# PLC01: Pick-and-Place Robot

## Interdisciplinary Automatic Controls Laboratory - ME/ECE/CHE 389

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## Contents



## 1 Overview

A programmable logic controller, or PLC, can be used to control any process that requires automation, such as processes found in a chemical plant, automated machinery, or laboratory equipment. When used in such a process, the PLC is programmed to perform a set of logical steps in a specific order to complete the desired task. These steps are programmed into the PLC using a ladder logic program, which consists of a specific set of instructions which will be used to define the process and control the machine.

## 2 Goals

1. Learn the basics of the ladder logic, the primary programmable logic control language
2. Design and implement a ladder logic routine to control the pick-and-place manufacturing type robot. See here for a demonstration from a previous group. Note the implementation in this video is somewhat inefficient and can be significantly improved.

## 3 Experimental Procedure

The necessary files to carry out the laboratory are available in the controls drive (T drive). The drive should be visible from the windows “Computer” pane

`T:\PLC_01_PickPlace\`

- You can read files in this folder but cannot edit them. Copy the files to your own directory.
- The folder contains a the user manual for the PLC processor we will be using, the Micro Logix 1000.

### 3.1 Description of Apparatus

The machine which will be used in this lab is designed to move five square blocks from their initial positions on a radial disk to their final positions in a single line on a track. There are five separate pneumatic cylinders that are used to perform the five movements needed to relocate the blocks. One cylinder rotates the disk on which the blocks are initially placed in order to align each block into the proper position to be picked up off the disk. Three of the cylinders are used to control the movement of the mechanical arm which picks up the blocks and places them on the track. These movements include the opening and closing of the clamps which grab the block, the vertical movement of the arm, and the horizontal movement of the arm. The fifth cylinder is used to slide each block along the track in order to create room for the next block to be placed there. The cylinders are controlled with the programmable controller.

| Input Function | Input | Output Function | Output |
|---|---|---|---|
| Stop Button | I/0 | Vertical Extension of Gripper Arm | O/0 |
| Start Button | I/1 | Horizontal Extension of Gripper Arm | O/1 |
| | | Block Movement along Shelf | O/2 |
| | | Block Gripper | O/3 |
| | | Disk Rotation | O/4 |

### 3.2 Experimental Procedure

It is important to carefully read and understand the PLC Supplementary material before proceeding with the following Lab Work exercises. In particular, be sure to go through the RSLogix tutorial.

**Lab Work 1: A Simple Test Program**

1. To get started, construct a ladder logic diagram that is initiated by the start switch (input I0). When the start switch is activated load the output which extends the horizontal arm (Output O1). Then use the stop switch (input I1) to unload the output causing the horizontal arm to retract (unload Output O1).
2. See `T:\PLC_01_PickPlace\Ladder_Files_RSLogx_TUTORIAL_ME389.RSS` to help get started.
3. Do not turn the air pressure on until you are sure your program is functioning correctly.
4. You can verify the correct implementation by looking at the LED on the solenoid connected to Output O1. When it is loaded the LED should be lit.

**Lab Work 2: Pick and Place Loop**

1. Write a ladder logic program that will control the actions of the five cylinders such that each block is picked up from the disk and placed on the track. This must include the necessary logic to control the cylinder that rotates the disk for initial pick-up and the cylinder that slides the blocks across the track when they are dropped off.

2. Include in the program two gates that allow the external inputs to be entered into the system.

   - The first gate, which is used to start the program should be energized by input I0 (the ON button). See, the PLC supplementary for a similar example.
   - The other gate, will serve as an emergency stop. Use input I1 (the OFF button) to activate a gate that moves all of the cylinders into their safest positions, where pinch points are minimized (i.e. in this case all Outputs unloaded). (Many machines in industry use the emergency stop to "blow the air", or release all the air from the system). Additionally, the OFF button should act as a program reset. It should return the logic program to the initial state, so that the program can be restarted without error with the ON button.

**Lab Work 3: Pick and Place Stopping Criteria**

1. Now add a counter to the logic program. The counter will count the number of blocks collected, and once the robot has collected all the blocks it should automatically shut it self off.

   - This can be done by attaching an OR statement to the emergency off gate.

2. When designing the ladder logic program, keep in mind that the amount of time needed to complete the process must be minimized. Therefore, remember that some steps in the program may be completed simultaneously in order to reduce time. For example, the mechanical arm could lower the block to the track at the same time that the disk is rotated. Modify your program so that it is as efficient as possible.

**Lab Work 4: Pick and Place with Ordered Collection**

1. **Extra Credit:** Now, imagine the blocks are out of order. Assume the 4 block and the 5 block have been switched, such that the order of the blocks is 1, 2, 3, 5, 4. Modify your program so that robot skips past the 5 block and picks up the 4 block. If time permits, modify the program further such that the robot then returns to pick up the 5 block. For this part make use of counters, Memory Push and Memory Pop.

## 4 Video-based Report

The best way to report the outcomes of the different steps in this lab is by recording videos. Shoot a video for every Lab Work showing how the experiment behaves under your PLC code. Upload the video to YouTube and just include the link in your report.