# Reliable Engineering Testing on a Wiper Motor Test Bench

## Time-synchronous recording and evaluation of bus messages and physical parameters during endurance testing

**Synchronizing the bus communication with measured physical parameters is one of the most difficult requirements for reliable tests of ECUs. The data from four data acquisition boards was evaluated in real-time and synchronized with the bus communication of a control module in real-time. The specialists of Vector Informatik developed an individual solution based on the development and test tool CANoe for the requirements of Valeo Wiper Systems.**

Valeo Wiper System develops wiper modules using electric controlled reversing DC motors to realize complex wiper movements based on the OEM customer specifications. The wiper system has to react flexibly and "intelligently" to environmental conditions. This can be realized with the use of a bus communication system. Additional features of reversing wiper motors are:

- Software-based wiper field control
- Alternating park position to prevent permanent set of the rubber element
- Software control of wiper movement and other operating states
- Service position for the exchange of wiper blades
- Load-dependent speed control
- Overload protection

Unlike conventional fully rotating DC motors, the output shaft of this motor type reverses at an angle less than 180 degrees. The motor drives a linkage that moves the wipers across the windshield.

In conformance with the vehicle architecture, Valeo uses a CAN or LIN data bus to control the reversing wiper motor. This new wiper system technology also requires new standards for testing technology, which needs to be developed in addition to the actual product. Therefore, Valeo has derived the requirements for an endurance test bench and test processes based on customer specifications:

- Test duration of more than 1.5 million wiping cycles which is equal to a continuing test time of more than 28days.
- Automated, software-controlled test sequences
- The highest level of test system stability (software and hardware)
- The simultaneous testing of up to 5 motors using individual control (voltage, motor loads, current limitation, etc.) including the remaining bus simulation.
- Sequential measurement of physical motor parameters such as angle, current, voltage, and temperature; calculation of speed and RMS values
- Continuous monitoring of bus communication, motor output shaft movement profiles as well as other physical parameters and their evaluation by comparing actual measurements to envelop curves.
- Control of the climate chamber according to specified climate profiles

In order to validate the correct function of wiper motors controlled by bus messages, Valeo needs to record and evaluate the physical parameters such as angle, revolutions, and current on the test bench. The determination and documentation of violations to customer specifications shall be rather simple and convenient. Valeo engineers worked with different suppliers on various proposals for the realization of such a test bench. Finally the concept of Vector Informatik GmbH from Stuttgart, which is based on the flexible development and test software CANoe, was most convincing. A decisive factor for choosing Vector Informatik was Valeo's experience in the successful application of Vector tools such as CANalyzer, CANoe, and CANister.

The "CANoe Application Development" team of Vector managed the implementation. Through numerous test and simulation projects,

**Figure 1:**
**Wiper test bench at Valeo**

the team has the necessary experience and know-how to create customer-specific test systems with CANoe. The Valeo test engineers and the Vector team worked jointly to determine requirements for the configuration interface of the test process control. Both project partners created the requirements for recording and evaluating measurement data collectively. The development was initially based on a simulated test environment prior to testing and adjusting the CANoe test system on the actual Valeo test bench (Figure 1).

## Customer-tailored hardware for recording measurement data

The test bench hardware was build by the Gesellschaft für Mess- und Systemtechnik (GMS) [Association for measuring and system technology] in Spaichingen, Germany. DAQ cards from National Instruments were used for recording analog and digital signals. The parameters such as angles, currents, voltages, and torques are recorded for each test station individually. Vector integrated the four data acquisition boards into the CANoe test system (Figure 2). For standard applications this integration is realized using the CANoe port link feature. At that time (before version 6.0), CANoe did not support the signal block transfer between data recording board and CANoe. Thus Vector developed a CAPL-DLL customized for the application, which expanded the CAPL programming language in CANoe to include user-defined functions and interfaces.

This DLL is used to read and condition the measured signals directly from the input buffer of the hardware. This allows nearly real-time signal processing with a high sampling rate. Then these signals are forwarded to the data recording within CANoe (Figure 3). Parallel to the data processing via the DAQ boards, the test bench control activates the motors depending upon the test scenarios using a low-speed CAN bus or a LIN-1.3/2.0 bus.

In order to achieve the required test coverage, the test bench is equipped with five individual stations, permitting independent operation. Each station is equipped with its own power supply, brake, and bus interface. The brake provides the load of the wiper motor with a maximum torque of 15 Nm. The test engineer specifies the individual load in the test setup.

The bus communication between each test specimen and the CANoe control is also provided separately in order to simulate the communication characteristics between the electric motor and the ECU as realistically as possible. Vector created a remaining bus simulation for the CAN or LIN bus communication for activating the wiper motor. Since there was not a real wiper ECU at the beginning of the project, the remaining bus simulation was expanded by an additional node that simulated the characteristics of the wiper motor. After the integration of the real ECU, this node was simply deactivated.

The test bench is equipped with a standard industrial PC for the simulation and control functions as well as for the evaluation of the measured signals in parallel for all five test stations. The PC is also responsible for activating the wiper motors via the CAN or LIN buses. A CANcardXL and two CANboardXL with the appropriate CANcabs or LINcabs from Vector are used as interface for the bus interface.

## Permanent set point/actual comparisons make the evaluation easier

The test sequences of an endurance test are customer specific and include all functions of the wiper motor. For example, an endurance test might last more than 1200 hours. The wiper motor is operated at different loads and temperatures in all modes such as high and low speed, interval mode, off and sleep mode.

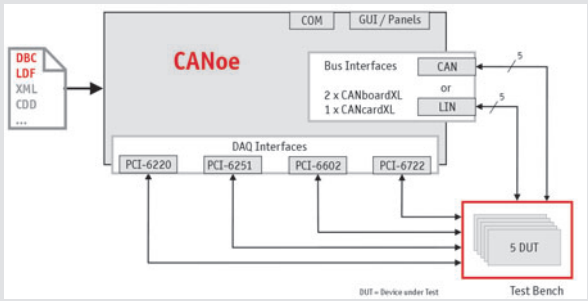


**Figure 2:**
**Integration of CANoe in the wiper test bench**

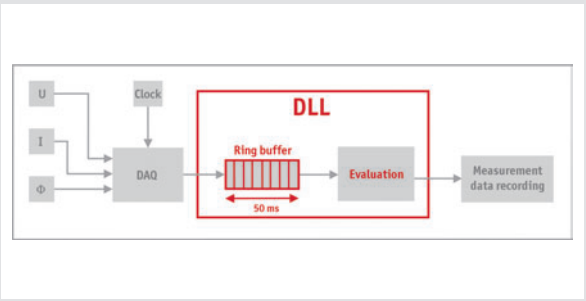


**Figure 3:**
**Data evaluation in the CANoe node layer DLL**

During these tests, the monitored physical parameters such as current, rotation angle, the position of the motor output shaft, and motor temperature are allowed to vary within specific limits only. The limits are specified as envelope curves (Figure 4). In order to achieve the required accuracy for example of the RMS value of the current, the data is recorded with a sampling rate of up to 20 kHz. Post processing of the raw data reduces the data to one single value within 2 ms.

A part of the evaluation is the permanent comparison between the measured signals and the specified envelope curve. The data is temporarily stored in a ring buffer. In case of deviations, CANoe stores pre and post event data values (logging). The data volume is adjustable (Figure 5). The Vector software application is able to record real time bus communication between the motor control and the wiper motor in parallel to the measured signals. If communication errors occur, the CANoe logging function records the measured physical parameters as well as the corresponding bus communication, including the pre and post event data.

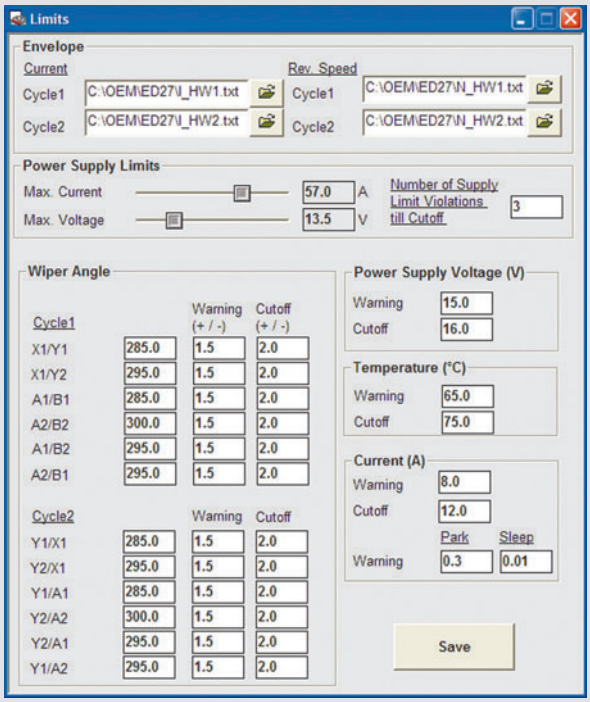


**Figure 4:**
**Configuration of limit values**

Synchronous recording of the bus communication with the physical measurement values already mentioned above is the critical factor in achieving the most useful test results. It has shown to be especially favorable that the recording of the bus communication, the measurement recording and the control of the test bench be done by a single software tool with a common time basis (CANoe).

CANoe is also responsible for comparing the measured physical parameters and the bus communication with the specified limits. If critical events occur the results are recorded. I.e. if defined limits are exceeded or if switch-off criteria are reached. The latter is also used to switch off the test.

## The clear operating structure simplifies test configuration

According to the specification of Valeo the Vector team also developed a CANoe user interface to create various test sequences, visualizations (Figure 6) and for the test bench control. The operator-friendly user interface allows the test engineers to create complex test procedures and test sequences, based on time, event, or cycle. The different levels of the user interface support the test engineer in specifying a logical structure of the individual test parameters according to the test specifications. The activation of the climate chamber as a part of the test benches is also integrated in the user interface. The status display (Figure 7) shows the current number of operating cycles and error messages as well as the violations for current, speed, or angle limits for each of the five test motors.

The Automobile manufacturers only tolerate rotation angles within specified tolerances in the endurance test of the output shaft from a reversing wiper motor. Thus Valeo continuously monitors this angle. The CANoe application is able to distinguish different levels of limit violations.

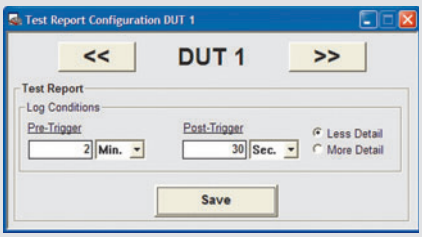


**Figure 5:**
**Configuration of pre and post trigger times. In case of an error, all events which occur in this time window are stored.**

In case of low-level violations the software issues an error message (Figure 4). If a high-level violation occurs the software interrupts the test immediately. The different levels are adjustable in the setup.

The application developers of Vector have prepared similar test procedures for the parameters current and temperature. The Valeo test engineer can pre-select how often the limit may be exceed before the software will terminate the test. In general, each tested wiper motor can be started individually, i.e. it is possible to interrupt and continue a test individually. Parameters such as loading torque, voltage, or current can be adjusted separately.
Error logging stores the data in small blocks, which allows the test engineers to perform analyses during the test. The test bench software includes status logging which stores the current signals in freely adjustable intervals.

## Compensation of environmental influences

Some boundary conditions made the development of measurement and test algorithms very challenging. For example, the test bench is attached to a climate chamber for temperature testing. The compressor of the chamber transmits vibrations to the test rig and the tested wiper motor. The high-resolution angle sensor is able to realize the vibrations as movements of the wiper motor even thought the motor output shaft is not moving. A damping or physical disconnection of the compressor from the test bench would be extremely difficult, and an angle sensor with a lower resolution would not fulfill the required measurement accuracy.

In order to compensate such errors, the measured data are post processed using digital filtering and compared with specified speed limits. In case the software detects a continuously oscillating movement within certain limits, it is able to differentiate these signals from a true motor output shaft movement. The elimination of false data must occur rather fast due to the real-time signal comparison between the physical angel signals and the bus communication.

## Different wiper test benches – one solution

After the successful implementation of the CANoe test application in the durability test bench for reversing wiper motors, both development partners extend the application to test conventional rotary wiper motors. While other test benches monitor the motor speed and temperature only, this application improves the data acquisition, real-time data monitoring and data analysis.

Valeo has already planned an additional expansion: the CANoe test system should be enhanced to a mobile operating and data acquisition system for bus controlled wiper motors for the use in conventional test benches and even onboard test vehicles. This allows simple analysis of wiper systems in a wind tunnel or road testing.

With the planned extension of the application Valeo benefits from the large data acquisition and analysis capability of the CANoe software tool. The development team just needs to specify the options that have to be implemented in the software. The expense is relatively small: Valeo employees supported the Vector team with their specific product know-how and the definition of the application. The "CANoe application team" from Vector started the development of the test regimen, bus communication and the data acquisition as well as the evaluation of the test data with two engineers. Subsequent expansions has been realized with one person form both partners.

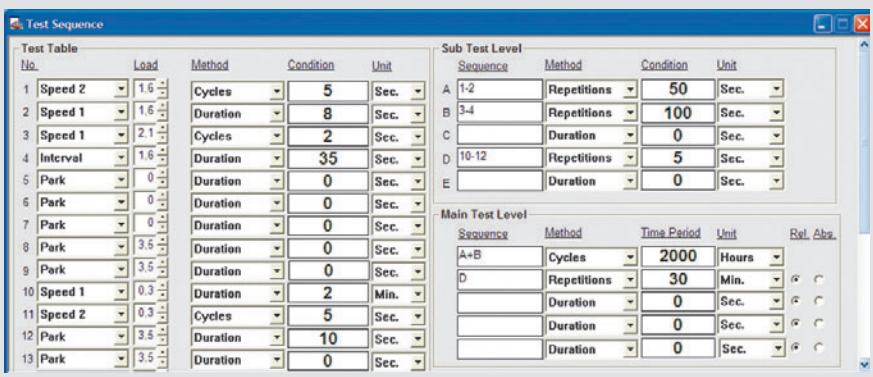


**Figure 6:**
**Configuration of test procedures**

Valeo and Vector clearly exceeded the objectives set for this project by reacting flexibly to unforeseeable challenges along the development and implementation process. Furthermore they are planning an extension of the application as more capabilities of the CANoe tool become apparent during the application development. During the execution of the project the specification had to be redefined in order to realize additional test features. Usage of elegant software solutions allows optimizing the application. With the new wiper motor test bench, Valeo will use the multifunctional CANoe tool as a continuous system platform from the start of the product development to the validation, thus guarantying its customers the delivery of reliable products.

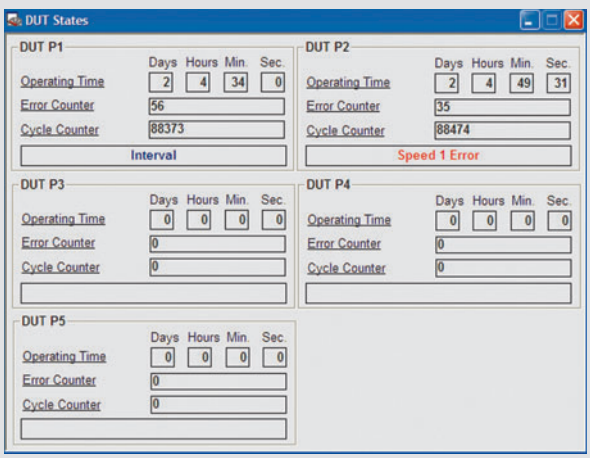


**Figure 7:**
**Current status of the five test specimens**

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