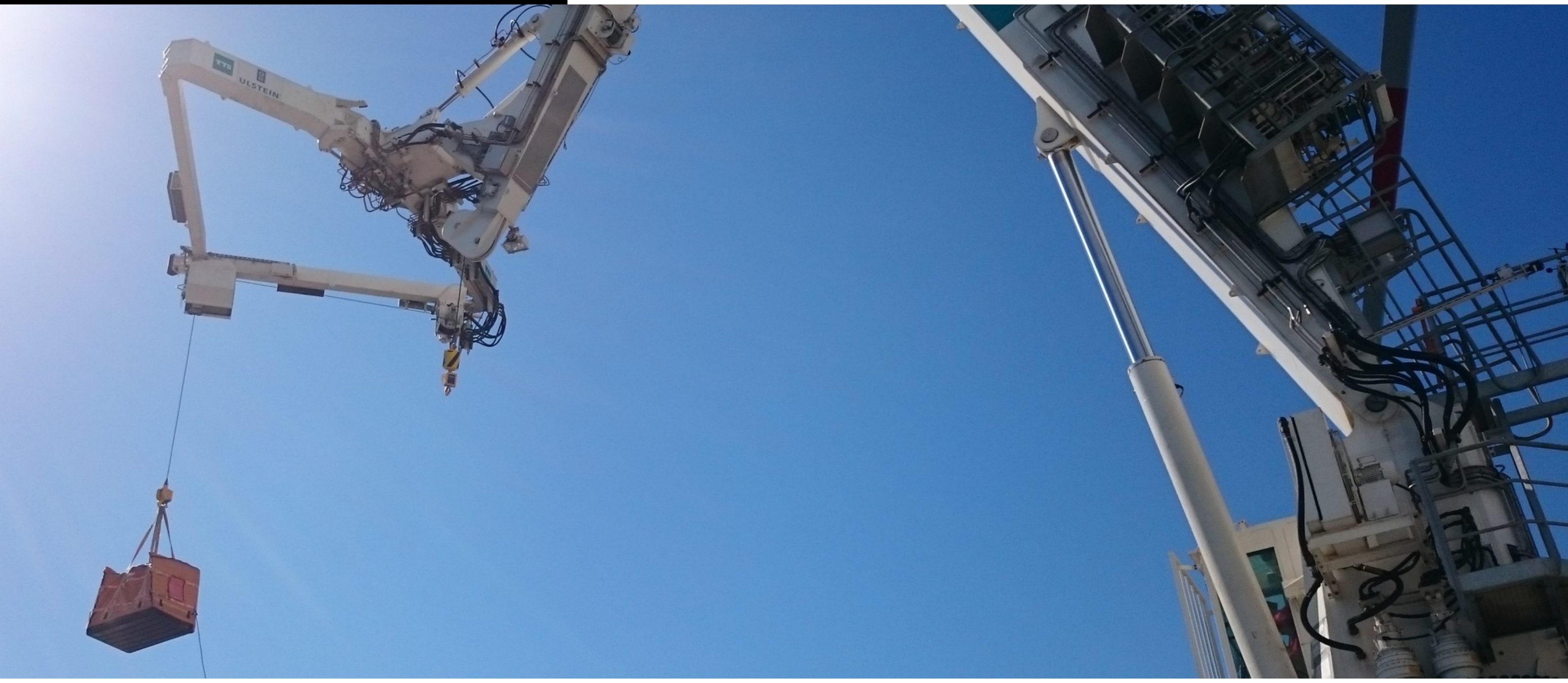
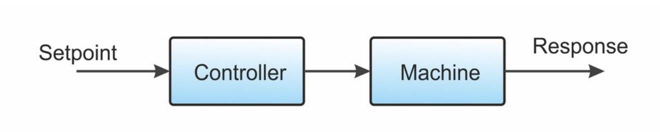
Closed Loop Control



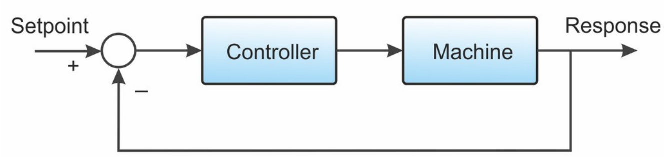
Open and Closed Loop Control

In manual control systems, a human input (e.g. a joystick or lever) is converted into a signal that will drive an actuator (e.g. a valve or a throttle) to run a machine.



Open Loop Control System

The software of open loop control system may contain complex mathematics and extensive libraries, but in essence, it is a one way operation. Manual control systems are also known as open loop control systems. They are relatively easy to design.



Closed Loop Control System

In automatic control systems, there is a feedback loop in which the response is measured and compared with the setpoint. Because of the feedback loop, automatic control systems are also known as closed loop control systems.

Closed Loop is Superior

In closed loop control systems, using sensors and a feedback loop, the machine response is compared with a setpoint. If a difference is observed, the controller will drive the actuator in such a way that the machine will go to the setpoint.

When high precision sensors are applied, accuracies can be achieved impossible with open loop control. With fast sensors, machine speeds can be obtained which are impossible for a human operator to follow. Moreover, the controller can compensate for environmental changes (e.g. temperature, wind) and machine variations (e.g. friction, gravity). This makes closed loop control superior to open loop control.

Closed Loop is Different

For engineers who are trained in open loop control, the design and implementation of closed loop control system can be a tough job. They usually do not realize that loop propagation makes closed loop systems fundamentally different from open loop systems.

In open loop control systems, software errors are easy to find and solve. You simply track the control signal from the manual input, through the system to the actuator. At the point where the signal starts to deviate from the expected, the error is caused. An error in a closed loop control system is much harder to track. If somewhere in the system an error is caused, the resulting deviation will start to travel around the loop. Distinguishing between cause and result is very hard in closed loop systems.

Deviations, travelling around the loop may be amplified. This may lead to exponential growth: the system gets unstable with devastating results. You can experience this when changing the control parameters. With the parameters set to a mild value, the system may be responding stable and slow. When you increase the control parameters, the system will become faster but it also starts to oscillate.

Design Tools and Methods

For closed loop control systems, tools and design methods have to be applied that are different from those used in open loop control. Controllab is specialized in closed loop control systems design. We use the following tools and methods:

- Modelling & Simulation: We make a simulation model of the machine and control system. This allows us to design and test control systems, without causing any harm.
- Frequency Domain Analysis: The simulation model and control system can be converted to the frequency domain. Frequency domain analysis is a mathematical design method that allows us to investigate the exponential growth of loop deviations and the stability of the control system.
- Time-Domain Analysis: In the simulation model we can limit the actuator performance, reduce sensor accuracies and introduce limits that are common in machines. Using simulations, we can test the robustness of the control system to these limits.

Controllab has more than 20 years of experience with the design and implementation of closed loop systems. We help companies you to create superior machines. The following sections give some examples.

Boom Lock

The company High Wind (a subsidiary of DEME) has developed the Boom Lock system. The Boom Lock consists of a trolley that can travel up and down the crane boom to catch and secure the crane hook. It is used to install wind turbine components at high wind speeds.

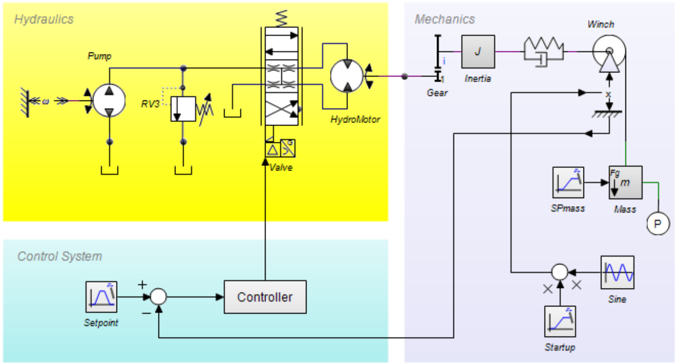
The Boom Lock system during tests.

The Boom Lock is equipped with horizontal and vertical tag lines to control the swinging and orientation of the load. One of the key issues with the tag line system for the Boom Lock was the ability to suppress the swinging of the wind blades and follow the main hook during luffing and hoisting. To achieve this goal a hybrid control strategy with closed loop position and force control was developed. The control software was tested on a digital twin, an in-house developed crane and blade simulator. This allowed us to use frequency and time domain analysis to find a control system that performs well and keeps stability under all wind conditions.

The tag line system was implemented on the jack up vessel Neptune. The system was first tested using a container and then upgraded to a wind blade. The tag lines could stabilize the wind blade in wind speeds up to 15 m/s. Since 2015 the system is in full operation and used for hoisting wind blade, nacelles and other loads.

Colibri

The TTS Colibri™ is a double arm lifting device that can be placed on top of a knuckle boom crane to provide motion compensated cargo lifts. The tip of the Colibri compensates in the horizontal plane while the winch takes car of the vertical motion. The Colibri is equipped with servo controlled hydraulic cylinders. Controllab has developed the closed loop control system for servo valves. The control systems assures that a given speed setpoint is met by the hydraulic cylinders of the Colibri.



The Colibri is now successfully used on a windfarm support vessel, and new orders an on the way.

Track Record

Controllab is active in the High Tech and Maritime markets for more than 20 years. Our engineers have gained a thorough understanding closed loop control. Please contact us if you need help.