ELEC A233: AUTOMATION 3 - INDUSTRIAL NETWORKS, HMI, AND SCADA

Item	Value
Curriculum Committee Approval Date	12/02/2020
Top Code	093420 - Industrial Electronics
Units	4 Total Units
Hours	108 Total Hours (Lecture Hours 54; Lab Hours 54)
Total Outside of Class Hours	0
Course Credit Status	Credit: Degree Applicable (D)
Material Fee	No
Basic Skills	Not Basic Skills (N)
Repeatable	No
Grading Policy	Standard Letter (S)

Course Description

This course covers connecting PLCs and control components together using industrial network protocols. Students will learn how to create Human Machine Interfaces (HMIs) which are touch displays that control industrial processes. Finally, students will learn how to implement Supervised Control and Data Acquisition (SCADA) systems to collect data and monitor a network of PLCs. ADVISORY: ELEC A232. Transfer Credit: CSU.

Course Level Student Learning Outcome(s)

1. Students will gain understanding of SCADA system architecture by commissioning a SCADA server.
2. Students will acquire the skills to reliably terminate and test network cabling.
3. Students will become proficient at drafting system diagrams of industrial networks.
4. Students will acquire the skills necessary to build a Local Area Network and segment it into multiple subnets. 5. Students will gain an understanding of Operator HMI Displays by programming PC based dashboards and HMI displays.

Course Objectives

- 1. Reliably terminate multiple common types of network cables.
- 2. Draft system diagrams of industrial networks.
- 3. Design and build an industrial Local Area Network.
- 4. Segment a network into multiple subnets.
- 5. Bridge subnets as appropriate.
- 6. Install hardware in server racks and network racks.
- 7. Analyze network load.
- 8. Audit a network for security issues.
- 9. Create a SCADA system capable of monitoring a network of PLCs.
- 10. Create Dashboards for the SCADA system to monitor and control PLCs.
- 11. Create Operator HMI Displays to monitor and control PLCs.

Lecture Content

Industrial Network Overview Purpose Special Considerations Topology Technologies Fiber protocols Coaxial protocols Ethernet protocols Serial protocols Wifi protocols Mesh protocols Local Area Networks TCP/IP Routers Managed and Unmanaged Switches Network Redundancy Hardening against noise Cabling High Bandwidth Mediums Coax Fiber Network Segmentation Analyzing Network Load Creating Subnets Managing connectivity Open Protocols vs. Proprietary Protocols Overview of common open protocols CIP Modbus PROFINET ControlNet Overview of Proprietary Technologies Allen Bradley Siemens Security in Industrial Networks Physical Separation Network Separation Whitelists Password Policy Backups SCADA Architecture Hardware Systems Overview Data Storage Data Display Control Functions Safety Concerns Latency Human Machine Interface (HMI) Displays Design Ergonomics Intuitive Actions Safety Concerns Employee Access Concerns Programming to dis play an input status Programming a button to control an output Networking and reading data from SCADA servers

Lab Content

PC Hardware Students will establish a test bench by building a computer system. Students will install an OS Students will load appropriate Drivers Students will load appropriate Software Students will image the system in case of corruption Terminating Cables Students will learn to use crimp tools to properly terminate the following connectors- Ethernet Connector-CAT5 and CAT6 Coaxial Connector Terminal Blocks Students will learn how to use test equipment to verify the integrity of their terminations. Local Area Network Build Students will install a router in a network rack. Students will install a switch in a network rack. Students will establish an Uninterruptible Power Supply to the rack Students will submit a report detailing their system design- System Overview System Diagram Bill of Materials Industrial Automation Network Build Students will segment their network to provide a subnet for PLC Controllers to communicate Students will connect PLCs to the network Students will establish a bridge between the subnets to allow access to the PLCs. Students will submit a report detailing their system design- System Overview System Diagram Instructions for Accessing PLCs SCADA Server Build Students will install a server in a server rack. Students will commission a SCADA database on the server. Students will connect the PLCs to the SCADA server. Students will connect a button, a simple relay and lamp to the PLC for purposes of testing connectivity. Students will submit a report detailing their system design- System Overview< / System Diagram Bill of Materials SCADA Display Students will implement a PC based dashboard displaying the state of the button input. Students will implement a PC based dashboard to control the state of the lamp. Students will implement a PC based dashboard to display historical data regarding button state and lamp state. Students will submit a report detailing their system design- System Overview System Diagram Operator Instructions HMI Display Students will connect a HMI to either the PLC or directly to the industrial network. Students will program the display as an operator control panel to control the state of the lamp and report the state of the button. Students will submit a report detailing their system design- System Overview System Diagram Bill of Materials

Method(s) of Instruction

- Lecture (02)
- DE Live Online Lecture (02S)
- DE Online Lecture (02X)
- Lab (04)

- DE Live Online Lab (04S)
- DE Online Lab (04X)

Instructional Techniques

Lecture Detailed whiteboard lectures with opportunity for student engagement. Discussion of media provided and assigned via Canvas. Demonstration of tactile skills. Demonstration of computer skills via projector or teleconferencing. Lab Students build and test networks. Students operate on the same network to simulate real-world conflicts. Lab projects reinforce lecture topics and are paced to coincide or lag the lecture content. Lab projects generate content that students use to generate reports and documentation, enhancing writing and critical thinking skills.

Reading Assignments

Students will spend approximately 2 hours per week on reading instructor created handouts provided via the LMS

Writing Assignments

Exams Technical reports Engineering journals Approximately 2 hours per week.

Out-of-class Assignments

Students will spend approximately 2-3 hours per week on out-of-class assignments such as the following, in addition to reading/writing assignments: Daily review of student Engineering Journal and notes. Technical reports for each project assigned.

Demonstration of Critical Thinking

Students will design, build, commission several industrial networks. Students will develop operator displays. Students will develop schemes for data display and storage.

Required Writing, Problem Solving, Skills Demonstration

The students are required to keep a portfolio of lab projects. Students will demonstrate the skills necessary to commission an industrial network. Each lab project requires a technical report consisting of a description of the system and a system diagram.

Eligible Disciplines

Electromechanical technology (industrial mechanical technology): Any bachelors degree and two years of professional experience, or any associate degree and six years of professional experience. Electronic technology (radio, television, computer repair, avionics): Any bachelors degree and two years of professional experience, or any associate degree and six years of professional experience. Engineering technology: Masters degree in any field of engineering technology or engineering OR bachelors degree in either of the above AND masters degree in physics, mathematics, computer science, biological science, or chemistry, OR bachelors degree in industrial technology, engineering technology or engineering AND a professional engineers license OR the equivalent. Masters degree required.

Textbooks Resources

1. Required Ronald L. Krutz, Ph.D., P.E. . Industrial Automation and Control System Security Principles , 1st ed. research triangle park, NJ: ISA, 2013 Rationale: Legacy Legacy Textbook Transfer Data: Marshall, P, Rinaldi, J. Industrial Ethernet, 2d ed. ISA, 2004 2. Required Wilamowski, B, Irwin, J. D. Industrial Communication Systems (The Industrial Electronics Handbook), 2d ed. CRC Press, 2011

Other Resources

1. Material provided via LMS.