Getting Started in Automation with Arduino

DAY 5: Building a Start-Stop Automation Control Circuit

Webinar Logistics

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Dr. Don Wilcher

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Course Kit and Materials

Arduino Opta

12VDC @ 500mA Wall Mount Power Supply

DC Motor: Medium Torque

Adafruit Parts Pal Kit

Solderless Breadboard
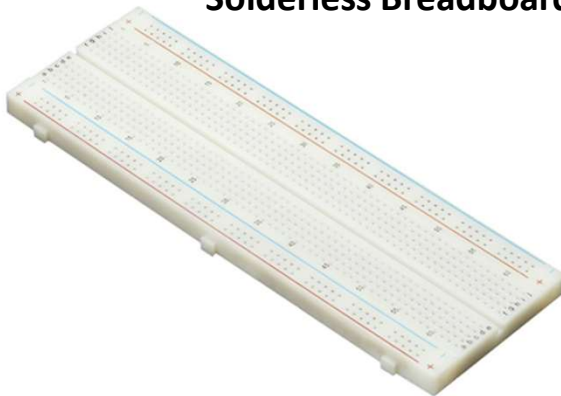
Jumper Wires: Male to Male

Solderless Breadboard Power Supply

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Agenda:

- Origins of the Ladder Diagram
- Control Circuit Anatomy
- Set- Reset Digital Circuit (Memory Circuit)
- Start-Stop Automation Control Circuit
- Lab: Build a Start-Stop Automation Control Circuit

Seminal Research Perspective

"Programmable Logic Controller (PLC) is the most important component in industrial automation, and it has become one of the three pillars (robots, PLC, and CAD/CAM) of the modern industrial control technology"(Liao, 2007).

Ladder Diagram Basics

Origins of Ladder Diagram

- The Ladder Diagram (LD) programming language originated from the graphical representation used to design an electrical control system
  - Control decisions were made using relays
- After a while, Relays were replaced by logic circuits
  - Logic gates used to make control decisions
- Finally, CPUs were added to take over the function of the logic circuits
  - I/O Devices wired to buffer transistors
  - Control decisions accomplished through programming
- Relay Logic representation (or LD) was developed to make program creation and maintenance easier
  - Computer based graphical representation of wiring diagrams that was easy to understand
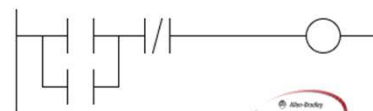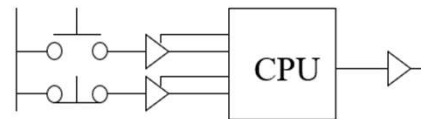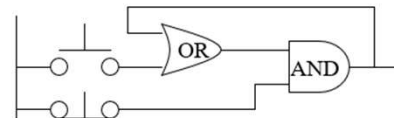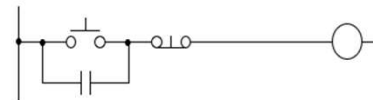 - Reduced training and support cost Computer-based
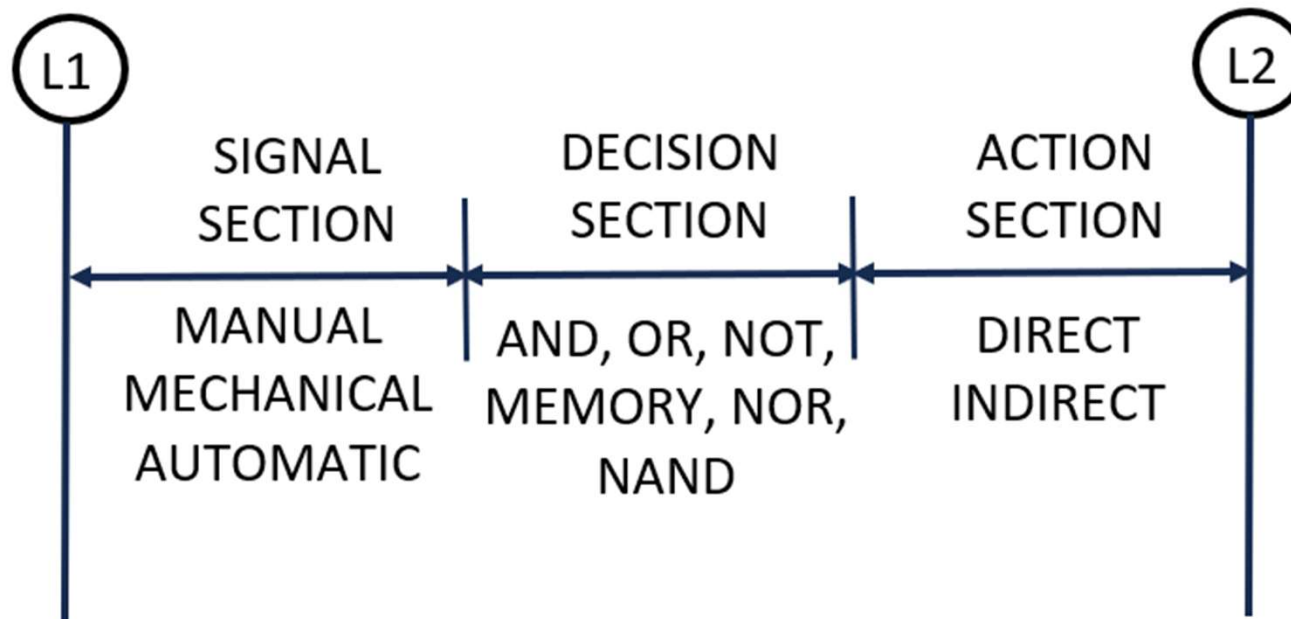
Illustration courtesy of Rockwell

Question 1

In reviewing slide 7, relays were replaced with _____.
   a) FPGAs
   b) microcontrollers
   c) logic circuits
   d) a PLC

Control Circuit Anatomy

L1

SIGNAL
SECTION

MANUAL
MECHANICAL
AUTOMATIC

DECISION
SECTION

AND, OR, NOT,
MEMORY, NOR,
NAND

ACTION
SECTION

DIRECT
INDIRECT

L2

Control Circuit Anatomy...

- **The Signal Section** starts or stops the current flow by closing or opening the contacts of the control device (Rockis & Mazur, 2014).
- Closed contacts allow current to flow to the control device.
- Open contacts do not allow current to flow to the control device.
- Examples of control devices include but are not limited to:
  - a) pushbutton switches.
  - b) limit switches.
  - c) foot switches.
  - d) temperature switches.
  - e) pressure switches.

Control Circuit Anatomy…

Control
Devices

Pushbutton Switch

Foot Switch

Temperature Switch

Pressure Switch

Limit Switch

Control Circuit Anatomy...

- The Decision Section determines the processes that are to be done by the Ladder Diagram (LD) program.
- The Ladder diagram program initiates arithmetic and logic processes.
- Traditionally, the decision section processes are guided by logical elements.
- Logical elements provide single or complex decisions based on the section's configuration.
- Based on the signal section input(s), the decision section will provide the appropriate output control to drive an electrical load like an actuator or visual device.

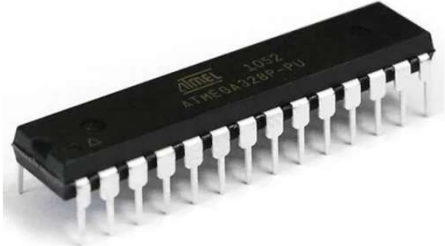# Control Circuit Anatomy...

Embedded Controller

Decision
Devices

Microcontroller IC

PLC

Digital Logic IC

Control Circuit Anatomy...

- **The Action Section** drives the electrical load based on the decision section output response.
- The action section is primarily responsible for driving electrical loads like:
    - a) motor contactors.
    - b) solenoids.
    - c) indicator lights.
    - d) control relays.
- The electrical load's action is based on the decision section's output response.

Control Circuit Anatomy...

Action
Devices

Solenoid

Control Relay

Motor Contactor

Indicator light
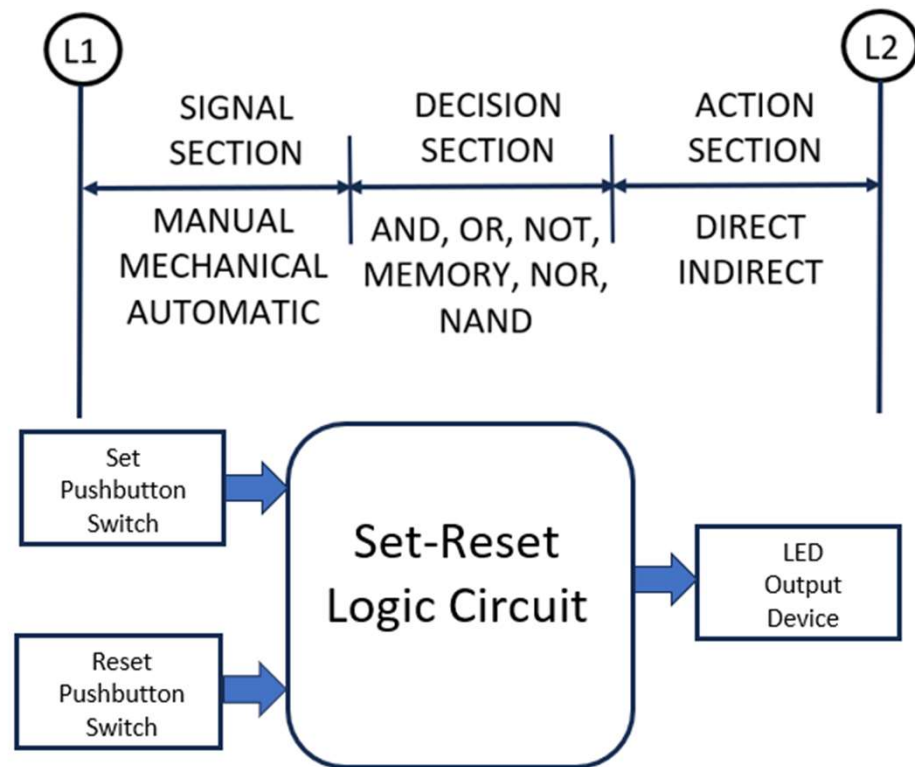
Set-Reset Logic Circuit (Memory Circuit)

The Alignment of the Set-Reset Logic with the Control Circuit Anatomy Diagram.

Question 2

The Control Circuit Anatomy section that starts or stops current flow by closing or opening the control device is the_____.
  a) Decision Section
 b) Action Section
  c) Signal Section
  d) Memory Section

Set-Reset Logic Circuit (Memory Circuit)...

- Control circuits are logic functions.
- Automation systems use logic functions to make decisions based on received inputs.
- Logic functions can be derived or built from electronics, hydraulics, and pneumatics components to perform computational thinking tasks.
- Basic logic functions can be combined to perform complex computation or decision-making tasks.
- One important aspect of computation tasks is the ability to store data.
- The Set-Rest Logic circuit is a basic memory circuit that stores either binary 1 or 0 bit.

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# Set-Reset Logic Circuit (Memory Circuit)...

2 Crossed Wired NOR Gates create a Set-Reset Logic Circuit. The control function performed is a Start-Stop Automation operation. Set stores binary 1 bit, Reset stores binary 0 bit
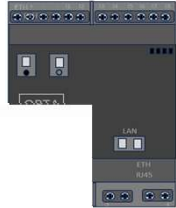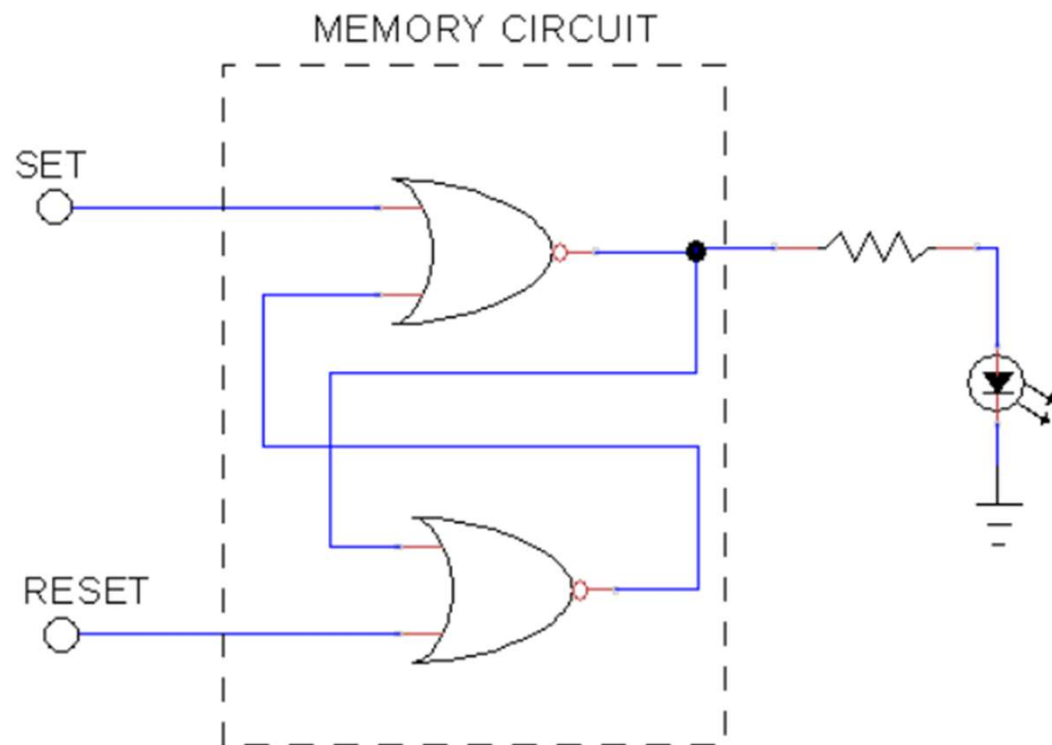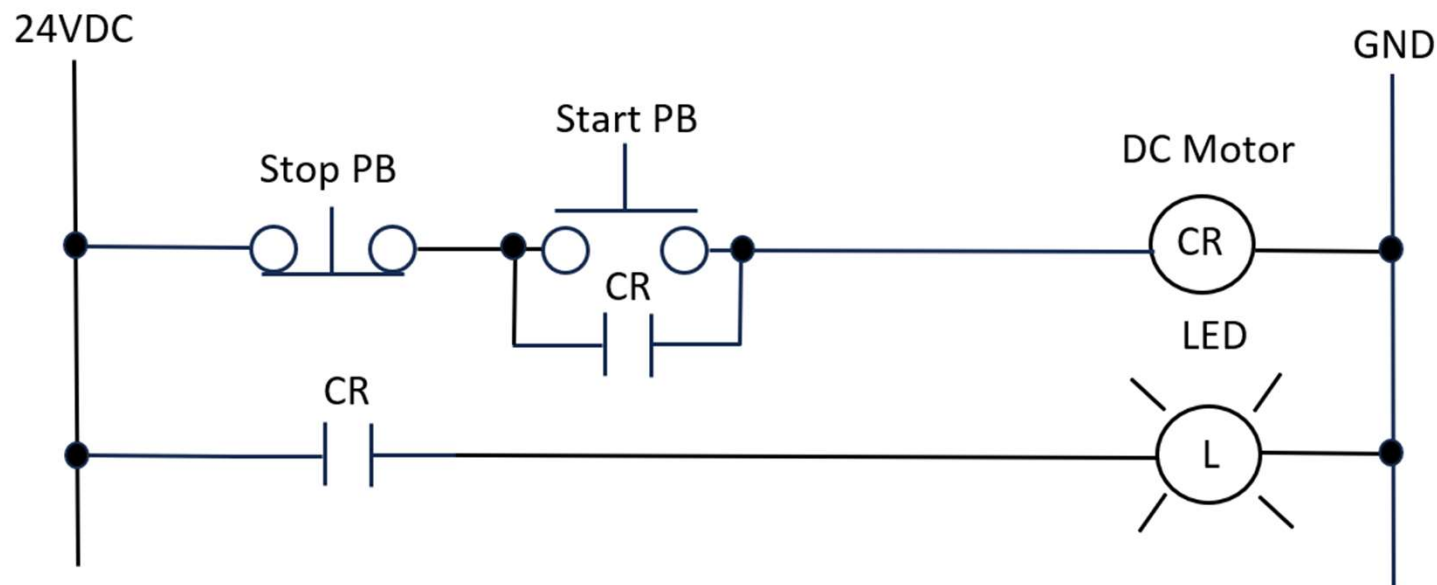

MEMORY CIRCUIT

Set-Reset Logic Circuit (Memory Circuit)...

Start-Stop Automation Control Circuit

Start-Stop Automation operation = Set – Reset Logic Circuit.
Set = Start PB
Reset = Stop PB
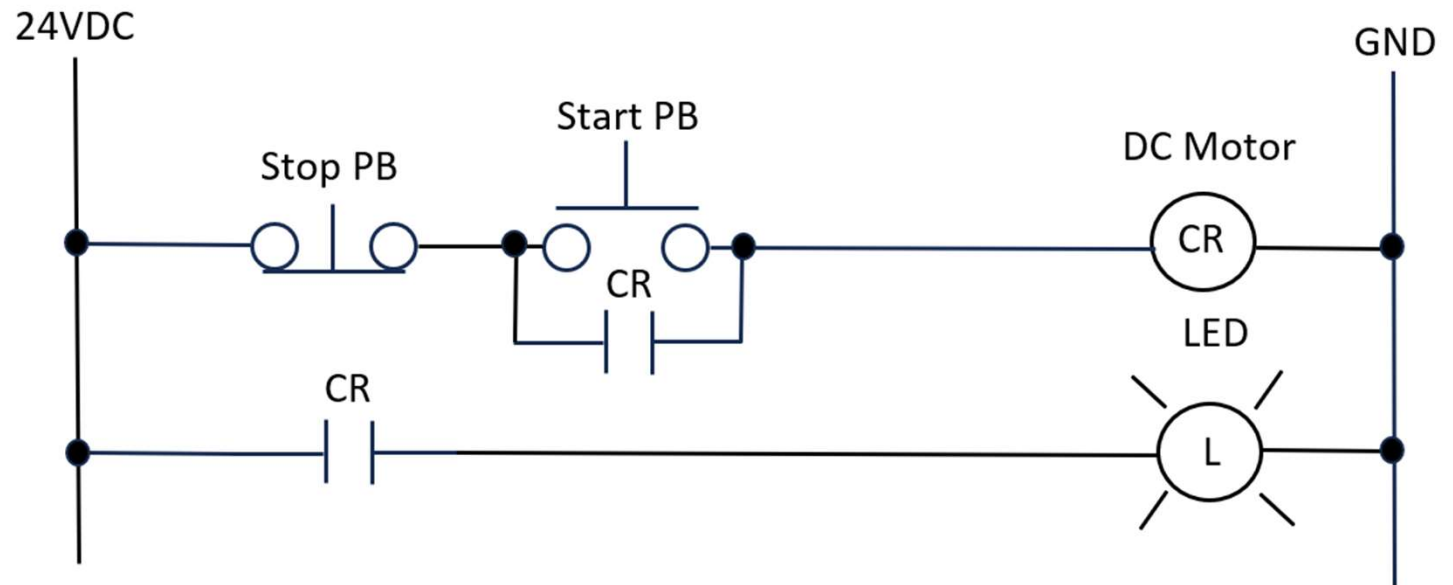
Start-Stop Automation Control Circuit...

The NOT logic of a Stop PB allows the creation of a Start-Stop Control Circuit. The CR(Control Relay) contact seals the Start PB function, allowing the release of the controlled device.

Question 3

Cross wiring 2 _____ can create a Set-Reset Logic circuit.

a) Op-Amps
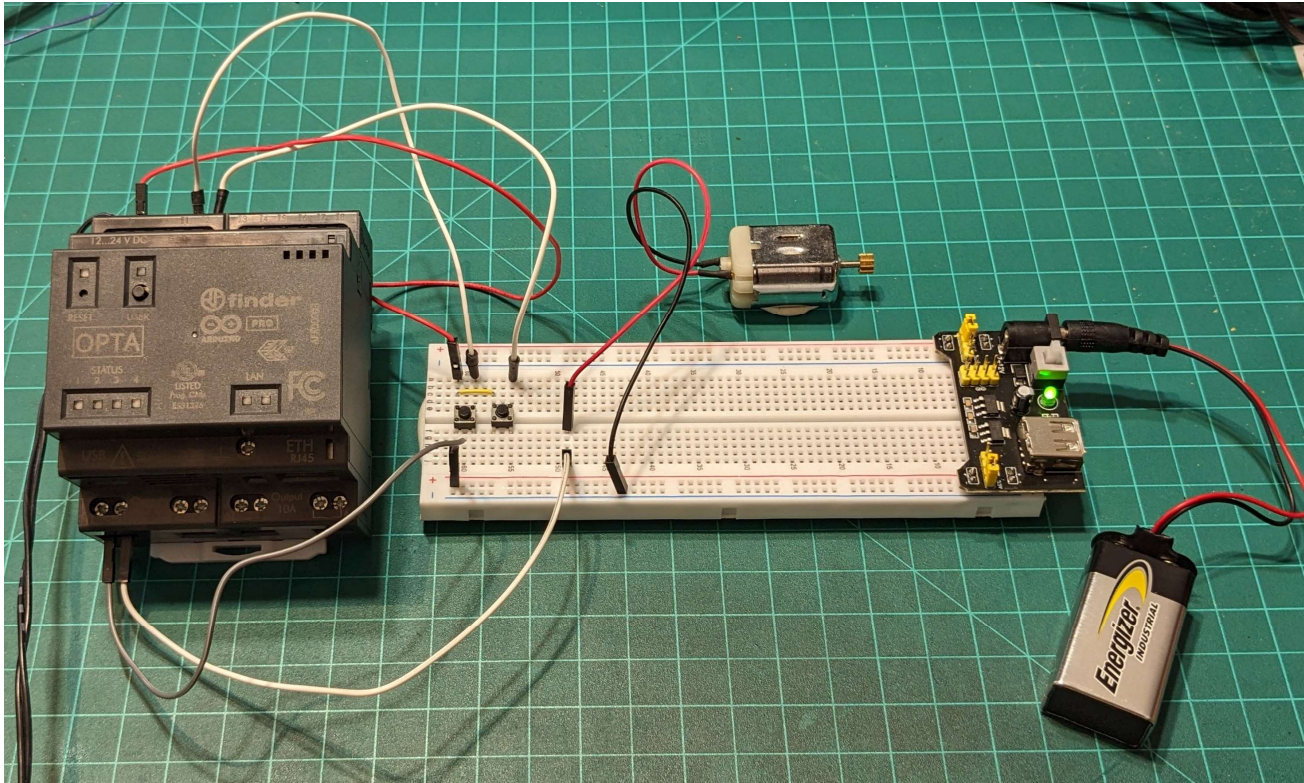b) AND Gates
c) OR Gates
d) NOR Gates

Start-Stop Automation Control Circuit...

Final Note:
All control and process operations are built around a Start-Stop
Automation Control Circuit.

Lab: Build a Start-Stop Automation Control Circuit

Lab: Build a Start–Stop Automation Control Circuit...

Lab Objectives:
- Participants will learn to set up communications using the Arduino PLC IDE.
- Participants will learn to create a Ladder Diagram Logic Function program using the Arduino PLC IDE.
- Participants will learn how to create a new rung (network).
- Participants will learn how to program and control an Arduino Opta Relay.
- Participants will learn to download, run, and test a Ladder Diagram Logic Function program.
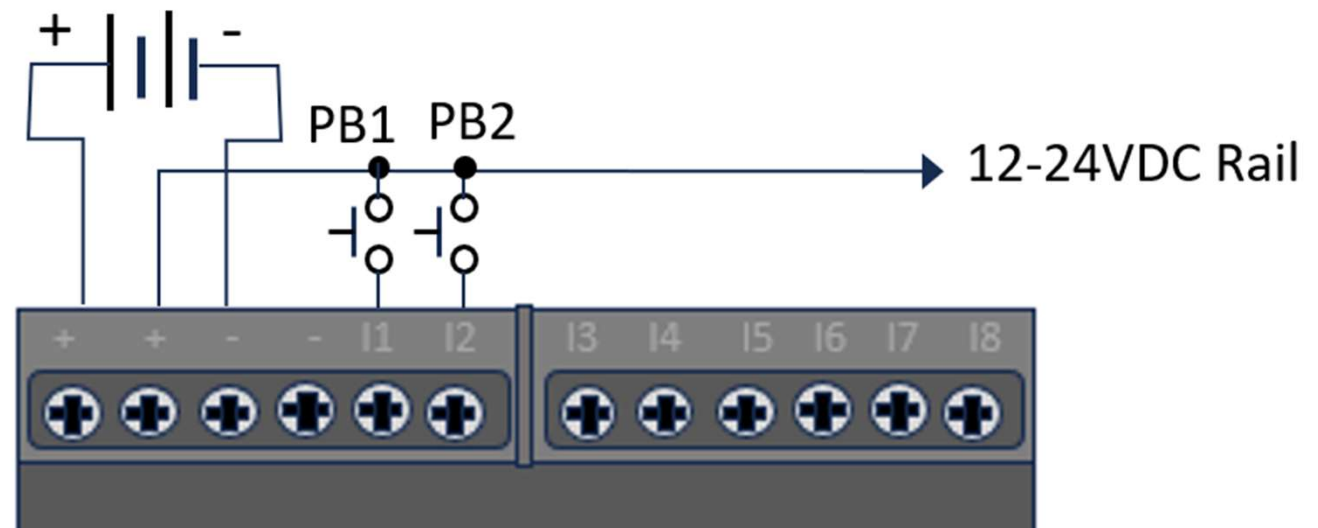
Wiring 2 Pushbutton Switches To the Arduino Opta. . .

A Prototyping Concept for a Digital Switch Simulator: Input Terminal Wiring Diagram

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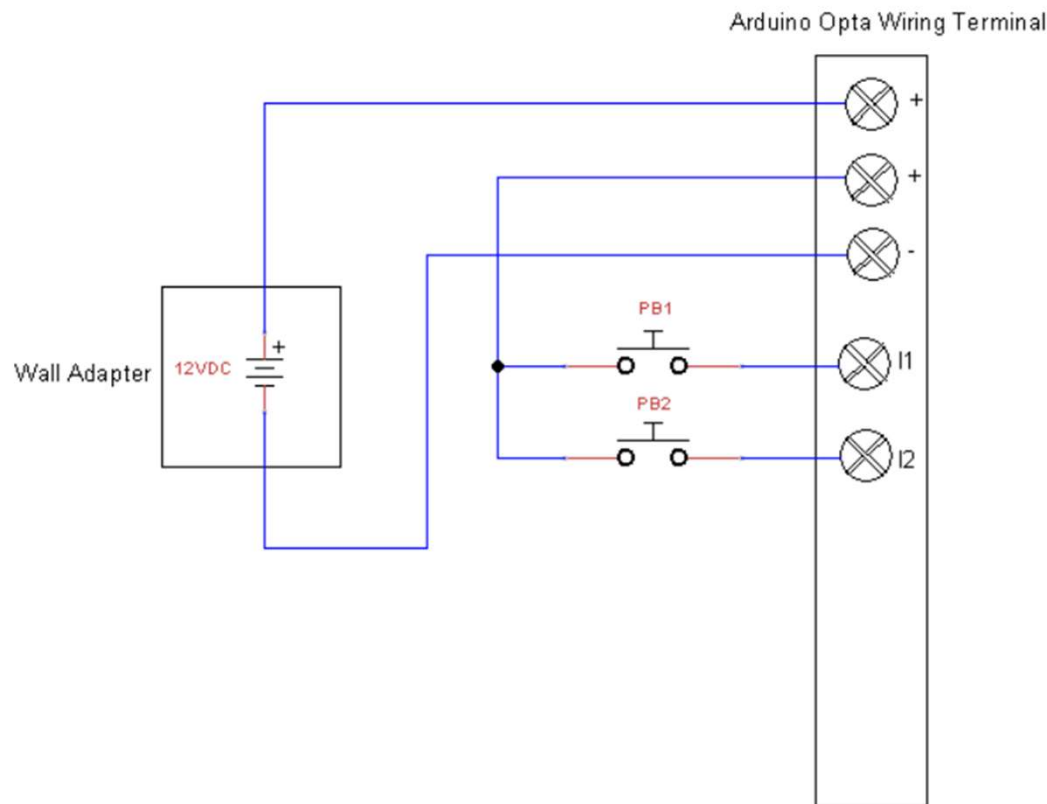
Wiring 2 Pushbutton Switches To the Arduino Opta...

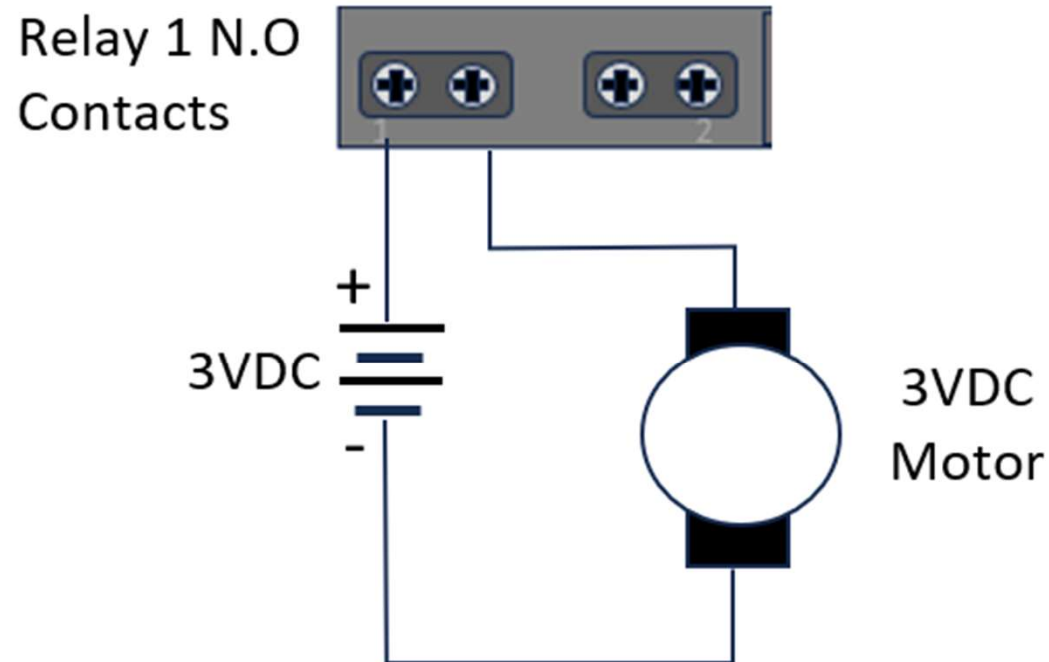2 tactile pushbutton switches are wired to the terminal points I1 and I2 of the Arduino Opta.
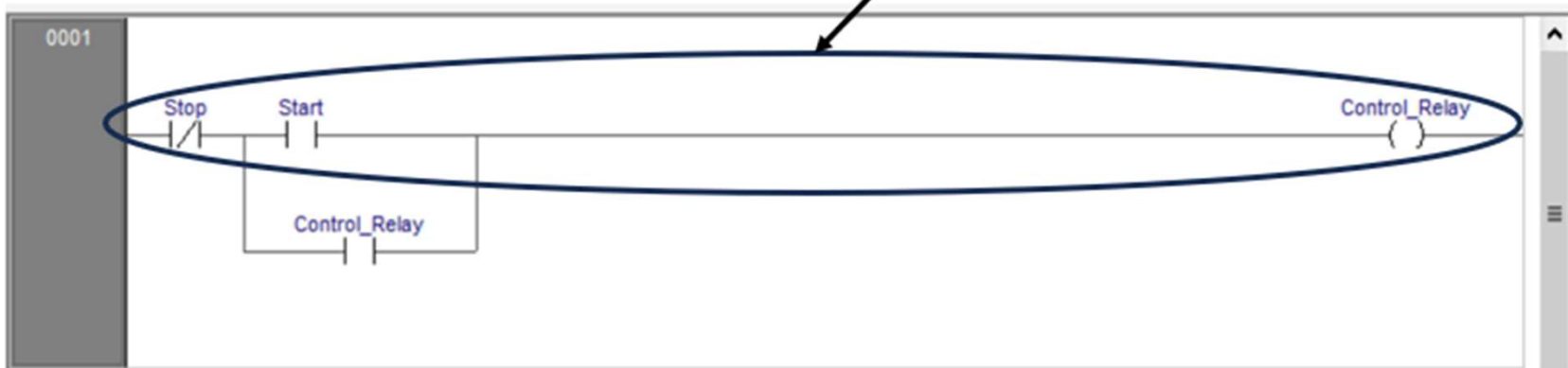
Wiring an A 3VDC Motor To the Arduino Opta

A 3V DC Motor wired to the terminal point "1" Relay Contact of the Arduino Opta.

Relay 1 N.O Contacts

+

3VDC

-

3VDC Motor

Lab: Build a Start–Stop Automation Control Circuit. . .
Programming 1st Ladder Diagram Rung

Use Day3 Slides to program
this top Ladder Diagram Rung

Lab: Build a Start–Stop Automation Control Circuit. . . Programming a Seal-In Contact/Bit Instruction

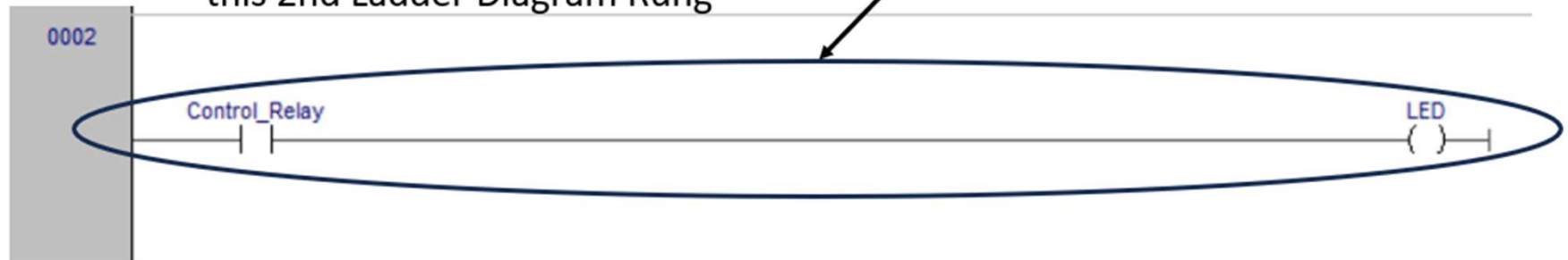# Question 4

Which icon is used to create a branch rung?
a) Open Object
b) Series Contact
c) Parallel Contact
d) none of the above

Lab: Build a Start–Stop Automation Control Circuit. . .
Adding a Second Rung (Network)

Scheme>New>Network>After

Use Day2 Slides to program
this 2nd Ladder Diagram Rung

0002

Control_Relay

LED

Lab: Build a Start–Stop Automation Control Circuit. . .

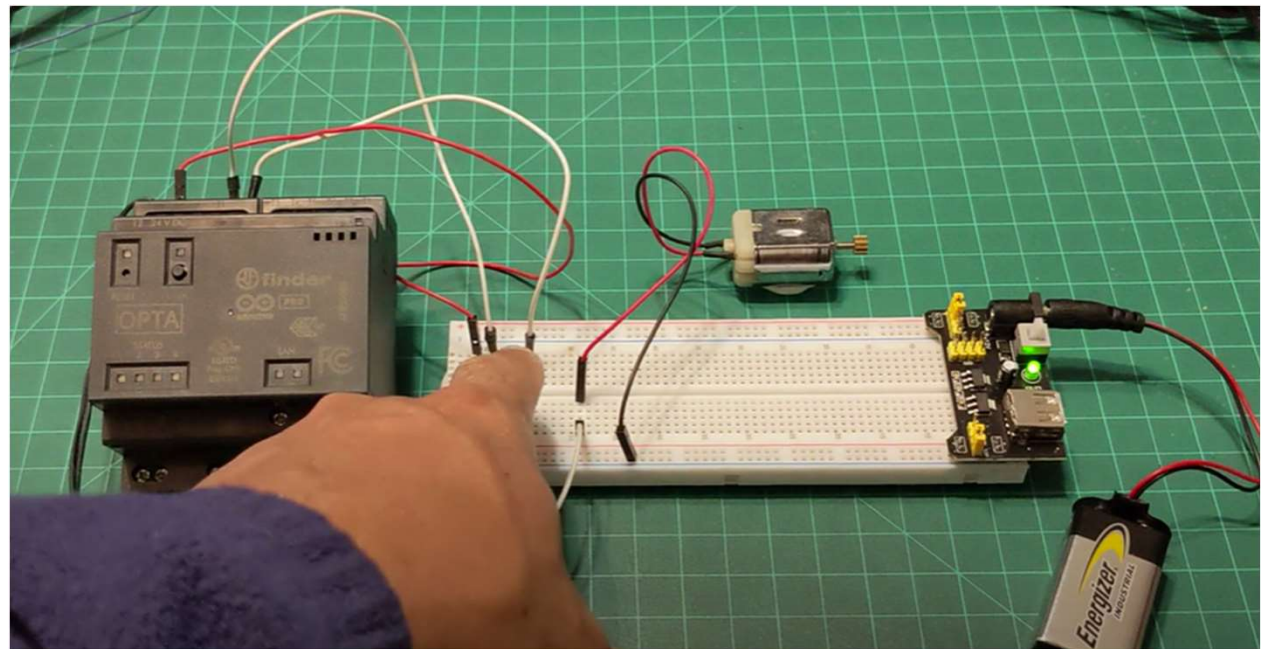Completely Start-Stop Automation Control Circuit

Download LD program to the Arduino Opta using slides 36 and 37 from Day 2 ppt/pdf.

Lab: Build a Start–Stop Automation Control Circuit. . .

Functional Start-Stop
Automation Control Circuit

Watch Video Clip!

https://youtu.be/71wkFKk_3b4

Question 5

In reviewing slide 33, which Tag bit instruction performs the negation function for Network 1?
   a) Start
   b) Control Relay
   c) Stop
   d) none of the above

Thank you for attending

Please consider the resources below:

Bagur, J. ,& Linares, J . C. (2023, March 11). *Opta user manual*. https://docs.arduino.cc/tutorials/opta/user-manual/

Finder.(n.d.). *Getting started with arduino opta*. https://opta.findernet.com/en/tutorial/getting-started

Liao, C.C. (2007). *Programming and application of S7-200 plc* (3rd ed.). Mechanical Industry Press.

Mandal. R, Maity, T., Prasad, G.M., & Verma, R. P. (2015). Automation of underground coal mines using plc. *Journal of Mines, Metals, and Fuels*, 174 – 181.
    https://www.researchgate.net/publication/317038146_Automation_of_underground_coal_mines_using_PLC#:~:text=This%20paper%20presents%20applications%20of,flammable%20gases%20exceeds%20permissible%20limit

Rockis, G. J. , & Mazur, G. A. (2014). Electrical motor controls for integrated systems (5th ed.). American Technical Publishers.

Wilcher. D. (2024, February 21). *Turn a raspberry pi into a plc using openplc*. https://control.com/technical-articles/turn-a-raspberry-pi-into-a-plc-using-openplc/

Course_Lab_project_code.zip folder: Github Repository: Course_Lab_project_code.zip folder: Github Repository:
    https://github.com/DWilcher/DesignNews-WebinarCode

Thank You

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