WROCŁAW UNIVERSITY OF SCIENCE AND TECHNOLOGY

FIELD: Automation and Robotics
SPECIALISATION: Embedded Robotics

Intermediate Project

Inteligentny sterownik BLDC

Smart BLDC Driver

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Abstract

The report describes the results of work that was done in designing a controller for brushless direct current (BLDC) motors. This report describes the results of the work done in designing a controller for brushless direct current (BLDC) motors. Information about the controller design, operation and capabilities is included.

All project objectives have been met.

0.1 Introduction

The aim of the project is to design and manufacture a three-phase BLDC motor controller (electronic commutator), allowing the use of several control methods such as 6-step, SVPWM, FOC. The controller will also be equipped with components allowing monitoring of operating parameters[4] in order to facilitate research on particular control techniques. This monitoring will be done via USB protocol.

Brushless motors, unlike brush motors, do not rotate coils but magnets. The coils are attached to the stator and therefore do not move. This eliminates the need for physical commutators or brushes. Since this motor cannot operate without a conventional commutator, an electronic equivalent is used instead of a physical one. As in the brush motor, here too the rotation works on the principle of attraction between the magnetic halves of coils and magnets. So a current must flow through the stationary windings so that it generates a rotating magnetic field which sets the motor's rotor in motion. This whole procedure is carried out in a synchronous manner. The angular velocity of the generated field is equal to the speed of the rotor. For this reason, this motor, is classified as a 'synchronous' motor.

The electronic commutator, which replaces the brushes, introduces many advantages over the classic brush DC motors:

- higher efficiency and reliability,
- better speed and torque characteristics,
- longer service life,
- smaller size and lighter weight,
- less noise.

0.2 Commutator design

The power supply of a three-phase motor requires the use of three H-bridges. Each of the H-bridges consists of at least two power transistors, which must be controlled in an appropriate way depending on the applied control algorithm and additionally respect the so-called dead time (the time when both H-bridge transistors are open causing momentary circuit short circuits) in order to maximize the efficiency of the controller.

Figure 1 shows a simplified diagram of the electronic circuit. It contains the most important elements that will allow for effective implementation of the mentioned control algorithms Based on the monitoring circuitry, the logic unit can determine which control

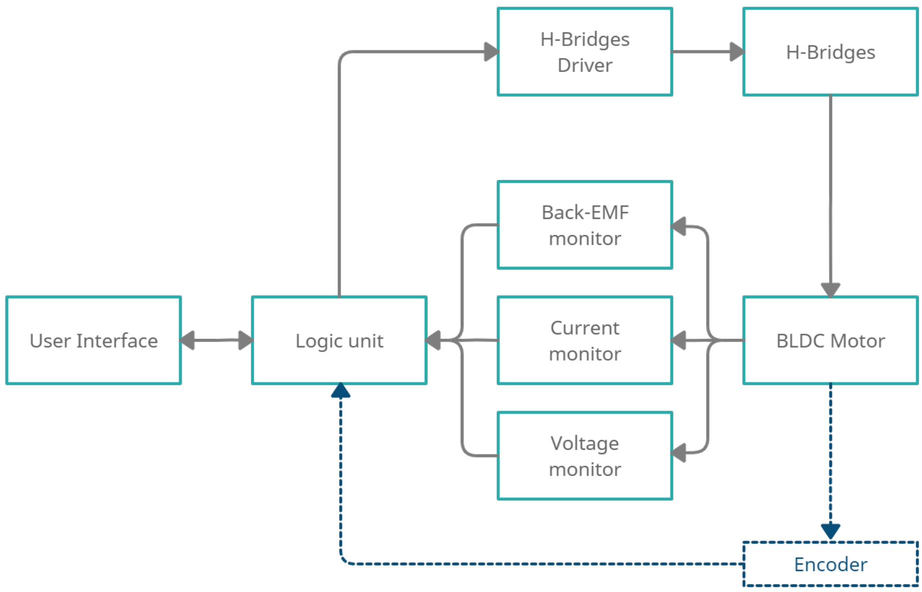

Figure 1: Diagram of the electronic circuit

to use for the current motor conditions. The logic unit can take information from 4 different circuits:

- The Back-EMF monitoring circuit is used to implement a sensorless 6-step control algorithm.
- Current sensors control the torque and protect the system from excessive current consumption
- Voltage and current sensors allow for rotor position estimation based on a mathematical model of the motor
- An encoder that will allow for sensor-based control. Does not have to be used

A high current flowing through the gates is required to minimize the switching time of the transistors. For this reason, an external MOSFET gate driver is used to ensure fast switching and to protect the transistors from simultaneous opening of the upper and lower transistors in the H-bridge. To reduce energy loss due to transistor resistance and to increase heat dissipation capability, 4 transistors were used for one H-bridge instead of 2.

User can communicate with the controller via USB interface or via analog potentiometer to control motor speed.

Eagle environment was used to design the PCB. The physical representation on the PCB design is shown in Figure 2. Since the sensors operate in a noise-sensitive environment, it was important in the design to ensure that noise caused by high-frequency current flowing through the transistors was isolated as much as possible. For this purpose, among other things, a ground shield was used to absorb most of this noise. Figure 3 shows that one whole PCB layer is dedicated to the ground polygon.

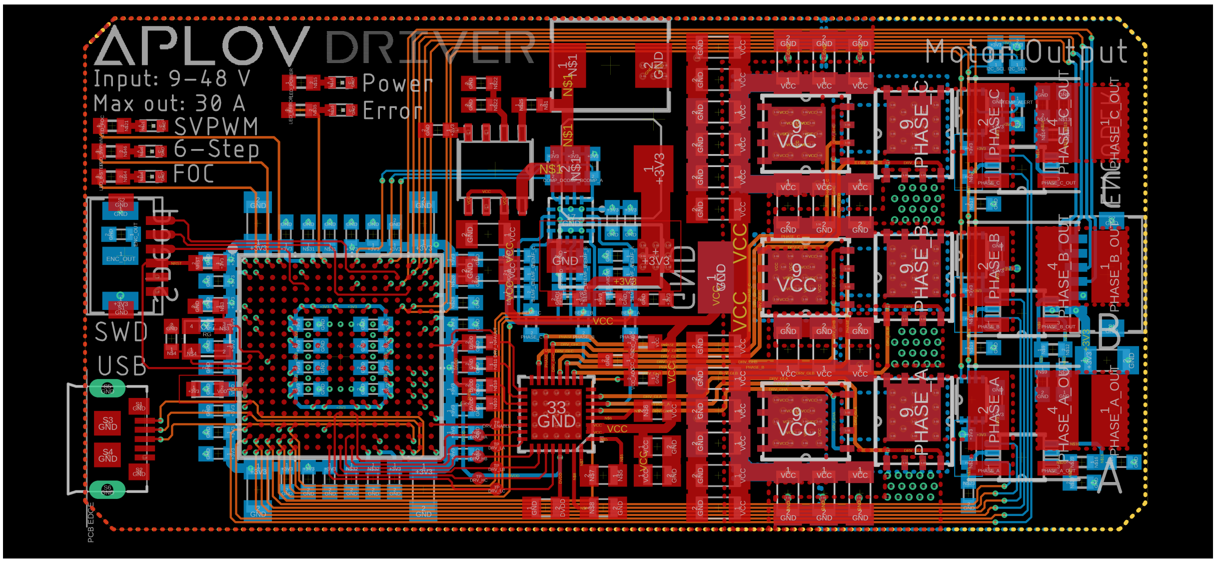

Figure 2: PCB Layout

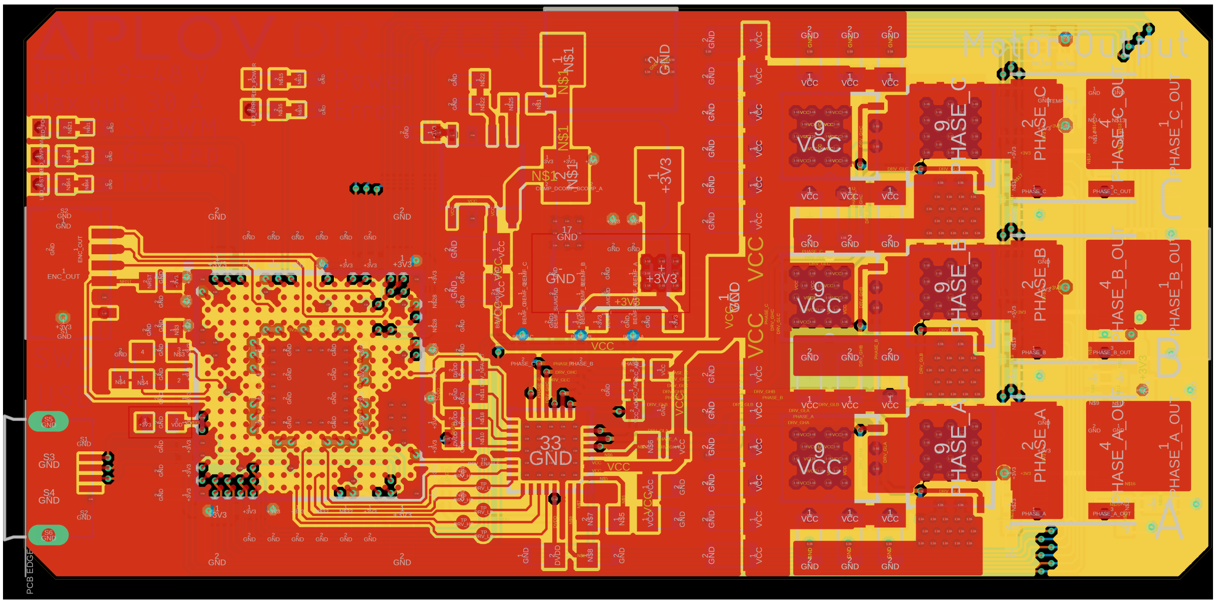

Figure 3: PCB Layout - ground shield

0.3 Electronic assembly

The assembled electronic circuit is shown in Figures 4 and 5

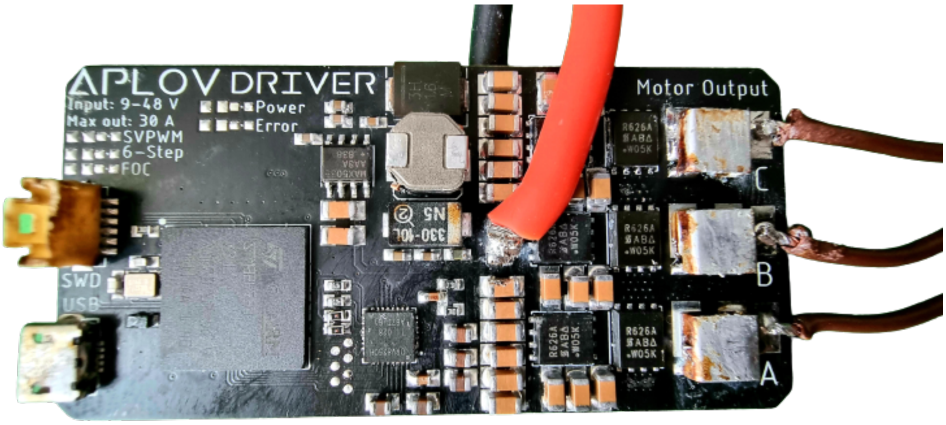

Figure 4: PCB - up

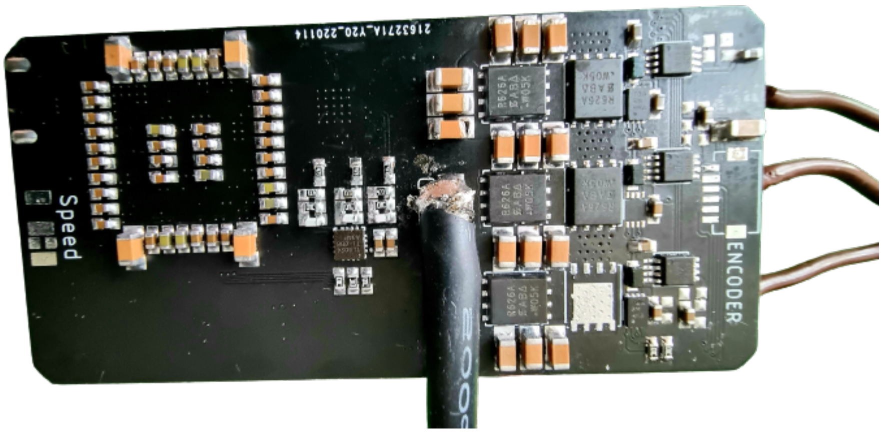

Figure 5: PCB - down

Limitations of the BLDC controller:

- Supply voltage: $9V$-$48V$
- Maximum continuous output current: up to $5A$ without heatsink.

0.4 Performance test

The critical components to test were to verify the operation of the H half-bridges, the MOSFET transistor driver, and the current sensors. The rest of the components are converted to voltage, which is directly measured through an analog-to-digital converter built into the logic unit.

Figure 6 shows a snapshot of the PWM waveform, which represents the output voltage from the controller that powers the BLDC motor (blue waveform) and the superimposed current sensor output that converts the output current to voltage. The measured wave-

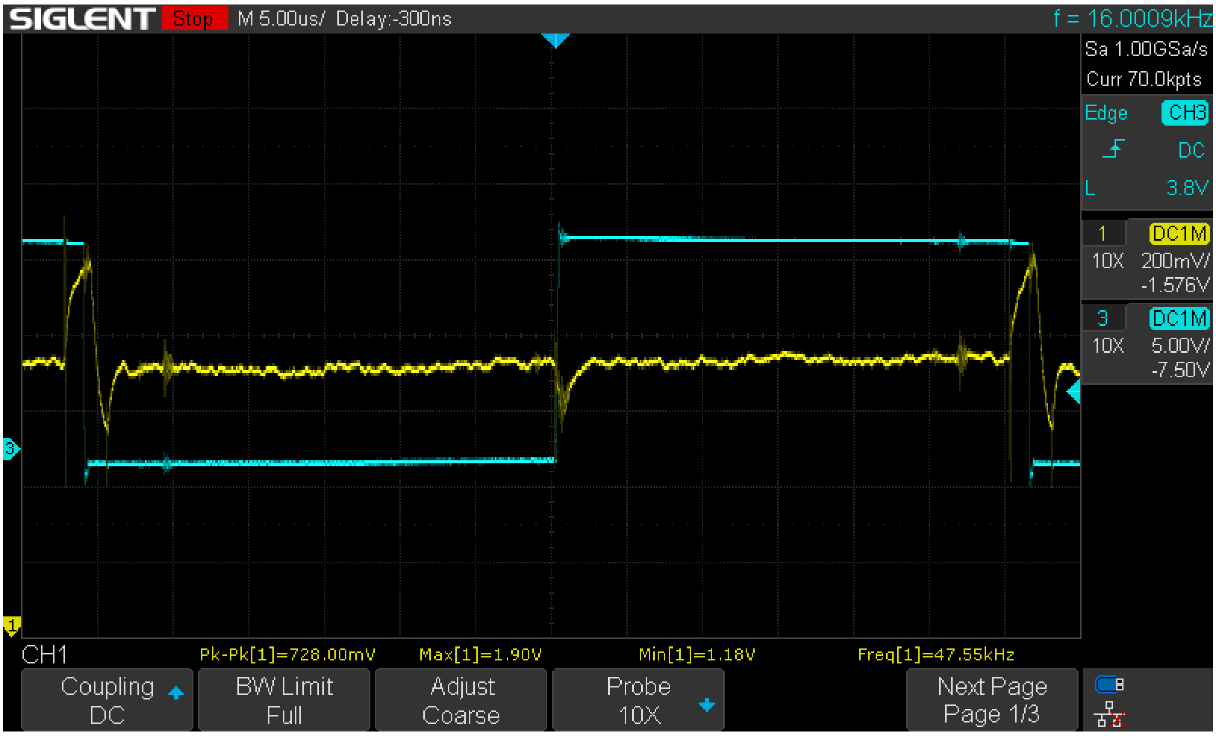

Figure 6: Performance test

forms show the correct operation of both the transistor gate driver and the H-bridge. The output waveform was generated with the motor connected. You can see that the current is measured correctly based on the current spikes when changing states from high to low and vice versa. This is caused by the motor coils, which counteract the change in current flowing in the windings.

0.5 Summary

The report presents, how the designed electronic commutator works and presents the key aspects of operation. The final result meets all the objectives and is ready for further software development.

Bibliography

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