Quickly Converting Test Benches Worldwide in Record Time

Record-Breaking

The numerous tests that are required before an ECU is released for production represent a considerable share of the development costs for the ECU. In addition, the effort required for conceptualizing test benches and programming test sequences has grown immensely in recent years. Of equal interest are the impressive cost and time savings that automotive supplier ZF TRW is realizing in its new generation of test benches. For example, the company was able to reduce its test bench setup times from many months to just a few weeks by using component-based test benches.

Years ago, anti-lock braking systems (ABS) were considered ambitious equipment for vehicles and were only offered beginning with upper mid-class vehicles. Today, complex extended traction control systems such as ESC (Electronic Stability Control) are now state-of-the-art. The evolution from ABS to ESC clearly illustrates how the complexity of automotive electronics continues to grow in all fields. In contrast to an ABS system, which is only active when the driver brakes, an ESC system operates practically autonomously. Accordingly, more sensors are needed to provide the system with acceleration data and information on transverse and longitudinal forces, torsional motion, etc. Therefore, newer ECUs must be able to process the data of increasing numbers of signals from their own sensors and data from connected bus systems.

Testing Effort Reached Pain Threshold

The products that automotive supplier ZF TRW develops at its Koblenz facility in Germany include controllers for ESC systems. The growing complexity of its developments is reflected not least of all in its increased testing effort. Both the numbers of ECUs and their extended functionality are resulting in test cost increases. Over the past ten years, the number of ECUs installed in a premium vehicle has grown from around 30 to as many as 200. The technical effort involved in the numerous test scenarios for testing every ECU type under all conceivable operating and environmental conditions is tremendous. A special ECU version is required for each vehicle model and each OEM. At ZF TRW, one ECU variant is implemented as an ESC system and one variant has an integrated parking brake as well.

Each ECU must pass numerous electrical, functional and mechanical, environmental in addition to EMC tests before product release. Simulations must recreate environmental

parameters as well as mechanical and electromechanical stresses and in extreme situations. In temperature cycle durability tests, for example, the devices and PC-board assemblies are subjected to thermal shocks from -40 to +120 °C. Mechanical stresses can range from vibration tests with sinusoidal oscillations and noise characteristics to individual mechanical shocks with accelerations as high as 30 g. Moreover, sealing tests are performed in tests with salt spray fog, extremely fine sand and splash water, while high-pressure cleaning devices simulate engine washing.

Virtual ECU Environments

A precondition for these tests is that the ECU must be electrically and functionally active. However, representative tests and comprehensive diagnostics of ECU functionality are only possible if the test bench seamlessly emulates the electrical and electronic vehicle environment. This means that signals must be generated with realistic voltages and currents at all digital and analog inputs. This also applies to connected loads and to what is known as remaining bus simulation. That is because, in addition to CAN, other bus systems – such as FlexRay, LIN and MOST – have become well established in the automobile with numerous ECUs communicatinge simultaneously on multiple buses. These multibus systems further increase complexity and must also be simulated properly in the remaining bus simulations – and sometimes the functionality of gateways must be simulated as well.

Some time ago, the test bench engineers began their search for a more advanced and flexible test bench solution that could handle the growing complexity of ECU tests and available timeframes that would meet their future needs. The solution was to be implemented globally and uniformly at all ZF TRW business sites. Since then, the automotive supplier has started up a total of 32 of the new test benches in Germany, the USA, Czech Republic and China. Each test bench consists of a 19″ cabinet with six rack-mounted units, so each stand can test six ECUs in parallel **(Figure 1)**. Each cabinet has a scanner, a touchscreen and a keyboard for user inputs, display of results and readout of status messages **(Figure 2)**. The individual rack-mounted units are supplied with energy from a central power supply that can supply electrical currents of up to 500 A for high-current for consumers and a nominal voltage of up to 30 V. These high power levels are required for tests of the ESC controllers, in which 580-Watt drive units are responsible for building up brake hydraulic pressure, and high ramp-up currents occur. Despite its high energy capabilities, it is neces-

Figure 1: Six rack-mounted units or subsystems, each of which represents a unit for testing one ECU. One test bench can test a total of six ECUs simultaneously.

Figure 2: User-friendly concept with touchscreen, scanner and keyboard simplifies operation of the test benches

Figure 3: The modular VN8900 network interface with integrated real-time computer plays a central role in the ECU's network communication.

sary to manage energy consumption during parallel tests to ensure that not all of the rack-mounted units demand maximum power simultaneously.

Focus on Intelligent Network Interface

Using the VN8900, a special hardware device from Vector, plays a central role in the solution used for the component-based test bench **(Figure 3)**. The ZF TRW test bench supplier, the company Smart Testsolutions GmbH – not to be confused with the manufacturer of small cars – integrates one VN8900 system per rack-mounted unit in its solution **(Figure 4)**. The VN8900 system is a modular network interface for FlexRay, CAN (FD), LIN, J1708 and K-Line bus systems that is equipped with a dedicated x86 real-time computer. Specially designed for applications with many parallel accesses to multiple bus channels, it offers high I/O performance with extra-ordinarily short reaction and response times and very minimal latencies. Along with variably configurable bus interfaces, the system also offers extension options for analog and digital inputs/outputs. This intelligent interface is easy to configure from a PC over USB or Ethernet.

Since the VN8900 systems was optimized for the use with Vector CANoe and CANalyzer simulation and analysis tools, the new test benches can easily and seamlessly be integrated into the tool chain at ZF TRW. This means that existing CANoe remaining bus simulations, which are available in the development departments, can be reused practically in tests with minimal modifications. These remaining bus simulations are already verified internally, so that no additional effort is needed for quality assurance when they are reused. This approach essentially eliminates all internal concerns from the outset, and it leads to noticeable workload relief for employees and especially for the project leader. The approach reduced changeover times drastically: before it could take up to eight months to retrofit an ECU test from OEM1 to OEM2, to a time period of just two to three weeks now. At the same time, there was a tremendous increase in flexibility in responding to late customer software changes shortly before the start of testing with modification times of less than one week.

Robust Test Sequences

Another special aspect of the VN8900 system is the option of automatic operation without requiring a connection to an operating or monitoring PC. The test engineers use CANoe at a normal PC workstation to create the remaining bus simulations and test sequences in the CAPL script language. They can then be simply loaded into the VN8900 system and executed there. Some of the benefits that

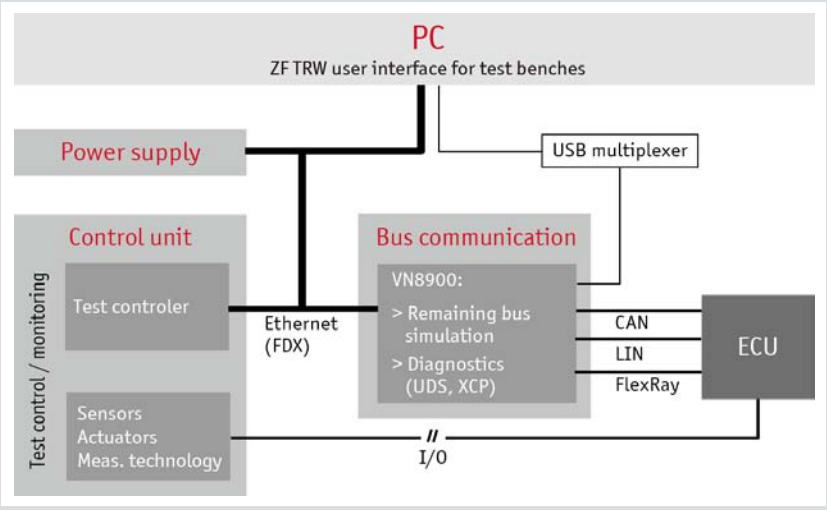

Figure 4:
Block circuit diagram of a stand-alone subsystem; six of these units are installed per test bench.

ZF TRW realizes from this are greater stability and durability in long-term tests. Previously, the PC would sometimes crash after a couple of months in the long-term tests which took up to six months to complete. This was annoying, because the computer could then no longer provide any monitoring of the ongoing test process. Such problems have yet to occur so far with the new test benches.

Today, a strict separation is made between test controlling, visualization and communication with the ECU. The VN8900 system communicates with a Linux-based host computer from Smart Testsolutions via the LAN interface. In this case, a special real-time capable Ethernet/UDP protocol supplied by Vector, which is known as FDX (Fast Data Exchange), is used. By working closely together with Vector, ZF TRW was able to modify the FDX protocol to meet its own needs. In this framework, it implemented data exchange by the FIFO principle, for example. In turn, Vector got ideas from ZF TRW about ways to further develop the VN8900 system. FDX offers wide-ranging access to automatically running tests along with enabling starting and stopping of applications. It also offers such capabilities as reading out and clearing error codes, reading and saving XCP variables, influencing remaining bus simulations and much more.

Budget-Friendly Solution

For ZF TRW, extensive support of the necessary protocols was a key argument in favor of the Vector solution. Vector has specific solutions that support any of the commonly used protocols and OEM-specific automotive networks and diagnostic systems on the market. When customers turn to lower cost hardware components from other manufacturers, they often experience higher subsequent costs that offset any hardware savings when protocols need to be redeveloped for individual buses or for the XCP support for various OEMs that is often lacking.

Vector also advantageously resolved a licensing issue for customers, because users like ZF TRW essentially do not incur any additional costs for updates by using what is known as the CANoe stand-alone extended license. Any number of test bench applications can be created using just one CANoe license on a development PC. Updates of the VN8900 systems to newer CANoe stand-alone extended versions are always included. Even towards the end of the life cycle of the new test benches, the customer can continue to use the VN8900 devices meaningfully at the workplace instead of having them become unused dead capital.

Development Continues

With its new test benches, which were first used to test ESC controllers, the automotive supplier ZF TRW has a component-based test system that consists of six to seven modules which may be combined in various configurations. The company can rapidly adapt the test bench concept to tests for other types of ECUs, e.g. for airbag controllers or driver assistance systems. The drastically shortened changeover times and the speed with which managers can now respond to changes in requirements are very impressive. Future systems for autonomous driving are already envisioned. When testing the radar and camera systems, which are indispen-sible for these future systems, the new test bench concept will offer many opportunities for further exploiting its capabilities and streamlining potential.

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Links:
Homepage ZF TRW: www.trw.com
Homepage Vector: www.vector.com

Stefan Siefert-Gäde, ZF TRW
studied electrical engineering at the Technical College of Koblenz. In 2006, he began work at TRW Automotive in Koblenz. Since 2014 he has been coordinator for the global, strategic development of test equipment in the Global Electronics area.

Katja Hahmann, Vector
studied Electrical Engineering at the Technical University of Chemnitz. In 1997, she joined Vector Informatik GmbH in Stuttgart, where she is now group leader for CANoe application development in the Networks and Distributed Systems product line.