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Case Study

Scalable development for microcontroller platforms

JUNGHEINRICH

Jungheinrich is known worldwide for high-quality logistics systems. The diverse product portfolio ranges from classic forklifts to energy systems and individual industry solutions.

The firmware for the control units is developed in Norderstedt near Hamburg. In order to master the growing complexity, Jungheinrich relies on the embeff ExecutionPlatform to test the software components.

We use a two-digit number of different microcontrollers from various manufacturers. With the embeff ExecutionPlatform, we have the possibility to test the entire functionality of the hardware abstraction layer without dependence on real control units. Our hardware-independent software modules are also tested in parallel on all microcontrollers. By dispensing with labor-intensive in-house developments, we save time and also have a standardized, easy-to-use and automatable test solution and documentation of the test results. Our developers are enthusiastic about the possibilities.

Jan Schröder
Head of Basic System & Standard Modules,
Jungheinrich Norderstedt AG & Co. KG

Challenge

Today, every forklift has extensive safety, assistance and comfort functions. As with cars, these functions are implemented by a large number of different control units.

In the past, the development of embedded systems at Jungheinrich was comparatively simple in terms of requirements and low overall complexity. This meant that individuals were already able to develop control units for industrial vehicles and take responsibility for the further maintenance of the software throughout all phases of the product life cycle.

Over the years, the variety of products and the combination of electronic and software components used has increased significantly. At the same time, the demands on the software have grown due to regulations, market requirements and digitalization.

Today, Jungheinrich engineers develop software for a double-digit number of different microcontrollers - and maintain them in the long term.

Modularization and reuse of the software modules therefore now play a central role. To ensure that the modules can run on different microcontrollers, a standardized interface (HAL, Hardware Abstraction Layer) had to be defined. In addition to simple pin functions such as GPIO, the HAL also offers communication interfaces such as CAN or I^2C.

In the context of safety-critical control units, the stability and fault tolerance of these interfaces are extremely important at Jungheinrich.

The challenge with this development is that the combinatorial explosion of software modules and microcontrollers quickly exceeds the amount of testing that can be done manually. At the same time, the appropriate target hardware must always be available, which is often not possible in practice.

To automate these tests, Jungheinrich initially relied on custom in-house hardware. However, this solution proved to be too time-consuming and difficult to maintain. Another particular challenge was testing the hardware-related HAL interface, which was only possible to a limited extent and without edge cases.

Solution

The embeff ExecutionPlatform is a standardized test system for microcontroller software.

The test device can test software modules including their behavior at pin level. The user can call up code functions and specify or evaluate pin behavior. With these innovative open loop tests, Jungheinrich can easily test the stringent requirements for all hardware-related software.

The tests are carried out on the microcontrollers that are identical to the later production series and are therefore fully reliable. In order to have all the microcontrollers used at Jungheinrich available in the ExecutionPlatform, the engineers only had to send a list of their respective order codes. After a brief review of the basic circuitry, the devices could be manufactured.

embeff supplied executable sample software and tests for each ExecutionPlatform. This also included integrations for all popular unit test frameworks. The examples for the Unity test framework proved to be particularly helpful. As Unity was already in use at Jungheinrich, the existing unit tests could be executed automatically on all microcontrollers without additional effort and integrated into the continuous integration with Jenkins.

With the supplied open loop examples and the automatically visible documentation within Visual Studio Code, the engineers were able to start testing the hardware abstraction layer on their own. The onboarding through executable examples ensured an optimal learning curve.

The ExecutionPlatform applies the required communication signals as input signals to the microcontroller on freely selectable pins. Outputs of the microcontroller are automatically recorded and compared as a result in the test. This approach made it easy to test complex error scenarios such as bus errors or overload situations on the central CAN bus for all control units.

Overall, the following interfaces are tested at Jungheinrich with the embeff ExecutionPlatform: GPIO, SPI, ADC, UART, CAN, PWM, I^2C.

The very good insight into the microcontroller behavior down to the pin is particularly helpful in day-to-day work. The freely programmable logic analyzer and integrated debugger allow complex behavioral scenarios to be fully displayed and understood. The fact that this is possible without unplugging cables and also from the home office makes the ExecutionPlatform a valuable tool for me.

Fabian Frese
Senior Software Architect, Jungheinrich Norderstedt AG & Co.KG

Result

Despite the prevailing time pressure due to ongoing projects, the embeff ExecutionPlatform has established itself step-by-step as a central test tool in embedded development at Jungheinrich. The **open loop tests** carried out with it at pin level **guarantee the quality standards** for safety-critical firmware required by standards and practiced at Jungheinrich. Running the unit tests on the ExecutionPlatform already led to the detection of critical errors on the microcontrollers that were not recognizable during previous use on the developer PC.

Due to the numerous variants, Jungheinrich uses the ExecutionPlatform in the compact rack version.

Continuous Integration now automatically checks all software versions on the target hardware for a double-digit number of different microcontrollers. The engineers use the ExecutionPlatform **during development** as a quick test option for hardware-related code and test-driven development.

As a modern employer, Jungheinrich makes it possible to **work from home**. The fully network-based ExecutionPlatform is integrated into the company network. Engineers can work on various microcontrollers at any time and from anywhere via a VPN connection.

Software development for new microcontrollers now begins shortly after the decision for a new chip. This is made possible by the prompt **provision** of suitable test devices **in 4-6 weeks**. With the ExecutionPlatform's help, software can be implemented and tested on the microcontroller - months before the final hardware is available.

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