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Plant Process Emulator

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ELECTRICAL & COMPUTER ENGINEERING

Plant Process Emulator

ECE411 | **Team members:** Ben Horstmann, Krista Wood, David Adu-Mensah, Felix Baffoe-Ofori | **Faculty adviser:** Dr. Carl Elks | **Sponsor:** VCU School of Engineering | **Sponsor adviser:** Dr. Robert Klenke

CAPSTONE DESIGN EXPO 2017

Motivation

Programmable Logic Controllers (PLCs) are a pervasive technology in the Industrial Automation Industry. As shown in Figure 1, the VCU Industrial Automation and Controls Lab in the Electrical and Computer Engineering Department provides hands-on learning and experimentation with PLC based technology. To farther extend the capabilities of the lab, there is a need to emulate real world "hydraulic flow" based processes such as level control, temperature control and flow measurements.

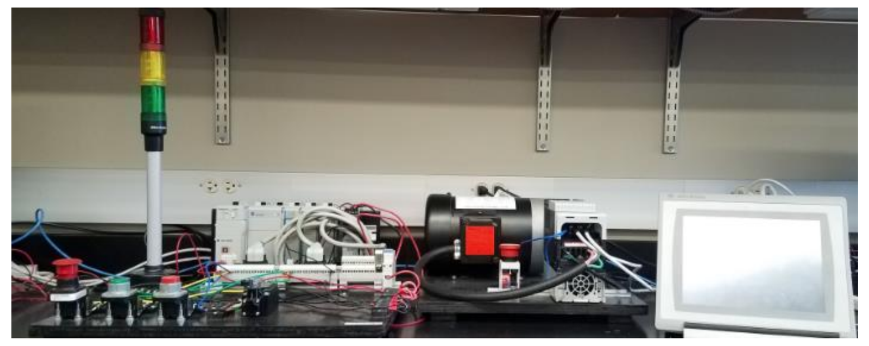

Figure 1: VCU PLC Lab Training Station

How it Works

By using Proportional-Integral-Derivative (PID) Control, which is a control loop feedback mechanism, an error value e(t) is calculated based off the difference between an user-defined set point and a measured process variable. The process variable is either the level transmitter for level control or a thermocouple for temperature control. After the error value is calculated, a correction is applied using the Proportional, Integral, and Derivative terms. The adjustment of a control variable u(t) sets the position of a set of solenoid valves for level control or a heating element for temperature control. The control variable is set to a new value as determined by a weighted sum: $u(t) = K_p e(t) + K_i \int_0^t e(\tau)\,d\tau + K_d \frac{de(t)}{dt}$ where Kp, Ki, and Kd are the coefficients for the Proportional, Integral, and Derivative terms. The Proportional term accounts for present values of the error. The Integral term accounts for the past values of the error. The Derivative term accounts for the future trends of the error.

Process Design

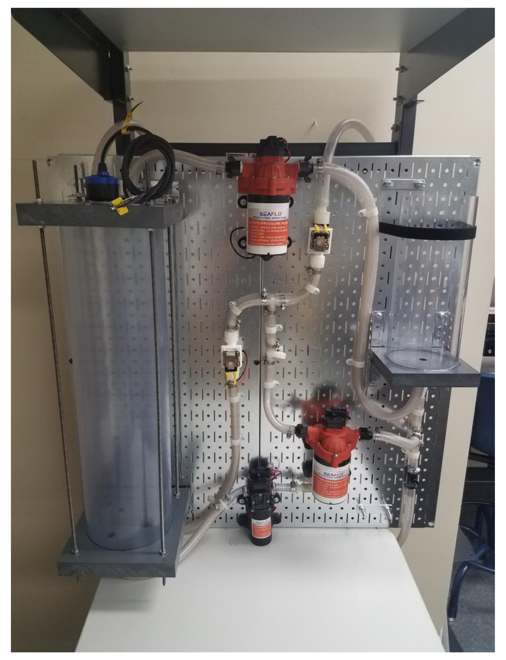

Figure 2: Plant Process Physical System

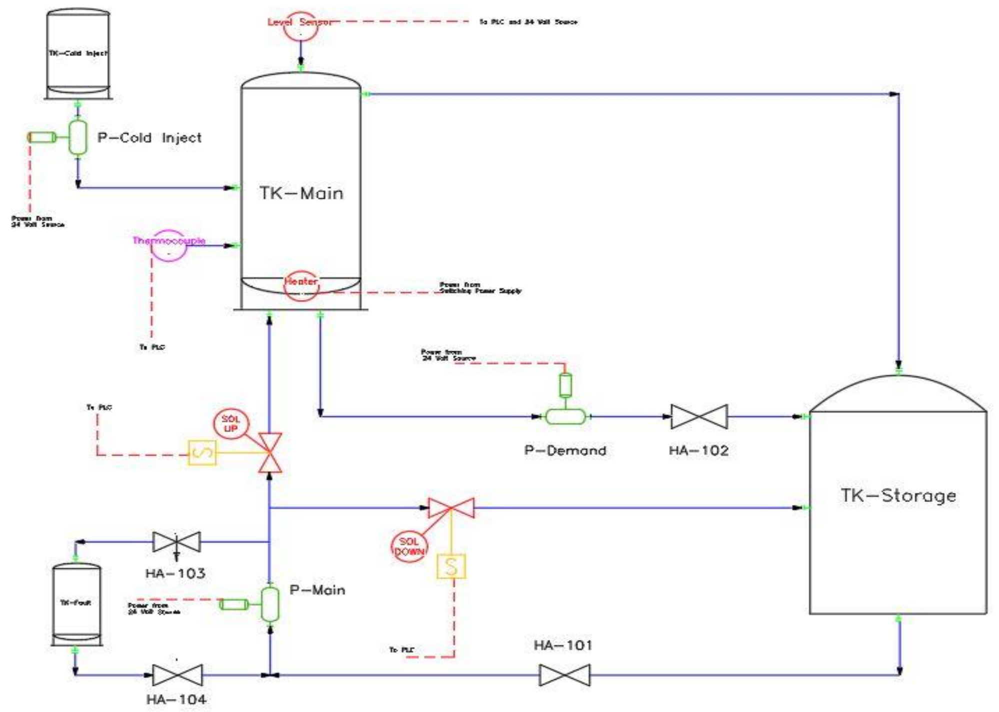

Figure 3: Plant Process Piping Diagram

Level Control was achieved by using two solenoids as the control variables. One to make the water level go up and one to make the water level go down. The direction of flow is determined by the process variable which is the level transmitter.

Temperature Control was achieved by using a cold water injection tank with a pump as the catalyst to change temperature. A heating element is the control variable and a thermocouple is the process variable.

A small Fault Tank was added to simulate a leak in the system for potential troubleshooting.

Future Plans

Any future additions to this project would add to the current training capabilities of the overall system. Some potential future additions could include:

- Another method of control (Flow Control or Pressure Control)
- A combination of multiple processes (i.e. Flow Control with Level Control or Level Control with Temperature Control)
- Changing the physical layout of the components for portability and compactness
- Adding a PLC designated strictly for this training system.

PID Feedback Control Model

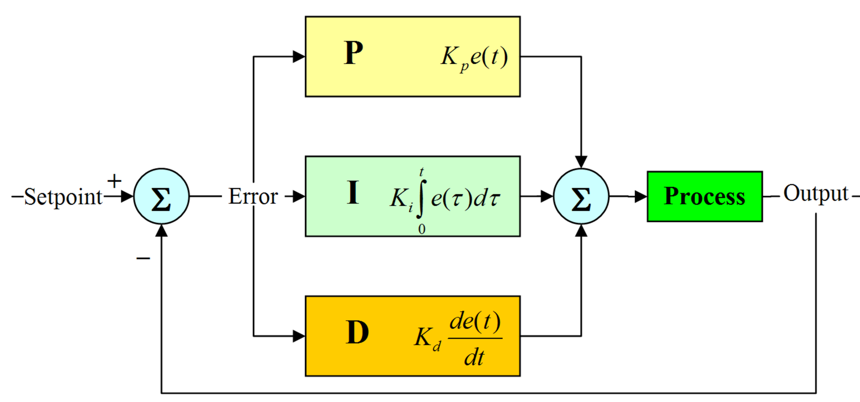

Table 1. The effect of changing PID parameters on the system response.

	Rise Time	Overshoot	Settling Time	Steady-State Error	Stability
Increasing Kp	Decrease	Increase	Small Increase	Decrease	Degrade
Increasing Ki	Small Decrease	Increase	Increase	Large Decrease	Degrade
Increasing Kd	Small Decrease	Decrease	Decrease	Minor Change	Improve

Figure 4: PID Control Loop Feedback Mechanism and Coefficient Response Table

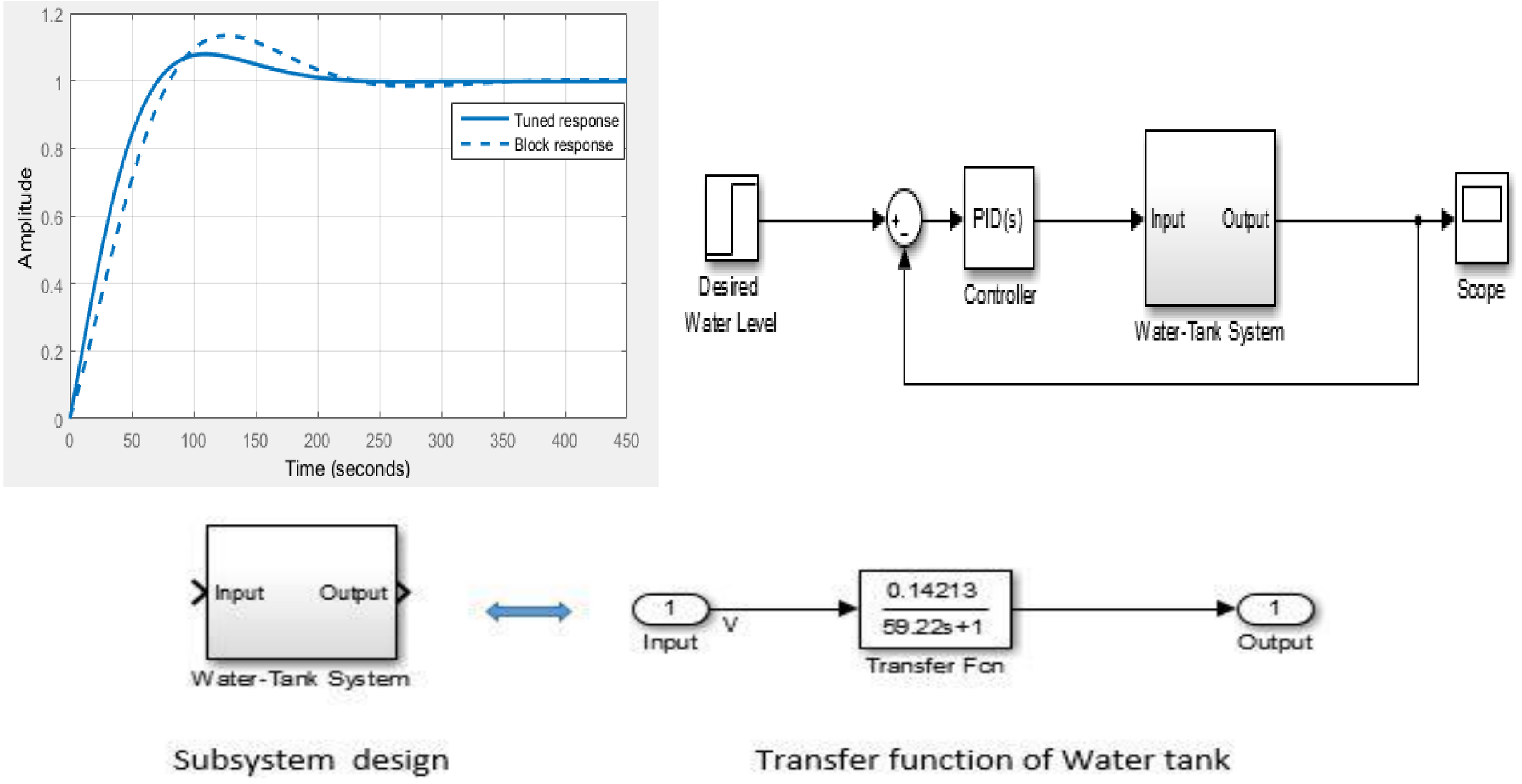

Figure 5: Plant Process Level Control

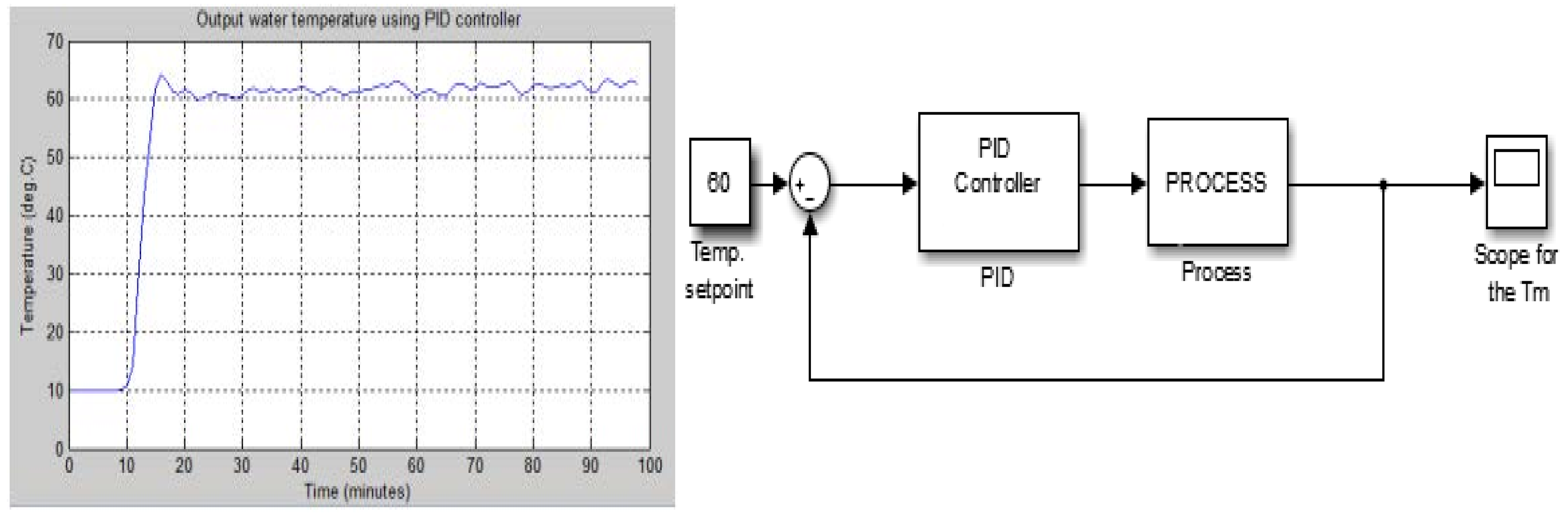

Figure 6: Plant Process Temperature Control

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