FOSWEC2 Repair and Upgrade

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# Introduction

This report documents the efforts in repairing and upgrading the FOSWEC2 device. Major efforts include:

* Replacement of motor encoders from analog to digital based design
* Pendulum testing of motors and new encoders to establish torque constants
* Comparison of
* Dry swing tests of flaps in an upside-down configuration of the FOSWEC2
* Repair of 6DOF load cell whose cable was compromised
* Complete update to MATLAB/Simulink operating software to update to new Speedgoat operating system and user interface
* Wave basin testing of the FOSWEC2 to verify all changes

# Encoder swap

A feedback stability issue with the FOSWEC2 deployment in February 2020 was identified and potential solutions explored. One issue identified was encoder noise. The original absolute encoder used on the FOSWEC2 was the Sick SKS36-HFA0-K02 with Hyperface interface. The encoder specs include 128 sine/cosine periods per revolution and 4096 total number of steps. As this is a hybrid analog/digital transducer, it is possibly susceptible to noise from the surrounding environment.

The Heidenhain ECN 1123 512 with EnDat2.2 interface was chosen as a fully digital replacement absolute encoder. This encoder has 23 bits per revolution or 8388608 position values per revolution. Custom adapter pieces were designed and fabricated by Sandia National Laboratories to allow for integration of the new encoder. A cad rendering of these pieces is shown in Figure 1

Logo

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Figure : Custom adapter parts for new encoders

# Pendulum tests

Pendulum tests were used to verify functionality of the new encoders and verify the torque constant for the motors. These tests are designed to determine the relationship between torque and current. This is necessary and relevant because most motor drives have current as their input and a relationship between commanded current and actual torque measured is desired. For these tests a custom coupler needed to be fabricated connecting the motor to the torque transducer. The rest of the test stand was repurposed from another project. The bench test setup is shown in Figure 1.

A picture containing text, floor, indoor, wooden

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Figure : Bench setup of pendulum tests

Ramp tests were conducted to estimate the torque constant with a maximum current of 20A achieved. The test consisted of four ramp events two clockwise and two counterclockwise alternating as shown in Figure 2.

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Figure : Torque vs. Time for pendulum ramp tests

The torque-current relationship was plotted for each ramp segment as shown in Figure 3.

Chart, line chart

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Figure : Torque vs. Current relationship used to estimate torque constant

and the MATLAB polyfit command was used to estimate the torque constant. This was done for the four ramp segments and the Kt values averaged. This was then repeated for the Bow motor and the results are summarized in Table 1.

Table : Kt estimates from pendulum tests

|  |  |
| --- | --- |
| Motor | Kt (Nm/A) |
| Aft | 0.9636 |
| Bow | 0.9438 |

The datasheet for the motor (MF0150025 with the 300V winding) lists a torque constant of 1.021 Nm/A +/- 10%, which gives limits of 0.9189 Nm/A and 1.1231 Nm/A. The measured torque constants for the bow and aft motors fall within these limits.

# Encoder Comparison

Initial evaluation of the noise characteristics comparing the old and new encoders position is detailed in this section. Ten seconds of data from dry testing on 12/18/2019 at 12:32:30 was used for the old encoder data. A section of test period where no commands were being issued to the drive was used. For the new encoders a pendulum bench test (aft20amps.mat and bow20amps.mat) from 9/1/2022 and 8/29/2022 respectively was used. Comparison of the time series of the two encoder signals are shown in Figure 5. Time from the two tests have been shifted to be on the same axis. Also, the means have been subtracted from both signals to be on the same rotation scales.

A picture containing graphical user interface

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Figure : Comparison of old and new FOSWEC encoders

Comparison of the variance of the signals is shown in Figure 6. While this result is very encouraging, the true test will be when we are applying feedback in an in-water test.

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Figure : Variance comparison