CEC Continuing Education Center

DesignNews

PLC-HMI Automation Applications

DAY 1 : PLC Overview: Ladder Logic Program - Hello World

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Don Wilcher

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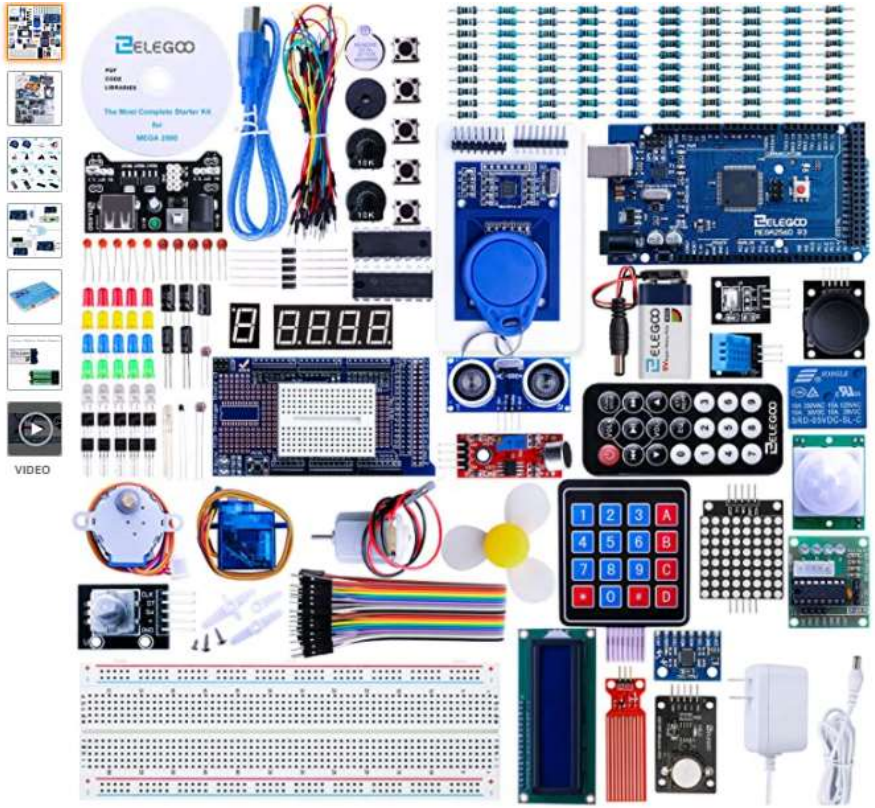
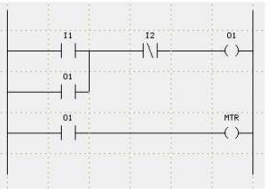
Course Kit:
The ELEGOO Mega 2560 Project: The Most Complete Starter Kit w/Tutorial



Course Components:

ELEGOO UNO R3 2.8 Inches TFT Touch Screen with SD Card Socket w/All Technical Data in CD for Arduino UNO R3

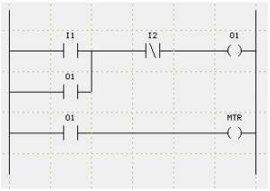
TWTADE SSR-40 DD 40A DC 3-32V to DC 5-60V SSR Solid State Relay + Heat Sink



Agenda:

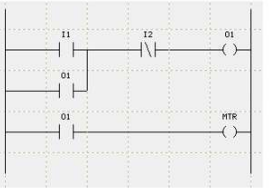
- What is a PLC?
- PLC System Architecture
- International Electrotechnical Commission (IEC) 61131-3: Programming Languages
- Lab Activities
  a) Building an Arduino PLC Controller
  b) Installing plcLib library
  c) Bare Minimum plcLib PLC program: Hello World

What is a PLC?



- PLC is the abbreviation for Programmable Logic Controller
- Is computing device designed for industrial control systems
- Can be referred to as a high-level microcontroller

Source: CircuitDesign



What is a PLC?

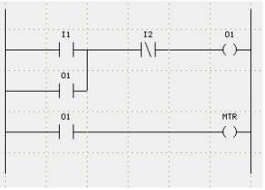
Can be referred to as a high-level microcontroller

ATMEGA 2560:

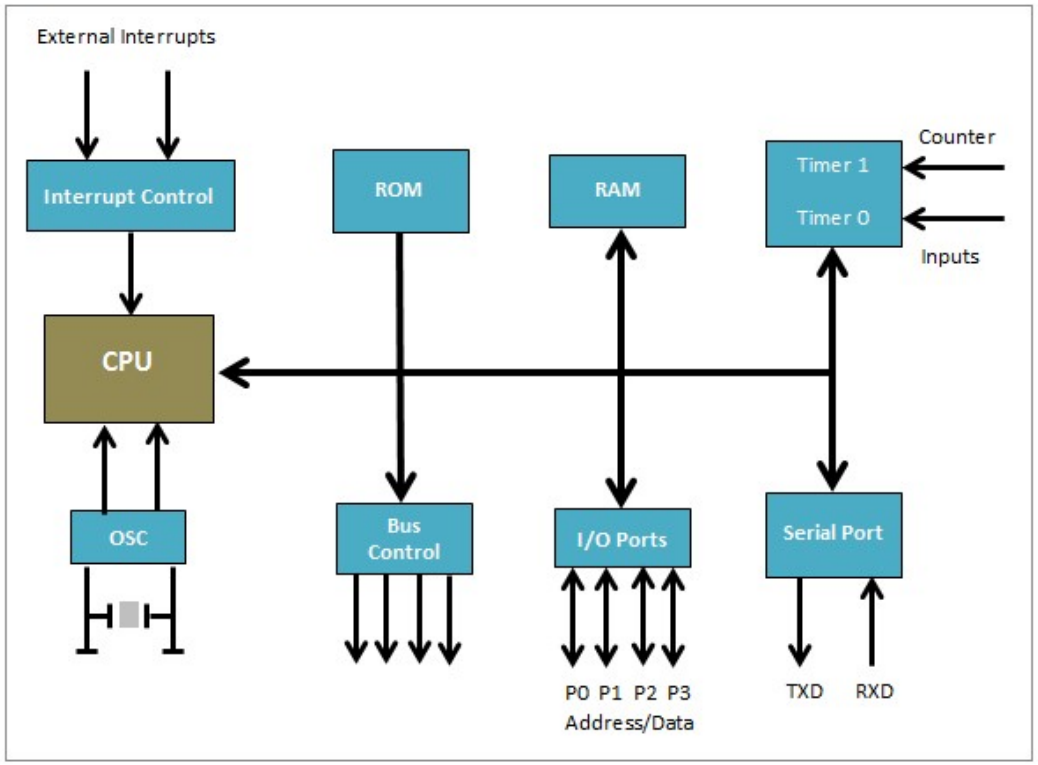
- 8 Bit microcontroller
- 256Kbytes of flash memory

What is a PLC?

Can be referred to as a high-level microcontroller



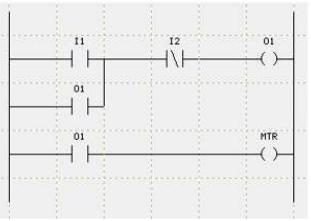
Typical System Architecture for a microcontroller



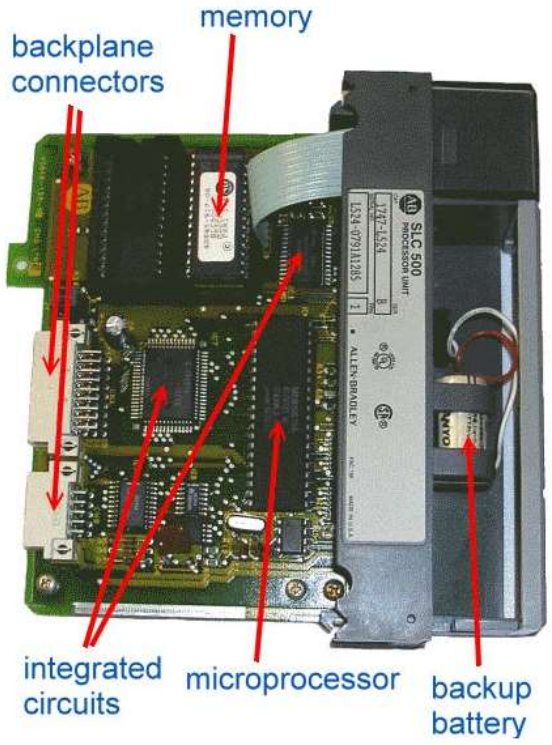
Source: CircuitDesign

What is a PLC?. . .

PLC typically uses a microprocessor for processing input/output (I/O)data



Allen Bradley SLC500 PLC CPU

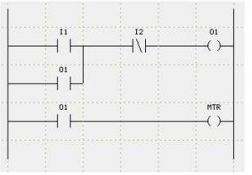


Source: CircuitDesign

Question 1

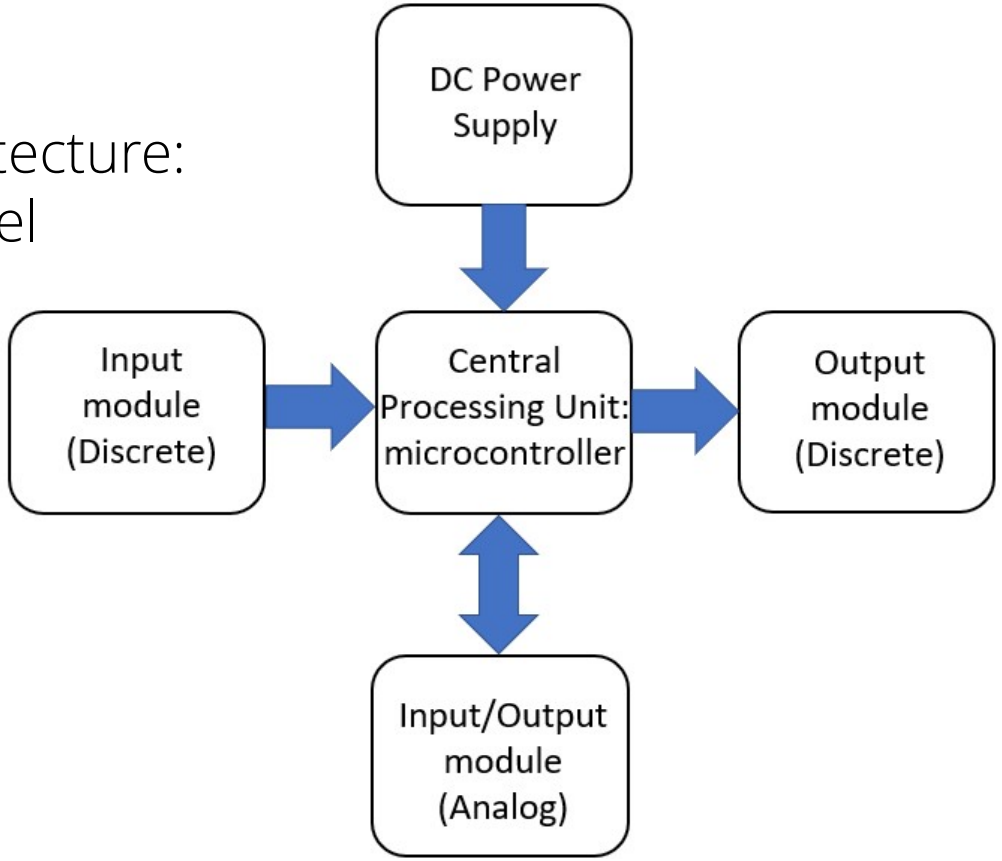
In reviewing slide 9, what subcircuit block is incorrect?

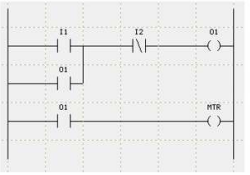
a) ROM
b) RAM
c) Interrupt Control
d) Parallel Port



PLC Architecture

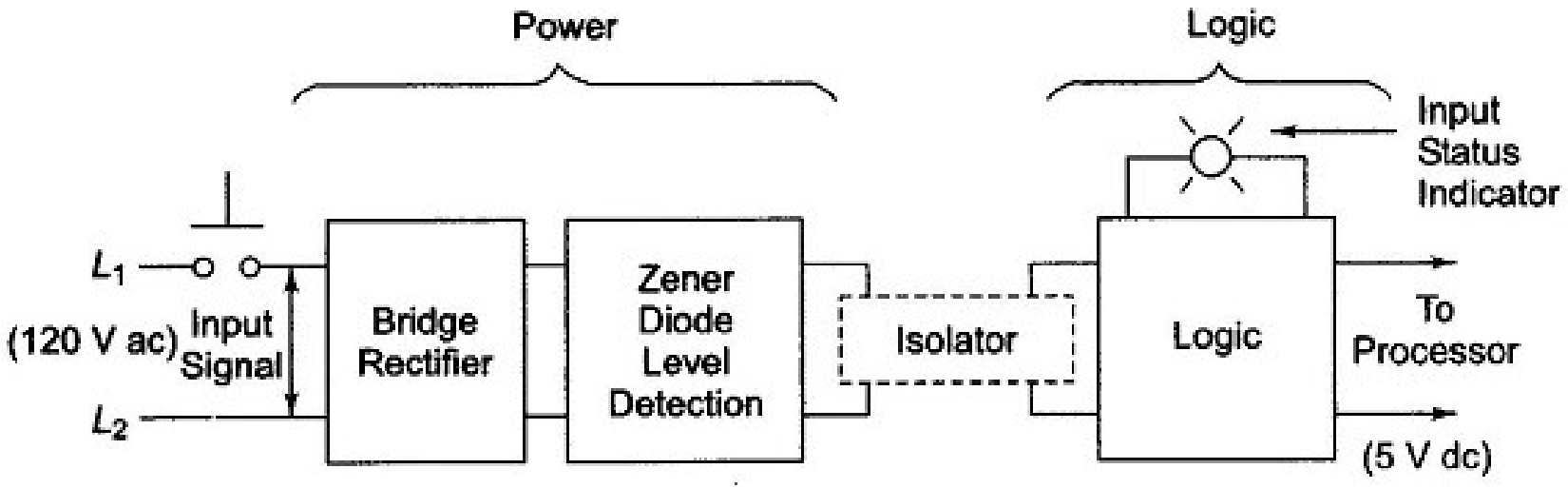
A typical PLC System Architecture:
High Abstraction Level



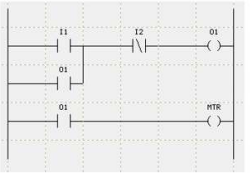


PLC Architecture. . .

AC Discrete Input Module: Block Diagram

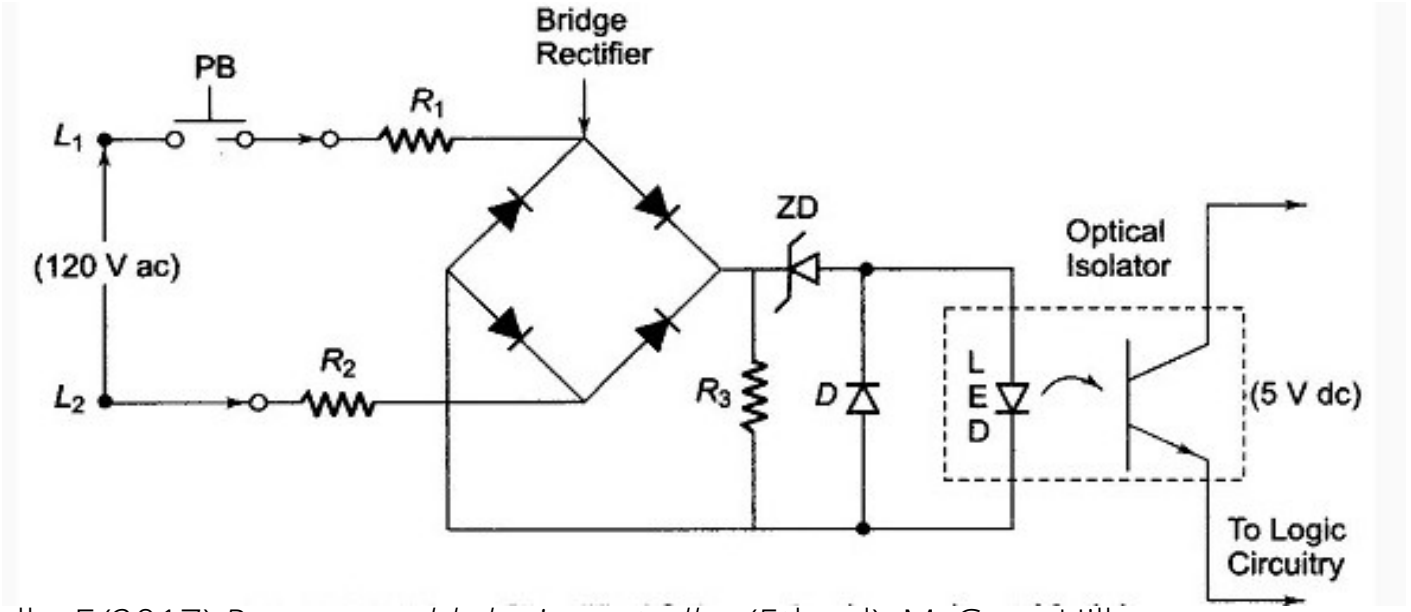


Source: Petruzella, F.(2017).*Programmable logic controllers*(5th ed). McGraw Hill.



PLC Architecture. . .

AC Discrete Input Module:
Electronic Circuit Schematic Diagram

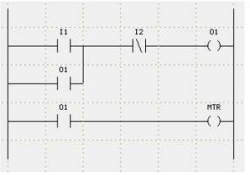


Source: Petruzella, F.(2017).*Programmable logic controllers*(5th ed). McGraw Hill.

Question 2

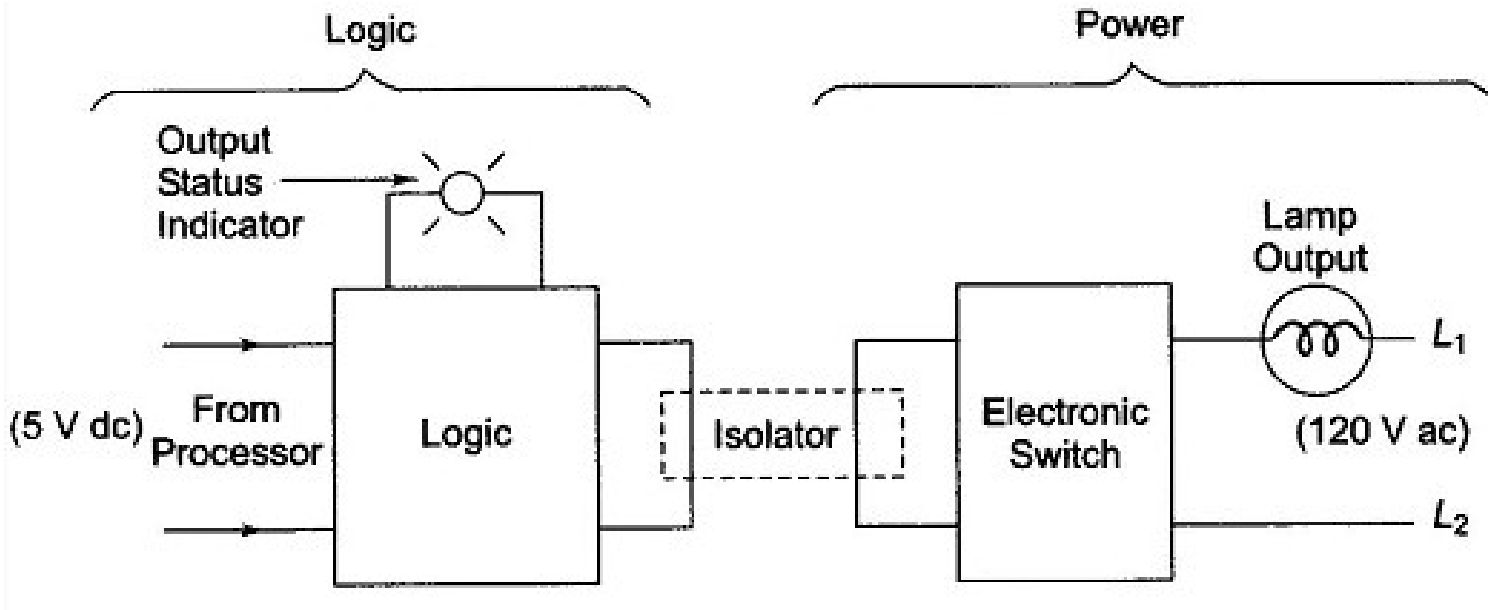
In reviewing the circuit schematic diagram on slide 14, which circuit is responsible for creating pulsating DC voltage?

a) optical isolator
b) R3
c) ZD
d) Bridge Rectifier



PLC Architecture. . .

AC Discrete Output Module: Block Diagram



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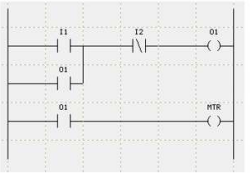
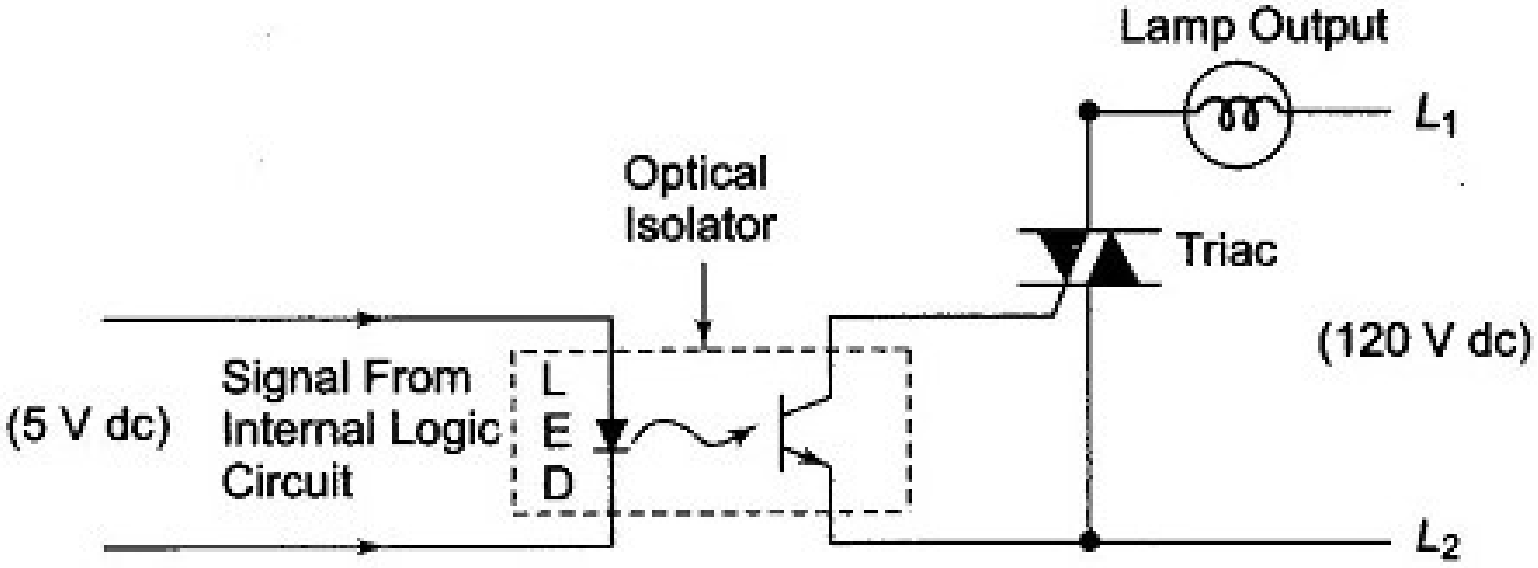


PLC Architecture. . .

AC Discrete Output Module:
Electronic Circuit Schematic Diagram



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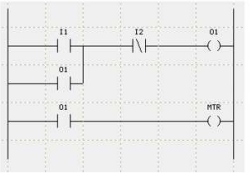
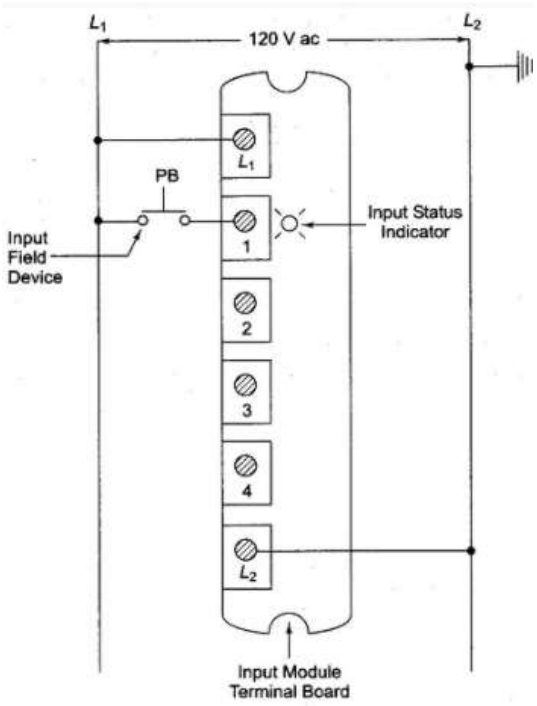
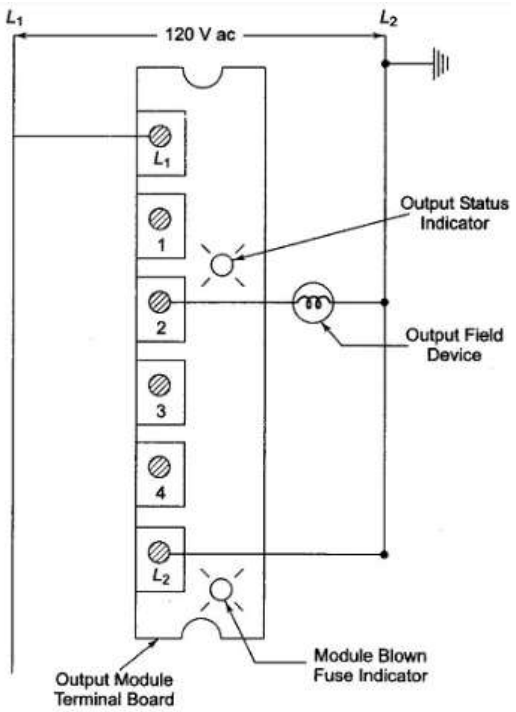
PLC Architecture. . .



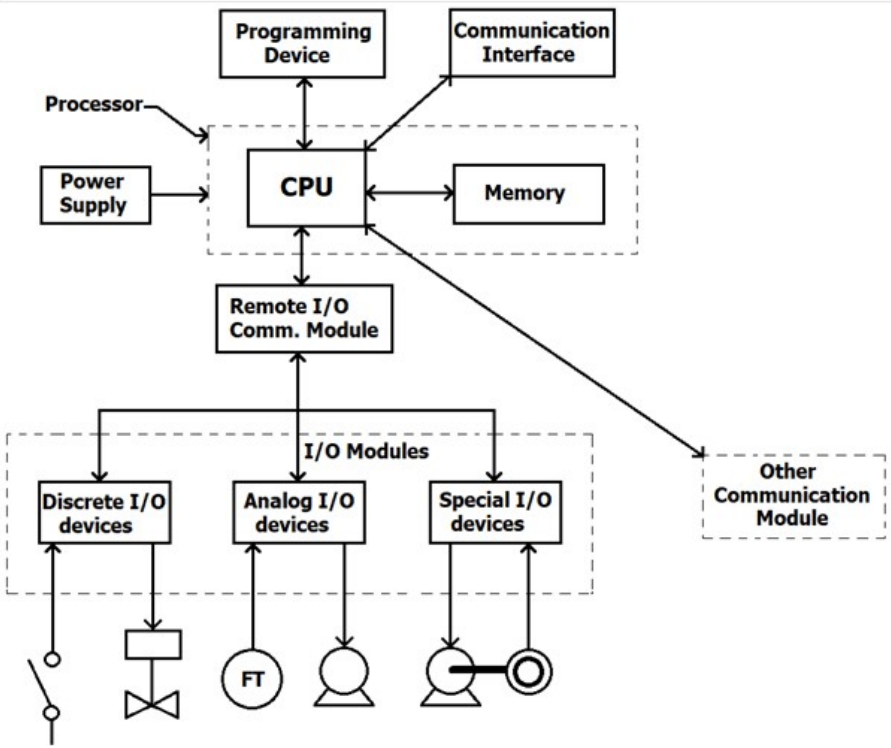
I/O Wiring Module Approaches





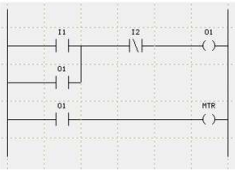
Source: Petruzella, F.(2017).*Programmable logic controllers*(5th ed). McGraw Hill.

A typical PLC System Architecture

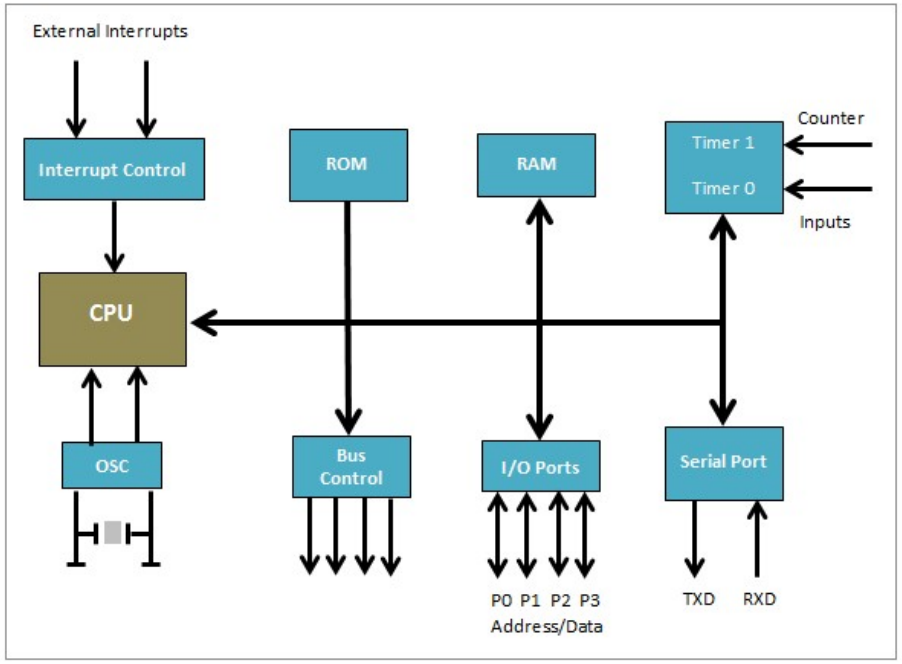


Source: CircuitDesign

PLC Architecture. . .



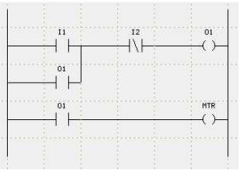
A typical microcontroller System Architecture



Question 3

In reviewing the typical PLC System Architecture block diagram on slide 19, which circuit block is responsible for entry of a ladder logic program?

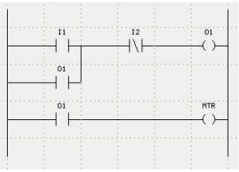
a) Communication Interface
b) Remote I/O Comm. Module
c) Other Communication Module
d) Programming Device



International Electrotechnical Commission (IEC) 61131-3: Programming Languages

- The IEC 61131-3 standard's focus is on basic software architecture and programming languages of the PLC's control program.
- The IEC 61131-3 defines:
  a) 3 graphical languages
  b) 2 textual programming language standards.
    i. Ladder Diagram (LD), graphical
    ii. Function block diagram (FBD), graphical
    iii. Sequential Function Chart (SFC), graphical
    iv. Structured text (ST), textual
    v. Instruction list (IL), textual

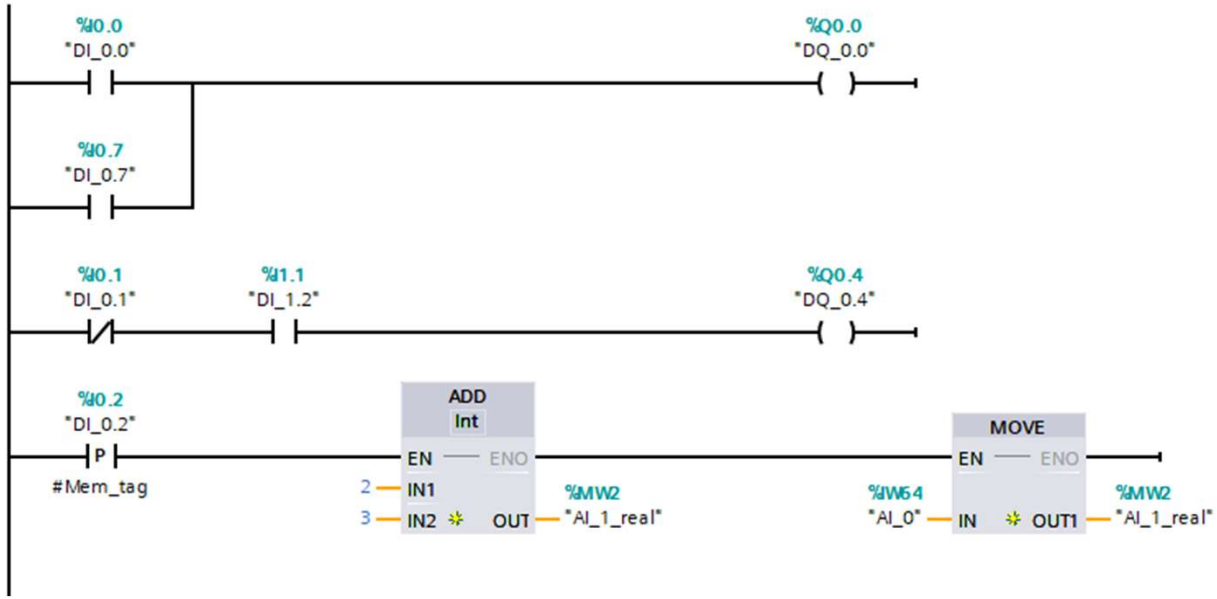
Source: CircuitDesign



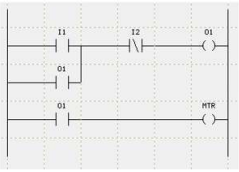
International Electrotechnical Commission (IEC) 61131-3: Programming Languages

Ladder Diagram (LD), graphical

- The most common language used in PLC programming.
- It was developed to mimic relay logic.
- Reason syntax is very simple.



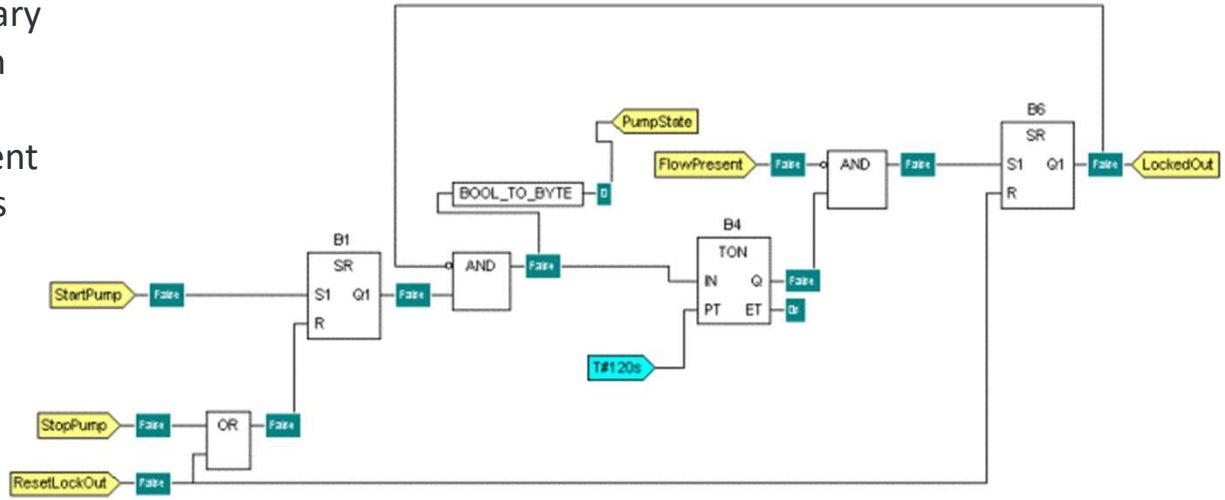
Source: isd



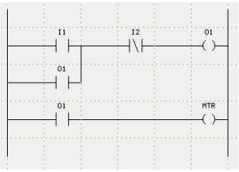
International Electrotechnical Commission (IEC) 61131-3: Programming Languages

Function Block Diagram (FBD), graphical

- A graphical programming language.
- Each function, even an elementary one, is described by a block with inputs and outputs.
- The logic is performed by different connection lines between inputs and outputs of the blocks.



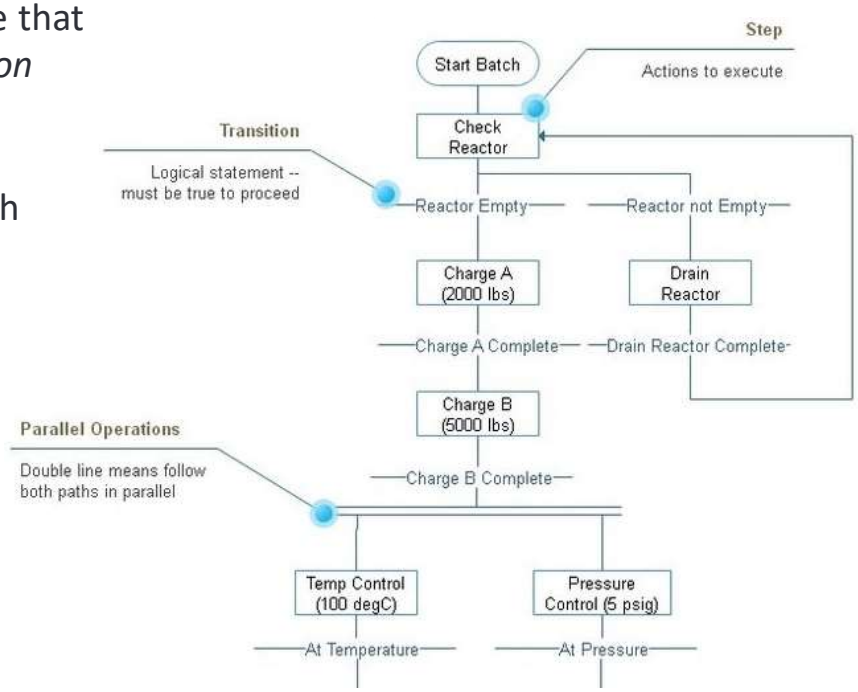
Source: isd



International Electrotechnical Commission (IEC) 61131-3: Programming Languages

Sequential Function Chart (SFC), graphical

- A graphical programming language that is defined as *Preparation of function charts for control systems*.
- Based on GRAFCET
- GRAFCET is a stage-transition graph



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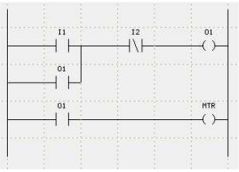
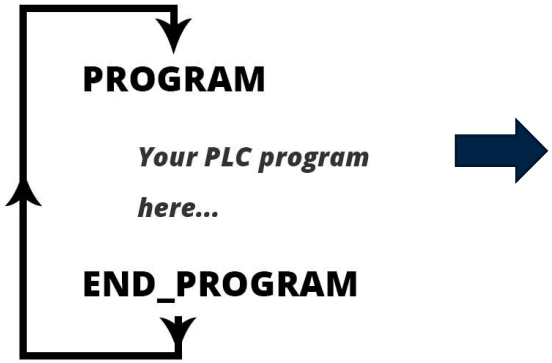


International Electrotechnical Commission (IEC) 61131-3: Programming Languages

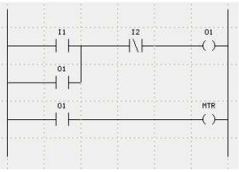
Structured Text (ST), textual

- Structured Text is PLC programming language defined by PLCOpen.
- The programming language is text-based, compared to the graphics-based ladder diagram or Function Block Diagram.




```
1  IF #start = 1 THEN
2      //comment
3      "Max_nr" := #Array[0];
4      FOR #i := 1 TO 10 DO
5          // Statement section FOR
6          IF #Array[#i] > "Max_nr" THEN
7              "Max_nr" := #Array[#i];
8          END_IF;
9      END_FOR;
10 END_IF;
11
```

Source: isd



International Electrotechnical Commission (IEC) 61131-3: Programming Languages

Instruction List (IL), textual

- A low-level language that resembles the assembly language.
- A program consists of a series of instructions, listed as in an assembly program.

Keywords			
TRUE	FALSE	LD	ST
AND	OR	XOR	ADD
SUB	MUL	DIV	LT
LE	EQ	NE	GE
GT	CAL	JMP	RET

```
    ld    true
    st    blinker.run
    ld    t#1s
    st    blinker.cycle
    cal   blinker

    ld    blinker.q
    st    trigger.clk
    cal   trigger

    ld    trigger.q
    jmpnc LBmodulo
    ld    counter
    add   1
    st    counter

LBmodulo:
    ld    counter
    lt    4
    jmpc  LBout
    ld    0
    st    counter

LBout:
    ld    counter
    eq    0
```

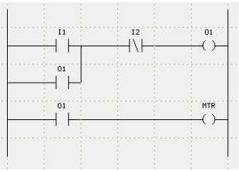
Source: isd

Question 4

Instruction List (IL) represents a textual program that does not resemble assembly language.

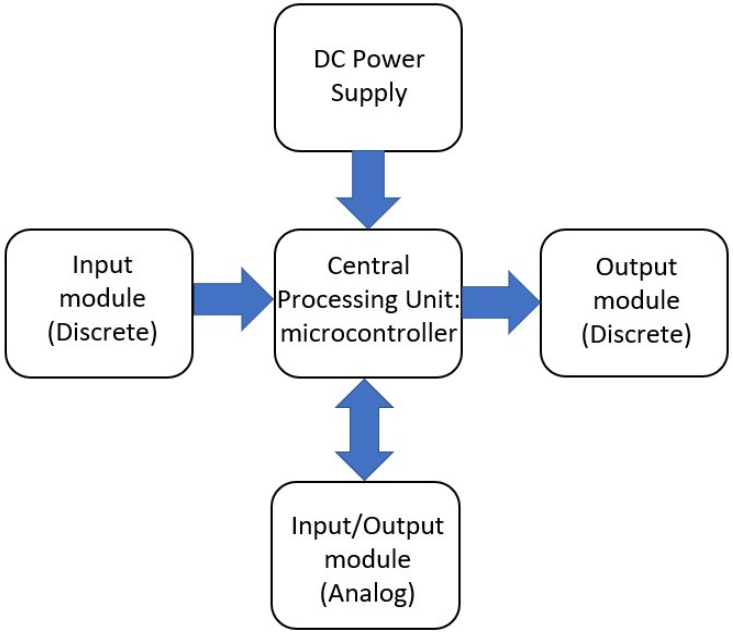
a) True

b) False

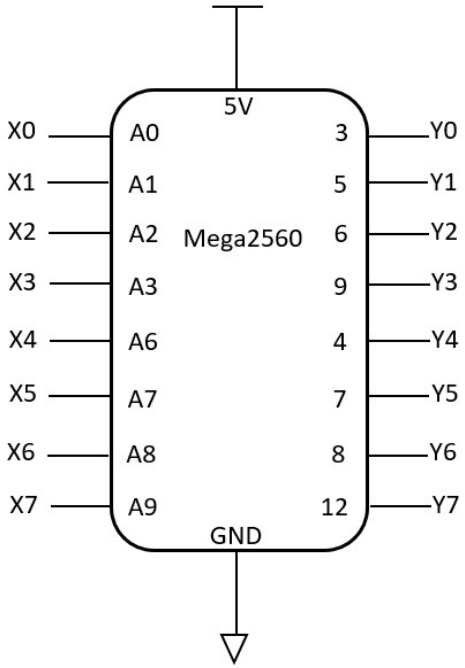


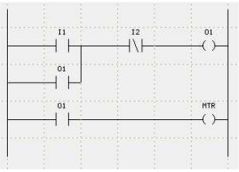
Lab Activities:
Building an Arduino PLC Controller - Concept

A typical PLC System Architecture:
High Abstraction Level



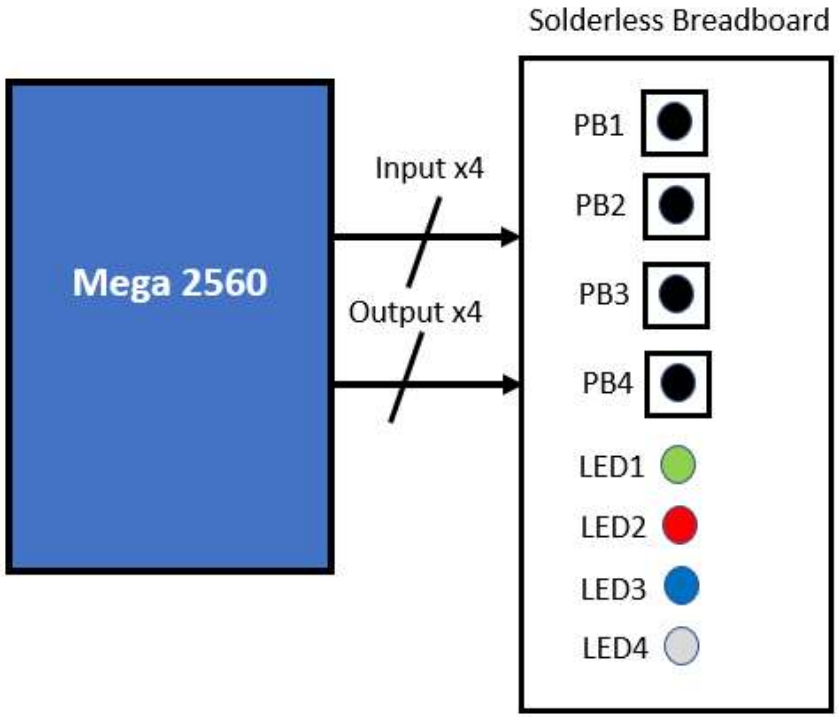
Arduino PLC Controller Low
Abstraction Level

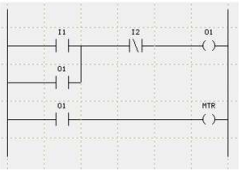




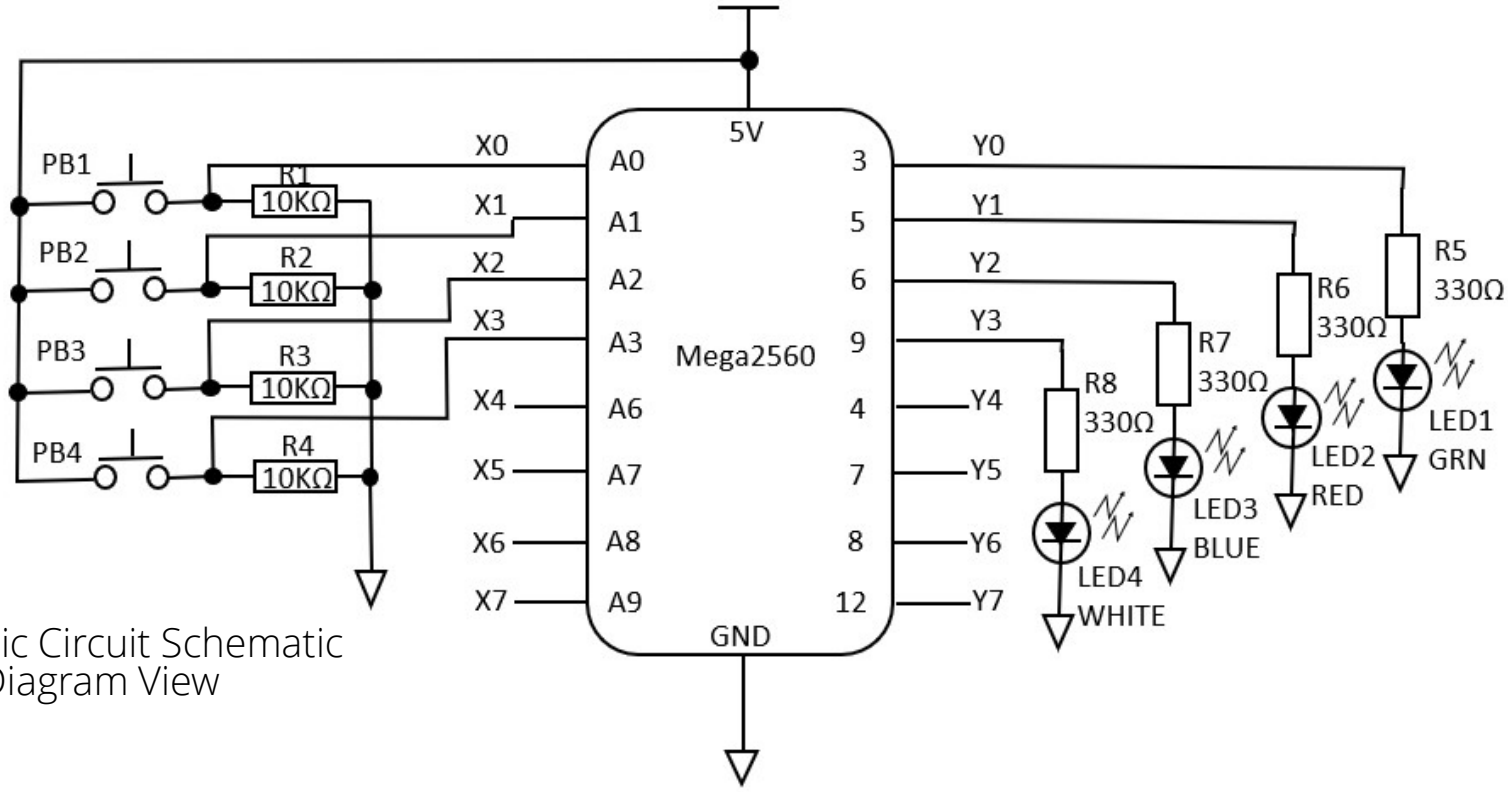
Lab Activities:
Building an Arduino PLC Controller - Concept

Functional Block Diagram View

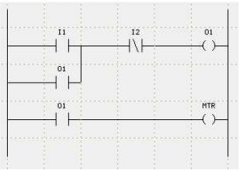




Lab Activities:
Building an Arduino PLC Controller - Concept

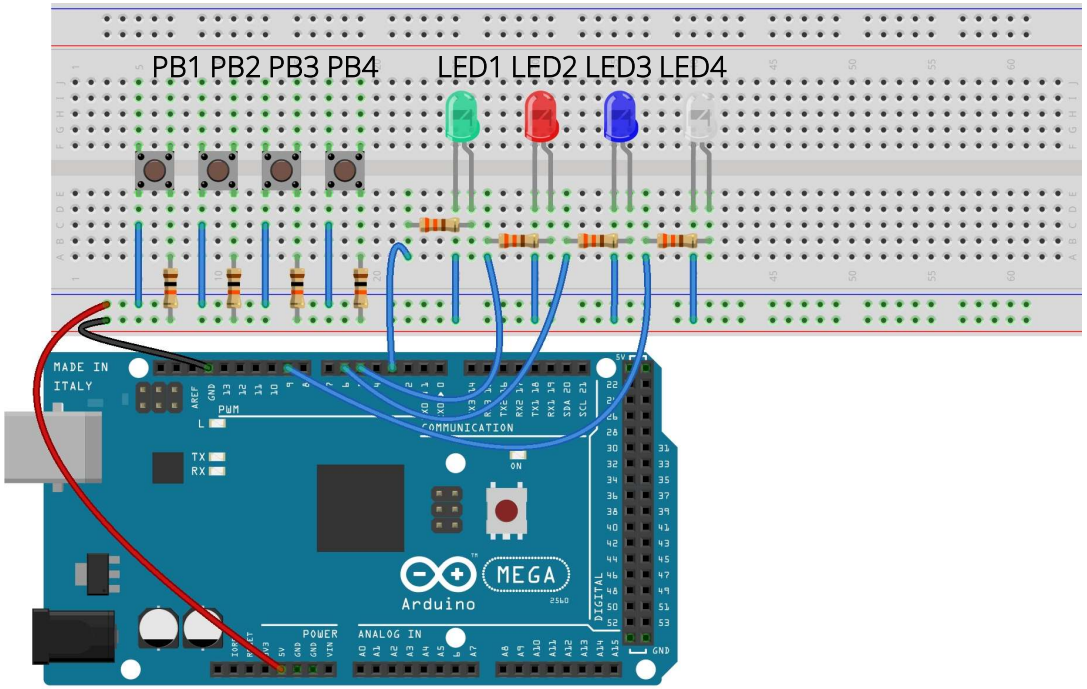


Electronic Circuit Schematic Diagram View



Lab Activities:
Building an Arduino PLC Controller - Concept

Breadboard Diagram View



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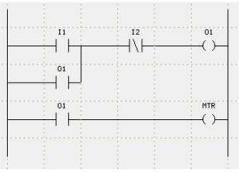
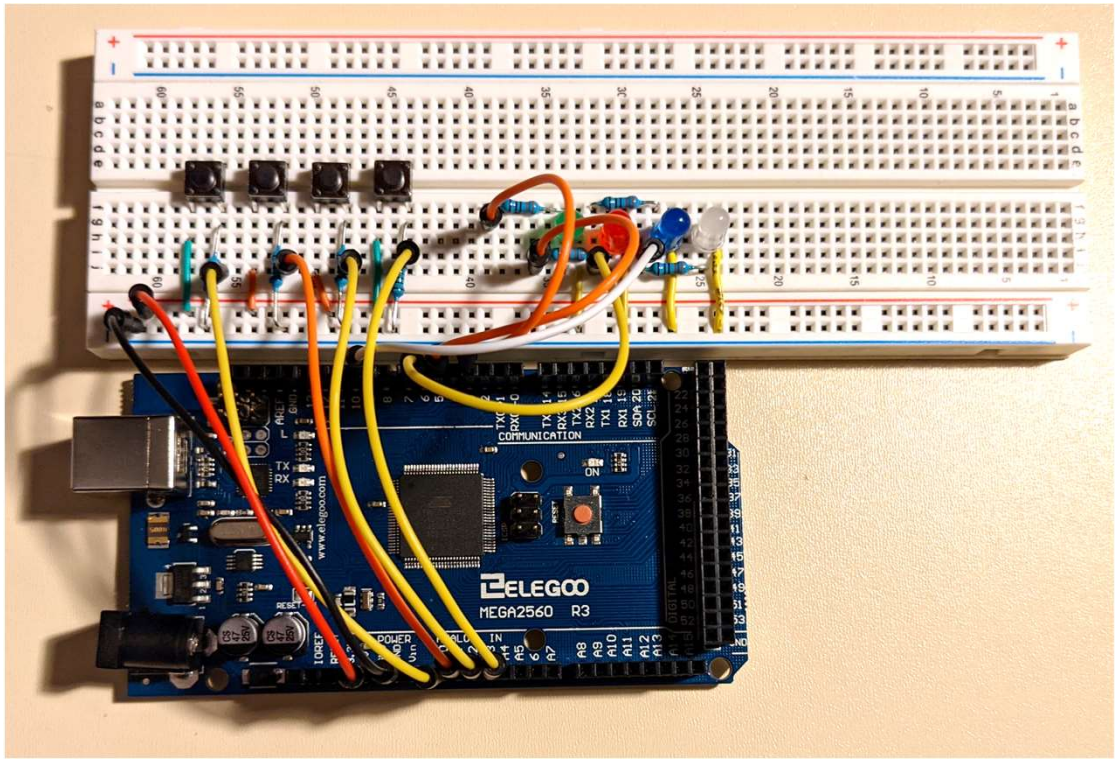
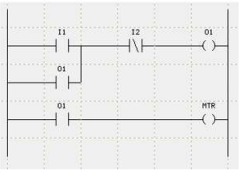


Lab Activities:
Building an Arduino PLC Controller - Concept

Actual Wired Breadboard View





Lab Activities:
Installing the plcLib library

plcLib github repository

wditch / plcLib

Code | Issues | Pull requests | Actions | Projects | Wiki | Security | Insights

master | 1 branch | 0 tags | Go to file | Code

wditch Merge pull request #9 from wditch/plcLib-Version-1.4-Update ... e180a05 on Oct 2, 2017 19 commits

examples	Version 1.4 Update	4 years ago
.gitattributes	Added .gitattributes & .gitignore files	6 years ago
.gitignore	Added .gitattributes & .gitignore files	6 years ago
PlcLib Arduino User Guide Version 1.4...	Version 1.4 Update	4 years ago
README.md	Version 1-3 Update	5 years ago
keywords.txt	Version 1-3 Update	5 years ago
library.properties	Version 1.4 Update	4 years ago
plcLib.cpp	Version 1.4 Update	4 years ago
plcLib.h	Version 1.4 Update	4 years ago
plcLib.zip	Version 1.4 Update	4 years ago

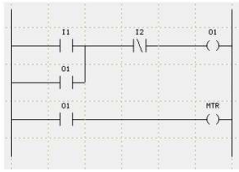
README.md

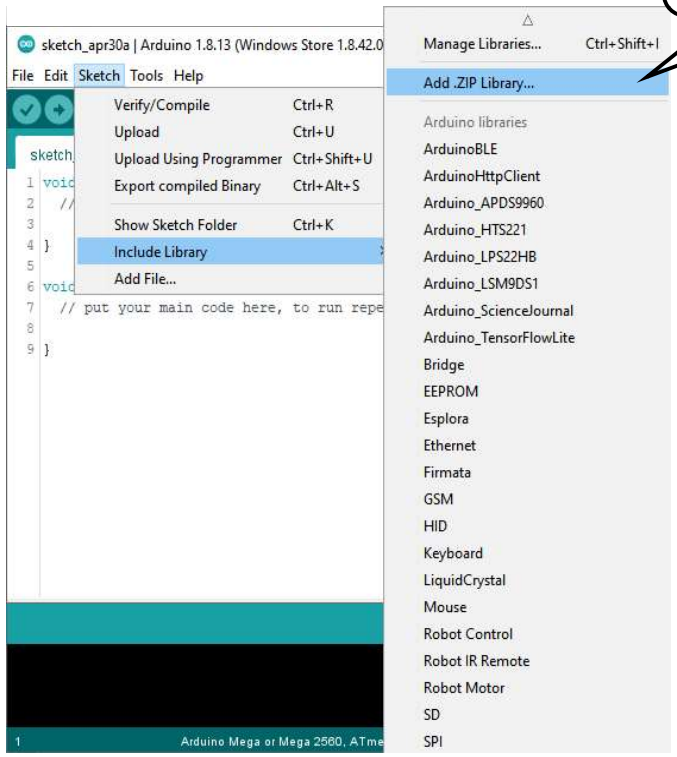
plcLib

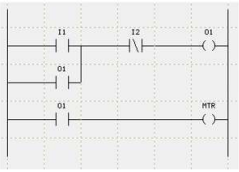
A simple C/C++ code library to allow PLC-style programming of Arduino-based systems and compatibles.

Source: https://github.com/wditch/plcLib

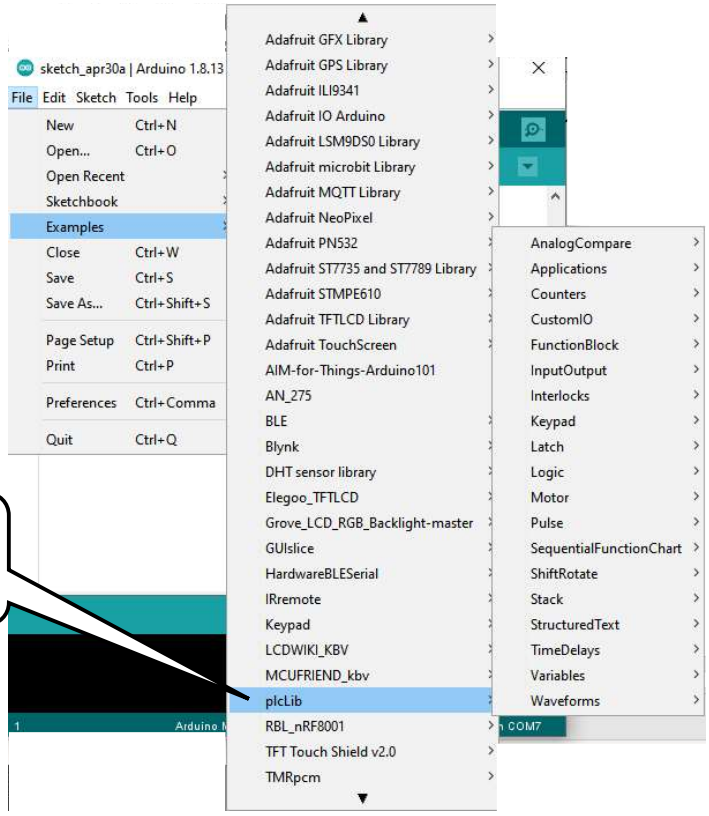
Lab Activities:
Installing the plcLib library

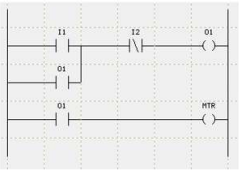






Lab Activities:
Installing the plcLib library

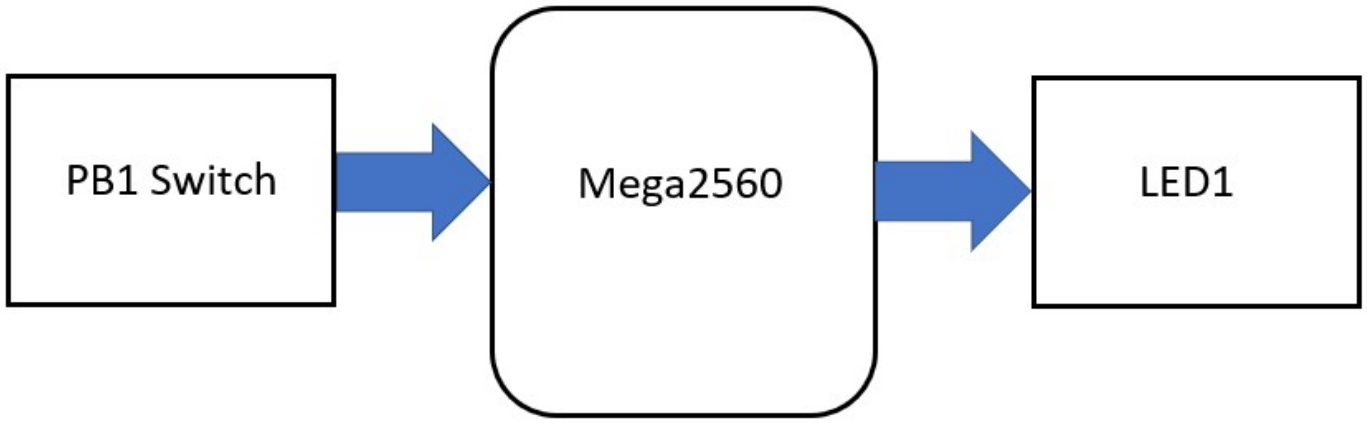


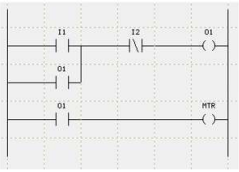


Lab Activities:
Bare Minimum plcLib PLC program: Hello World

Learning Objective:
After completing this lab exercise, you will learn how to program the Mega2560 to perform a basic PLC control operation of turning on a LED.

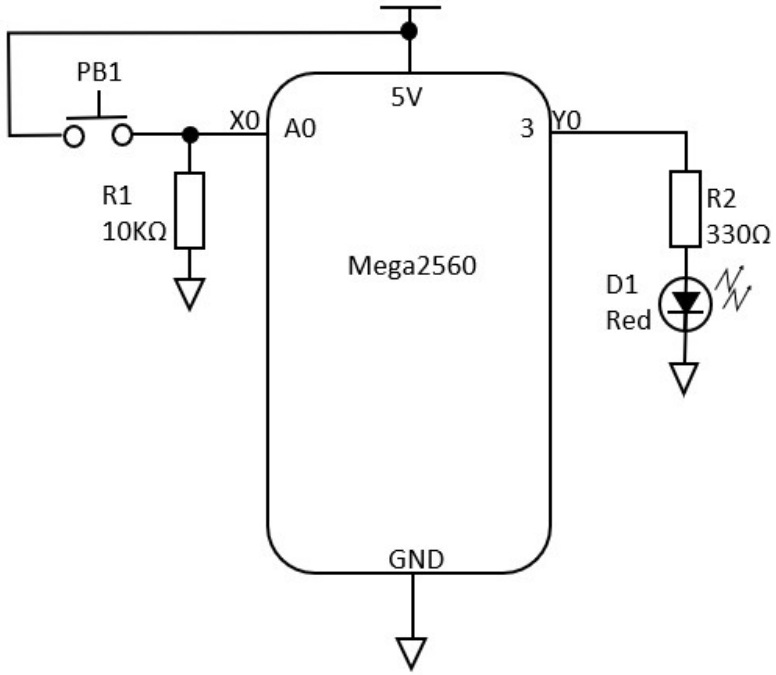
Basic PLC Control Operation Concept

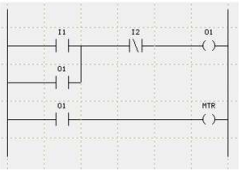




Lab Activities:
Bare Minimum plcLib PLC program: Hello World

Electronic Circuit Schematic Diagram



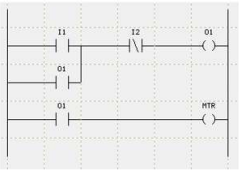


Lab Activities:
Bare Minimum plcLib PLC program: Hello World

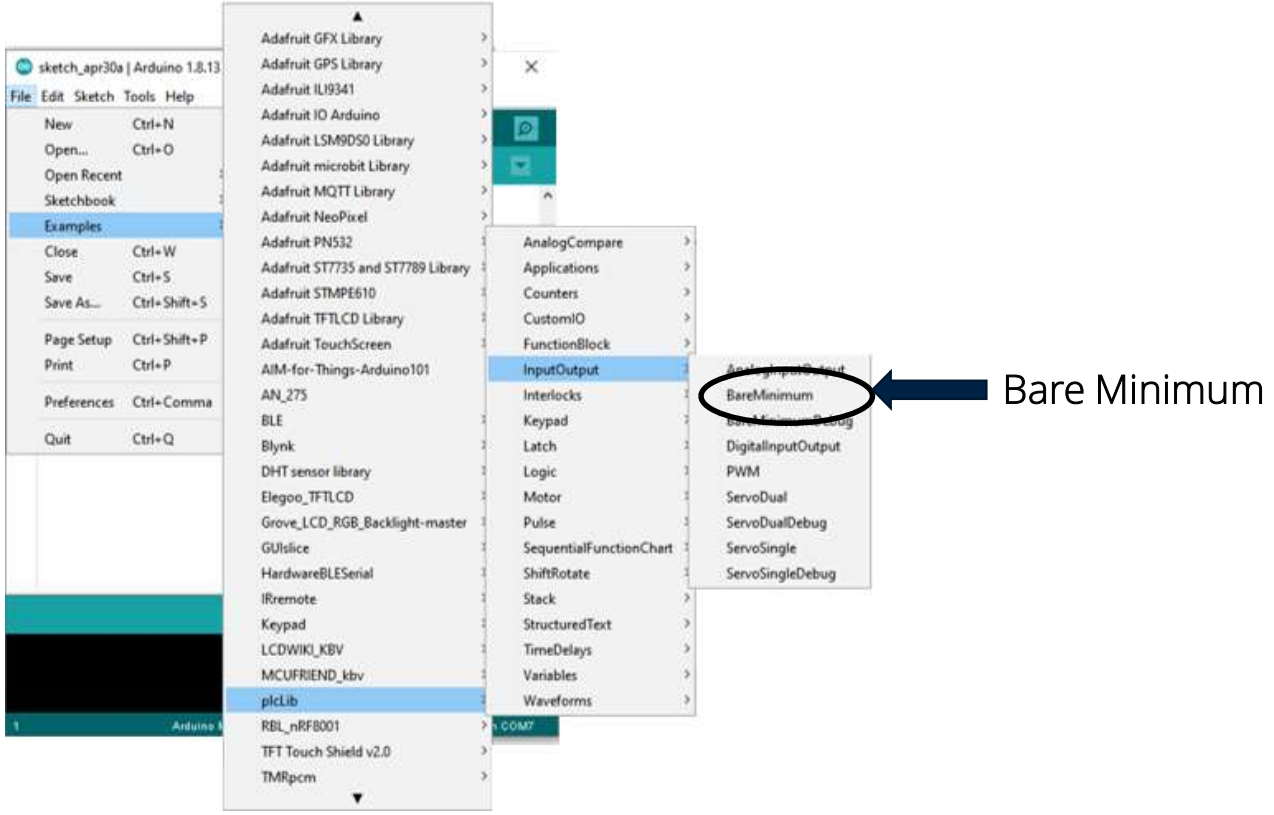
PLC Ladder Logic Program

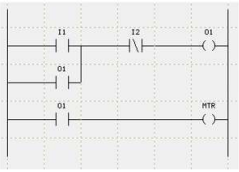
PB1 = X0

LED1 = Y0



Lab Activities:
Bare Minimum plcLib PLC program: Hello World

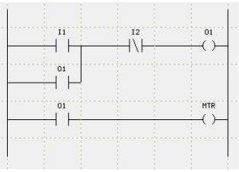




Lab Activities:
Bare Minimum plcLib PLC program: Hello World

Code

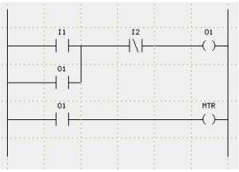
```
#include <plcLib.h>

void setup() {
  setupPLC();  // Setup inputs and outputs
}

void loop() {
  in(X0);      // Read Input 0
  out(Y0);     // Send to Output 0
}
```



Lab Activities:
Bare Minimum plcLib PLC program: Hello World

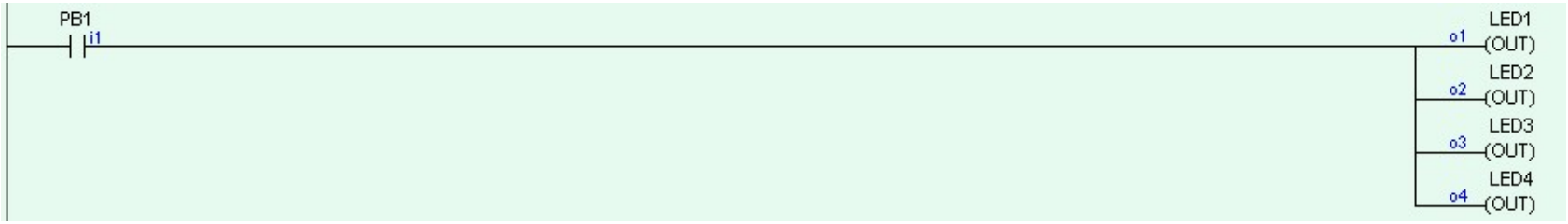
Code for operating all LEDs

```
#include <plcLib.h>

void setup() {
  setupPLC();  // Setup inputs and outputs
}

void loop() {
  in(X0);      // Read Input 0
  out(Y0);     // Send to Output 0
  out(Y1);     //  Send to Output 1
  out(Y2);     //   Send to Output 2
  out(Y3);     //    Send to Output 3
}
```



Lab Activities:
Bare Minimum plcLib PLC program: Hello World

PLC Ladder Logic Program for operating all LEDs



Question 5

In reviewing the ladder logic program on slide 42, LED1 is represented by what plcLib coding designator?

a) X0
b) Y1
c) Y0
d) Y2

Thank you for attending

Please consider the resources below:

- Circuit Design https://circuitdigest.com/article/microcontroller-vs-plc-detailed-comparison-and-difference-between-plc-and-microcontroller#:~:text=PLCs%20generally%20can%20be%20referred,unit%20(CPU)%20and%20memory.
- Petruzella, F.(2017).*Programmable logic controllers*(5th ed). McGraw Hill.
- isd https://isd-soft.com/tech_blog/plc-programming-languages-short-overview/
- plcLib Library https://github.com/wditch/plcLib

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