Development of test setup for direct driven hydraulic actuator

Content

1.Introduction

Todays industry is constantly trying to improve their profit and reduce their impact on the environment. Within different industries there is a wide use of hydraulic systems, these systems typically use valve-controlled systems. The valve-controlled systems are not very efficient due to throttled pressure losses and heat losses[1][2][3]. With new technologies and improved affordability of electric drives, direct driven hydraulic (DDH) systems have become an interesting topic for improving current valve controlled hydraulic systems. DDH systems can be more efficient and compact compared to the traditional systems, additionally they also offer improved controllability [4]. Several major companies have started to incorporate this technology on their products[9][10]. They claim that it improves the efficiency and reduces the emissions.

The goal of this project to develop a test setup of DDH. The test setup is driven by a brushless DC motor which drives a hydraulic bidirectional motor/pump. The pressure generated from the motor is then used to drive a hydraulic cylinder. The system should be fitted with sensor so that all necessary data can be red from the system, e.g. efficiency, power and temperature.

2. Method

2.1. System description

The system has two sections, one being the mechanical section consisting of the hydraulic components, the other section is the electronics drive and sensing. The cylinder is a symmetric cylinder with a piston diameter of 63 mm, rod diameter of 43 mm. The hydraulic power comes from a bi-directional hydraulic motor with a displacement of 1,48 cc/rev. These are the major components of the hydraulic system, besides these there is also a hydraulic accumulator, pressure sensors, pressure relief valves and check valves.

The electric drive is built around three major components, the electric motor, motor controller and micro controller. The electric motor is a brushless outrunner DC motor with a power of 5300W and max voltage of 44V. To control this motor a programmable motor controller was used. The logic for the system is given by an Arduino Uno. The Arduinos task is to decide how the actuator behaves by setting different outputs to the motor controller. The Arduino also monitor the system by reading different inputs from the sensors of the system to make sure that the system is working within safe margins. The main safety measurements will be temperature of the electric motor, temperature of the MOSFETS on the controller and temperature of the hydraulic fluid. To be able to measure the efficiency of the system, torque measurements of the electric motor are also needed. Two types of position sensors were also used one magneto restrictive and a time of flight sensor. To power the whole system three 12V batteries in series are used. For more details of the components please see table 1 and 2.

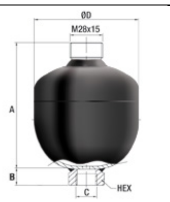
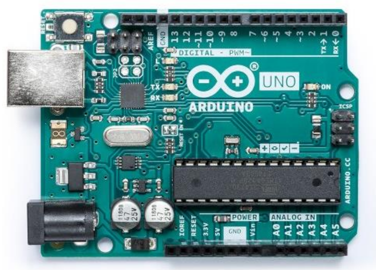
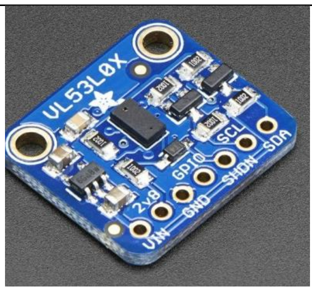
Component	Picture	Specifications
Hydraulic cylinder		Type: welded milled Symmetric cylinder Piton Ø :63 mm Rod Ø : 45 mm
Hydraulic motor		Rotation - Bi Directional Displacement: 1.48 cc/rev Torque – Approximately: 1.47 Nm/70 bar
Accumulator		Volume: 0.05 l Pressure: 50/330 bar
Pressure sensors	No picture atm.	2 Pc. 100 bar 1 Pc. 1->5 bar

Table 1. Components of the Hydraulic system.

Component	Picture	Specification
Electric motor		Turnigy RotoMax 50cc Brushless outrunner motor. Max current: 120A Watts: 5300w No load current: 44V/1.65A Internal resistance: 0.021 ohm Kv(rpm/v): 172.00
Motor controller		FM Pacer Motor Controller-based the VESC® Open Source Project Voltage: 8V – 60V Current: Up to 240A for a couple of seconds or about 50A continuous
Arduino		Microcontroller: ATmega328P Operating Voltage: 5V Input Voltage: 7-12V Digital I/O Pins: 14 (6 PWM) Analog input pins: 6
Linear displacement transducer		GEMCO 955A BRIK Gen III Input voltage: 13.5-30VDC Output voltage: 0-10VDC Non-Linearity: +/- 0.05% of Stroke Repeatability: +/- 0.006% of Full Stroke Internal Resolution: 0.001"
Time of Flight sensor		VL53L0X Range: 2m

Temperature sensor		OL-SNS-TMP10K NTC Range: -30+110°C Precision: 1% Resistance: 10KΩ ±1% at 25C
Torque sensor		Undecided
Battery		3 x 12V batteries in series.

Table 2. Components of the electric drive and sensing system

2.2. Programming of Arduino

The Arduino the test setup is done in the Arduino, here the number of operation cycles are defined and the speed of the actuator can also be decided. The Arduino controls the speed by sending a pulse position modulation (PPM) signal to the VESC. The VESC in turn feeds a signal back via the UART port to the Arduino informing about the temperature of the motor, MOSFETS and the electromagnetic rotation speed. The Arduino monitors these values to make sure the system is operating within its limits. In case some limits are exceeded the operation stops.

2.3. Design and construction of piping

[This is the last stage of the project, we have not started on this yet]

2.4 Other work

[Explanation and reporting of project work]

3. Results

[Results from our work]

4. Discussion

[possibility of further improvements]

5. References

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