Industrial Automation in Sustainable Solutions for the Container Farm Project

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Reliable Controls Corporation

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College of Engineering

Mission

Reliable Controls is requesting a cost-effective control system for the NMSU Container Farm Automation Project. The system must control the following variables:

- Water Flow
- Tank and Bed Water Level
- Nutrient Levels
- Electrical Conductivity (1.2 – 1.5 mS/cm)
- pH (5.5 - 6.5)
- Humidity (55 - 65%)
- CO_2 (700 - 1000 ppm)

NMSU's Industrial Automation Team strived to ensure that all deliverables exceeded expectations.

Research

Research started with the current AgrowTek control system to narrow variables and select the best PLC option for components:

- Programming method (C/C++, Ladder Logic, Python)
- HMI integration
- Input/Output (I/O) capabilities
- Improved modularity
- Scalability options for additional variables
- Sensors

Manufacturer	Product Name	Programming Methods	Integrated HMI or Full-featured OS?
Industrial Shields	RASPBERRY PLC 38AR	Python, C/C++, Bash, etc.	OS (Linux)
Industrial Shields	RASPBERRY PLC 58	Python, C/C++, Bash, etc.	OS (Linux)
Industrial Shields	RASPBERRY PLC 42	Python, C/C++, Bash, etc.	OS (Linux)
Industrial Shields	RASPBERRY PLC 38R	Python, C/C++, Bash, etc.	OS (Linux)
Industrial Shields	RASPBERRY PLC 19R	Python, C/C++, Bash, etc.	OS (Linux)
Industrial Shields	RASPBERRY PLC 21	Python, C/C++, Bash, etc.	OS (Linux)
Industrial Shields	RASPBERRY PLC 57AAR	Python, C/C++, Bash, etc.	OS (Linux)
Industrial Shields	M-DUINO ETHERNET PLC ARDUINO 21	Arduino C/C++	No
Industrial Shields	M-DUINO ETHERNET PLC ARDUINO 42	Arduino C/C++	No
Industrial Shields	M-DUINO ETHERNET PLC ARDUINO 57AAR	Arduino C/C++	No
Industrial Shields	M-DUINO ETHERNET PLC ARDUINO 58	Arduino C/C++	No
Industrial Shields	M-DUINO ETHERNET PLC ARDUINO 57R	Arduino C/C++	No
Industrial Shields	M-DUINO ETHERNET PLC ARDUINO 19R	Arduino C/C++	No
Industrial Shields	M-DUINO ETHERNET PLC ARDUINO 38AR	Arduino C/C++	No
Industrial Shields	M-DUINO ETHERNET PLC ARDUINO 38R	Arduino C/C++	No
Industrial Shields	ARDBOX Relay ARDUINO based PLC	Arduino C/C++	No
Industrial Shields	ARDBOX Analog ARDUINO based PLC	Arduino C/C++	No

Final Design

The final design considers the following:

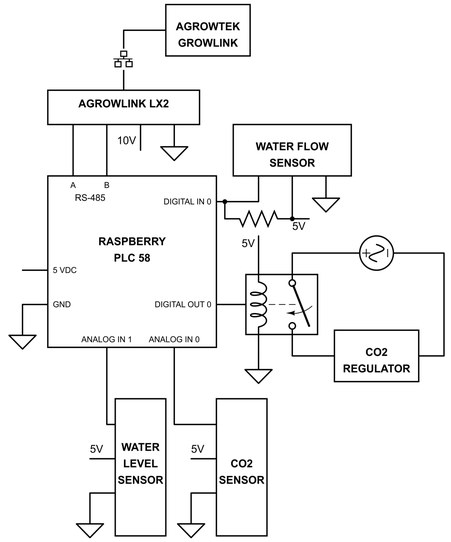
- Modularity
- Scalability
- Integration with current AgrowTek sensors

Specifications of the **RASPBERRY PLC 58**:

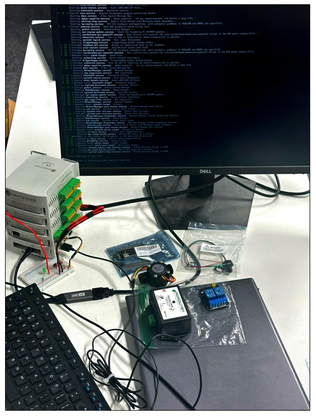
- Inputs: 21 digital and 18 convertible
- Outputs: 15 digital and 9 convertible

Variables are addressed by the following parts:

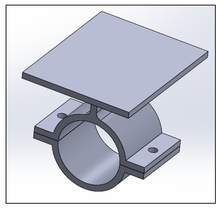
- Seeed Water Flow Sensor
- SST Sensing Water Level Sensor
- Agrowtek LX2 ModLINK
  - Nutrient Levels
  - Electrical Conductivity
  - pH
- Sensirion Humidity Sensor
- Teyleten Robot CO_2 Sensor



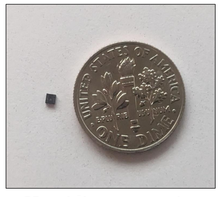
Part Testing and Implementation



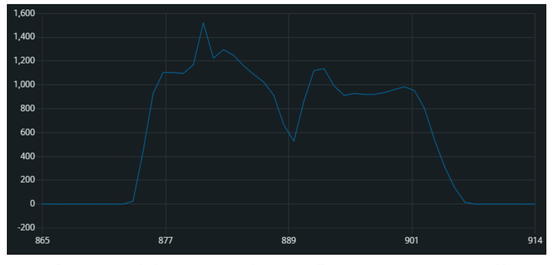
Initial hardware testing with all parts present



CAD model of CO_2 sensor bracket



Humidity sensor size relative to US dime



Plot created during initial water flow sensor testing. All values fell within the manufacturer's specified ranges

Coding

The final prototype was developed using C-compliant C++ code to integrate with Industrial Shields' native C++ libraries.

Control Architecture

- Program centers around a main control loop with modular functions for each input and output
- An on-disk config file is used to control environmental variables

Open-Source Licensing

- Control program licensed under the BSD 2-clause license, a permissive open-source license, allowing:
  - More open and customizable control system
  - Adaptability for different use cases
  - Reusability across diverse hardware systems
  - Use in and with proprietary software

Human-Machine Interface

- Locally accessible using a keyboard and monitor
- Remote access available using secure shell (SSH)
- Command Line Interface (CLI)
  - Used for system interface, monitoring, and instructions
  - More lightweight, flexible, and customizable than a graphical user interface
  - Can be more readily ported to nearly any operating system or computer architecture

Concept Development

NMSU's Industrial Automation team selected a PLC based on several factors, including input/output (I/O), programming language, and price. The PLC is the most important component in our project, as it controls the other sensors. We considered two programming languages to select for the PLC: Ladder Logic and C. However, we decided to go with C based on the team's greater coding experience with this language. Between several options, we considered Industrial Shields because it aligned with our project's budget parameters. The Raspberry Pi family supports the two programming languages we considered, so we left the door open to work with Ladder Logic.

We have set our most important factors:

- Product Family
- I/O capabilities
- Programming method
- Price

With these guidelines, we decided to work with the Raspberry PLC 58. Additionally, this PLC offers a higher flexibility of I/O, including increased scalability.

References

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