ECE 499 Projects offered by CfAR

About UVic CfAR

University of Victoria Center for Aerospace Research (UVic CfAR) has become a Canadian leader in Unmanned Air Systems research, design, integration and testing. UVic CfAR has provided services for major aerospace companies as well as supporting small to medium Canadian businesses as they prepare to enter this fast growing market. In Canada, these companies include Bombardier Aerospace, Meggitt Training Systems Canada, Rigid Robotics, Terra Remote Sensing, Brican Flight Systems, DRDC, Viking Air, and internationally, UVic CfAR has been collaborating with Boeing (USA) and EMBRAER (Brazil).

UVic CfAR is offering four unique projects for students registered in ECE 499 in summer 2020. These projects are as follow:

**Project 1:** Design, control and optimization of the hybrid electric propulsion system design and optimization for unmanned aerial vehicles (UAV)

**Project 2:** Design a motor controller with regenerative capability for hybrid electric propulsion system design and optimization for unmanned aerial vehicles (UAV)

**Project 3:** Design, assembly and manufacturing a Power Distribution Board.

**Project 4:** Battery monitor.

Description of each project is next:

Hybrid Electric Propulsion System Design and Optimization for Unmanned Aerial Vehicles (UAV)
Project Description

As the aviation industry transitions to more efficient propulsion technologies, hybrid electric propulsion systems offer several benefits over more conventional propulsion systems. At UVIC CFAR unmanned aerial vehicles (UAV) of various sizes and configurations are designed and tested for airworthiness and research purposes. A parallel configuration hybrid electric test bench was developed and provides opportunity for detailed experimentation and analysis. The results of these experiments will provide valuable information in the design and implementation of a hybrid propulsion system onto a UAV.

Project 1: Client Resources

CFAR will evaluate the recommendations for the project and procure necessary components to achieve the objectives of this project. CFAR will provide funding for the approved components that will be used directly in the test bench, as well as raw materials. CFAR will provide facilities and assistance for the experiments. Prototyping of components for this project is possible with the 3D printer at CFAR. Babak Manou is the primary contact at CFAR for this project.

*Figure 1: Hybrid Test Bench First Prototype - CAD and Assembled Test Bench*
Figure 2: Hybrid Test Bench Revision - Upgraded Transmission and Torque Sensing
Project 1: Intended Scope & Deliverables

The primary objective of this project is to make improvements to the preliminary design of the parallel hybrid-electric propulsion system test bench developed at UVIC CFAR. The engineering design group is to make recommendations to improve system efficiency, and experimentally show this improvement compared to the baseline performance data provided. The engineering design group will also work to increase robustness of the supervisory controller design of the test bench that is implemented in National Instruments LabView. The scope of this project includes detailed electrical design of power electronics, PCB development and bread-boarding of prototype designs, testing and handling of power electronics and instrumentation, and software engineering for controller design.
Project 2: Intended Scope & Deliverables

The client is looking to create an electronic speed controller to implement into the hybrid test bench. This speed controller needs to improve upon the specifications of the baseline controller from Enertion RC, the VESC. (Hardware Specifications Voltage rating of components 8V-50V. Compatible battery 3S to 12S. Recommended 10S battery. 300A Peak Current Limit. 60A Continuous Current.) Regenerative braking capability must be included as well, to match or exceed the performance of the VESC at 30A regenerative brake. The VESC is based on open-source project, including firmware and GUI from Vedder (http://vedder.se/) GIT Hardware, Desc, PinOuts, Gerber, 3D Files at: (https://github.com/vedderb/bldc-hardware)

Project 2: Client Resources

CFAR will evaluate the recommendations for the project and procure necessary components to achieve the objectives of this project. CFAR will provide funding for the approved components that will be used directly in the test bench, as well as raw materials. CFAR will provide facilities and assistance for the experiments. Prototyping of components for this project is possible with the 3D printer at CFAR. Babak Manou is the primary contact at CFAR for this project.
Figure 4: Example of Files provided for VESC.
Figure 5: Available schematic for BLDC controller.
Project 3: Design, assembly and manufacturing a Power Distribution Board.

The Power Distribution board (PDB) is a four-layer PCB. The PDB houses all the circuitry required for the Buck and Boost converters to boost or buck voltage for desired value. PDB provides 5 different voltage levels required in the aircraft. The nominal voltage level is unregulated 12V input from the battery.

The 8V, 5V and 3.3V converters are designed and tested for this board. CFAR is looking for a team to improve the design and add 24V, 6A boost converter to the circuit. In addition, all the protection circuitries like over voltage, reverse polarity and over current protection needs to be design and added to the board. Also board should have control over output voltage and be able to monitor the voltage and current at each channel and report it to the autopilot.

Figure 6 - CfAR Power Distribution Board
Skills required for this project:

- PCB design using Altium software.
- Capable of processing data and applied mathematics of test results
- Independent development and debugging of software programs
- Experience with standard interfaces / protocols (e.g., SPI, UART, I2C, USB, BLE, CAN) a plus

Project 3: Client Resources

CFAR will evaluate the recommendations for the project and procure necessary components to achieve the objectives of this project. CFAR will provide funding for the approved components that will be used directly in the test bench, as well as raw materials. CFAR will provide facilities and assistance for the experiments. Prototyping of components for this project is possible with the 3D printer at CFAR. Babak Manou is the primary contact at CFAR for this project.
Project 4: Battery monitor PCB design and test.

The purpose of this project is to design a small PCB to monitor and report the condition of flight batteries like State of the Charge (SOC), Voltage, Current, number of cycle etc. This project involved the use of several communication protocol standards and state-of-the-art components. The final design contains four sub-systems. A primary PCB is designed and manufactured for this project. Also 50% of coding and 100% of CANBUS communication is accomplished. This project is well documented and is available for review.

Project 4: Client Resources

CFAR will evaluate the recommendations for the project and procure necessary components to achieve the objectives of this project. CFAR will provide funding for the approved components that will be used directly in the test bench, as well as raw materials. CFAR will provide facilities and assistance for the experiments. Prototyping of components for this project is possible with the 3D printer at CFAR. Babak Manou is the primary contact at CFAR for this project. List of available components and software for this project is as follow:

**bq40z80 Evaluation Board**

This device acted as a surrogate for the Monitor PCB while the latter was in development. It is a circuit board containing the same monitor IC, the bq40z80, as our custom PCB. It also contains the same connections to battery balance leads and to a host processor. The device is an evaluation product from Texas Instruments made for the purpose of gaining experience with the bq40z80 IC.

**BQ Studio Software**

This MS Windows software package is used for initial configuration of the ‘golden file’ of the battery monitor IC. This file contains detailed information on the predicted behaviour of the battery during its lifetime. This information helps it produce a more accurate State of Charge measurement.

**Arduino Uno SMBus Interface**
For the initial prototype version of the OnTrak Battery Monitor, an Arduino Uno acted as an intermediary between the Monitor IC and the Host Micro-Controller. In effect the Arduino became the host by polling the Monitor IC for data and forwarding it to the NUCLEO-446 via a UART standard serial connection.

Skills required for this project:

- Microcontroller prograning (STM32)
- Experience with standard interfaces / protocols (e.g., SPI, UART, I2C, USB, BLE, CAN)
- Capable of processing data and applied mathematics of test results
- Independent development and debugging of software programs

Figure 7 - OnTrak System Architecture.