Power Management System Design for In-Flight Power Generation and Storage in UAVs

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Unmanned aerial vehicles, or UAVs, have played a dominant role in modern day society. The usage of UAVs ranges from agricultural analysis and precision military operations to surveillance and weather observation. Although UAVs have a variety of routines and are manufactured in different shapes, one aspect remains constant: every UAV must possess a viable, affordable, and efficient power management system that will allow the vehicle to maintain functionality. This project involves designing an inflight power generation, management, and storage system applicable to UAVs. To extend the battery charge, aircraft range, and overall capabilities of a UAV, power can be generated from multiple environmental sources during flight, including solar power and wing structural vibration induced power generation. These sources of "free" energy can be harnessed and used to power an electric motor and propeller propulsion system while the UAV is in operation. In this project, we will explore several methods of power generation, power management, and power storage devices including ultra-light weight 3-D printed graphene super capacitors to replace heavy Li-Ion batteries. These devices will be connected to a power management system, and the system will optimize power usage throughout the entire vehicle and storage of the excess electricity into graphene supercapacitors.

The main power management system draw power from three sources: photovoltaic solar energy from the solar cells, flex-compressive strain energy harvested through the piezoelectric generators, and mechanical energy, induced by subcritical flutter, from the spring-motor-generator device. The solar cells will be located on top of the UAV, maximizing exposure and electricity generation. Piezo electric generators will be attached to the root of the wing where most bending strain occurs. The spring-motor generator will be situated inside the UAV where it will convert movement from wing vibrations into electricity. The power management system itself consists of six components: rectifiers, Maximum Power Point Tracking (MPPT) boards, balance boards, alarms, diodes, and supercapacitors. Rectifiers on the MPPT boards will allow the generated power to be inputted into the system at an optimal level. The MPPT board will maximize battery life and power output. Connected to the MPPT boards, the balance board will distribute energy evenly to the graphene supercapacitors, and diodes will prevent negative current feedback into the generation devices. An alarm system is implemented to alert whenever the output voltage reaches a low level because it could potentially harm the entire system.

This project will be entering its fourth year of development under the supervision of Professor Jenny Yu. Every year, each project team builds upon the research and progress of the previous team. This project is one of four support technology development projects under the Aerospace Engineering Department Aeroelastic Power Generation Project, which began in 2012 under Professor Steven Dobbs.

This joint project includes four Cal Poly Pomona engineering departments: The Electrical and Computer Engineering (ECE) Department, the Aerospace Engineering (AE) Department, the Chemical and Materials Engineering (CME) Department, and the Mechanical Engineering (ME) Department. The ECE Department will oversee the creation of the power management system as well as the assembly of a robotic arm which will be used to aid in the development of a supercapacitor. The ME department will continue to conduct thermal management designs for the power management sub-system. The CME Department will assist in the optimization of the supercapacitor, the device in which power will be stored. The AE Department is developing a 3-D printed, fiber-reinforced flexible composite structure wing wind tunnel model, a power pod to house the motor-generator mechanisms, and conducting wind tunnel tests of the wing-power pod in the presence of simulated gust and flutter excitation.

The power generation and management system will be implemented onto our solar powered UAV electric propulsion test aircraft in the future and eventually can be applied to other UAV systems to expand their usage and effectiveness. Application of the system could possibly be scaled to accommodate larger crafts, reducing the need for heavy battery banks. Our system may prove useful in certain situations such as mandatory reconnaissance or important research and may lead to new concepts for UAV design. We also strive to one day produce UAVs that will be capable of sustaining record-breaking endurance flights.