



DesignNews

PLC-HMI Automation Applications

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

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Don Wilcher

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

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**

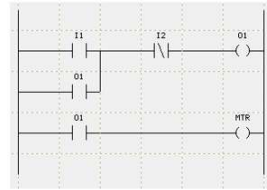


**TWTADE SSR-40 DD 40A DC
3-32V to DC 5-60V SSR Solid
State Relay + Heat Sink**



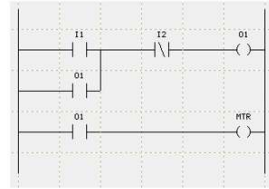
Agenda:

- 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



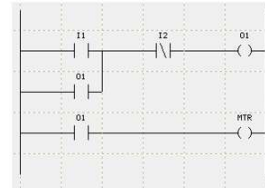
Source: [CircuitDesign](#)

What is a PLC?

Can be referred to as a high-level microcontroller

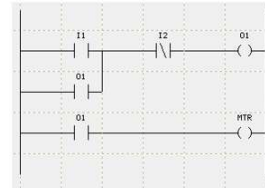
ATMEGA 2560:

- 8 Bit microcontroller
- 256Kbytes of flash memory

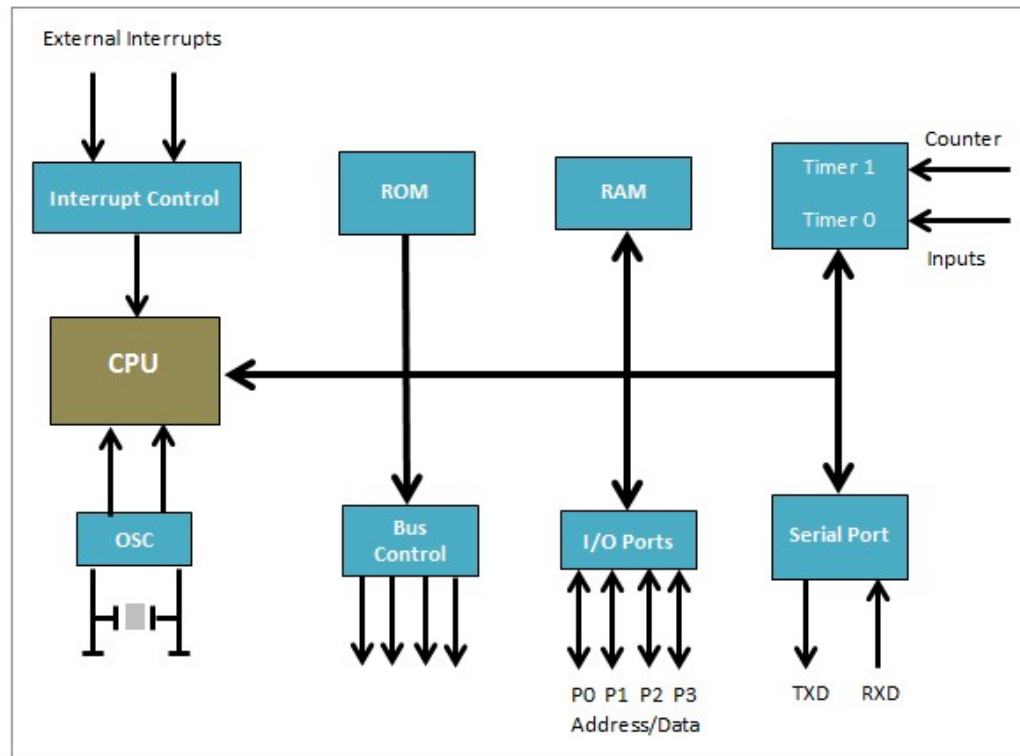


What is a PLC?

Can be referred to as a high-level microcontroller



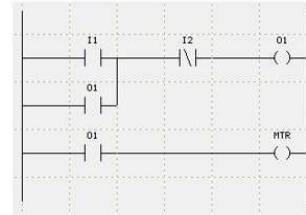
Typical System Architecture
for a microcontroller



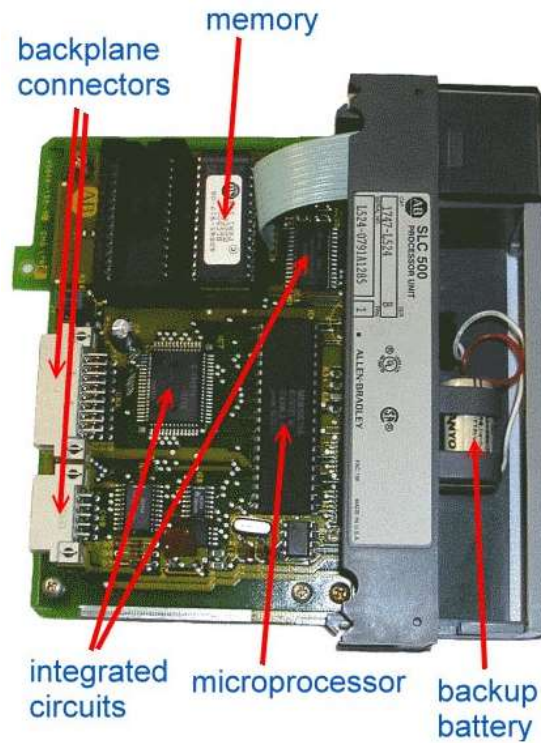
Source: [CircuitDesign](#)

What is a PLC?...

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



Allen Bradley SLC500 PLC CPU



Source: [CircuitDesign](#)

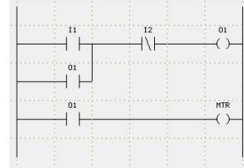


Question 1

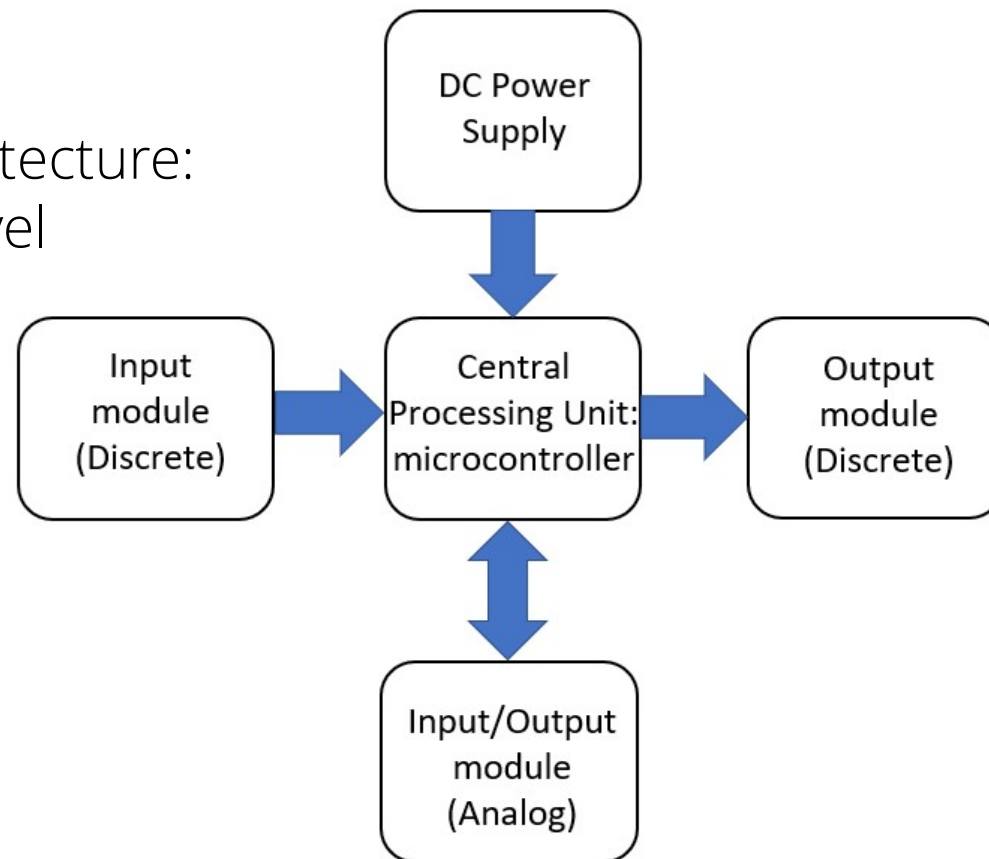
In reviewing slide 9, what subcircuit block is incorrect?

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

PLC Architecture

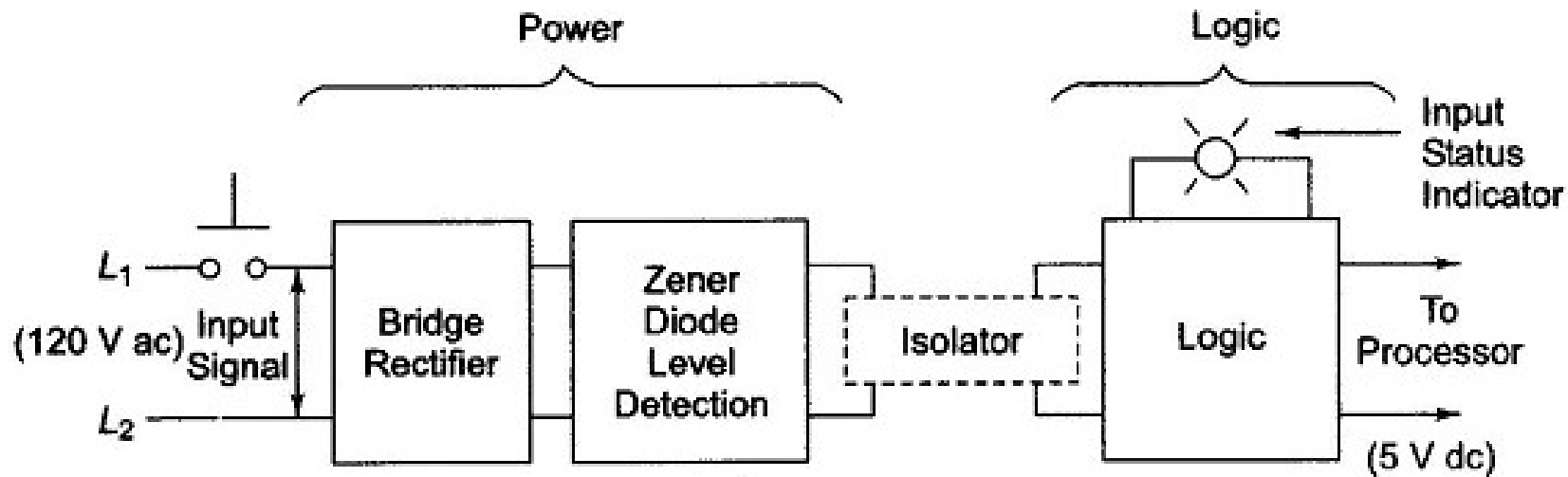
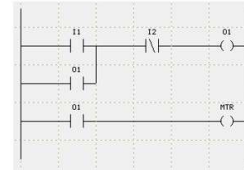


A typical PLC System Architecture:
High Abstraction Level



PLC Architecture . . .

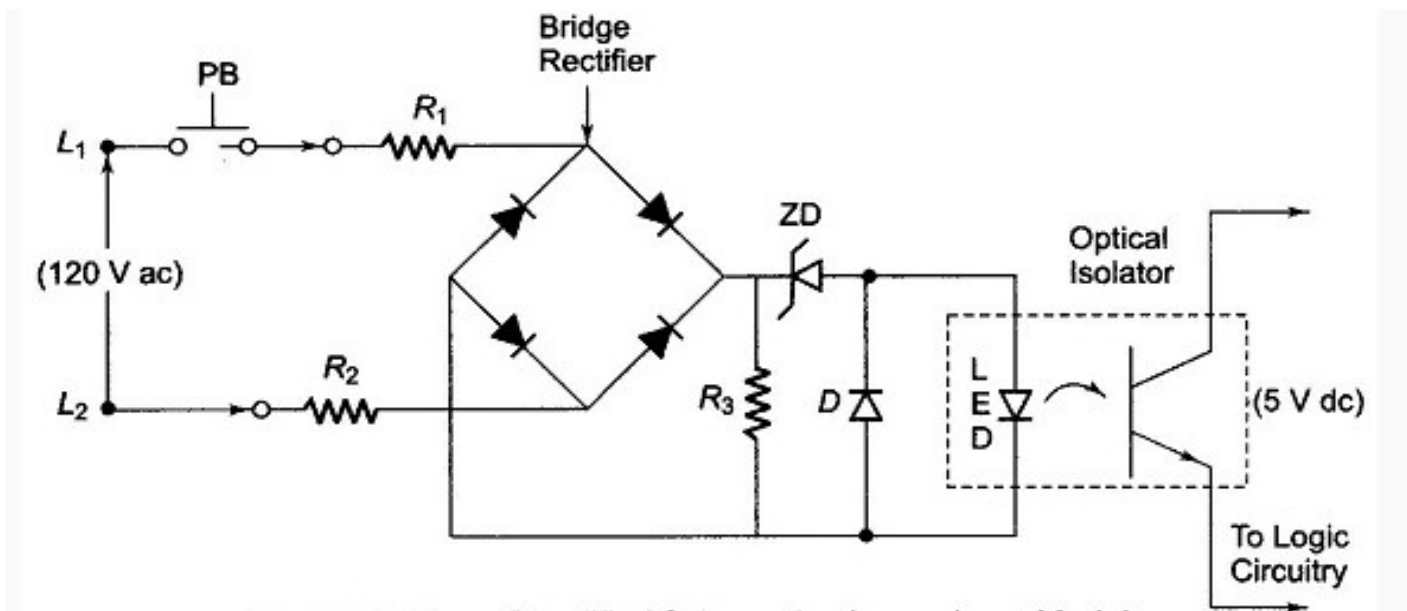
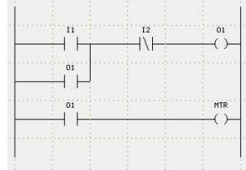
AC Discrete Input Module: Block Diagram



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.



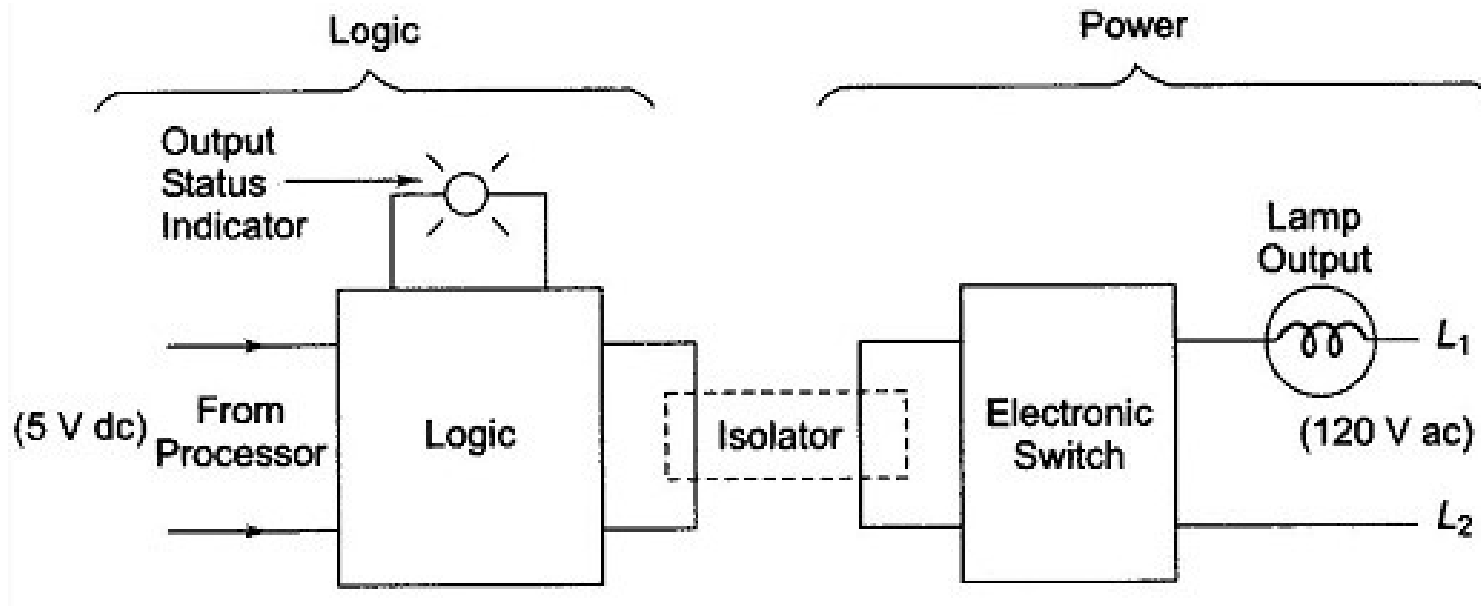
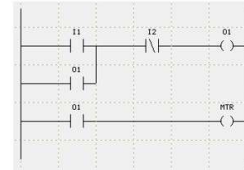
Question 2

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 . . .

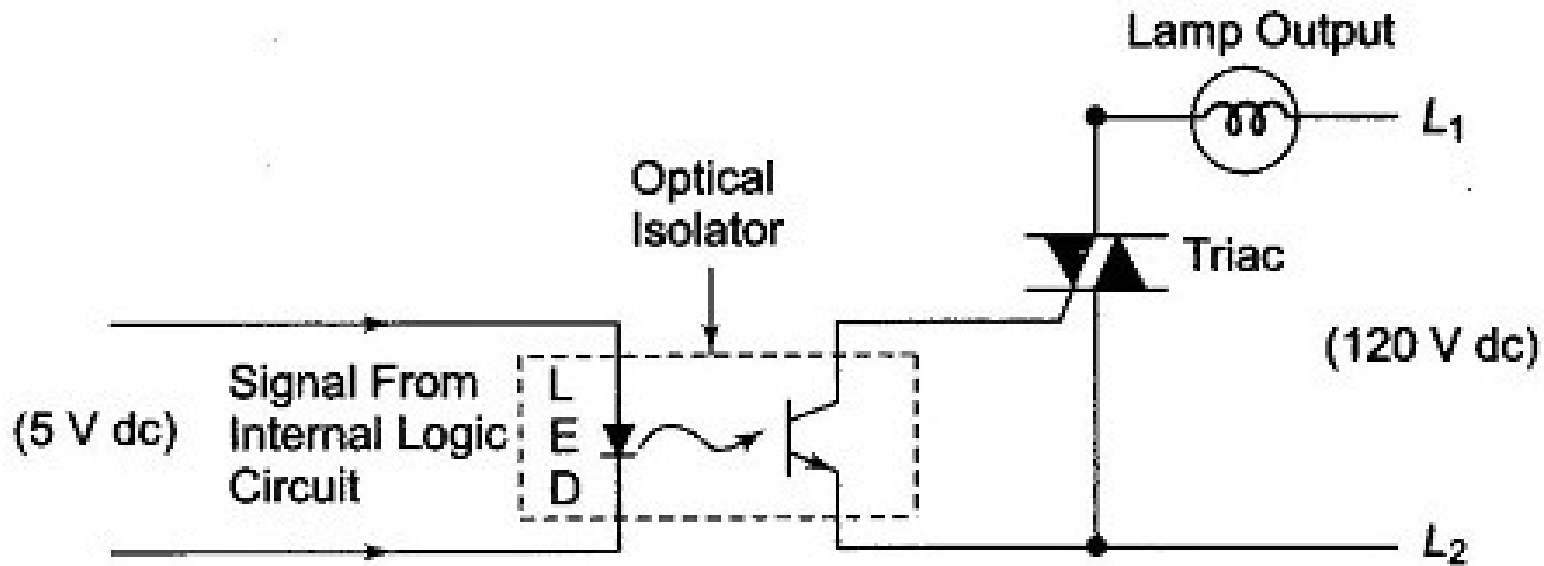
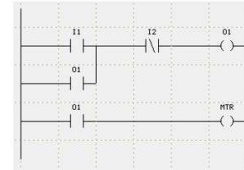
AC Discrete Output Module: Block Diagram



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

PLC Architecture. . .

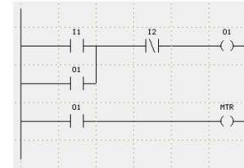
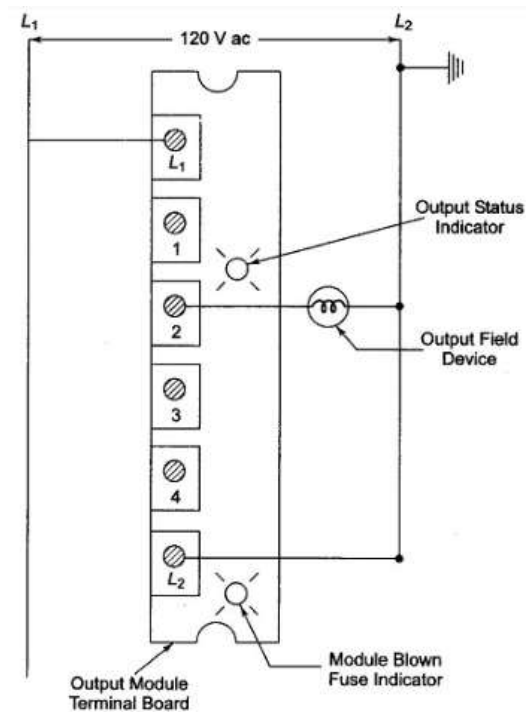
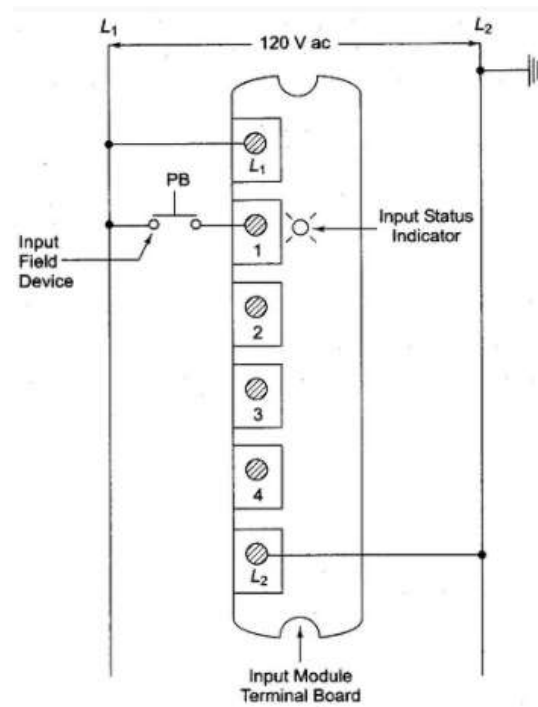
AC Discrete Output Module: Electronic Circuit Schematic Diagram



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

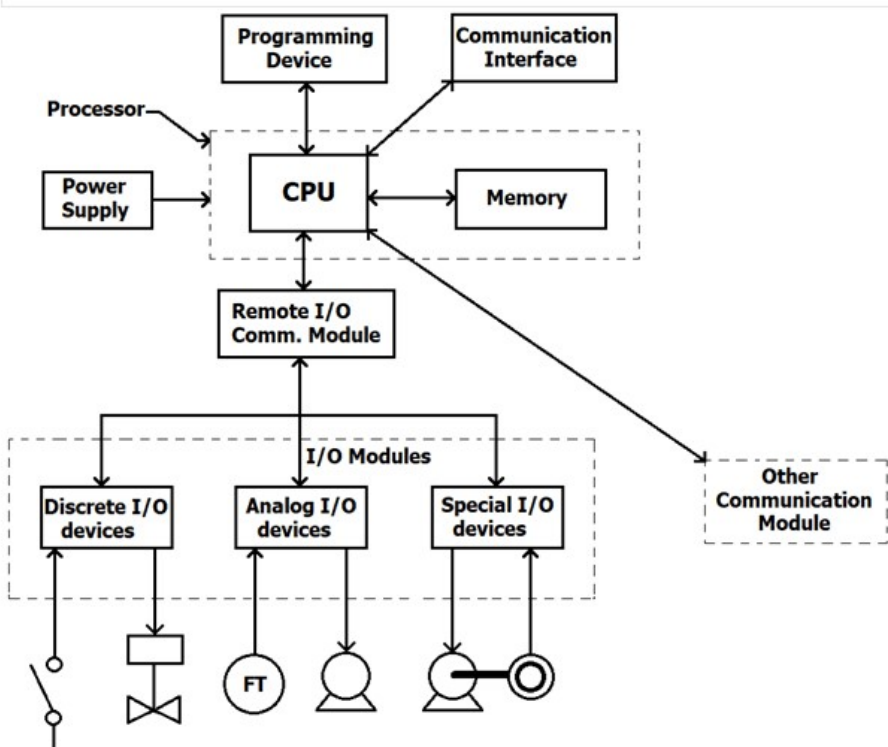
PLC Architecture . . .

I/O Wiring Module Approaches



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

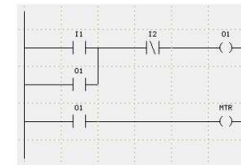
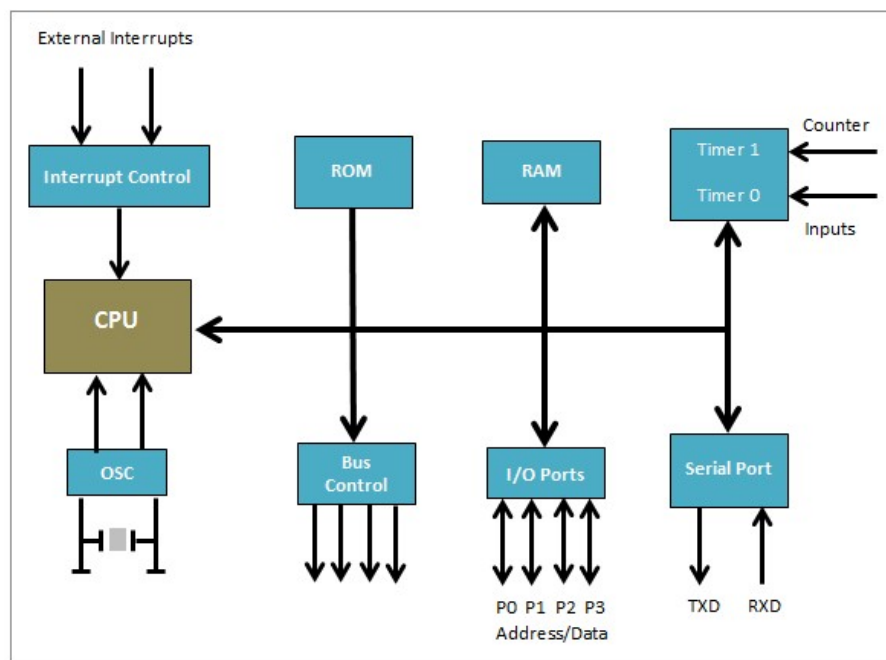
A typical PLC System Architecture



Source: [CircuitDesign](#)

PLC Architecture...

A typical microcontroller System Architecture



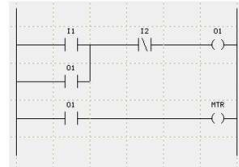


Question 3

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

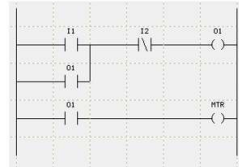
- a) Communication Interface**
- b) Remote I/O Comm. Module**
- c) Other Communication Module**
- d) Programming Device**

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



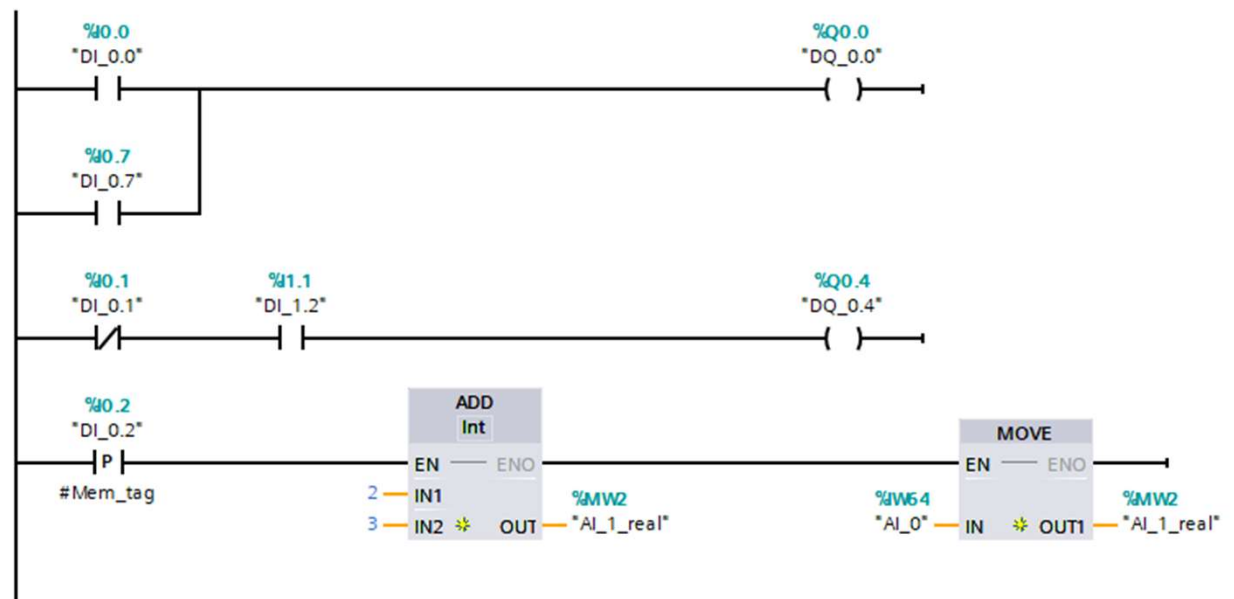
- The IEC 61131-3 standard's focus is on basic software architecture and programming languages of the PLC's control program.
- The IEC 61131-3 defines:
 - a) 3 graphical languages
 - b) 2 textual programming language standards.
 - i. Ladder Diagram (LD), graphical
 - ii. Function block diagram (FBD),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

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



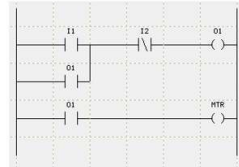
Ladder Diagram (LD), graphical

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



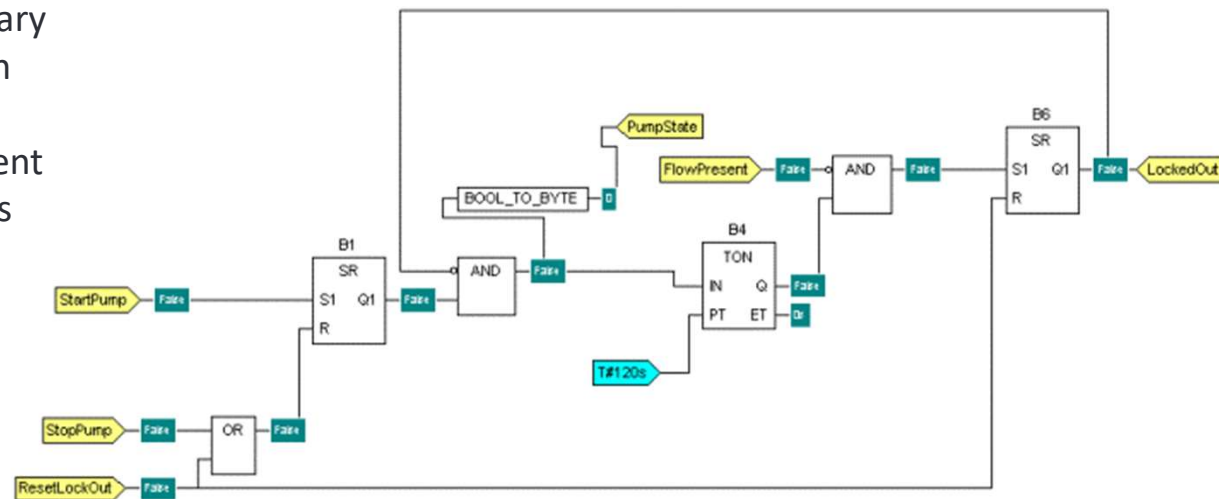
Source: [isd](#)

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.

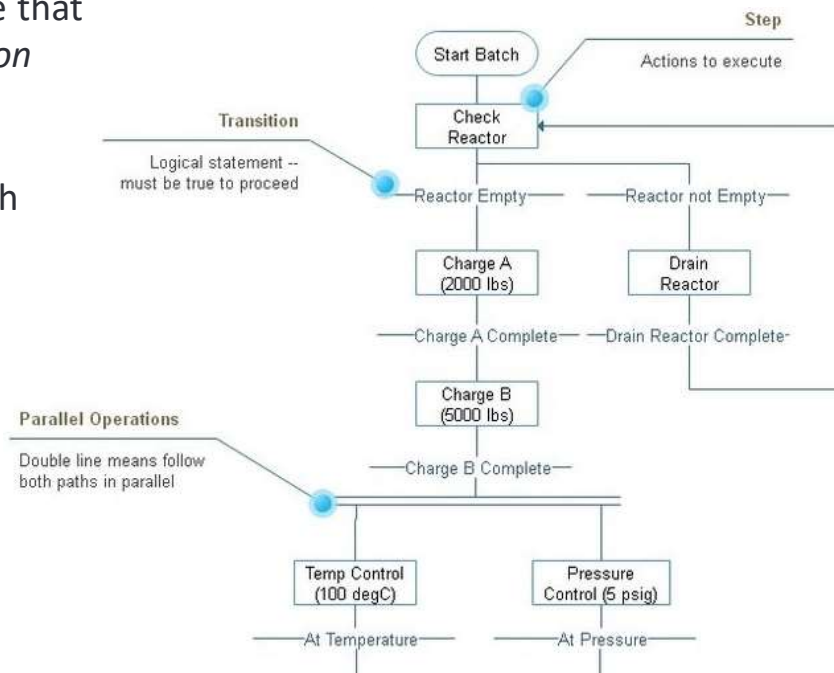


Source: [isd](#)

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

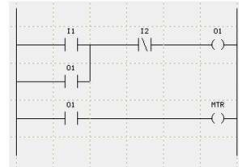
Sequential Function Chart (SFC), graphical

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



Source: [isd](#)

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



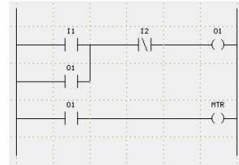
Structured Text (ST), textual

- 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
```

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.

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 LModule
ld counter
add 1
st counter
```

```
LModule:
ld counter
lt 4
jmpc LBout
ld 0
st counter
```

```
LBout:
ld counter
eq 0
```

Source: [isd](#)



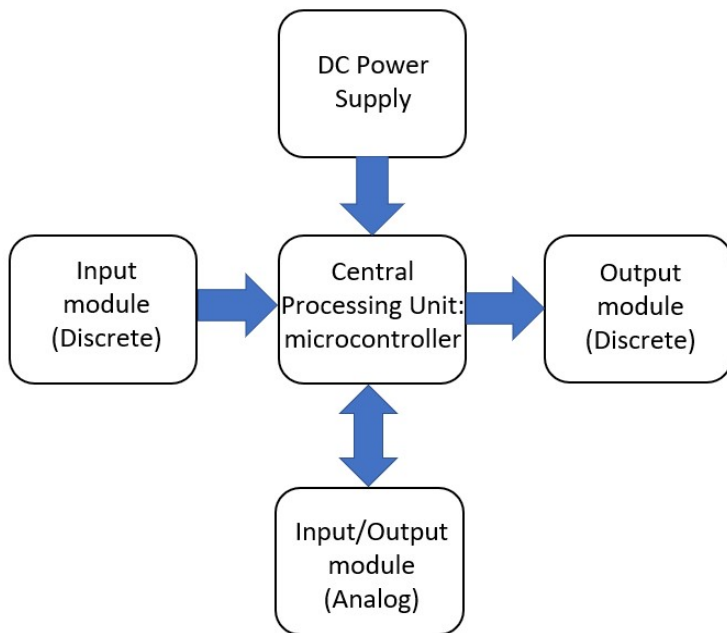
Question 4

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

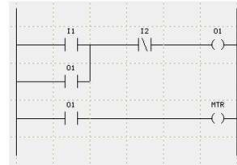
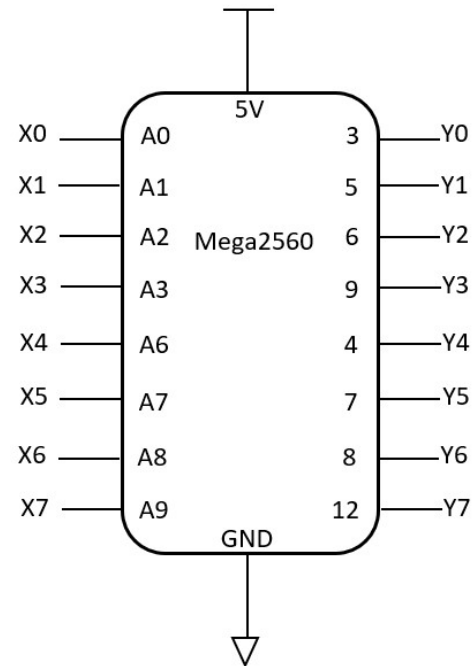
- a) True**
- b) False**

Lab Activities: Building an Arduino PLC Controller - Concept

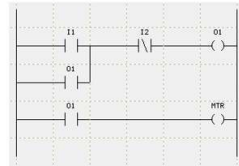
A typical PLC System Architecture:
High Abstraction Level



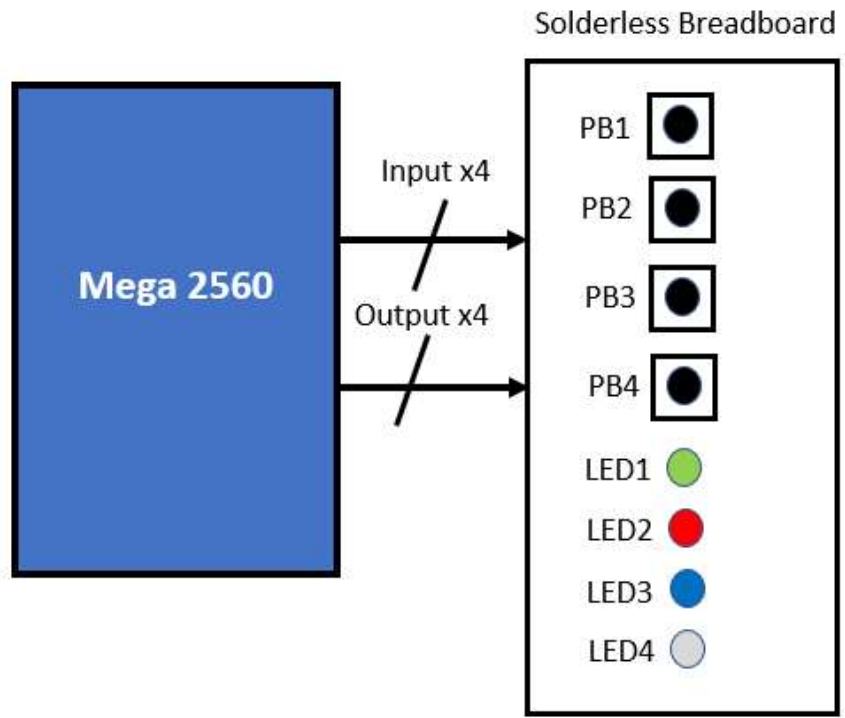
Arduino PLC Controller Low Abstraction Level



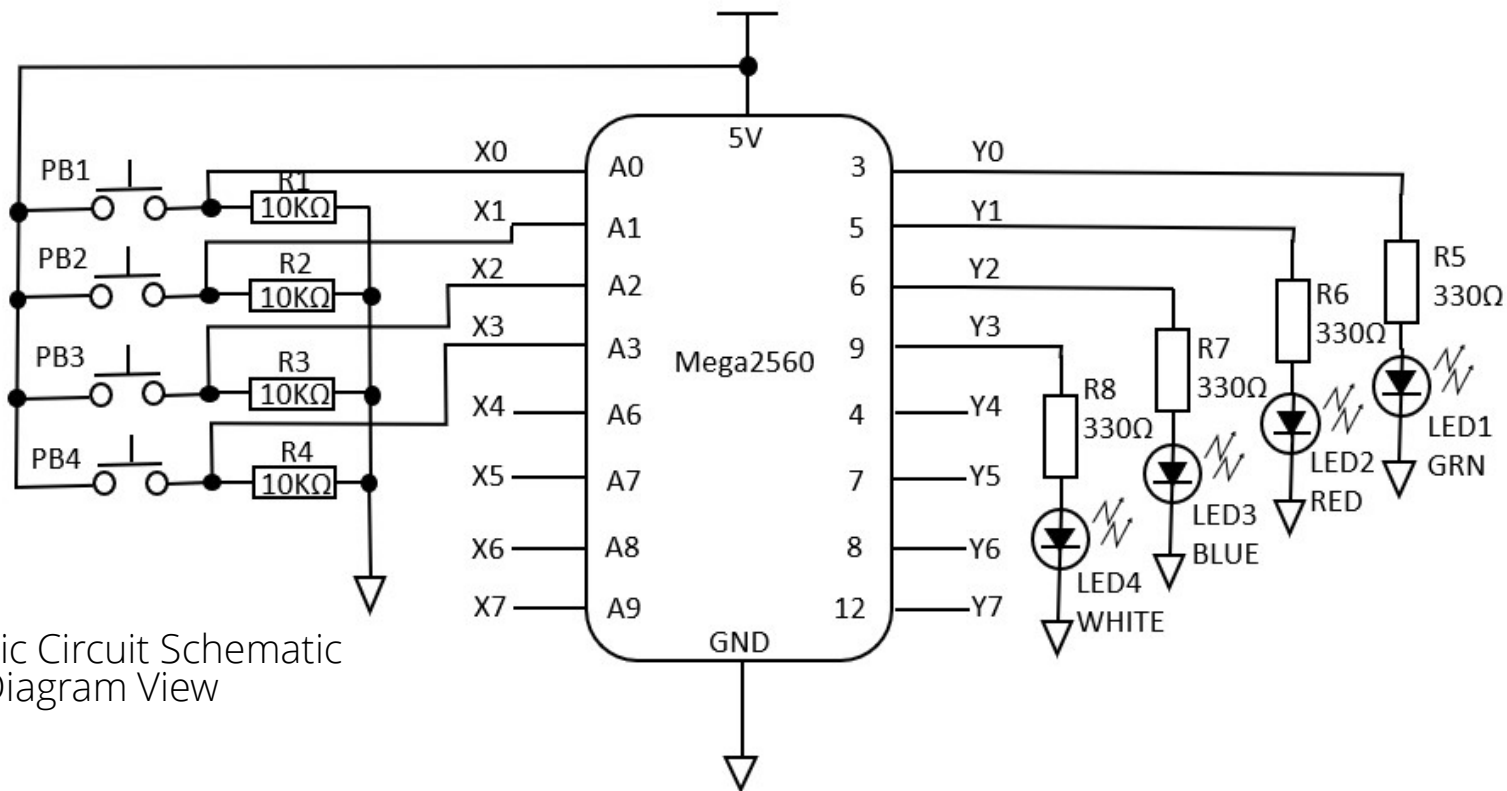
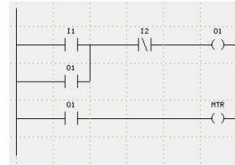
Lab Activities: Building an Arduino PLC Controller - Concept



Functional Block Diagram View

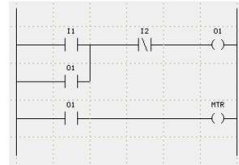


Lab Activities: Building an Arduino PLC Controller - Concept

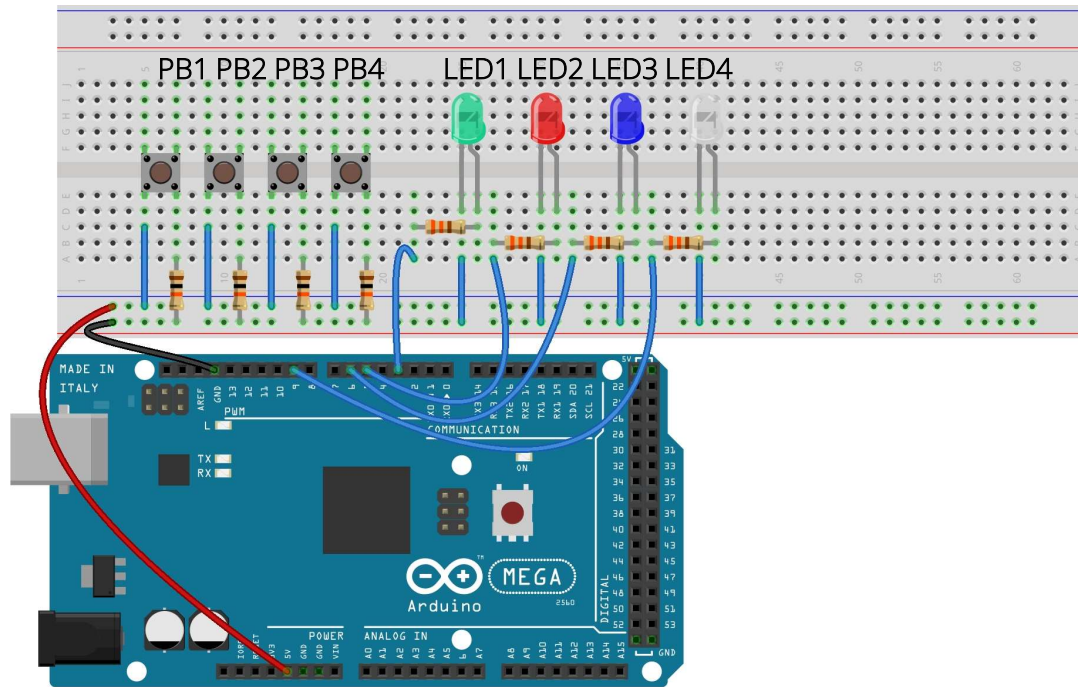


Electronic Circuit Schematic Diagram View

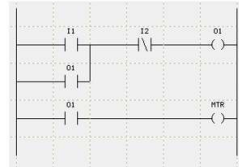
Lab Activities: Building an Arduino PLC Controller - Concept



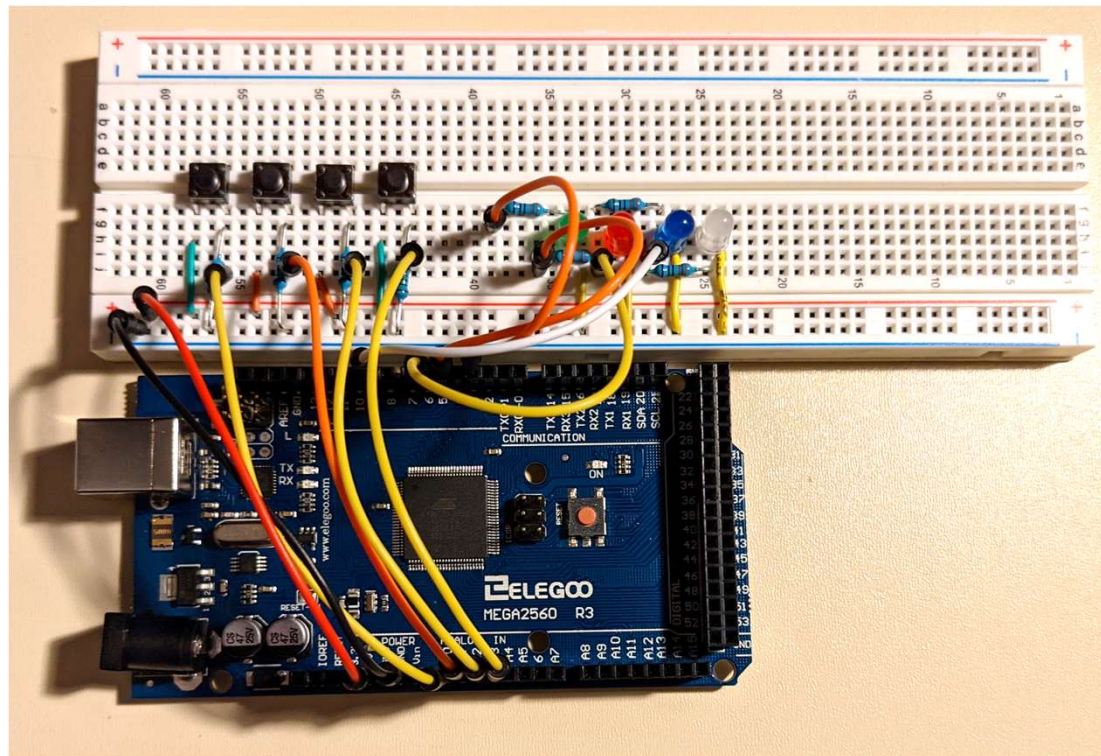
Breadboard Diagram View



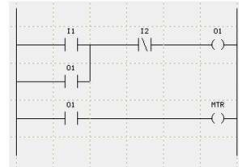
Lab Activities: Building an Arduino PLC Controller - Concept



Actual Wired
Breadboard View



Lab Activities: Installing the plcLib library



wditch / plcLib

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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

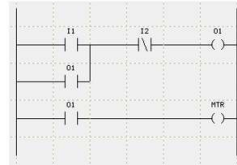
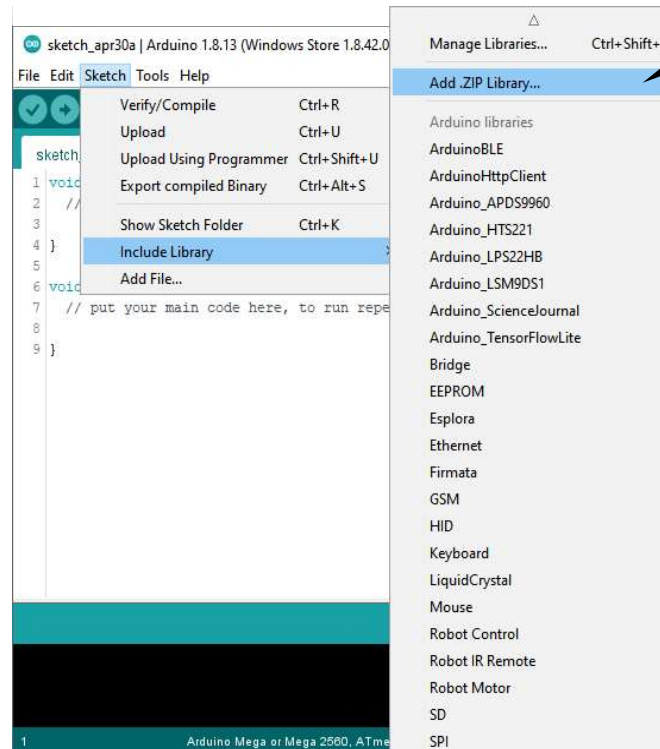
A simple C/C++ code library to allow PLC-style programming of Arduino-based systems and compatibles.

plcLib github repository

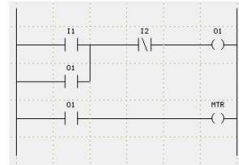
Source: <https://github.com/wditch/plcLib>

Lab Activities: Installing the plcLib library

Add the zipped plcLib folder to the Arduino Library

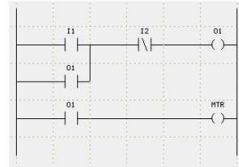


Lab Activities: Installing the plcLib library



plcLib added to Arduino IDE

Lab Activities: Bare Minimum plcLib PLC program: Hello World

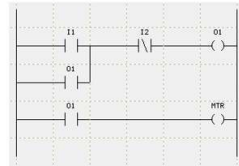


Learning Objective:
After completing this lab exercise, you will learn how to program the Mega2560 to perform a basic PLC control operation of turning on a LED.

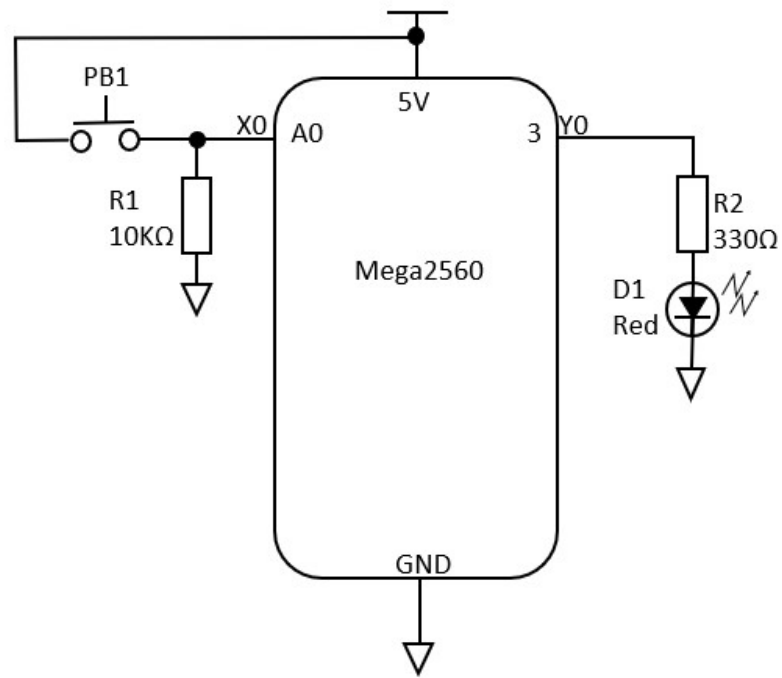
Basic PLC Control Operation Concept



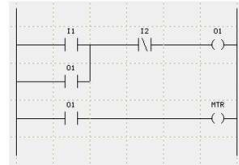
Lab Activities: Bare Minimum plcLib PLC program: Hello World



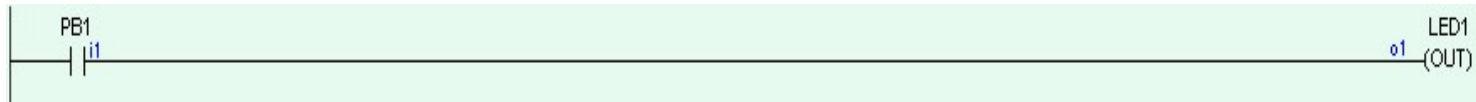
Electronic Circuit Schematic Diagram



Lab Activities: Bare Minimum plcLib PLC program: Hello World



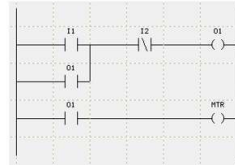
PLC Ladder Logic Program



PB1 = X0

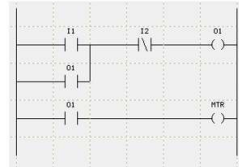
LED1 = Y0

Lab Activities: Bare Minimum plcLib PLC program: Hello World



The screenshot shows the Arduino IDE interface with the Library Manager open. The 'Libraries' list is expanded to 'InputOutput', and the 'BareMinimum' library is selected. An arrow points to this selection with the text 'Bare Minimum'.

Lab Activities: Bare Minimum plcLib PLC program: Hello World



```
BareMinimum | Arduino 1.8.13 (Windows Store 1.8.42.0)
File Edit Sketch Tools Help
BareMinimum
1 #include <plcLib.h>
2
3 /* Programmable Logic Controller Library for the Arduino and Co
4
5 Bare Minimum - Single bit digital input and output
6
7 Connections:
8 Input - switch connected to input X0 (Arduino pin A0)
9 Output - LED connected to output Y0 (Arduino pin 3)
10
11 Software and Documentation:
12 http://www.electronics-micros.com/software-hardware/plcLib-
13
14 */
15
16 void setup() {
17   setupPLC(); // Setup inputs and outputs
18 }
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```

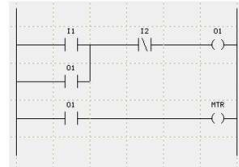

Lab Activities: Bare Minimum plcLib PLC program: Hello World

Code for operating all LEDs

```
#include <plcLib.h>

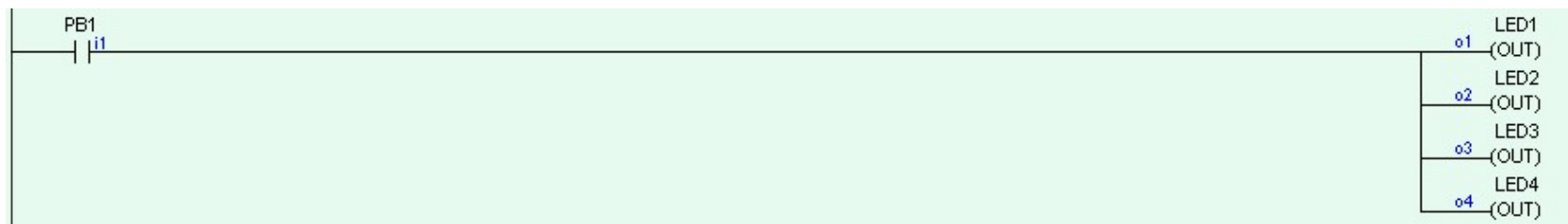
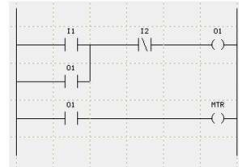
void setup() {
  setupPLC(); // Setup inputs and outputs
}

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.](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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