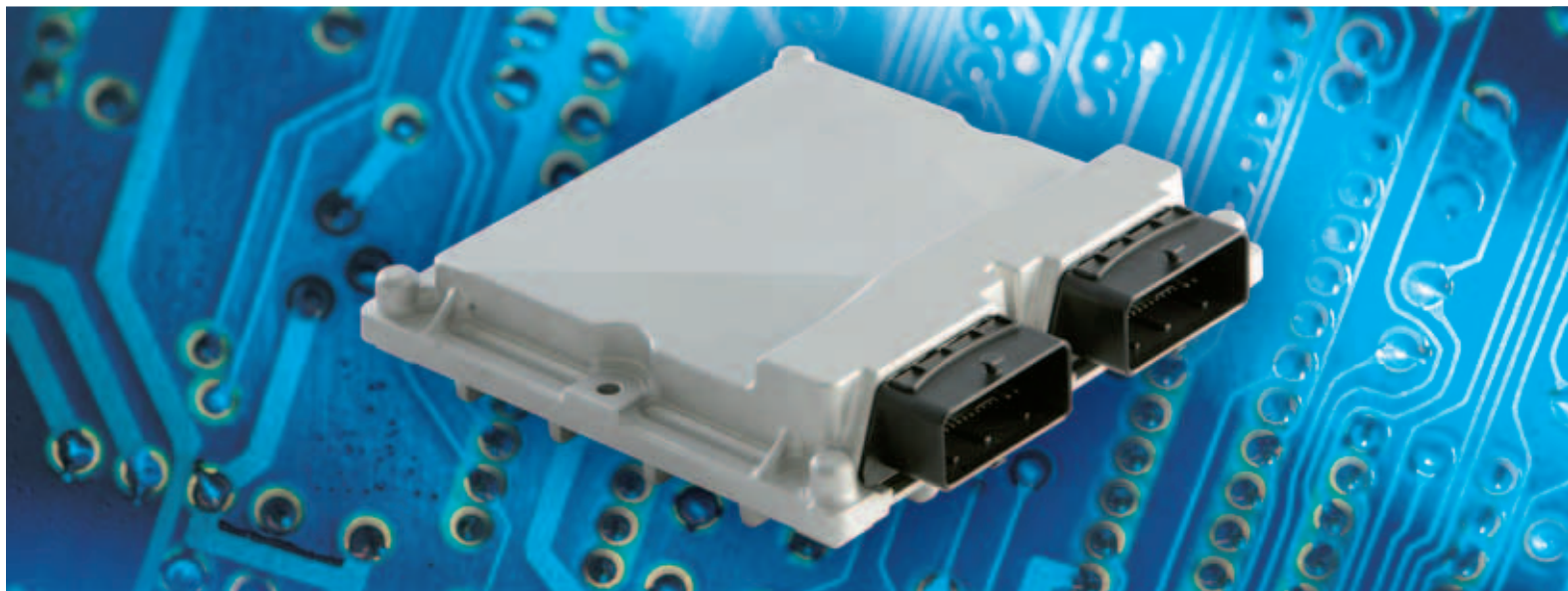


# Software Test Engineering

## Open-Loop Test Systems as an Alternative to HiL Systems



### Testing in the Development Process

Advancing modern-day internal combustion engines, intended to reduce fuel consumption and emissions, require new and innovative approaches. To make this possible, it is necessary to develop new algorithms and integrate them into engine control units. Validating the quality of such software involves various tests. This is where an end-to-end test process permits high-level fault detection and thus cost-efficient development modification options coupled with fewer recalls in the field.

Regardless of whether testing forms part of the development process or ensures satisfaction of the requirements that need to be met, the task remains the same: Validation tests are indispensable. They can take place on HiL (closed-loop) or in the form of open-loop testing.

### Service portfolio

Testing is planned in stages on the basis of an all-embracing test process starting from the test management schedule and extending through to individual test cases. Most test cases are generated automatically, e.g. from MATLAB®/Simulink® models, supported by appropriate tools (e.g. MOTCase-X, Reactis). Test cases are configured in such a way as to provide the capability of changing the test tool from an open-loop bench to a closed loop HiL.

### Using an Open-Loop Test System

*This system can be used when the aim of testing is to validate highly comprehensive control units, less complex control units with few pins as well as sequential control units found in retrofitted gaseous-fuel vehicles on a repercussion-free basis. Advantages include short set-up times and lower cost. Stimulation is given using actual measurements on the vehicle or synthetically generated signals, alleviating the need for engine modeling. Signals can be measured in real time. IAV uses this process in various projects as an alternative to HiL testing.*



Open-loop test system

### Minimum Demands on a Test System

- ▶ Manual control and measurements
- ▶ Linkage to a test automation tool
- ▶ Connection of a bus system (CAN, LIN, etc.)
- ▶ Connection of a break-out box, which easily permits the addition of further components

These demands are very easy to meet with a hardware-in-the-loop (HiL) system. Another alternative is available if closed-loop tests are not necessary.

For many tests, a stimulus and measurement system is sufficient for validating quality. As such, open-loop systems (e.g. NI CompactRIO) can be used for interface tests between basic and function software or for testing the integration of control-unit hardware and basic software.

### Implementation (application examples)

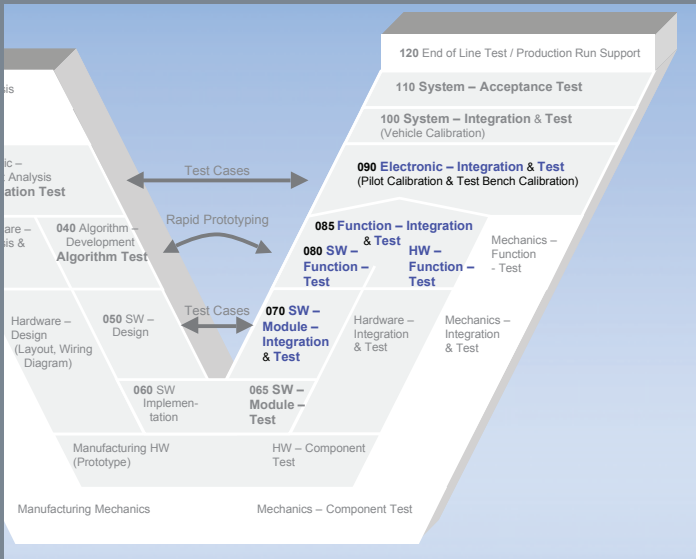
- ▶ Integration testing for algorithm and basic software modules
- ▶ Integration testing, e.g. in respect of linking function software and basic software
- ▶ Algorithm tests (in relation to functionalities requiring stimulation using the control unit PIN)
- ▶ Tests validating the electrical integration of (new) components
- ▶ Electrical validation of inputs
- ▶ Test-bench automation

Testing can be conducted throughout the V-model development process with an open-loop system to the point of electrical integration testing.

### Testing and Verification

The IAV staff can perform the software tests using IAV facilities or by working together with the clients staff to setup and conduct the tests using the customer's own facilities.

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V-Model at the development stage



Vehicle testing at IAV