Model Plant Simulation with SCADA HMI and Raspberry Pi

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Introduction

The Maine Maritime Academy Electronics and Instrumentation Laboratory gives students an introduction into industrial automation using PLCs and Rockwell Automation's Connected Components Workbench. As it stands, the lab does not provide insight into the use and design of Human Machine Interfaces (HMIs) with Supervisory Control and Data Acquisition (SCADA). Further, the Connected Components Workbench is used as an HMI, which is discouraged and sets an unhelpful precedent for students.

The purpose of this project is to provide a workflow for the Electronics and Instrumentation Lab which would allow students to become familiar with full-stack automation. To provide a more thorough automation system, the following deliverables will be provided with this project in order of decreasing abstraction:

1. A SCADA HMI running in Ignition by Inductive Automation®.
2. A simulated plant running on an Raspberry Pi 5 SBC functioning as a PLC.
3. A simulated suite of sensors and pumps networked to the Raspberry Pi.

Background

Automation is a field in increasing demand, and it is likely that graduates of Maine Maritime Academy will be required to demonstrate an increasing understanding of automation in the future. To further the understanding of Maine Maritime graduates, it is desirable to expose students to the full extent of the development stack of industrial automation. This automation is generally understood as follows:

1. Field-Level: Plant, Actuators and Sensors
2. Control-Level: Programmable Logic Controller (PLCs)
3. Network-Level: Communication Protocols (EthIP, Modbus RTU/TCP, LoRA, Wi-Fi)
4. Supervisory-Level: Monitoring and holistic control with SCADA, HMI, digital control systems (DCS)
5. Enterprise-Level: Business systems and analytics.

While engineering courses at Maine Maritime Academy elucidate a field-level and control-level understanding, such as with ET432: Power Control Electronics and ET401: Automation and

Control, respectively, the Academy does not provide guidance on networking and supervisory control systems such as SCADA or HMI. It is the objective of this project to create systems for the Automation and Control Lab that could provide students with a better understanding of these systems.

Experimental Approach

A headless Linux distribution will be installed onto a Raspberry Pi Foundation® RPi-5 running Docker[1] and PyModbus[2]. From there, containerized processes for each virtual device, i.e. a pump, valve, transducer, etc., will be initialized and connected as a Modbus TCP device over the integrated ethernet connection using Python[3] and the PyModbus API. Communication between these virtual devices will be confirmed using the other Automation Lab computers.

Next, a host instance of Python will be created to simulate the plant process (currently undetermined). This instance will communicate with the client instances for each of the virtual devices and set their state, effectively telling them their pressures, temperatures, voltages, etc. Conversely, the SCADA HMI may change the input to an end-effector like a pump or valve over Modbus, changing the properties of a simulation.

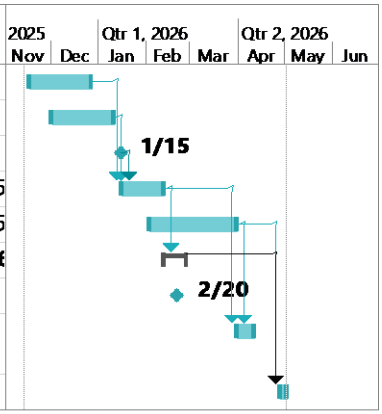
With the simulation created, the SCADA instance can handle the system automation, telling a virtual pump instance to activate when pressures are too low, or open a bypass valve if some criterion is achieved.

Deliverables

1. A simulated plant running on an RPi5 (or equivalently Modbus-capable microcontroller) as a modbus slave device comprising the following simulated devices:
    1.1. Pumps
    1.2. Valves
    1.3. Pressure/temperature sensors
    1.4. A simulated process (simple boiler, manufacturing, etc.)
2. A SCADA HMI that represents that process, built in Ignition.

Timeline

ID	Task Mode	Task Name	Duration	Start	Finish
1		Modbus Testing	6 wks	Mon 11/17/2	Fri 12/26/25
2		SCADA/Networking Researc	6 wks	Mon 12/1/25	Fri 1/9/26
3		Raspberry Pi Arrives?	0 days	Thu 1/15/26	Thu 1/15/26
4		Plant Simulation on RPi	4 wks	Thu 1/15/26	Wed 2/11/26
5		HMI Setup	41 days	Mon 2/2/26	Mon 3/30/26
6		**Report**	**2 wks?**	**Thu 2/12/26**	**Wed 2/25/26**
7		Draft Complete	0 days	Fri 2/20/26	Fri 2/20/26
8		Further Testing/Troubleshooting	9 days	Tue 3/31/26	Fri 4/10/26
9		IAC/Department Presentatic	4 days	Tue 4/28/26	Fri 5/1/26



Budget

Raspberry Pi 5 8 GB	$ 81.99
128 GB Micro SD card	$ 14.99
USB-C 5V Power Supply	$ 12.99
	$ 109.97

References

[1] Docker [Internet]. Palo Alto (CA): Docker Inc.; c2024 [cited 2025 Nov 13]. Available from: https://www.docker.com/.

[2] PyModbus documentation [Internet]. [place unknown]: PyModbus; [date unknown] [cited 2025 Nov 13]. Available from: https://www.pymodbus.org/docs.

[3] Python [Internet]. Wilmington (DE): Python Software Foundation; c2024 [cited 2025 Nov 13]. Available from: https://www.python.org/.