

EE314 – Microprocessor Systems
Laboratory Project 9
Water Experiment - Closed-Loop Control

Introduction

This experiment will take the remainder of the semester to fully develop and demonstrate. It will require several subtasks to be developed. The goal is to demonstrate a real-time, closed-loop control system.

The hardware consists of a water bucket with a valve to drain it, a pump to fill it, and a water depth level measurement circuit. There are two main goals. The first is to demonstrate that you can maintain a fixed water level depth regardless of how open the drain is (from fully closed to fully open). The second is to maintain a bar-graph video screen display showing both the current water level and flow rate.

The following requirements are to be met while achieving these goals:

- 1.—The control of the data sampling and display must be done with an interrupt service routine. This will mean replacing an existing routine with the new one, and then restoring the old one before exiting the program.
- 2.—The programming should be organized and written in C with in-line assembly language statements. ~~It should be compiled to assembly language, assembled with MASM and then executed from that level. You may test various pieces by compiling the C programs and then running them individually under DOS, but the final project must run entirely as a combined application.—~~The program can be run directly from the TCC produced executable. Compilation to assembly is NOT necessary (or productive).

Pre-lab (due at the beginning of the lab period)

Get your team together to determine which tasks need to be done and which person will do each task. Determine how you will organize the subtasks and when they will be brought together to solve the whole problem. Present your plan to the laboratory instructor. A measure of the work includes how well you organize and break the project into appropriate pieces.

Laboratory Procedure (Report due at the last lab session)

1. Write a procedure to fill the water tank. Then determine how long it takes the tank to empty. At the same time, use the oscilloscope to determine what values on the "depth" signal correspond to what depths. Plot this on a graph to show how linear the depth measurement scheme is.
2. Write an interrupt procedure, which replaces the BIOS ISR type 08. This is the timer interrupt.
3. Write a procedure to convert the "depth" pulse signal into depth information. Your procedure should be based on averaging the number of pulses for a fixed amount of time. Decide how many pulses must be averaged to get a good reading on the depth. Explain your reasoning on what time period you choose. Derive a method to accurately measure the time.
4. Organize the whole program to consist of the following steps:
 - (a) Initialize the system by setting up the new ISR.
 - (b) Start the system by filling the tank.
 - (c) Set a desired water depth to maintain.
 - (d) Enter closed-loop control, which holds the water depth at an adjustable level while showing water level and flow rate bar graphs on the video display.
 - (e) Terminate closed-loop control and restore the original ISR.
5. In the final report, elaborate on the design requirements for the project, the division of labor, and project management. Be sure to follow the standard report format.

(please see bonus credit options on reverse)

Bonus Credit Options:

- Use what you learned in Lab 8 about the PC speaker to output an audible "alarm" that is quiet when the water is at the desired level, but emits a series of beeps when it departs from the desired level.
- Do the same as above, but make the series of beeps go faster the farther away the water level is from its desired value to indicate "increased urgency".
- Extend the above idea such that the frequency (pitch) of the beeping tone also increases the farther away the water level is from its desired value.
- Use what you learned in Lab 7 about DACs to output DC signals which can be displayed using a digital multimeter (DMM) to indicate the water depth and/or flow rate. Calibrate the DAC output(s) so that the DMM display indicates actual measurements of depth and/or flow rate.