Abstract

Unmanned Aerial Vehicles (UAVs) have become increasingly popular in recent years, both in the commercial industry and in hobby applications. The applications of UAVs are very wide. These include taking videos and photos from a bird's eye view, monitoring threats such as fires, mapping areas, crop inspection, search and rescue works. Depending on the structure, geometry, power transmission method, and flight duration, the target purpose of the UAV may change.

One type of Unmanned Aerial Vehicles are Vertical Take-Off and Landing (VTOL). The ability to take-off vertically allows to start flight anywhere without the use of runway. The advantage of VTOL is also access to highly urbanized areas, remote areas, and observations in difficult weather conditions.

The issue that most limits UAVs and other flying vehicles is the flight time and range. The limited flight time of the UAV causes the need to land and the resulting loss of time in terms of interrupting the mission, charging or replacing batteries. In order to extend the mission, designers are looking for opportunities to obtain external energy. The goal is to achieve full energy autonomy enabling continuous flight without the need for unnecessary landings. Energy autonomy of UAVs is an important direction in the field of aerospace because, in addition to the possibility of continuous operation, an additional advantage is the lower cost of this type of application than using a satellite.

The aim of the doctoral dissertation was to develop a method to extend the flight time of an Vertical Take-Off and Landing Unmanned Aerial Vehicle. Due to its universality, the method was also supposed to be applicable to various types of UAVs, including: VTOL, HALE (High-Altitude Long-Endurance) UAV, LALE (Low-Altitude Long-Endurance) UAV, and other types of UAVs.

The doctoral thesis focused on developing a general model of the solar-powered UAV power supply system. It included, among others: a solar irradiation model depending on the date, location and weather conditions, a photovoltaic system model, an energy storage model, and an energy demand model.

The result of the author's work is a simulation model that has been appropriately tuned with data obtained during numerous laboratory tests — among others, photovoltaic cells, battery cells, and other systems on board the UAV.

The doctoral dissertation includes three case studies: two fixed-wing UAVs - one LALE and HALE class object - as well as a tail-sitter VTOL. A different power supply configuration was developed for each case study. The analyzes carried out allowed obtaining data of the energy balance, battery state of charge, and the degree of possibility of extending the UAV flight depending on the type of class of the flying vehicle.

During work related to the doctoral thesis, a LALE UAV prototype was built, which was included in this doctoral dissertation as one of the case studies. Verification of the systems and individual elements allowed for comparison of the results of the simulation model with the real system.