

**Cleveland State University**  
**Department of Electrical Engineering and Computer Science**

**EEC447: Programmable Logic Controllers (PLCs)**

- Catalog Description:**      **EEC447 Programmable Logic Controllers (3-0-3)**  
*Pre-requisite: EEC 315 or EEC 316*  
An introduction to programmable logic controllers used in industrial environments including basic concepts, programming, applications, troubleshooting of ladder logic, and interfacing of equipment.
- Textbook:**                      [www.plcopen.org](http://www.plcopen.org) (Great resource for IEC 61131-3)
- Petruzella, Frank D. Programmable Logic Controllers, 4th Edition , 2011
    - ISBN-13 9780073510880
  - Dunning, Gary Programmable Logic Controllers 3<sup>rd</sup> Edition, Thompson, 2007 (at bookstore)
    - ISBN-13: 978-1-4018-8426-0
    - ISBN-10: 1-4018-8426-1
- Coordinator:**                      Lucian Fogoros, BSEE, MBA
- Course Objectives:**
1. Provide senior level students with knowledge of physical components and software strategies of industrial control systems (PLC).
  2. Demonstrate the various configurations and designs of industrial factory automation systems.
  3. Develop skills to analyze, design, implement and troubleshoot industrial control systems.
  4. Emphasize the “hands on” and “real world” nature of designing control systems.
  5. Extend students 'programming expertise in higher level languages.
- Expected Outcomes:**              Upon completion of this course, students should be able to:
1. Understand the basic control strategy of industrial control systems---namely Boolean logic.
  2. Recognize and work with the various I/O of PLC control systems---namely sensors, operator's devices, signal transmitters, solenoids, motor controllers, and temperature, pressure, and flow controllers.
  3. Understand general control concepts such as sequential scan, I/O updates, one scan pulses, initializing data, seal ins, latches, timing, subroutines.
  4. Be familiar with typical industrial control strategies such as sequencers, temperature sampling, ramp/soak profiles, good part/bad part tracking, alarming routines, closed loop control, recipe accessing and data retrieval/storage.

5. Develop algorithms in higher level ladder logic using data manipulation, bit shifting, mathematics, trig, bit masking, data table operations.
6. Be familiar with distributive control systems, networking, messaging. and security.

**Prerequisites by Topic:**

1. Experience with Blackboard
2. Computer programming
3. Fundamentals of differential and integral calculus
4. Electric circuit analysis
5. Electronics circuit components design and application

**Topics:**

	Weeks
1. Basic concepts and Terminology The hardware of industrial control system hardware: sensors, operator devices, solenoids, pilot lights, contactors, motor starters. Boolean logic descriptions of machine operations.	1
2. Industrial Control Systems Prior to PLC's Relays and ladder logic	0.5
3. PLC Systems The PLC hardware components and configuration. I/O wiring, manuals, troubleshooting the hardware system, indicator lights.	1
4. PLC Programming Software “Walking” through the software environment and capabilities. Toolbars, file operations, print function, online vs offline, run vs program, editing operations, monitoring the ladder logic, power flow and forcing. Executing simple machine control programs as in tutorial.	1.5
5. Midterm Test#1 Hardwired relay ladder logic concepts and applications.	0.5
6. Sequencer Implementing a machine control application as a sequence of events, both initiated by event and/or timing. Emphasis on “sequential scan” nature of PLC control, the concept of a “one scan” pulse, and latch type coils.	0.5
7. Timers and Counters Implement machine and process control strategies which require timing and counters – from simple pick and place delays (milliseconds) to ramp/soak profiles for furnace control (hours).	1
8. Data Operations Working with “values” in the PLC control strategies – both integer values and floating point values. Applications include recipe set point storage, timer and counter values, initial values, stored constants. Strategies include data move, data compare, data convert, data clear. Implement sequencer using a counter and compares.	1

9. Math Operations	PLC control requires scaling, limiting, comparing of analog values. Applications include averaging, finding the mean, maximum and minimum values, and incrementing.	1
10. Analog Inputs and Outputs	Working with devices such as speed, pressure, flow, temperature transmitters and controllers which require DAC and ADC conversion routines to monitor and control these parameter values. Includes scaling for engineering units.	1
11. Bit Operations	Bit shifting and bit masking are functions used in many control algorithms and strategies. Applications include “bad part” tracking, rotating lights and sequencers. Bit masking using AND, OR, XOR operations with stored constants are used machine control applications, such as alarm/acknowledge routines.	0.5
12. Midterm Test#2	Basic PLC control applications including timing, counting, one shot pulses, data operations, bit operations, and math.	0.5
13. Modular Programming	Develop sub routines, call and return operations, nesting, jumps and global variables. Emphasis on divide and conquer” concept and developing efficient and understandable programs using subroutines.	0.5
14. Data Manipulations	Source to Table, Table to Destination, Table to Table operations with indexing and indirect addressing. Applications include process control for multiple part production, function generator, sequencer using stored constants to control multiple outputs.	1
15. LAN Communications	Distributive control concept is implemented through Ethernet network with PLCs sharing data, messages and control operations.	1
16. IEC 61131 Standard	PLC programming is Structured Text, a universal standard for control operations.	1
<b>Total</b>		<b>15</b>

**Grading Policy**

			• Assignments& 2 quizzes						70 points
			• Demonstrations						50 points
			• Midterm Test #1						95 points
			• Midterm Test #2						95 points
			• Final Examination						190 points
Points	461-500	441-460	421-440	401-420	371-400	351-370	321-350	300-320	
Grade	A	A-	B+	B	B-	C+	C	D	

### **Computer Usage:**

- PLC assignments are implemented using PLC manufacture's Windows based programming(development & runtime) software package. For EEC 447 Section 50 the software is RSLogix5 by Rockwell Software by General Electric.
- All assignments must include a cover page and project description in Microsoft Word
- The computers and PLCs are connected in both a network configuration and proprietary LAN configuration and the students must understand LAN concepts, Ethernet communications and TCP/IP addressing in order to download programs, monitor I/O and implement the distributive control assignment.

### **Lab Projects:**

1. Each of the assignment consists of a PLC application software design which must be implemented on a physical I/O simulator system to demonstrate real-time operation of the PLC design.
2. Some assignments will require the use of an oscilloscope, multi-meter or power supply to demonstrate the real-time operation of the PLC design.

**Prepared by:** Donald F Zeller

**Date:** 2/15/2002