Wireless analysis in a multi-protocol CAN environment

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In developing electronics for modern construction equipment, a large share can even be tested and simulated meaningfully on test benches. In later development stages, on the other hand, it is preferable to perform tests and trial runs under real conditions at construction sites or outdoor test sites. To avoid distracting the operator in the driver's cabin with test equipment, a wireless interface has now been realized for the first time with the CANoe and CANalyzer development and analysis tools from Vector Informatik. Electronics developers at Bomag GmbH now use this interface to log the communication on various vehicle buses at a distance and analyze it. Quality requirements in earthmoving work and highway construction are continually growing with a simultaneous rise in cost and time pressure. Soil compaction and cost-, raw material- and energy-saving methods of road preservation and reconstruction are often only possible with intensive use of high-tech electronic functions. Bomag is the global market leader in the field of compaction technology. At its lead-plant in Boppard, this company – part of the Fayat Group – produces about 30000 machines annually for soil, asphalt and garbage compaction as well as stabilizers/recyclers. Today, a large share of the company's expertise has its foundation in electronics.

When it comes to networking technology, Bomag bases its work on the CAN bus standards of the automotive industry. Initially, the electronics concept was established on the large 10-t to 15-t machines, and it was then ported to the smaller machines. Since Bomag would like to have hardware and software components be reused as often as possible within the overall corporate group, the focus was on a modular concept. This also required standardization of development and test equipment across their business sites.

Fig. 1: The electronics on the MPH 125 support efficient implementation in soil stabilization and recycling

Nothing works without electronics

High-tech equipment and electronics can be found everywhere in the machines, from remote controls to drive-by-wire steering systems to the use of GPS. Sensors continually acquire the soil composition, and the display graphically indicates to the driver where compacting work is still needed. The GPS option enables satellite-supported, large-scale compaction monitoring with seamless documentation of all parameters. In the future, radio networks will provide for data exchange between the machines driving in a group. The new type MPH 125 stabilizer/recycler – with an operating weight of 24.5 t and a power of 440 kW – is the machine with the most extensive electronics system and the most CAN nodes. First, it is used to improve and reinforce existing soil materials by mixing in lime, fly ash or cement, and secondly for milling, pulverizing and recycling existing materials in-place and locally.

Network cluster with multiple CAN buses

All Bomag machines of a given product line have the same control system, and they acquire their specific control functionality in end-of-line parameterization. Therefore, electronic developers mapped the machine's modular product concept to a modular CAN-based network cluster. CAN 1 – as the central Body-CAN bus – is connected to the most bus nodes. Its operation is based on the CANopen protocol, which enables the use of standard ▶

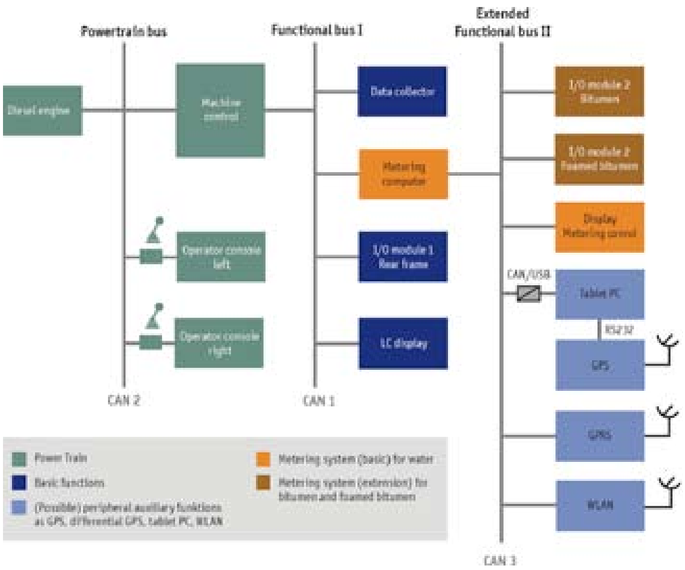

Fig. 2: The electronics concept reflects the modular layout of the machines

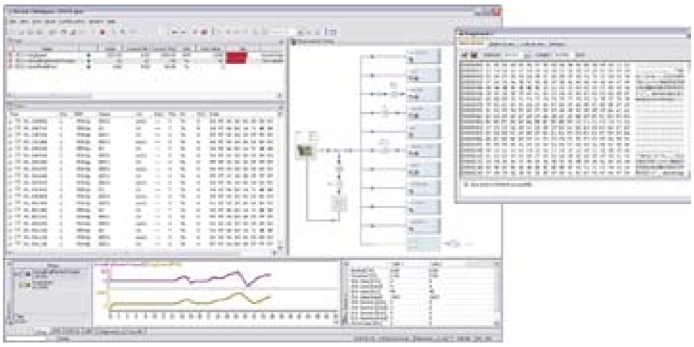

Fig. 3: J1939-specific interpretation of data in the Trace Window is performed with CANalyzer.J1939

automation components. Besides the vehicle's main computer, the data acquisition unit of the front frame and I/O module of the rear frame, CAN 1 nodes also include control and display components in the cockpit. Conventional analog and digital sensors are interfaced to the data acquisition unit, e.g. hydraulic pressure sensors and fill level sensors. The I/O module on the rear frame is responsible for control of the variable-height rotor, lateral tilt angle and lowering cabin feature for transport purposes. It was possible to significantly reduce wiring cost and effort by interfacing controls to the bus; these include the CAN-bus-capable joysticks, LC displays and external switches. Bomag created an in-house development of a CANopen driving lever with friction brake.

The powertrain bus is defined as CAN 2, and it interconnects the vehicle's main computer, engine controller, steering and driving levers, including operator consoles on the right and left. Interesting here is that the J1939 and CANopen protocols are implemented in parallel on CAN 2. A special feature of the drive control system is load-limit control of the Deutz diesel drive, which provides for dynamic power distribution between higher milling power at low speed and lower milling power at high working speed as a function of soil composition.

Besides CAN 1 and CAN 2 there may be a third CAN 3 data bus, depending on how the MPH 125 is equipped. It incorporates an optional metering computer with auxiliary display and the necessary actuators for water injection. Similarly, CAN 3 is needed to interface to the metering system for bitumen emulsion and foamed bitumen.

Multi-protocol capable tools

In electronics development, Bomag implements a number of software tools from Vector Informatik. The Stuttgart-based networking specialist offers tailor-made tools for all electronic development tasks, such as CANoe for network development and ECU tests, CANalyzer for analysis of bus data and CANape for calibrating ECUs. At the beginning of development, CANoe simulates the behavior of individual bus nodes or entire sub-networks (rest-of-bus simulation). Over the further course of ECU development, the models serve as a foundation for analysis, testing and integration of bus systems and ECUs. The C-like programming language CAPL and user-defined interfaces simplifies the user's work. A special real-time configuration significantly improved real-time capabilities even further, first by using separate PCs for rest-of-bus simulation and test execution, and second by graphic control/evaluation; this yielded the high performance of a component HIL tester. ▶

The CANalyzer analysis tool offers numerous functions for bus analysis. They range from tracing the bus data traffic to displaying signal values, performing statistical evaluations of messages, busloads and disturbances, and finally targeted generation of specific bus disturbances.

CANape is used in the calibration of electronic ECUs. All important variables and parameter sets can be modified and visualized in real time. Helpful in conjunction with the development of GPS applications is CANape Option GPS, which supplements the system with visualization of the momentary vehicle positions on an electronic map.

The universality of Vector tools is paying off at Bomag by helping it to master the complex challenges of working with multiple buses, and in particular the J1939/CANopen multi-protocol environment. The consistently applied database concept is an important pillar for the efficiency of the development tools. All members of the tool chain access the same data set, so that it is possible to save all data consistently without unnecessary redundancies or sources of error. Fitting for the bus systems used, the relevant databases of the network description are either already integrated or automatically generated to match the network configuration.

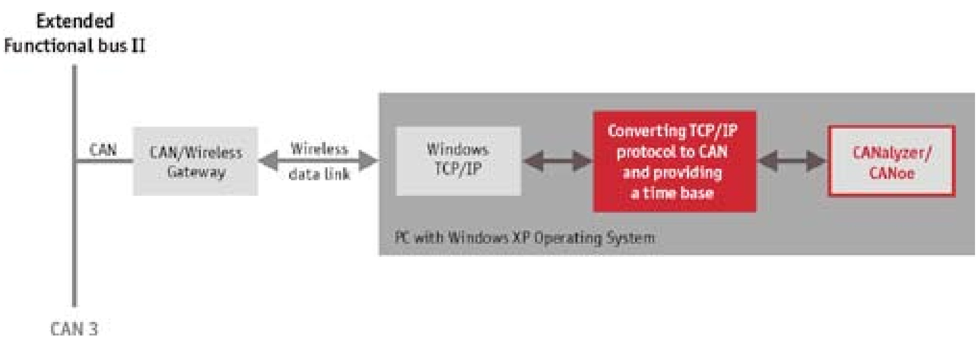

Fig. 4: The extended WLAN tunnels the CAN messages, including time stamp, via a TCP/IP interface, thereby enabling time-conformant representation of the data

Besides supporting CAN, the tools also support the LIN, FlexRay and MOST buses as well as the higher level protocols J1939, J1587, NMEA2000, ISO11783 and CANopen. In the case of Bomag, CANape and the CANalyzer/CANoe options for J1939 and CANopen are used. Protocol-specific extensions of the tools relieve the user of the need for detailed training in the J1939 or CANopen protocol; this avoids faulty interpretations of CAN frames. Last but not least, another important requirement in the analysis of muli-bus/multi-protocol environments is that a uniform time base must always be present as a foundation for analyses.

No need for an 'umbilical cord'

What has been difficult for Bomag electronics developers to achieve until now is time-synchronous analysis of the measurement data during the field tests mentioned in the introduction without having to be passengers in the machine. They were only able to examine the logged data afterwards, but not during a test. For these and similar cases, there is now a technically mature WLAN solution from Vector: While previously it was absolutely necessary to maintain physical contact to the bus system being analyzed when working with the tools, the specialists from Stuttgart have now made it possible to establish contact with the DUT by an extension via a modified WLAN system. So the transceiver cable between PC and CAN bus is quasi removed and replaced by the radio pathway. Noteworthy here is the fact there are no significant compromises with regard to accuracy or measurement requirements. In implementing the extension, special attention was given to satisfying requirements for correct timing in data transmission, low latency times and time-synchronous display of the data on the PC. The CAN messages – together with their time stamps – are tunneled via a TCP/IP connection, so that the time stamps provided with the messages can serve as reference times for CANoe and CANalyzer.

'Drilled out' WLAN solution

This solution offers some key advantages compared to the capabilities of a simple CAN/WLAN bridge.

Only a bridge header is necessary for this setup. Sufficient as a host is a WLAN-capable laptop/notebook, which maintains the connection via standard on-board resources and WLAN. The "probe" on the DUT that is responsible for converting from CAN to WLAN sends the messages in strict and chronologically-correct order by considering the time stamps originally logged on the bus, which would not be possible via a CAN-WLAN-CAN bridge. During machine operation at the construction site, the Bomag electronics developers can measure, observe and evaluate without a hard wire connection to the machine.

Summary and outlook

This example from the commercial vehicle sector shows that there are interesting and demanding challenges outside of the realm of automotive electronics for luxury cars, challenges that can only be handled by complex network clusters and high-performance development and analysis tools. The universality of Vector solutions pays off here. The tools enable analyses and simulations directly on the higher layers of J1939 and CANopen. The use of multiple buses or simultaneous use of different protocols on the same bus do not present any problems. The tools always ensure correct timing with the same time base in data acquisition and evaluation – even in the case of wireless communication. The Bomag developers already have their sights set on the next WLAN project involving automatic, multiday durability tests. Thanks to a WLAN connection, the electronics developers are able to continually observe events on the relevant bus systems with the mentioned tools. That can be done from the office or via the Internet, e.g. from home during the weekend.

Sources: Fig.1 and 2: Bomag GmbH, Fig. 3 and 4: Vector Informatik GmbH

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