EMBEDDED CONTROL OF A COMPACT GAS CHROMATOGRAPHY SYSTEM

NICHOLAS BARRETT
ZACH MCQUAID
SHAMUS MACDONALD

SUPERVISOR: MR. CHRIS L'ESPERANCE
SPECIAL THANKS TO MR. WILLIAM MCNAIR

DALHOUSIE UNIVERSITY
Department of Electrical and Computer Engineering

Background

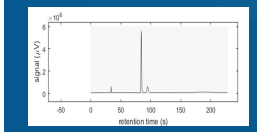
Gas chromatography is used to separate the constituents of a gas mixture and measure their respective concentrations.

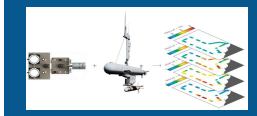
Tracer release experiments are performed by releasing a near inert tracer into the ocean and the distribution is measured over space and time.

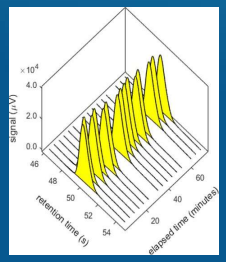
One problem with TREs revolves around the limited resolution of the measurements.

A solution is for the gas chromatography being done faster and more frequently.

This project focuses on the design and development of four system components under the umbrella of 'embedded control of a compact gas chromatography system'.







Objectives

The goal of this project is to refine the gas chromatography system prototype through development of software and hardware.

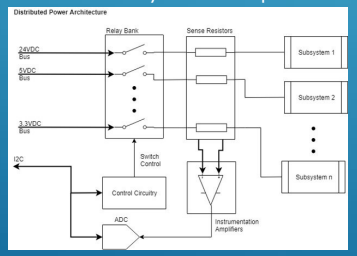
Deliverables include:

1. Design and implement a *relay switching circuit for power distribution*
2. Specify signal conditioning circuitry for driving the data acquisition system
3. Develop a board housing the mass flow sensor, humidity-temperature sensor, and pressure sensor
4. Develop low-level communication routines for devices including mass flow controllers and E2CA valve controllers

1. Power Relay Design

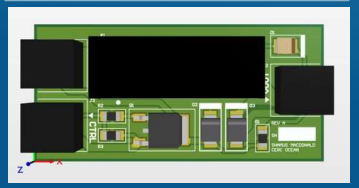
Requirements:
- Easy connectivity
- 24VDC input, 9-14VDC, 5VDC, and 3.3VDC switching
- I2C Communications
- Rated for 5A

Power Relay: Concept



Power Relay: Prototype

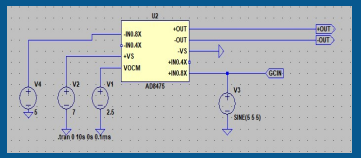
- Single module was breadboarded and verified
- A PCB was developed and verified

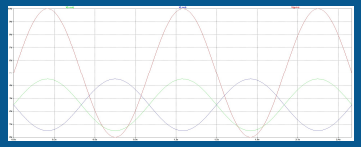


Power Relay: Tests

- Switching voltages verified
- I2C control verified
- Back EMF protection was verified
- 5A Switching verified

2. DAQ Signal Conditioning

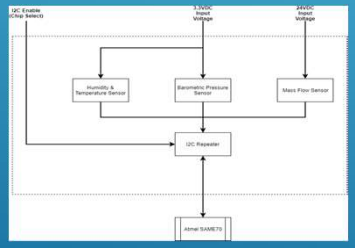




3. Sensor Board Design

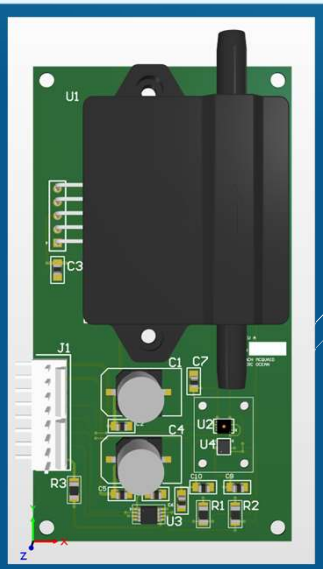
Requirements:
- Easy connectivity
- 3.3VDC & 24VDC Input
- I2C Communications
- Chip Select Function

Sensor Board: Concept



Sensor Board: Prototype

- The sensors being used were already implemented in the system
- A PCB was developed with these sensors on board



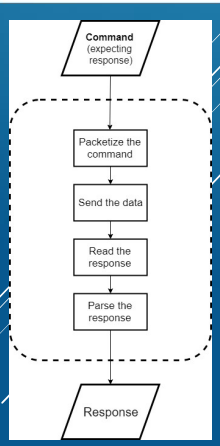
Sensor Board: Tests

- Verify I2C control
- Verify Chip Select

4. Drivers Design

Requirements:
- Software requires error handling/reporting and status monitoring
- Function, structure, variable, and macro naming must adhere to existing conventions of the software.
- The software must be board independent

Drivers: Concept



Drivers: Tests

Unit testing:
- Tested small sections of code

Integration testing:
- Tested multiple small sections working together

System testing:
- Test complete system

Acceptance testing:
- Evaluate system with requirements

Conclusions and Recommendations

The following components were successfully designed by the team:
- Power Relay Board
- DAQ Signal Conditioning Circuit
- Sensor board
- Mass-Flow Controller communication drivers
- E2CA valve controller communication drivers

The hardware and software developed represent significant advancements of the compact gas chromatography system in its ongoing prototype phase.

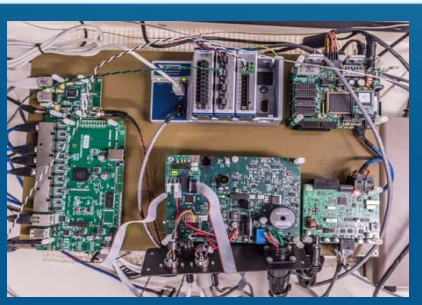
Recommendations:

Power System :
- Integrate current sensing into the relay module.

Sensor Board:
- Replace mass flow sensor with something smaller.

DAQ Signal Conditioning Circuit:
- Create a PCB of the DAQ system

Software Drivers:
- Use driver software design for development of remaining devices.



References

- Analog Devices, "SAME70-XPLD User Guide", ATSAME70-XPLD User Guide 12/2016.
- CERC Lab collection of graphs, figures, and images.
- Horowitz, P., & Hill, W. (2018). The art of electronics. New York: Cambridge University Press.
- Johnson, H. W., & Graham, M. (2011). High-speed digital design: A handbook of black magic. Upper Saddle River, NJ: Prentice Hall.
- Software Testing Levels, "Software Testing Fundamentals", http://softwaretestingfundamentals.com/softwaretesting-levels/.