The Power in Modelling

20-SIM

Marine & Offshore

Designing and Testing a Propulsion Controller

Kwant Controls

Kwant Controls was raised in 1937 as a manufacturer of nautical instruments. The company is located in the northwest of the Netherlands. With a worldwide market share of 30%, Kwant is one of the world's leading manufacturers of state of the art high end nautical controls and systems.

Propulsion Controller

One of the core products of Kwant are control levers for the remote control of marine propulsion plants. Marine propulsion systems typically consist of a combination of engine, propeller, gearbox, clutch and sub-assemblies. Remote Control is done from bridge level (WH Fwd, WH Aft, Port side wing or Starboard side wing). To achieve this, the levers are equipped with signal transmitters for engine RPM, clutch direction etc. that are wired to the propulsion plant control system.

Figure 2: Motorized Lever.

The control levers are electronically connected. This means that all connected operating levers have the ability to synchronize the position of the operating lever, which enhances the use and increases safety in emergency situations. This synchronization also enables switching of the operating position without changing the control signals for propulsion plant

Figure 3: Assembly of ship bridge

equipment with propulsion control units.

(bumpless take-over). To achieve this synchronization, the control units are equipped with servomotors (see figure 2). Kwant Controls has enhanced the use of these servomotors by allowing them to give 'haptic feedback' to the operator. This will prevent the operator to push a lever outside the operating area by inducing vibrations. All control levers are connected to a propulsion control system which contains the main propulsion controller software. This controller translates the lever position into an engine speed and propeller pitch.

Model Based Design

The growing complexity of the propulsion control systems and the striving for continuous improvement led Kwant Controls to the adoption of model based design. The modeling and simulation software 20-sim was adopted to form the cornerstone of a new design approach. One of the most important arguments for this was the fact that 20-sim uses a graphical representation of all the model components. Furthermore, 20-sim supports code generation, code deployment and HIL-testing for a range of embedded systems and industrial controllers. This allows Kwant to use a single software platform for the generation of a broad range of propulsion control systems.

Lever Unit

The first experiences with 20-sim were gained with the design of a new operating lever. The lever mechanics, servomotor and drive were modeled in 20-sim and coupled to a controller model that not only allows lever synchronization but also gives haptic feedback to the operator by inducing vibrations and detents.

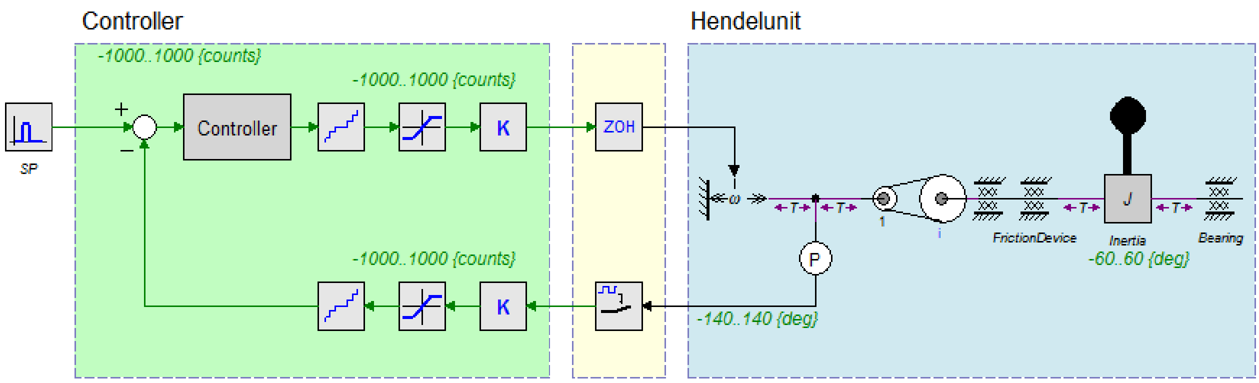

Figure 4: 20-sim model of the servo controlled lever.

After simulations showed the feasibility of the design, the controller code was exported to the program "20-sim 4C". 20-sim 4C is an extension to 20-sim which allows the deployments and testing of code on hardware. 20-sim 4C supports a range of hardware varying from low cost embedded systems to high grade industrial computers. For the lever unit, an embedded board with an ARM microcontroller is used. The code was directly deployed on this controller, showing a successful operation in tests.

Case study

As a manufacturer of propulsion control systems, Kwant Controls has delivered and commissioned a lot of control systems for various types of vessels. The existing range of controllers were implemented in 20-sim and coupled to a model of the propulsion system. Figure 4 shows an overview with the controller (green background) and the propulsion system (yellow background). Simulations were performed to validate the correct implementation of the controller and test its correct operation under normal and abnormal conditions.

HIL-testing

Kwant uses the Bachmann M1 controller hardware for its high end products. The M1 controller combines a traditional PLC with the ability to run custom C-code. The Bachmann M1 controller is supported by

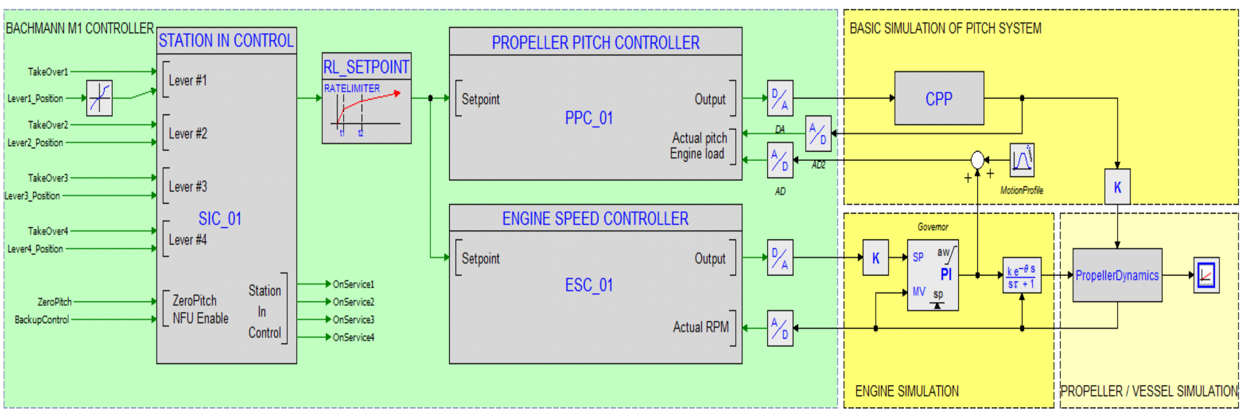

Figure 5: 20-sim model of the propulsion system and controller.

20-sim 4C and this allowed Kwant to directly convert the controller model (green part of figure 4) from 20-sim to C-code that was deployed on the Bachmann M1 system.

Figure 6: Propulsion control hardware.

Traditionally the propulsion control system would have been tested during a factory acceptance test and during commissioning onboard of the vessel, to gain confidence in the system. Instead, Kwant took a different approach using Hardware in the Loop (HIL) testing. With HIL testing, the ship hardware is replaced by a simulation model of the propulsion system.

First C-code was generated from the 20-sim model of the propulsion system (the yellow part of figure 4). This C-code was deployed on the Bachmann M1 system using 20-sim 4C. By exchanging the I/O signals of the ships propulsion system with the I/O signals of the simulation model, HIL testing could be applied. A batch of tests were carried out showing the correct implementation of the control system and validating it under a number of conditions. The HIL-tests were carried out in the factory of Kwant Controls.

Results

To assess the benefits of Model Based Design, two versions of a propulsion control system were designed in parallel. One using the traditional tools of Kwant and one using the

Figure 1: One of the ships that is equipped with products from kwant Controls.

20sim model based design software and the HIL simulation. Comparing the results showed that:

1) The design of the propulsion controller using 20-sim took some extra time. This was partly caused by design of the propulsion system model, partly by the simulations that were carried out to test the controller.
2) Traditionally the controller was hand coded on in Bachmann M1 controller. Significant time (approximately one week) was gained with model based design because of the automatic code generation out of 20-sim.
3) Traditionally the generation of the controller documentation according to the applicable standards, would take quite some time because of the manual labor involved. Using the documentation features of 20-sim, this was done automatically.
4) HIL-testing saved a considerable amount of time for the commissioning of the propulsion controller on board of the vessel.
Future savings are expected because of the reuse of controller and propulsion models.

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