Power Management, Generation, and Storage Methods for Sustainable UAV Flight

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The use of UAVs (Unmanned Aerial Vehicles) serve many different important roles in society, ranging from military use, space exploration, search and rescue, law enforcement, and the media and entertainment business. Drones are in their infancy, but with further developments in their flight sustainability can lead to numerous benefits. This paper investigates the recent research and testing of a multi-year project on the concept of an unmanned aerial vehicle being powered by the natural environment our drone will encounter during its path of flight. This project involves departments from the aerospace, electrical, chemical, and mechanical engineering departments and helps bring together expertise from each of these departments in research and developing this UAV. The drone's flight will be achieved with power generation, management, and storage systems that are seamlessly integrated together onto our UAV wings and fuselage, demonstrating a flying battery concept. After a baseline UAV flight is tested with lithium polymer batteries, different power generation devices will be added with a power management system in order to harvest available energy and increase flight endurance. Super capacitors will be added next in order to improve charge times the lithium polymer batteries are lacking in with the hopes to provide quick boosts of power for UAV takeoff and maneuvers and reduce parasitic weights. If proven successful, increased flight times can help improve better surveillance capabilities for military use or in helping search and rescue efforts look for lost hikers since the drones will be able to reach remote places more easily.

The power generation devices will consist mainly of three sources: flexible solar cells, thermoelectric generators, and two power pods installed under the wing which house vibration induced DC motors. These different forms of energy are both DC and AC and will be combined into one DC source for the UAV storage devices and help replenish the charge of these devices as the UAV flies during the day and night. The solar cells will be stretched into the form of wing skins and be placed as an upper layer on the wing and output a DC signal. The power pods will produce an AC signal since the motors are attached to a leaf spring and oscillate on a gear/rack mechanism from the vibrations and spin the motor shaft. Our thermoelectric generators produce voltage due to a difference in energy between the hot and cold plates at varying temperatures. These different signals are combined into a power management system that is based of off a hybrid power design and takes the input sources of power and combines them into one stable DC source to charge our power storage devices of lithium polymer or super capacitors to discharge and power the DC motor.

The power management system can combine these sources of energy with a power distribution board that combines the collective current from each source. Now the power distribution board relies on straight DC signals, the AC signal from the power pods will be rectified using a polyphase rectifier in which each AC signal is placed between two diode per phase with a resistive load connected in parallel. This configuration is a full-bridge rectifier and the diodes will only allow current to flow in one direction and block current in another. This essentially will only allow current to flow in one direction on each alternating wave and represent a DC signal. These DC sources will then be fed into a buck-boost converter and operate as a boost converter since the input voltage source will be lower than the required output voltage of 12 volts. Each end of our converter is at different polarities and energy is stored in an inductor between them with a passive and active switch turning the device on and off. The output voltage is then boosted from the change in current of the inductor and the duty ratio of our active switch. This boosted voltage will be fed into a power distribution board and an Arduino Nano and relay board. Our distribution board ensures our voltage will spilt evenly to charge each cell of our power storage device and the Arduino Nano will switch between our storage banks to power our DC motor.

The final component of our power system is power storage devices and will first be a lithium polymer battery and then modified to accommodate super capacitors. Lithium polymer batteries were chosen due to their higher charge and discharge requirements. The LiPo can generate enormous amounts of current for our DC motor and give it the required amount of current for each percent throttle on takeoff. The design will first include one 2200 mAH LiPo and then be downscaled to two smaller LiPos to match the original LiPo while decreasing charge current. Super Capacitors will be implemented due to their quick charge time and lighter weight and be used in limited applications for takeoff and maneuvers. The super capacitors will be in-house developed and be comprised of graphene while forming the bottom skin of the wing. Graphene was chosen due to its strong tensile properties and high capacitance. Polytetrafluoroethylene (Teflon) will be used as a dielectric and stainless-steel sheets to add flexibility. The electrolyte gel will finally be comprised of sulfuric acid, phosphoric acid, and polyvinyl alcohol.