Masters Project – Design of a Torque-Controlled Carrier for Non-Linear Braiding of Composite Materials

TECHNICAL REQUIREMENTS FOR THE MOTOR CONTROL SYSTEM BASED ON THE ODRIVE ROBOTICS MODULE

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Introduction

Currently, a system is being designed to be used in the braiding of composite materials and other subjects related to spool un-winding at controlled torque. Multiple tests have been made using a hobby brushless motor and the ODrive module v3.6, 24v. The tests have been conclusive and now the the project has to move on to the next phase, in which the ODrive module have to be adapted to our application. This present report will detail the technical requirements of the newly designed board based on the open-sourced hardware and firmware of the ODrive v3.6.

Project Overview

During the braiding process, the composite fiber (such as carbon, glass, aramid) has to be under a small tension (force) so that the fibers braid properly with good mechanical properties. Currently, the industrial braiding carriers uses springs, rollers and a release mechanism to ensure a certain force, but these mechanisms are not effective because the force is not constant due to the compression and decompression of the springs, and because at each release mechanism, there is an impact force on the fibers that damages prematurely the integrity of the material. To overcome these mechanical issues and to improve the mechanical performances, a torqued-controlled carrier will be used, thus replacing all mechanical components by a more compact and more efficient system. Although this solution will improve performances, it also has its challenges, such as carrying a battery for an 8h autonomy while being as compact and light as possible. The tests that has been made with the ODrive have been conclusive and it will be able to deliver the required performances after some modifications. For the braiding carrier, the range of force during the braiding is below 5N, which translates approximately to a current below 15A in the BLDC motor (in the *d-q* rotating reference plane), depending on the radius of the final spool design. In the following section, a brief overlook will be made on the currently used ODrive module, with specific remarks on critical components. The ODrive module is composed of both hardware and firmware.

ODrive Module – Hardware and Firmware

The ODrive's hardware is capable of running two BLDC motors (and two encoders), using a bus supply from 12 to 24vDC. Each of the motors is controlled by an DRV8301 driver that uses two shunt resistors (on phase B and C) to provide a feedback on the current of the motor. The current design of the ODrive uses shunt resistors that can handle currents over 60A, which is way beyond the scope of the braiding carrier. This translates in a current reading that has a lot of noise for low current applications, which causes performance issues. Regarding the firmware, it has to be modified to incorporate all the changes brought to the board (such as modyfing the shunt resistors values).

New Requirements

In the scope of the masters project, it has been determined that the fastest way to proceed is to change as little as possible the ODrive v3.6 module until a first prototype has been made as a proof of concept for the torque-controlled braiding carrier. After the proof of concept has been made, a completely new electronics board will be designed to minimize the volume of the electronics, making the prototype more compact. Here is a list of requirements:

1. Control one single BLDC motor and one single encoder
2. Use shunt resistors to handle up to 15A
3. Reduce the size of the board as much as possible
4. Compatibility with the Battery Management System (BMS) for a 4 cell Lithium-Polymer battery (14.8v)
5. Compatibility with a Raspberry Pi Zero Wireless