

## Monopile Grippers



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Today most offshore wind turbines are mounted on monopiles. These foundations are installed either by jack-up vessel or moored floating vessel. These installation methods are time consuming. Jacking a ship up or placing the mooring lines takes considerable time. Therefore a new installation method is getting more and more attention: installing monopiles with a DP crane vessel.

## Motion Compensation

During the early hammering of the monopile, the monopile has little interaction with the soil, because of the limited penetration. A pile gripper is required to keep the monopile upright.

Vessels that operate under DP, keep their position within a certain window. Pile grippers that operate on these ships also have to compensate for the motion of the ship.

Motion compensation is not an option that comes standard with suppliers of pile grippers, because of the complex mathematics that comes with these controllers. Controllab is one of the few companies in the world that supply motion control software.

To develop control software for pile grippers, we have a standardized production process with the following phases:

- Dynamics Simulation
- Controller Design
- HIL Simulation
- FAT
- SAT

## Dynamics Simulation

The forces of a monopile have to be countered by the hydraulic actuators of the pile gripper. With a DP vessel, the motion of the ship will also act on these actuators. The vessel, the pile gripper and the monopile are a complex dynamically interactive system, which can only

be analyzed thoroughly using simulation models. Based on the vessel, monopile and gripper data we will construct such a simulation model and run various scenarios to find the operational window of the pile gripper: maximum power, actuator speeds and forces, gripper range etc.

## Controller Design

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To run the pile gripper, a compensation control system is required that uses sensor data (MRU, GPS, inclination) and calculates the actuator setpoints. Controllab has a standardized motion control software module that performs all the necessary calculations:

- Measure ship and monopile position and orientation
- Use backward kinematics to calculate the actuator setpoints.
- Feedback loop controllers to turn the actuator setpoints into actuator positions.
- Feed-forward control to increase the performance.
- Safety system to prevent damage to the pile gripper in abnormal conditions.

The motion controller is implemented in the simulation model to tune the controller parameters and verify a stable and robust operation.

## HIL simulation

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The pile gripper controller will be deployed on a PLC. To test this PLC, we will couple it to the simulation model of

the ship, pile gripper and monopile. This is known as hardware-in-the-loop (HIL) simulation. HIL simulation will allow us to test the operation of the pile gripper control system before it is deployed on the ship.

## FAT

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At the factory, only limited operation of the pile gripper can be tested. Because we have used HIL simulation to test the complete operation of the pile gripper, we can get good confidence in the operational capability of the pile gripper, even with the limited factory acceptance tests.

## SAT

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After the pile gripper is mounted on the ship, deployment tests will be carried out. Step by step the operation of the pile gripper is tested. These tests are mirrored with a digital twin. With each test and digital twin simulation showing equal results, confidence in the proper operation of the pile gripper is increased.

## Track Record

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Controllab has a track record of successful motion compensation control systems for access bridges, cranes and other equipment like pile grippers. Please contact us if you are developing pile grippers and need help on the control system.

## Contact Us

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