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| Electron gun vacuum system control |
| Project in Embedded Systems |
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| **3/9/2017** |

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# Abstract

Short summary of the project, communicating the most important results.

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# Introduction

## Background

In the clean room of the Ångström Laboratory there is an electron gun system which is used to deposit thin films of metal onto a substrate. The electron gun uses an electric field to accelerate electrons which form an electron beam of high power. The electron beam is then directed using magnetic fields into a crucible that holds the metal to be deposited. The high energy of the electron beam vaporizes the metal and the metal vapor shoots upwards toward the substrate target.

To avoid oxidation and contamination of the samples, the process needs to be carried out in a vacuum chamber. The vacuum chamber for the system at the Ångström Laboratory utilizes two pumps, an air pump and a cryo pump. The air pump is able to bring the chamber from atmospheric pressure down to. At this pressure, the air pump is unable to lower the pressure further and the cryo pump is used. The cryo pump works by moving a portion of gas from the chamber to a separate chamber. The separate chamber is then cooled down using liquid helium, which compresses the gas inside. The compressed gas is then moved to a storage tank. The cryo pump is able to bring the pressure in the vacuum chamber down to. The air pump is required due to the limited volume of the cryo pump storage tank. The cryo pump storage tank fills quickly if the cryo pump is used at atmospheric pressure.

## Purpose of the project

The purpose for this project is to upgrade the control system for the vacuum system. Currently, there is no mechanism for ensuring that the user performs the correct sequence of actions to utilize the vacuum system. An example of erroneous usage is incorrectly turning on the cryo pump at atmospheric pressure which leads to the cryo pump storage tank filling up. If this were to happen, the cooling of the system has to be turned off and the gas has to be allowed to heat up before being ventilated. The system then has to cool back down. This entire process takes several days to complete during which time the electron gun cannot be used.

Also, the current control system is spread out over several controls. This project also aims to gather all controls in a single control device.

The project also aims to implement a universal PID-controller. The scope of the project does not include implementing the PID-controller in the vacuum system, but control of the metal crucible could be controlled using this type of controller. As such, the universal PID-controller enables further work on the control system in the future.

## Project specifications

The control system is to use a touch screen interface with a graphical user interface which displays the current state of the system. The various valves and pumps are to be controlled via the touch screen. The touch screen is run at 3.3V.

The main logic of the control system is implemented on a microcontroller. The microcontroller is interfaced with the touch screen and reads where the user is touching the screen as well as communicating what the screen is to display.

The valves and pumps have existing interfaces for control, however they operate at 24V. This means that an interface is required between the logic levels of the microcontroller, which is run at 3.3V, and the external 24V controls. To protect the microcontroller and touch screen, some form of insulation with regards to the external interfaces is required.

The system should disallow or warn the user when a selected action is not appropriate, for example if the user should attempt to open an erroneous combination of valves.

The universal PID-controller should also be controlled via the touch screen interface. The feedback gains of the PID-controller should be customizable, as well as the reference signal level.

## Project planning

### Hardware

The first objective to be achieved is to get the microcontroller online and programmable on a breadboard for prototyping and testing purposes. Related to this is also establishing correct procedure for communication between the microcontroller and the touch screen and getting the screen to display basic objects. Also, the touch interface should be made to output values when pressed.

Next, the touch interface coordinates should be calibrated such that the coordinates read for a press on the touch interface corresponds to the same position on the graphics display.

To insulate the microcontroller from the digital output side of the system mechanical relays are to be used. These should be tested. On the digital input side of the system, optocouplers should be used. Similarly, these should be tested.

When the components of the system have been prototyped and tested, a PCB is to be designed and ordered along with components. The components are to be soldered by hand to the PCB. When the PCB has been mounted, it is to be tested.

### Software

The first software objective is to program a hello world for the microcontroller to ensure functionality.

Functions for interfacing with the touch screen should be written, essentially an application programming interface (API). A set of functions that provide functionality for communicating with the screen, a set of functions that allow objects and text to be written on the screen and a set of functions for interfacing with the touch interface, for example to retrieve touch coordinates, form the main components of the API.

Using these functions, graphical user interfaces (GUIs) should be designed for the vacuum control system and the universal PID-controller respectively. The vacuum control system GUI should display the current state of the system and visualize a system overview. It should also have menu screen for the various components of the system. The universal PID-controller GUI should have a main screen displaying the current feedback gains as well as the current reference level. It should also contain numerical input menu screens for changing the feedback gains and the reference level.

A main routine is also to be written. This main routine should coordinate the subroutines that handle the touch interface, the drawing to the screen as well as the input and output logic. It should poll the touch interface for user input and draw the various GUI screens on the screen depending on what the user inputs.

# Working principles

## Touch screen

How the touch screen works

## Microcontroller

How the microcontroller works

## PID-controller

How the vacuum system + electron gun works

How the PID-controller works – Place earlier in background or sth?

# Implementation

## Overview of the system

Overview of the system

Touch screen

Microcontroller

MC to industrial grade electronics interface

PID-regulator

## Hardware and components

Microcontroller

PCB

Relays

Optocouplers

Touch screen

## Integrated Development Environment (IDE)

AtmelStudio

## Development tools

Sublime text

Git

USBasp programmer

AVRDUDESS

## Implementation

Present setups and source codes, discuss problems faced and how they were solved

# Results and discussion

Present the results with specific parameters and performance values associated with the specifications and discuss how well the results fulfill the specifications, what problems you encountered and how you found solutions and solved the problems.

# Conclusions

Conclude how well the project has been done and how well the system/project performs (in other words how well the finished system/project performs fulfill the specification). Summarize how the knowledge you’ve learned is applied to the project.

# References

References to code that was used as inspiration

# Appendix

Perhaps some code can be put here