Prague 27.7.2022

Review of thesis supervisor

Thesis title: Control Systems and Electronics for 2.9 kW Internal Combustion Engine and Battery Hybrid Multicopter Based on Power Tracking Method

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Study program: Master Program: Automation and Instrumentation Engineering

The goal of the thesis was to design and build a control system for electric power delivery in a hybrid powered drone.

The specific goals were:

1) Design of block connections for power electronics
2) Simulation model of a control system for a generator
3) Experimentally validated control system

The thesis focused on the design of the control system in terms of control of electric power that the generator is producing. It is related to a construction of a multicopter, but the multicopter design is not a part of the thesis. The multicopter design was students own private project. The goal of the hybrid system is to extend the flight time above what is possible with batteries. The generator is coupled to an internal combustion engine (ICE) fuel by gasoline. In flight it is necessary to control the delivered power with respect to the battery state of charge (SOC) and the agility of the maneuvers. The ICE is controlled by adjusting the throttle and choke, so two basically position signals, typically controlled by a servo. The herein designed control system captures the multirotor variables such as battery voltage, current, SOC, motor current etc. and based on them produces the control signal.

In the introduction the student explains the necessity of building such device and summarizes the benefits of the hybrid system. Next the student focused first on the design of the hybrid multicopter (HMC). Although not part of the tasks, it is necessary for the understanding of the generator control.

In chapter 3 the student explains in detail the block connection for the power electronics and explains the functionality of the parts. He also explains the reasoning, why did he choose specific components, based on what criteria. The block diagrams are made in a good graphical fashion.

Chapter 4 describes the design of the control system from the hardware and software point of view. The student has chosen a Nucleo board programmed from Simulink. This allowed him to develop and later verify the control system first with a simulation model of the HMC, and later to validate the simulations experimentally.

In chapter 5 the student describes experimental validations and presents description of the experiments. There is a details study of the signal acquisition of different measured variables on the HMC. He also describes the failures that occurred during the experimental testing. In general, this part has a good quality.

Overall, the thesis is very good. It is readable, the text is amended with many pictures in good quality. In general, I would prefer a shorter length, not 86 pages including the appendix, but the thesis is simply long because the student has done a lot of work, not because he tried to artificially extend it.

The **student was very active** it the thesis solution. He came regularly to our weekly meetings and has also shown results on other occasions. I was very satisfied with his activity, work and results.

I recommend the thesis for presentation and evaluate the thesis with grade „A - excellent“.

Doc. Ing. Martin Novák Ph.D. – thesis supervisor

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