Measurement Technology & Simulation in One System

Efficient Component and System Testing–Integrating HiL Methods into Innovative Measurement Systems

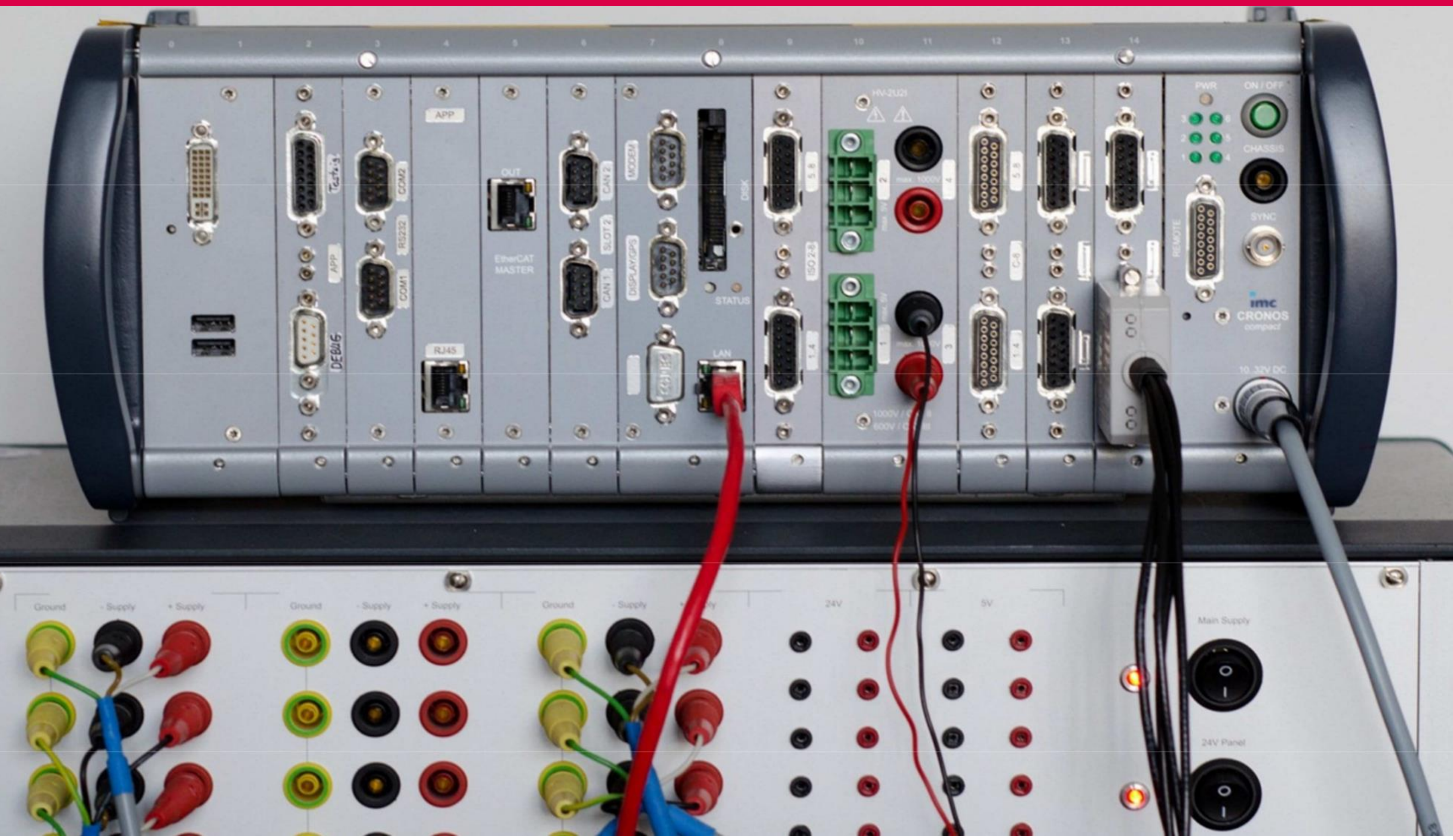


Abb. 1: imc CRONOS*compact* - universal modular measurement system expanded with HiL (embedded simulation processor)

For testing in the early development phase, measurement systems are united with real-time simulation and functions or components that are not available or are substituted by simulation models. This demands a comprehensive solution to measurement, control, regulation and simulation.

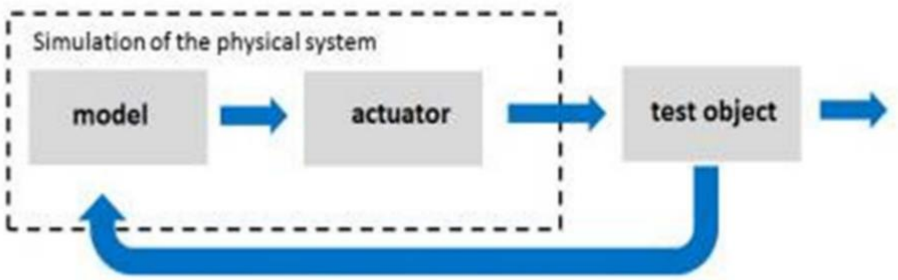
The imc HiL solution offered by imc Meßsysteme GmbH is a turnkey solution for Hardware-in-the-Loop (HiL) testing, bringing together real testing with simulation. Interfaces such as CAN, LIN, FlexRay and Profibus, EtherCAT and their protocols enable complete integration–on test stands as well as in mobile applications.

Modern product development particularly in the automotive industry is characterized by dramatically shortening product cycles and at the same time by increasing complexity. In the highly segmented and parallelized development process of today, measurement technology faces completely new challenges when it comes to developing components or subsystems for a complex and comprehensive system, or integrating these into the system. In a classic sense, measurement technology's task on the development test stand consists of verifying and optimizing the functionality of a mechatronic component. Often, however, this is requested at a stage in which vital parts of the environment or the components that need to be tested are not yet available. In order to achieve worthwhile results as early as possible and ultimately arrive at well engineered and reliable products, there is a growing need for measurement systems with the capability to embed real-time simulation and therefore close this gap: components or functions that are essential but do not exist yet, are replaced by simulation models.

Simulation is capable of substituting missing individual components in an otherwise completely real system, or it can create an entire virtual environment for an isolated real component. It is not even unusual for the actual target of development to be the simulation model itself, particularly when ECU or control device algorithms need to be tested and optimized under real time conditions by a measurement system as an "independent observer" – with, of course, the inclusion of a multitude of real quantities that need to be observed, correlated and analyzed.
This methodical – if somewhat technically demanding – approach is not entirely new. It has been successfully pursued in ECU development in particular for a number of years and is well-established. New, however, is the trend to liberate this tool from its niche existence within highly specialized expert systems, integrating it into universal measurement systems, and making it useable and easily mastered in wider circles. As a result, this modern development method is experiencing a boost in terms of its broader acceptance and is currently finding new fields of application.

Real process quantities flow into the simulation

Principle of the Hardware-in-the-Loop (HiL) test stand



The simulation is fed with real process quantities or measurement data. The calculated system or environmental behavior is in turn physically represented through equivalent output quantities such as analog voltage, controlled actuators, fieldbus communication or through control signals that operate and interact with the test object. This closes the loop in which "hardware" components for testing
and simulation can mutually interact with each other– hence, "Hardware-in-the-Loop".

The superior flexibility and efficiency of a method based on a configurable, universal measurement system with embedded HiL functionalities proves its worth especially in applications that involve a large number of very different physical quantities and transducers.

This allows the specific demands of both functions to be merged optimally into capabilities ranging from the seamless exchange of data, through exact timing synchronization and low latency deterministic real-time response, to comprehensive configuration management, data analysis and documentation of results.

The imc CRONOS*compact* solution is one such modular, individually adaptable test and measurement system that can be expanded with an HiL module. The HiL extension provides a dedicated processor that is directly embedded into the measurement system yet fully decoupled in terms of performance and therefore does not burden the main system in any way. The process has direct real-time access to data acquisition and can therefore – in complete synchronization and without additional latencies - input the measurement data into the simulation and feed simulated output channels back into the system. These outputs are mapped to real world signals like analog output voltages, digital control signals or fieldbus messages using respective modules integrated into the system. This avoids the need to transfer or exchange data using an external simulation system, such as a PC, and the system remains autonomous and mobile.

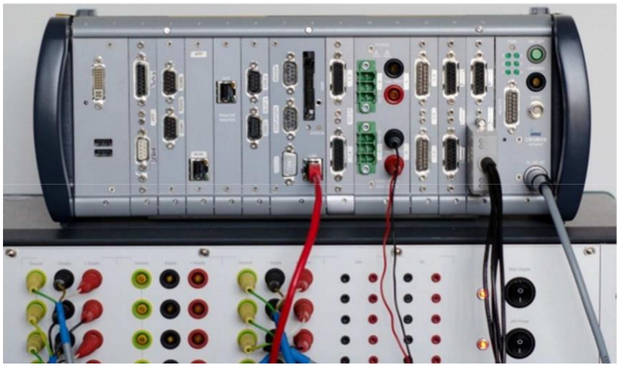


Abb. 3: imc CRONOS*compact*: universal modular measurement system with HiL extension (embedded simulation processor)

Controlled by a DOS-based real-time operating system, the simulation processor executes the simulation models which are loaded directly with the system configuration in the form of ready-compiled code. Matlab/SIMULINK® by MathWorks® has been chosen as the programming and execution platform for the simulation.

As this tool has established itself as an industry standard, many users benefit from the possibility to simply access existing models based on this environment. This is of enormous importance as a great deal of development and intellectual property has been invested in the models, and the process of whether to apply models or to create them can easily be decoupled.

Model development can take place on independent PCs, be performed by other experts who might be located elsewhere and using software licenses that are not even required in the target environment of the HiL system. The only step that needs to be performed in the measurement system is to define and map the interface – e.g., simply assigning the meaurement and output channels of the device to the inputs and outputs of the simulation.

Typical application: Vehicle dynamics and control system

A typical application carried out very successfully with this system was the development and testing of a vehicle dynamics control system (ESP, ABS). The task at hand was to examine the central control valves of the brake system on a test stand and in a climate chamber under changing conditions. The measurement system was required to acquire data in a variety of quantities, such as pressure, flow rate, voltages, currents and temperatures, as well as additional commands and data via CAN used to communicate with the ECU. The integrated HiL component took over complete simulation of the vehicle dynamics system,

including implementation of the ABS control, which needed to be optimized.
The simulation comprised domains such as wheel speed, brake pressure, characteristics of the different tracks (driving surfaces), friction values, etc. The relevant simulation output quantities were then converted via analog output into real physical voltages and, via PWM power stages, the valves were driven as the primary hardware object.
Particularly significant here was the direct, interactive manipulation and parameterization of the models.
Especially when it comes to live application-with real hardware under real-time conditions, it is absolutely crucial to be able to directly change model parameters during operation e.g., not by loading another model, but by adjusting the model at run time so that it becomes immediately effective in the next execution cycle. The imc CRONOScompact system supports such models with “tunable“ parameters which can be varied interactively or via other system variables. Thus, the control algorithms that were modeled using Simulink could be easily adjusted at run time and optimized by directly observing their affects within the measurement values.

Summary

The current trend is increasingly to use real-time simulation as an integral component of modern testing systems. Through the seamless and progressive integration of HiL methodology, measurement and testing in the development environment has taken on a completely new quality.

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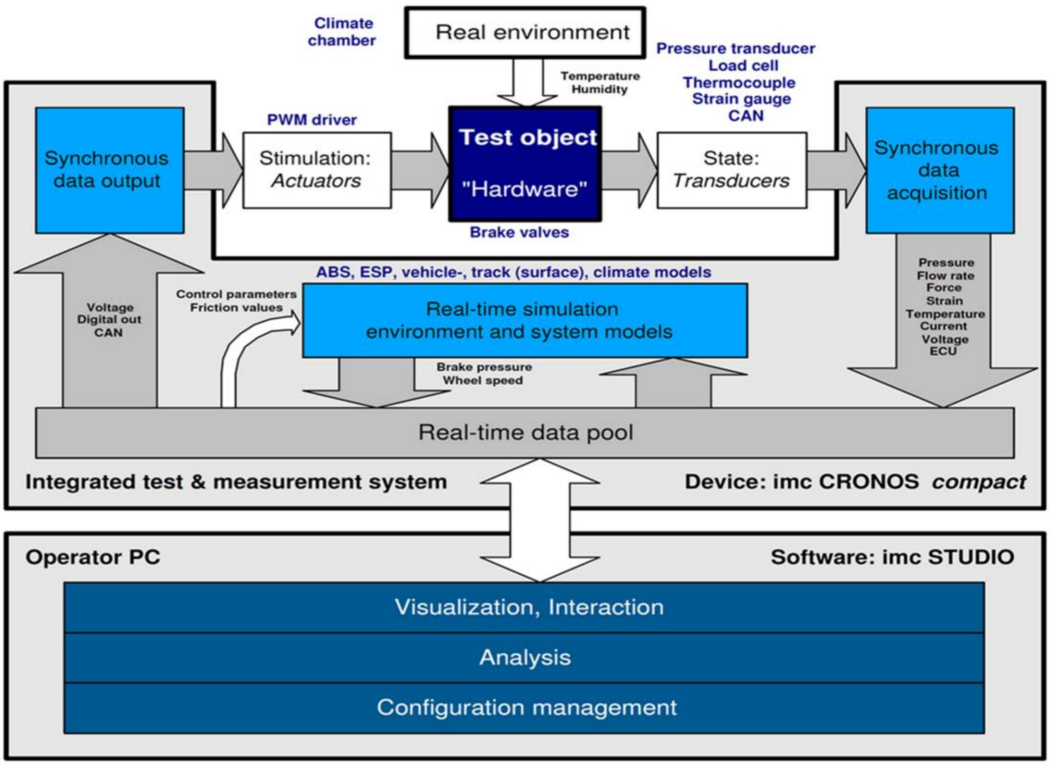

Abb. 4: Flow Diagram of Hardware-in-the-Loop (HiL)

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Our customers from the fields of automotive engineering, mechanical engineering, railway, aerospace and energy use imc measurement devices, software solutions and test stands to validate prototypes, optimize products, monitor processes and gain insights from measurement data. As a solution provider, imc offers their customers an attractive and comprehensive range of services. These include project consulting, contracted measurements, data evaluation, specialist deployment, customer-specific software development and system integration. imc consistently pursues its claim of providing services for “productive testing”.

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