A Simulation Technology for CAN-Based Systems

Experiences from developing and testing software for welding equipment

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Development and testing of software for distributed embedded real-time control systems is an area with great potential for improvements in terms of efficiency and quality. Debugging embedded systems in their target environment is challenging due to weak monitoring capabilities and lack of powerful debugging tools.

The simulation technology, CCSimTech, described in this article, is a toolbox aimed at improving the development and testing of distributed, CAN-based, embedded real-time control systems.

ESAB, a leading producer of welding equipment, has deployed this technology and their system is used as an application example (Fig. 1).

CCSimTech – description

CCSimTech enables control-system software to be developed and tested without access to target hardware. This is achieved by replacing all target hardware dependent operations (e.g. device driver and real-time operating system calls) with simulated equivalences. These equivalences are the core of CCSimTech. They are implemented as a set of software components (Fig. 2), simulating the behaviour of, e.g., CAN, LIN, I/O, RS232, EEPROM, and Flash.

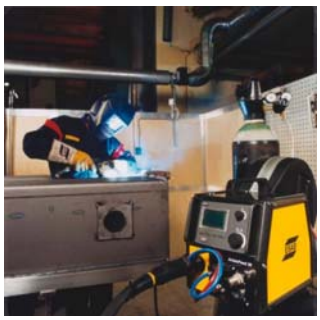

Fig. 1: Welding equipment with a CAN-based, distributed control-system

When using CCSimTech, the complete embedded system can be executed and tested in a single PC. It is important to emphasize that the software executed on top of CCSimTech uses the same source code as the target hardware system does, except that the device drivers and the operating system are replaced. The application programmer's interface, used to communicate with the environment, is the exact same regardless of whether the control-system is simulated or running on target hardware. This means that the target source code can be tested and debugged in a very efficient way, compared to black-box testing on hardware. Furthermore, powerful tools for debugging, automated testing, fault injection, and dynamic modelling of the target machine, available for PC's, can be used to guarantee the functional behaviour of the software. By incorporating these tools, complex and fast dynamic behaviours can be studied in a slowed-down environment, and slow behaviours can be speeded up.

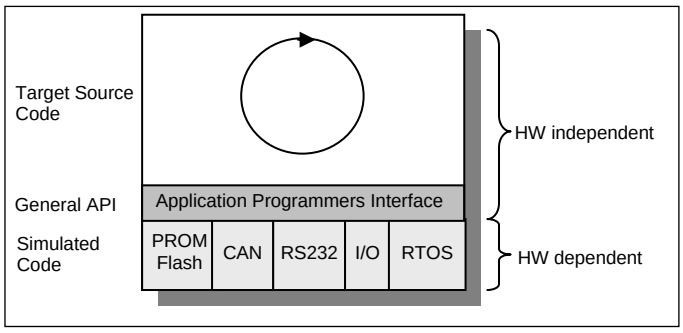

Fig. 2: Embedded software classification, separating HW dependent and HW independent control-system source code

CCSimTech can also be used together with target hardware, i.e. mixed simulation. Parts of the system are then executed in the simulated environment and other parts are run in target hardware. Mixed simulation can be used to facilitate hardware integration testing, by introducing and testing target hardware units in isolation together with the simulated system.

Application - ESAB

ESAB earlier used traditional methods to test and debug their control-system functionality. The functional behaviour of the software was tested by measuring the I/O-values on the electronic control units (ECU's) – a time-consuming and complicated method. Increased customer requirements on system functionality, leading to shorter release time-cycles, made it necessary for ESAB to look for new ways to improve efficiency and quality in software development and test. ESAB's choice was to introduce CCSimTech in the development process.

A schematic overview of an ESAB welding control-system, in its basic configuration, is illustrated in Fig. 3. This distributed, CAN-based, system has three ECU's; i) the weld data ECU, managing overall control of the welding process and HMI, ii) the power source ECU, controlling current and voltage in the power source, iii) the wire feed ECU, controlling the feed of welding wire.

When ESAB started to use CCSimTech, all target hardware dependencies in the control-system source code were identified and replaced with simulated system calls. After replacing these calls, the system became ready for execution in a PC. The simulated parts, e.g. the CAN communication, could now be logged and analysed using COTS tools.

By using CCSimTech, ESAB has managed to facilitate improved system tests, and shortened time to market.

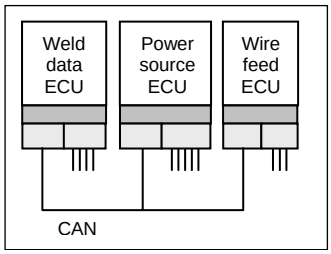

Fig. 3: ESAB welding equipment – system overview

Other Application Areas

The primary objective with CCSimTech is to shorten the turn around time for change, test, and evaluation in system development. However, since a complete control system can be executed in a single PC, CCSimTech facilitates software configuration management, customer tests and end-user evaluation in an early phase of system development. In addition, the technology can also be used to produce inexpensive training systems and advanced marketing support tools.

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