H), and the DC motor will turn ON. Press the SW1 pushbutton switch 10 times, the visual indicators and the DC motor will turn OFF.



Functional ESP32  
OpenPLC Conveyor  
Simulator

Watch the Video Clip!

<https://www.youtube.com/watch?v=f5QQeMH169w>





## Question 5

**In reviewing slide 30, which switch simulates the Retro-Reflective sensor?**

- a) SW1**
- b) SW2**
- c) SW3**
- d) none of the above**





## Thank you for attending

Please consider the resources below:

Jotrin. (2024.). *4 bit binary counter: Working, circuit diagrams & applications*.  
<https://www.jotrin.ru/technology/details/4-bit-binary-counter>

Sehr, M.A, Lohstroh, M., Weber, M., Ugaide, I., Witte, M., Neidig, J., Hoeme, S., Niknami, M., & Lee, E.A. (2021). Programmable logic controllers in the context of industry 4.0. *IEEE Transactions On Industrial Informatics* 17(5), 3523 – 3535. <https://ieeexplore.ieee.org/document/9134804>

Wilcher, D. (1983). *Electronic timer: A few simple circuit chips and their use provide a basic primer in timers*. Radio-Electronics Annual. [https://github.com/DWilcher/DesignNews-WebinarCode/blob/main/December\\_24\\_Webinar\\_Code.zip](https://github.com/DWilcher/DesignNews-WebinarCode/blob/main/December_24_Webinar_Code.zip)

Wilcher, D. (2024). *Understanding industrial controls with an esp32*. GitHub.  
[https://github.com/DWilcher/DesignNews-WebinarCode/blob/main/December\\_24\\_Webinar\\_Code.zip](https://github.com/DWilcher/DesignNews-WebinarCode/blob/main/December_24_Webinar_Code.zip)



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