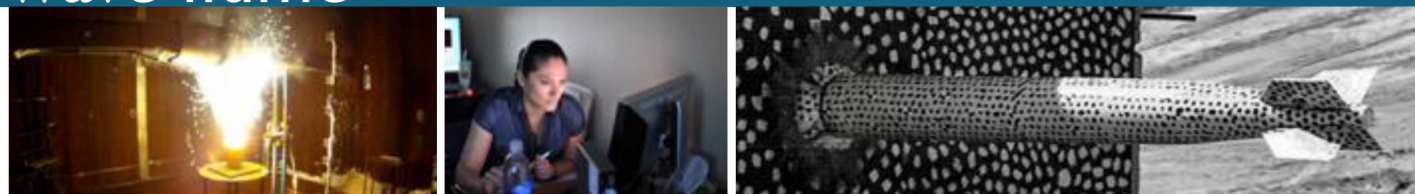




Sandia
National
Laboratories

SAND2019-10436C

Characterizing the dynamic behaviour and performance of a scaled prototype point absorber wave energy converter in a large wave flume



The 13th European Wave and Tidal Energy Conference
September 1-6, 2019

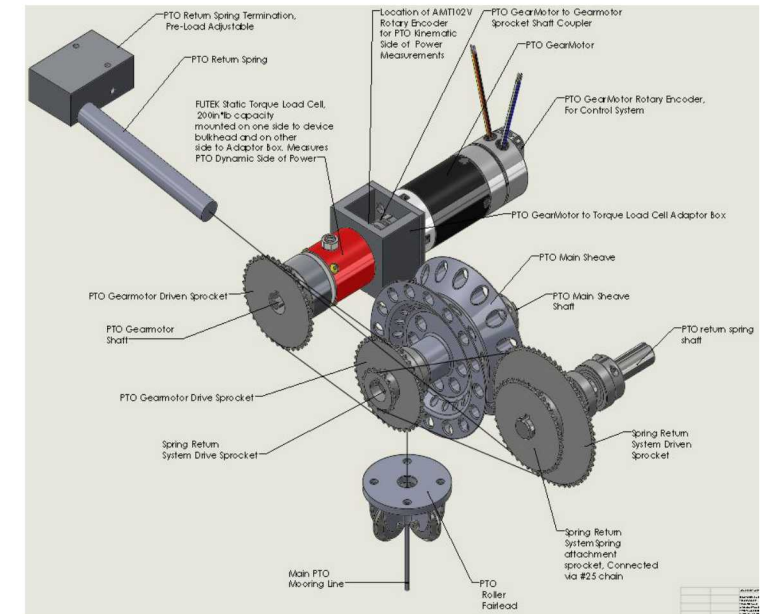
PRESENTED BY

Giorgio Bacelli, Alex Hagmuller, Max Ginsburg
and Budi Gunawan



Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Device description

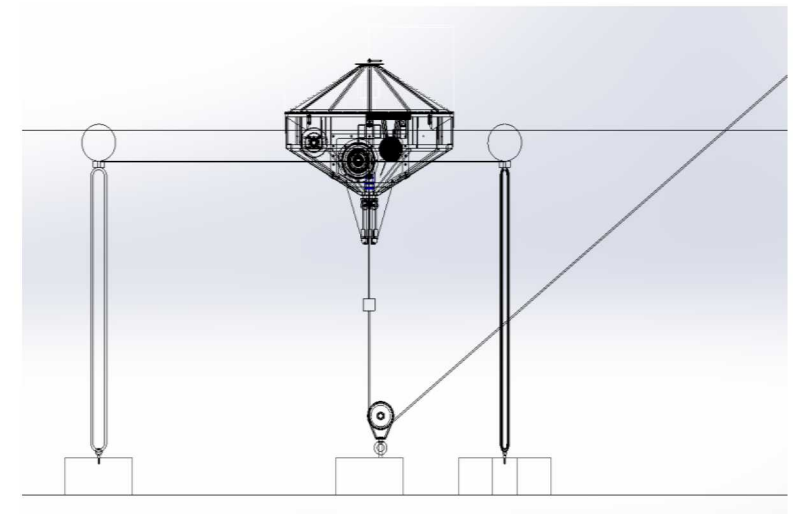


Updates:

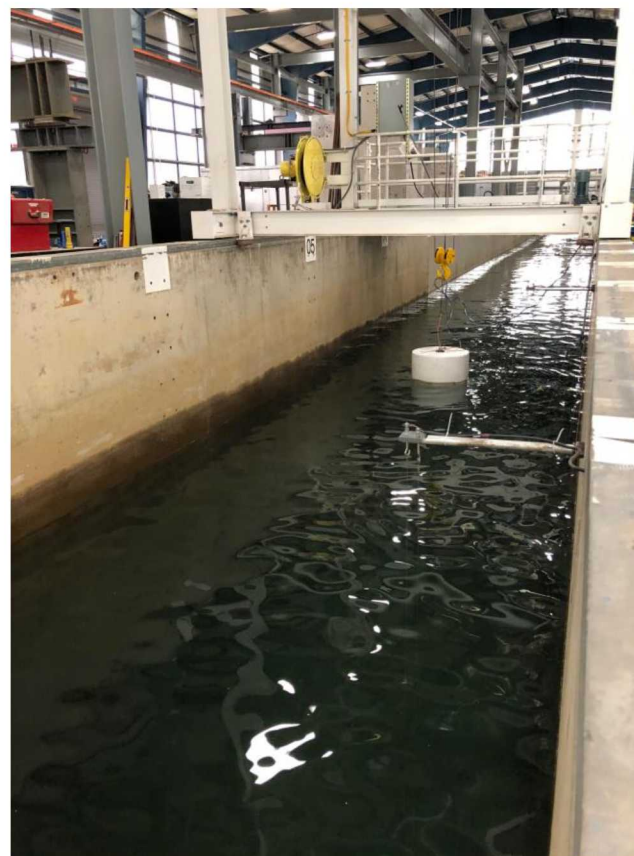
1. PTO:

- New motor/generator
- Lower gear ratio
- New Real-time system
 - Simulink Real-Time
 - EtherCat

2. Increased draft and pretension (Foam cylinder)



Testing at Oregon State University's wave flume



Wave flume:

Length: 104 meter

Width: 3.7 meter

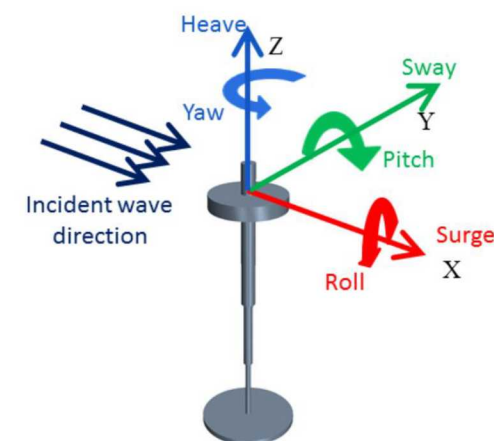
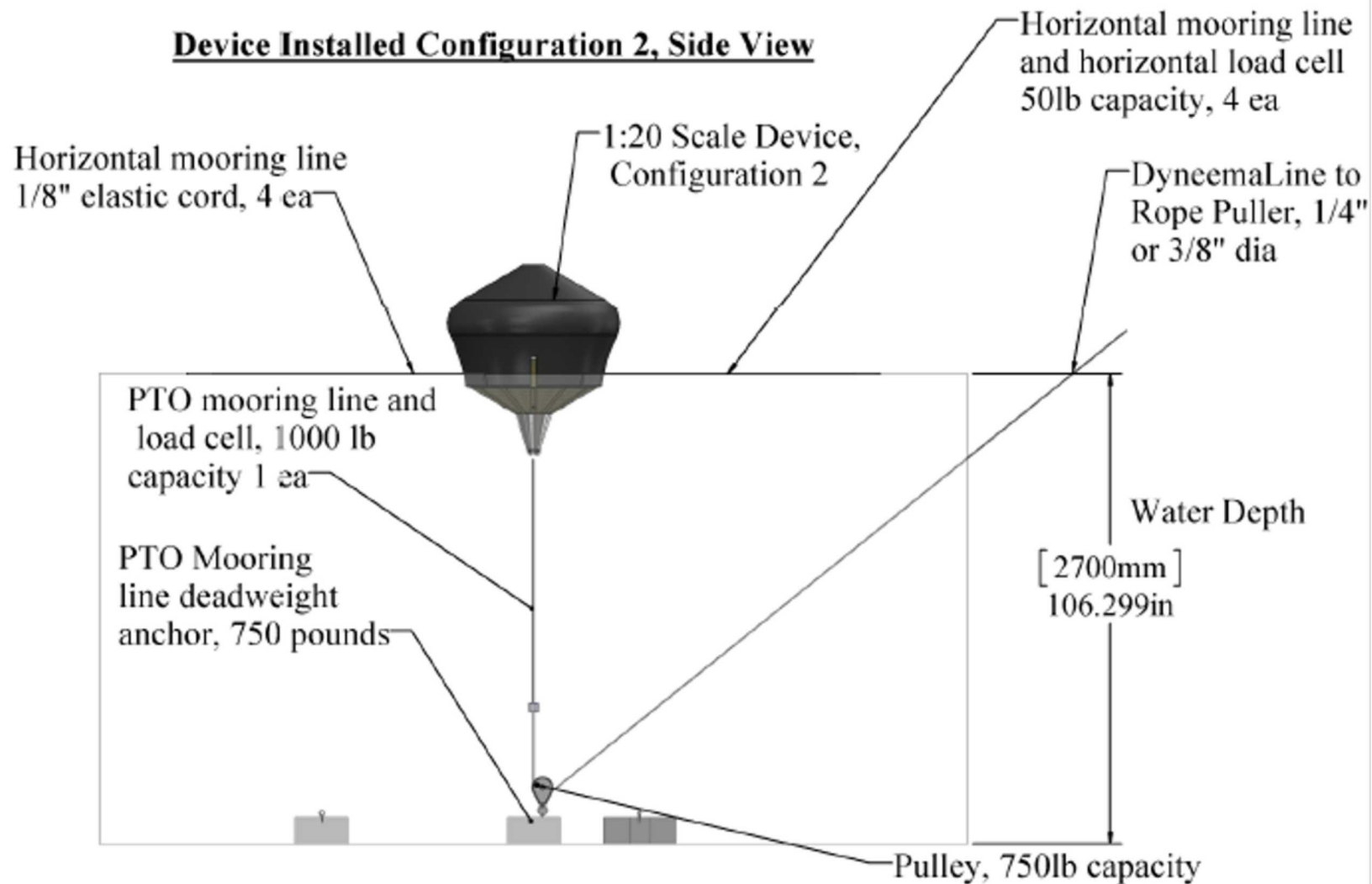
Max. still water depth: 2.74 meter

Wave period: 0.5 to 10 seconds

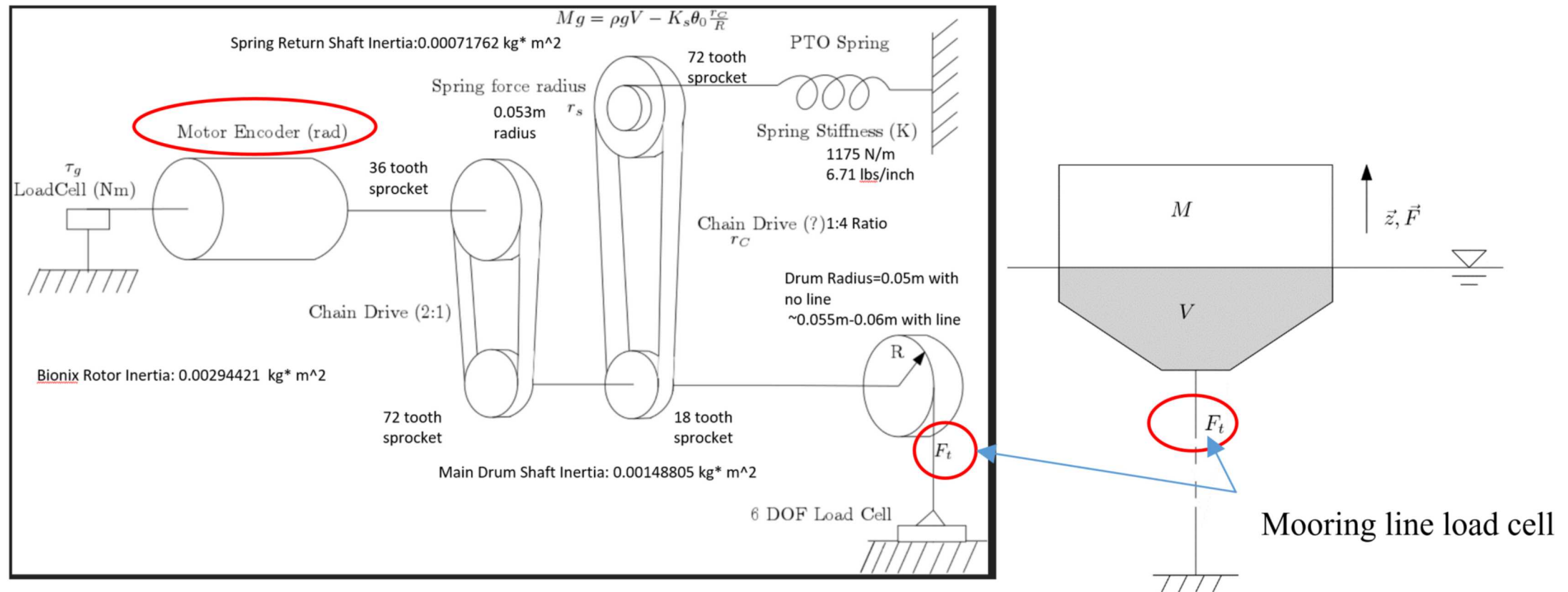
Max. Wave height: 1.6 meter

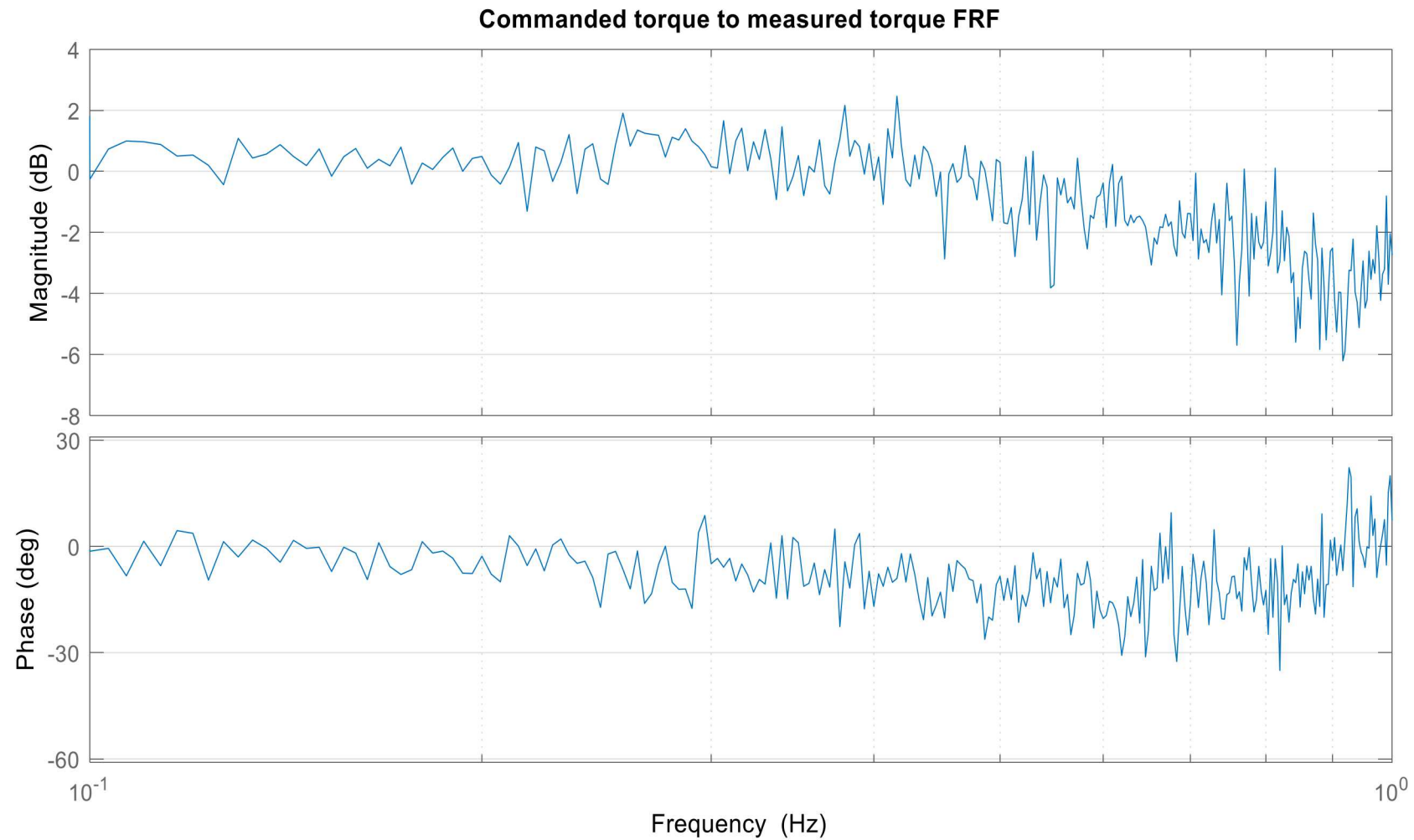


Test set up

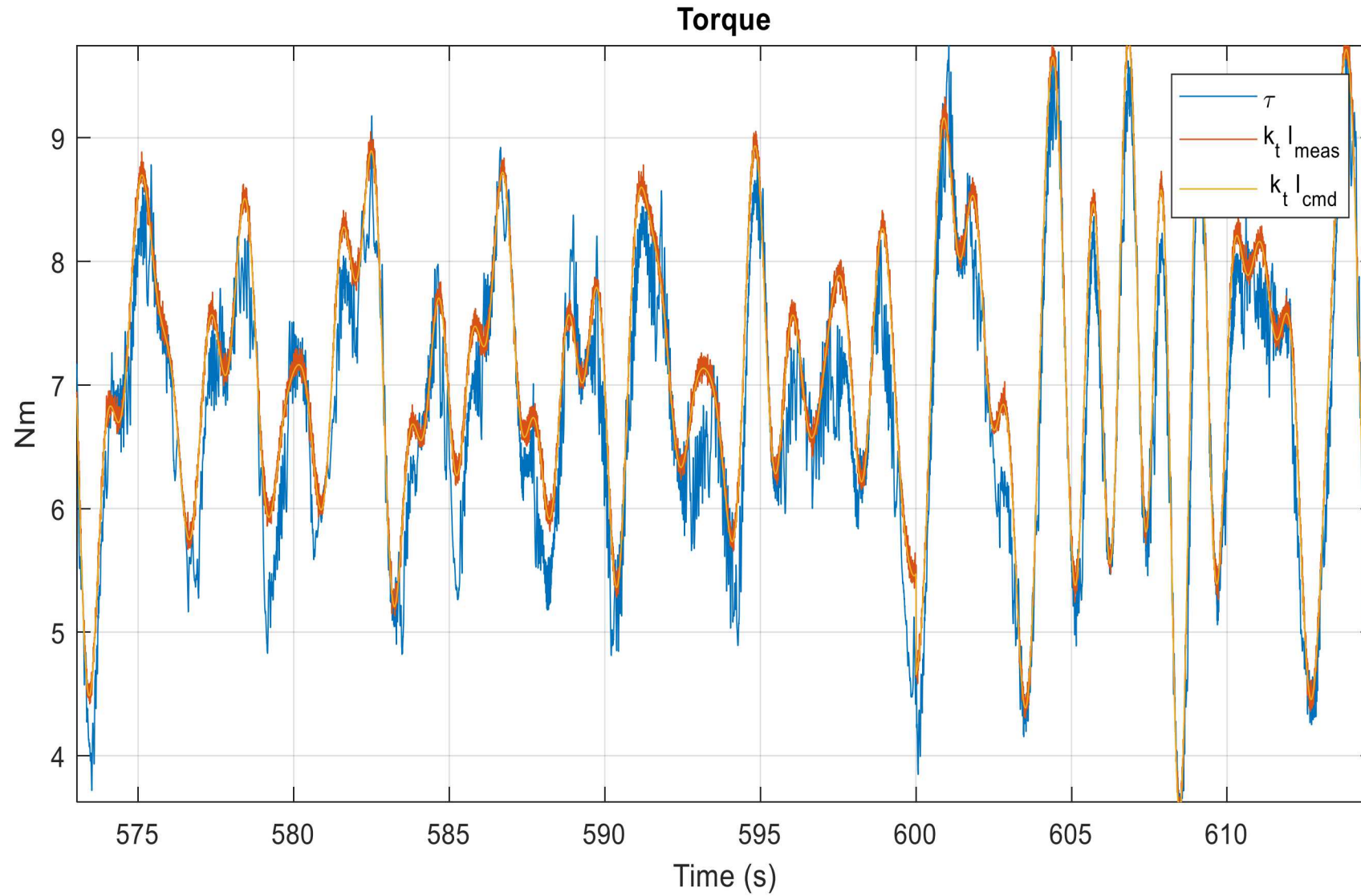


Test set up: PTO and sensors





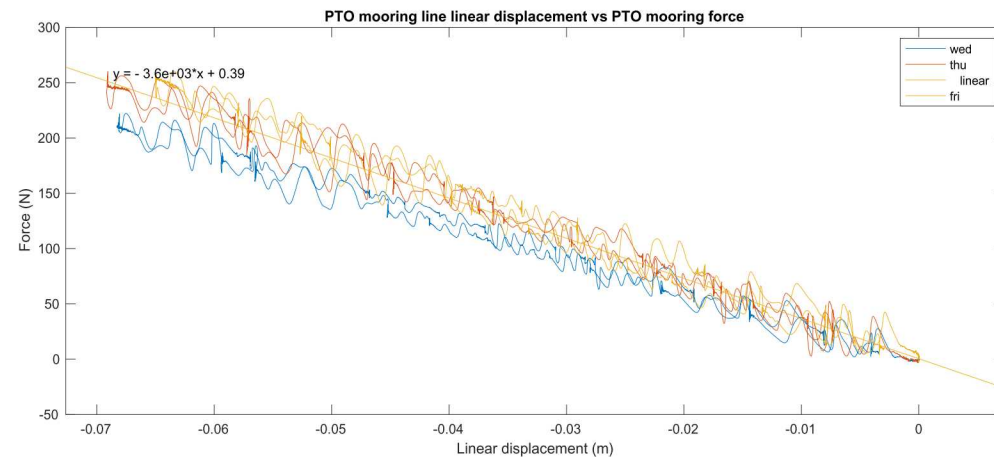
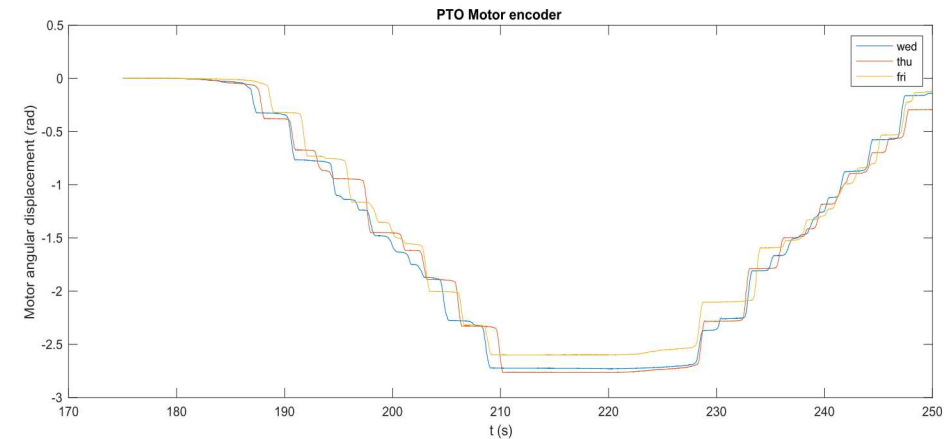
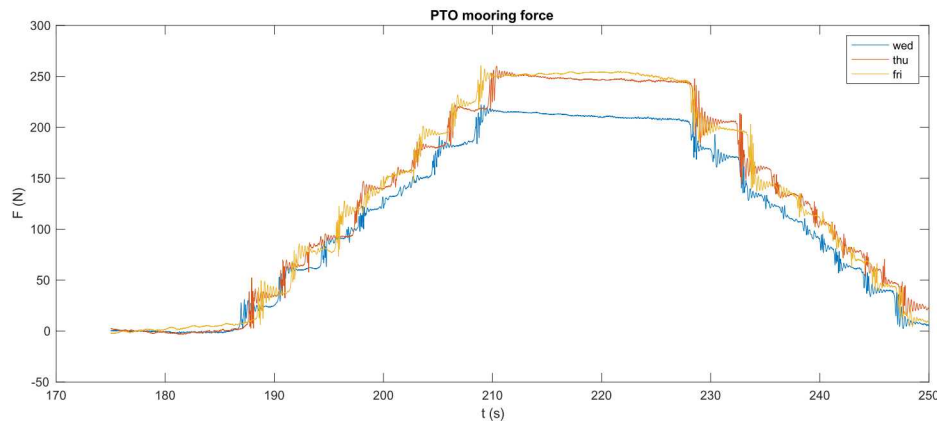
Bench tests: PTO torque tracking



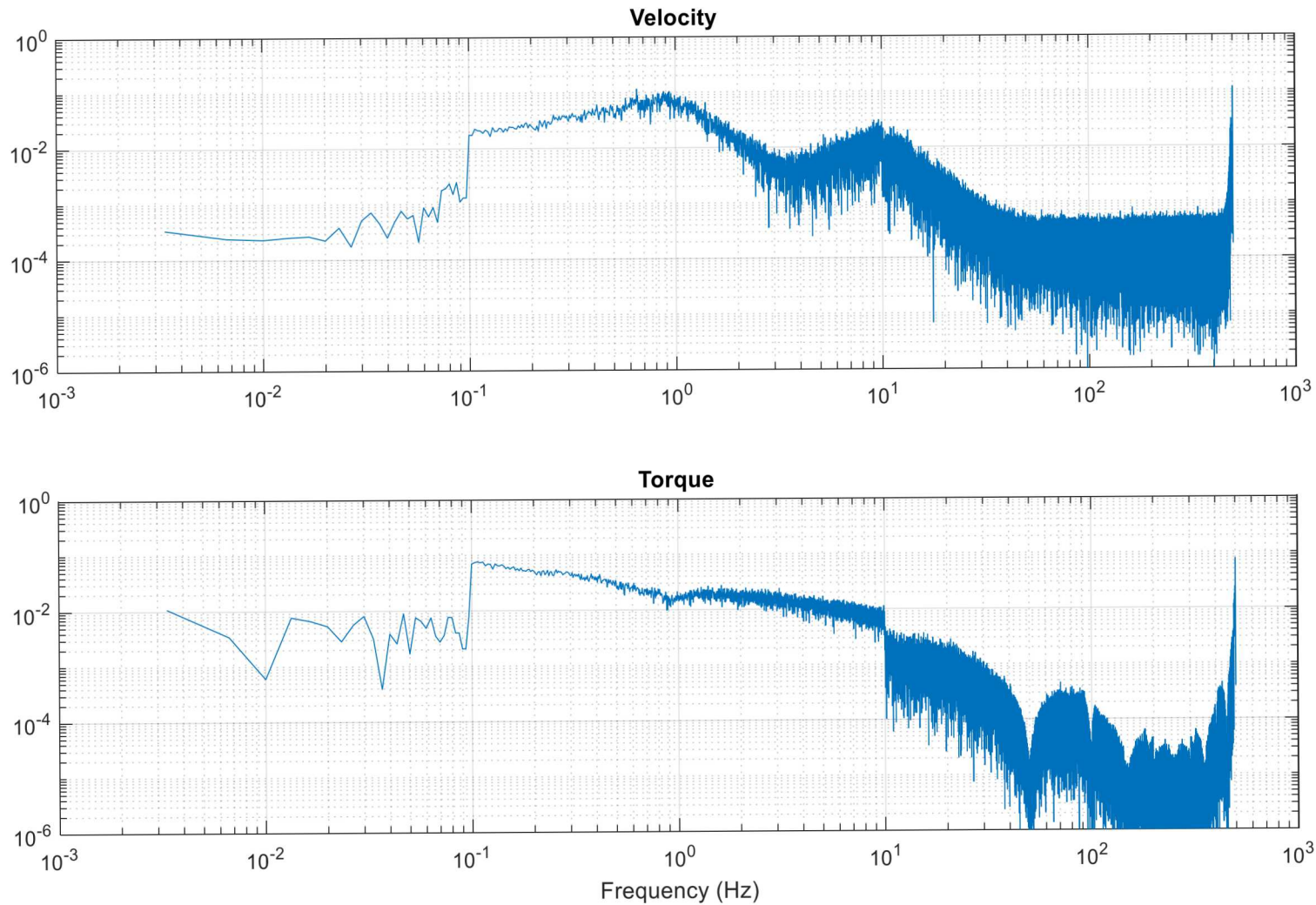
Integrity/Consistency checks experiments



- Performed at the beginning of each test day (Wed, Thu, Fri)
- Consisted of a sequence of three slowly varying ramps
- To check the consistency of WEC behavior throughout the test campaign



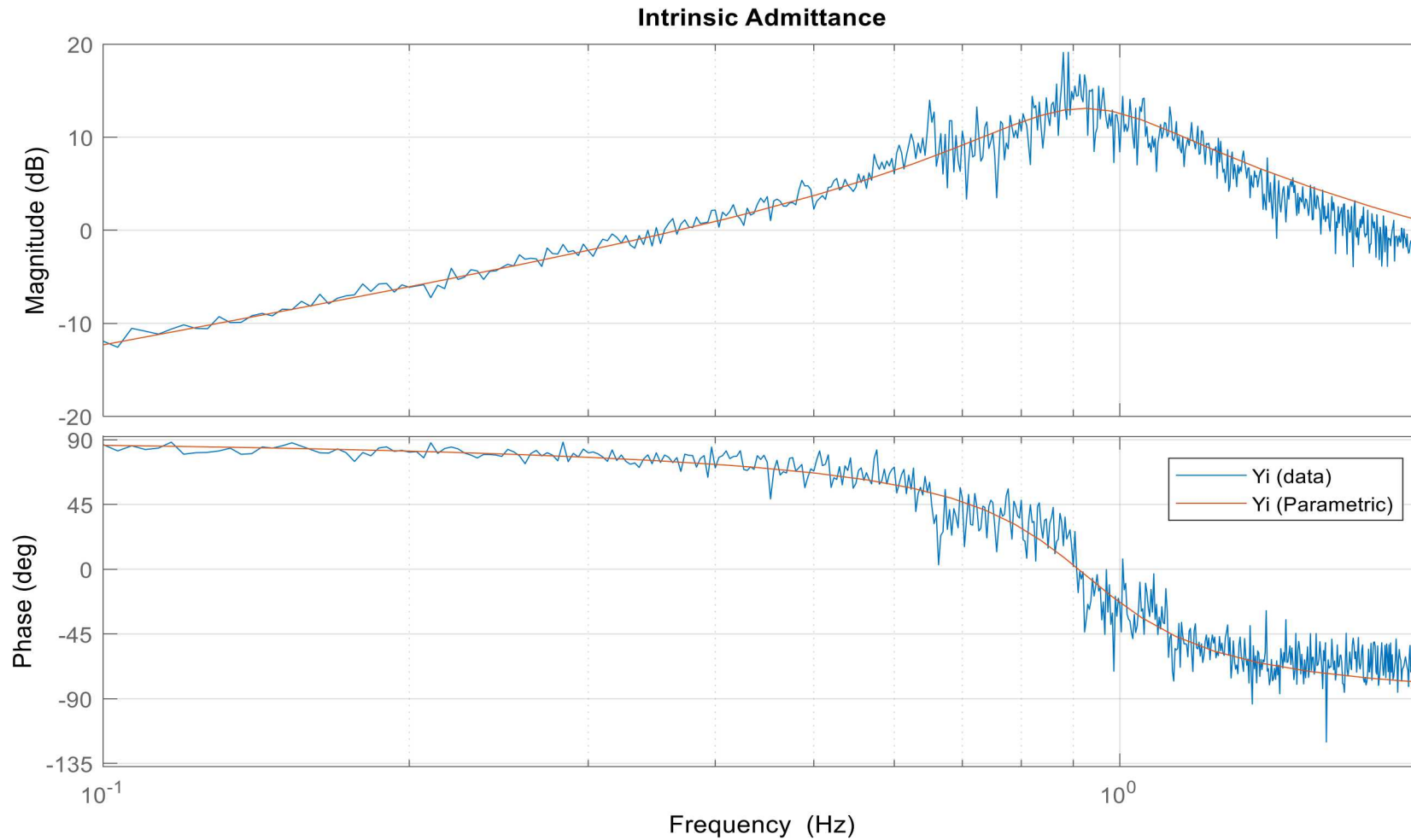
Open loop testing: System Identification of I/O response

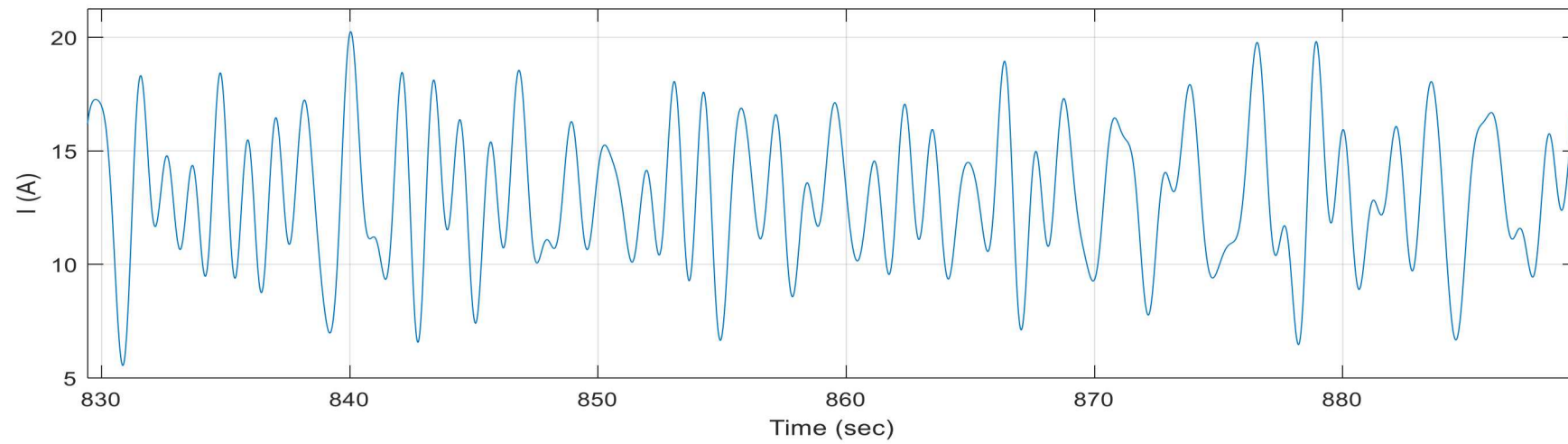
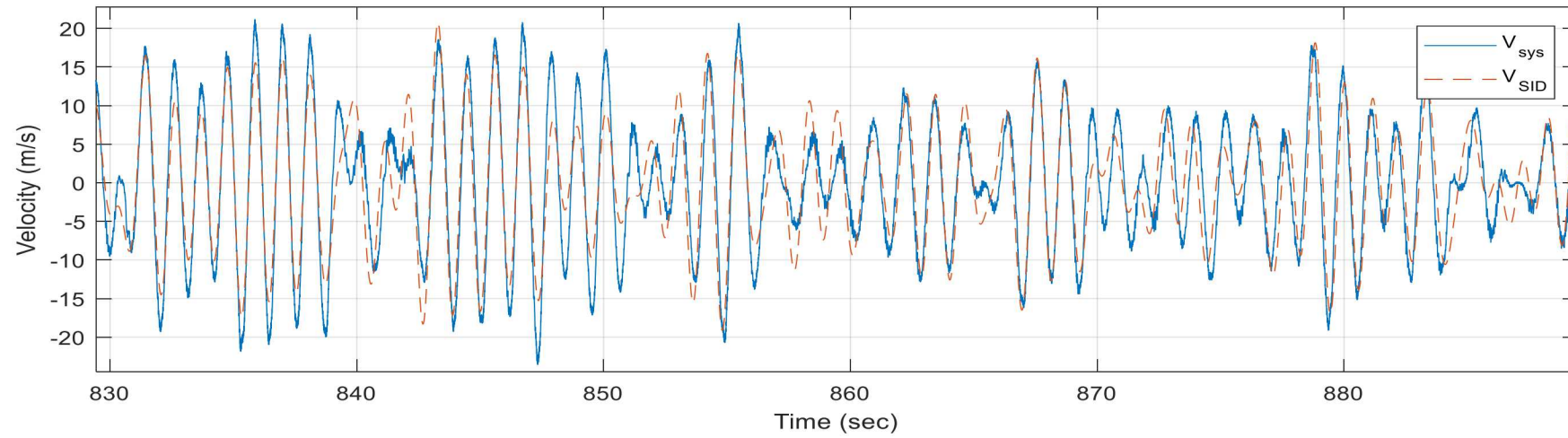


Output

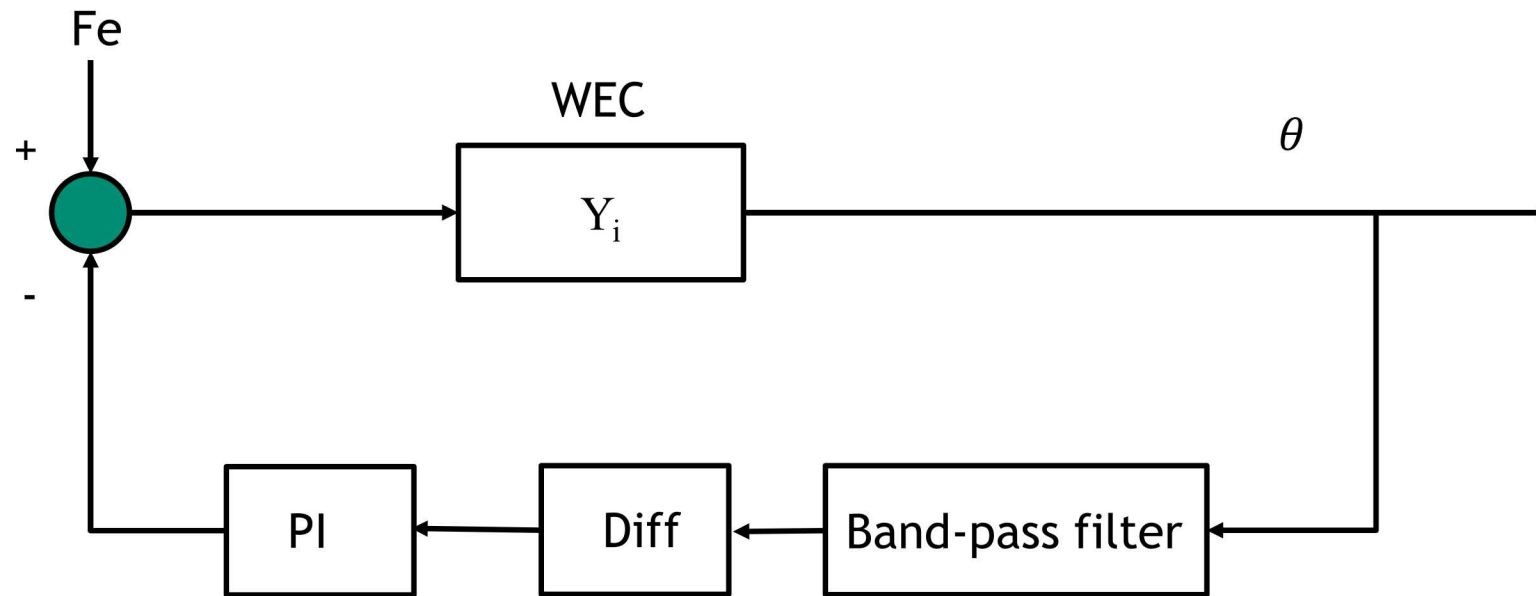
Input

Open loop testing: System Identification of I/O response

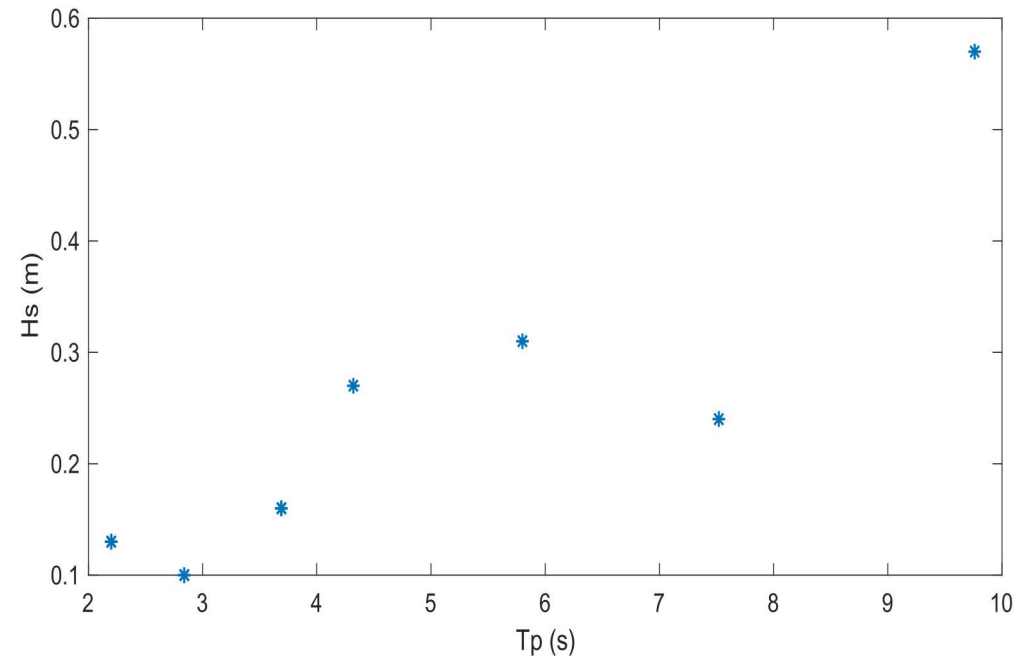




Closed-loop experiments: control system



Test case	Exp ID	Hs (m)	Tp (s)
1	33	0.27	4.32
2	35	0.24	7.52
3	37	0.31	5.8
4	41	0.13	2.2
5	42	0.13	2.2
6	43	0.1	2.84
7	44	0.1	2.84
8	45	0.16	3.69
9	46	0.16	3.69
10	55	0.57	9.76



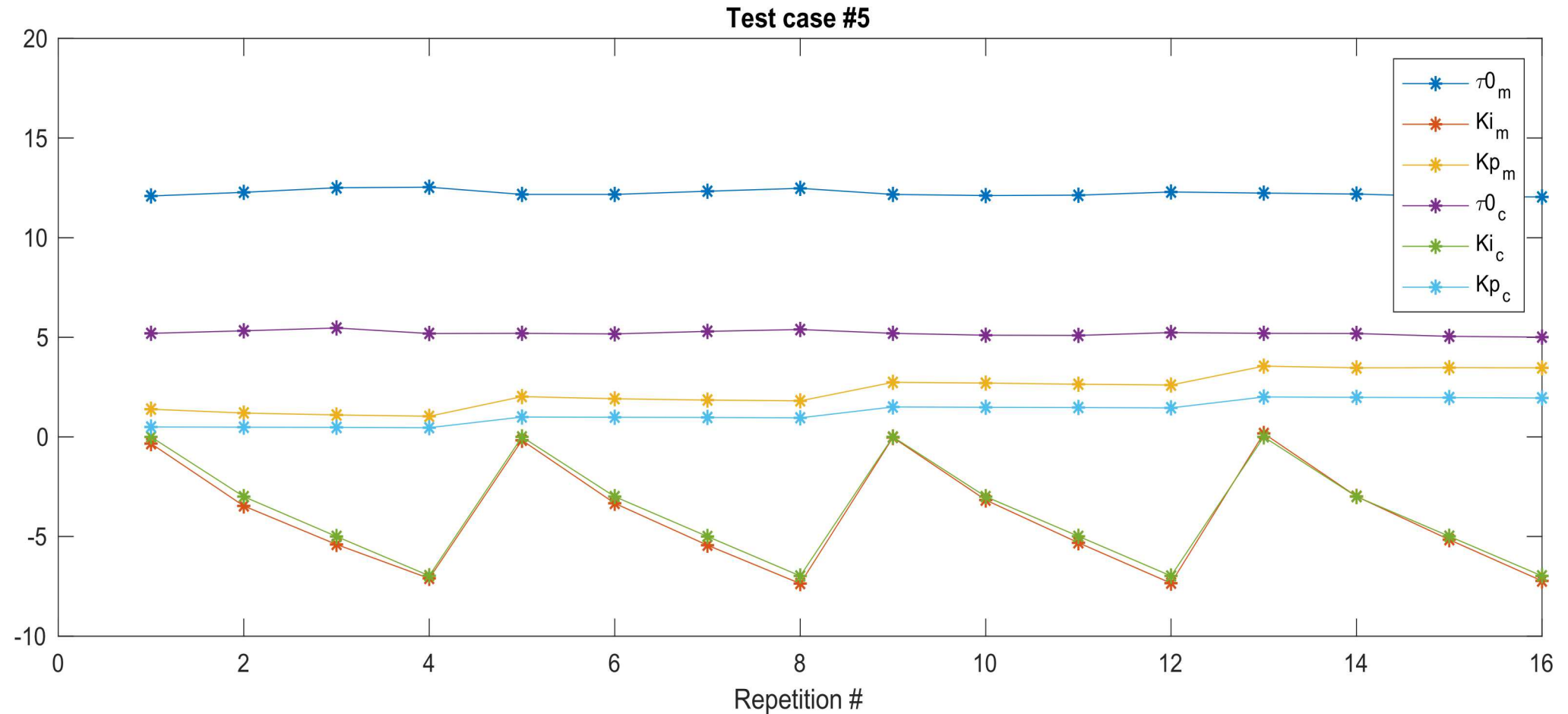
5 minutes repeating sequences

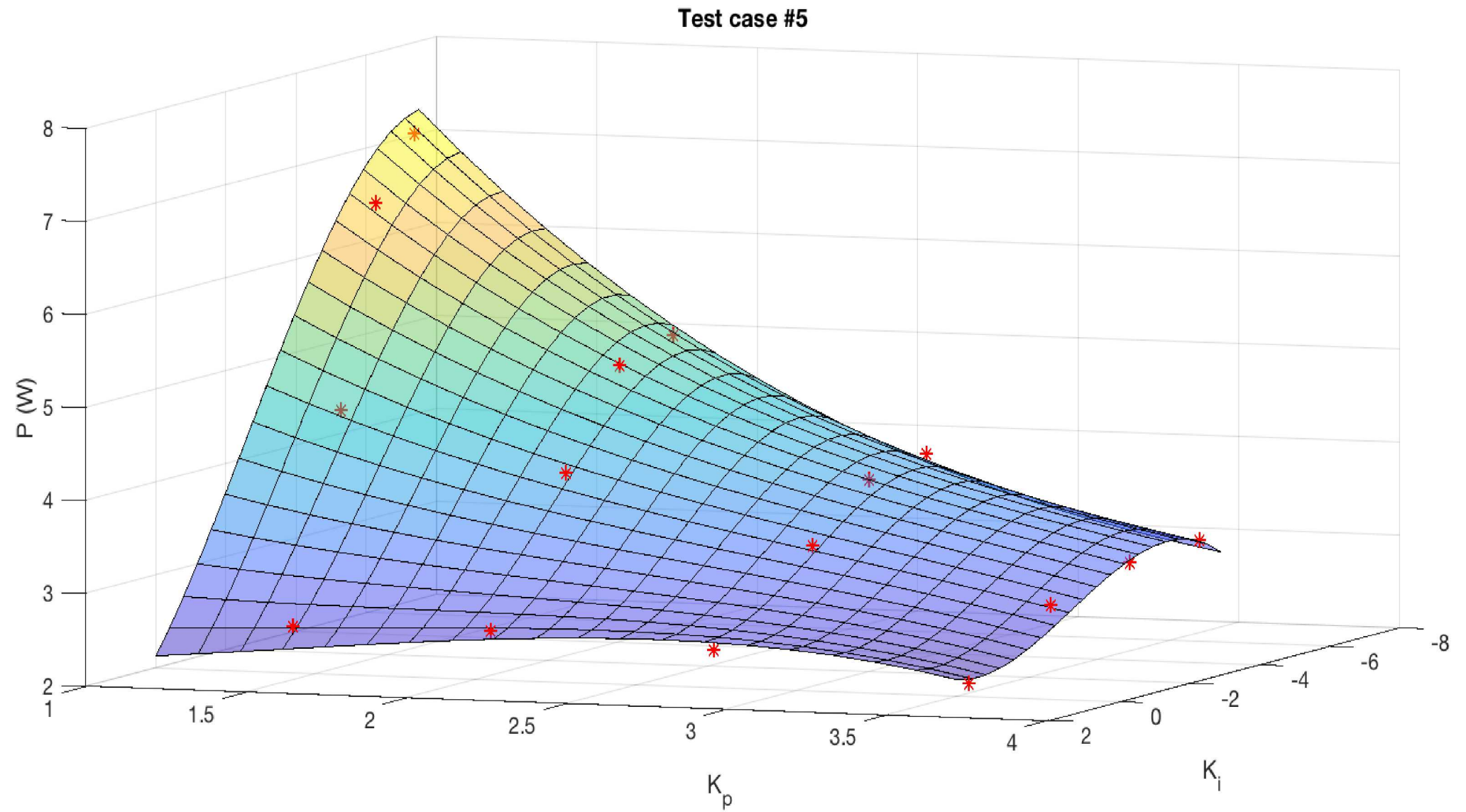
Note: Some tests have the same Hs & Tp, but different mooring pre-load (e.g., #4&5)

Control coefficients

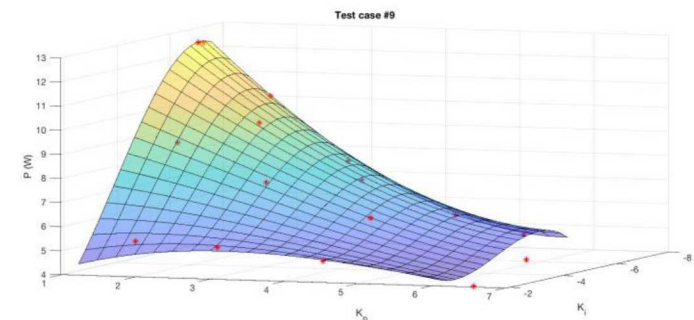
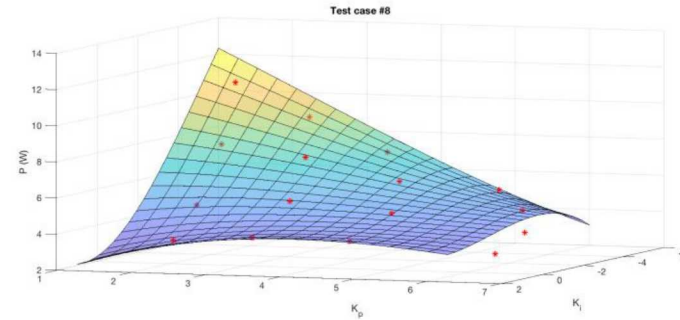
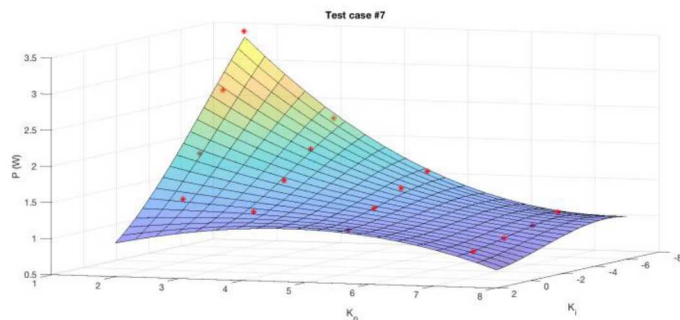
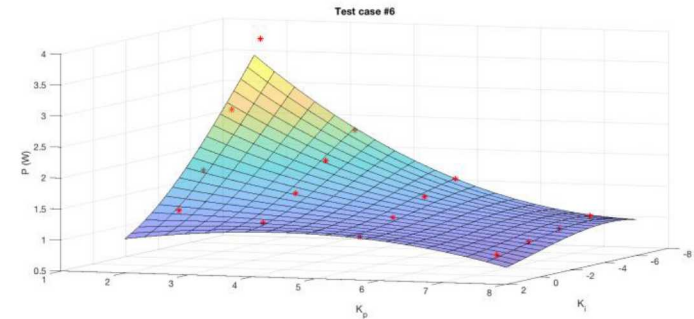
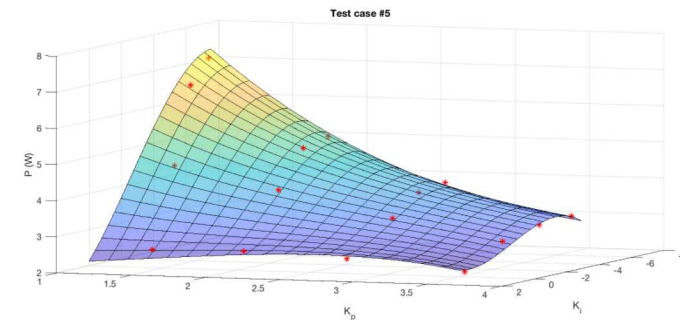
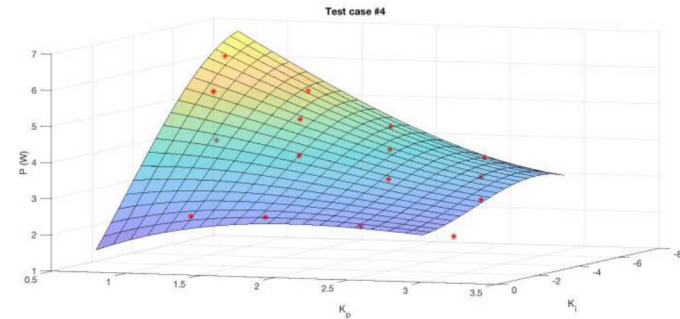
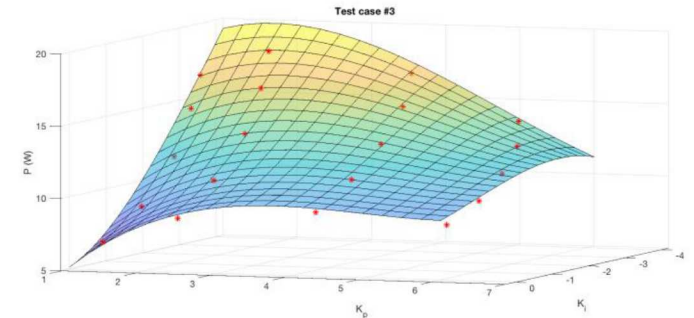
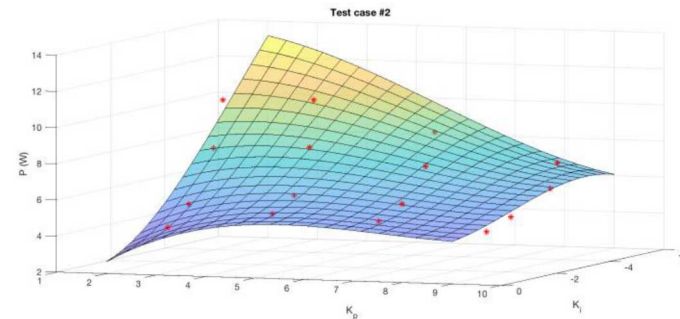
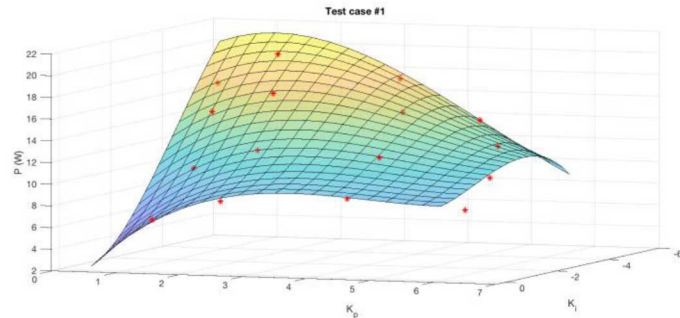
The effective values of the controller's coefficients (Ki_m and Kp_m) applied to the buoy by the mooring line can be estimated starting from the following model:

$$\tau_t = \tau_{0m} - Ki_m \theta - Kp_m \omega,$$

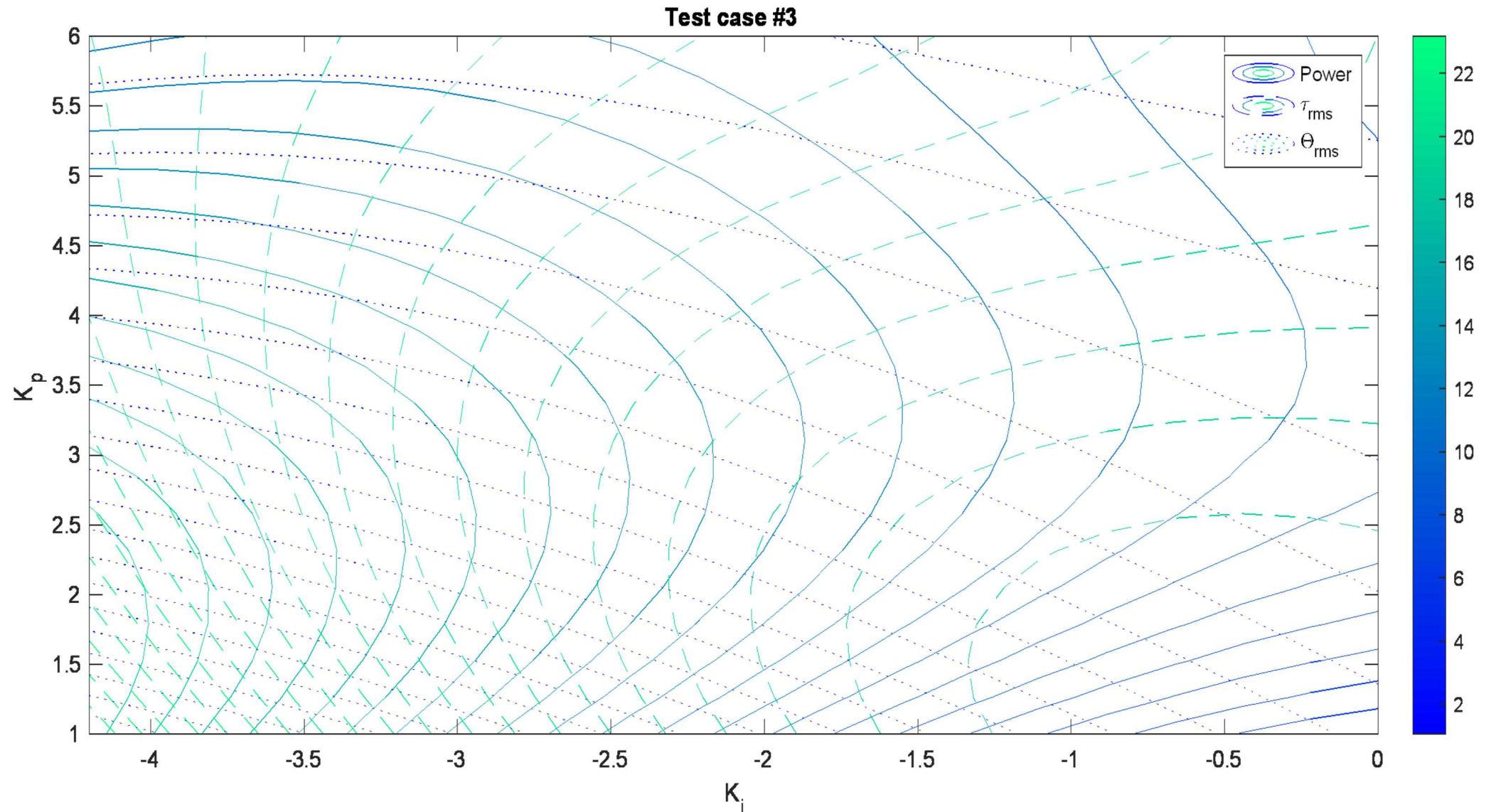




Absorbed power as function of the control coefficients (K_i & K_p)

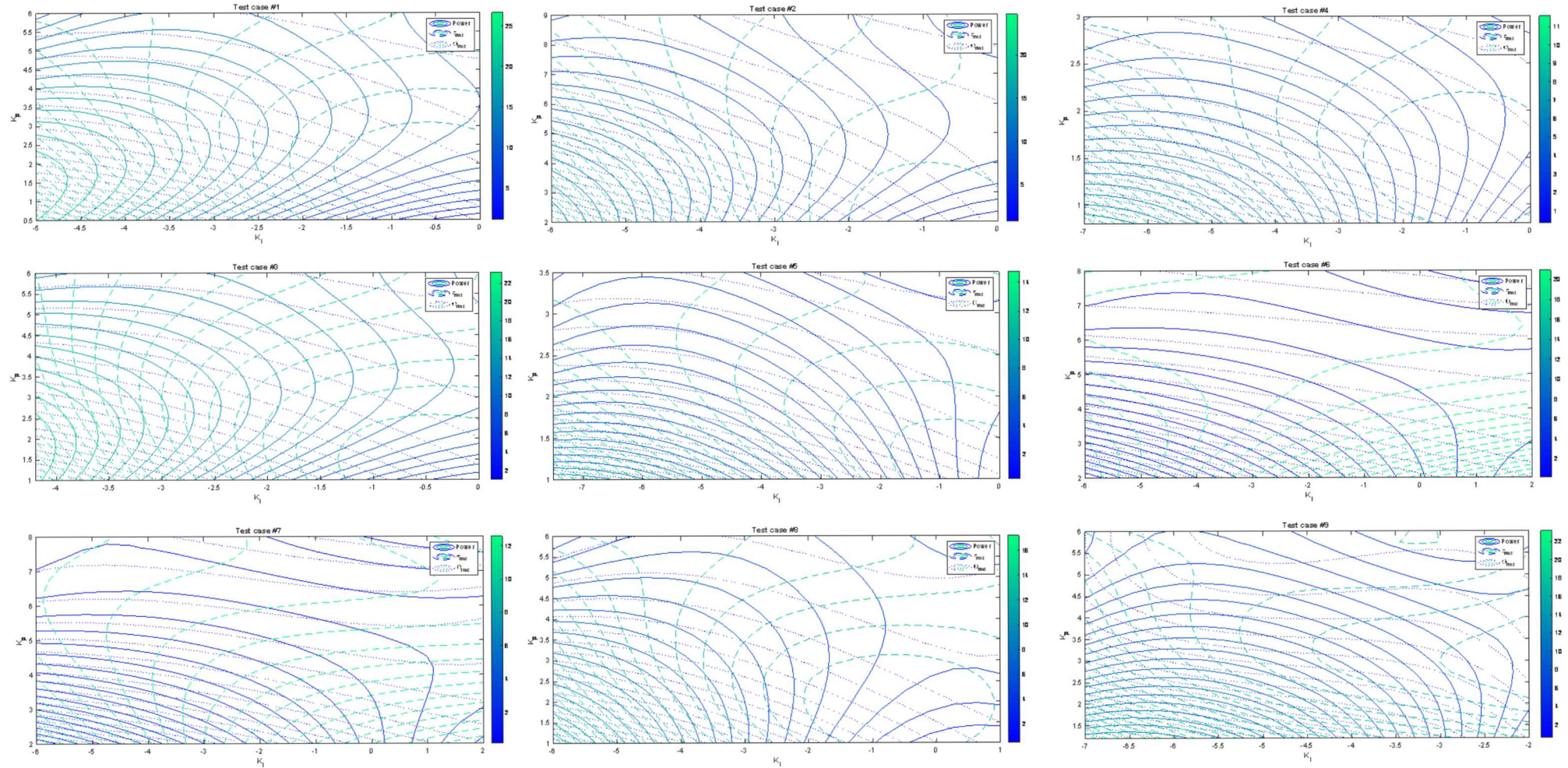


Power Throttling / load shedding



Contour plots of the absorbed power, rms value of the PTO torque, rms value of the angular displacement

Power Throttling / load shedding





Questions?

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