Scientific Automation and compact drive technology in end-of-line tester for the automotive industry

Highly-integrated automatic haptic testing devices for in-vehicle control elements

Engineering consultants Borrmann GmbH, based in Ingelheim, Germany and Schuhriemen Maschinenbau GmbH, based in Sommerloch, Germany manufacture extremely compact and high-performance automatic test devices for driver control features in vehicles, using PC-based control technology from Beckhoff. The concept of Scientific Automation, which combines control technology with very fast, high-precision measurement technology, offers significant advantages and results in cost savings of up to 70 percent when compared with existing solutions. An additional benefit is significant space savings through the use of compact servo drives in Bus Terminal I/O format.

Thanks to the high-performance PC-based control technology with integrated high-end measurement technology, the end-of-line tester is very compact.

The AM81xx OCT servomotors ensure high-precision movements in no less than seven axes.

The automatic test devices are end-of-line testers for the comprehensive testing of control elements for drivers in vehicles. Drivers use these features to operate the lighting, radio, air-conditioning, navigation system and much more. A wide range of vehicle functions are selected by pressing, pushing, tilting, turning or touching. Andreas Borrmann, Managing Director of an engineering consultant company under the same name, explains: "The main task of the test system is automatic haptic testing. Numerous sensors measure the forces and torques involved in actuating the different switching functions. Rotary plate applications are implemented with up to eight independently operating stations." These automatic units are among the most integrated haptic testers in the market, offering very compact control and drive technology. Coupled with the particularly powerful measurement technology, these features play a key role in providing a robust, powerful solution. Borrmann continues: "Whereas in the past special measurement technology was required for synchronous acquisition of force/path or torque/angle data, we can now use standard components from Beckhoff. The standard I/O terminals even enable additional synchronous acquisition of bus telegrams such as CAN or LIN from the devices under test." A single Industrial PC (IPC) handles all the control and measuring tasks for the eight stations. It is not uncommon to have up to 450 test parameters for each operator control element. Typical cycle times for a rotary plate cycle are 20 seconds, which corresponds to an annual production of more than 300,000 driver control elements.

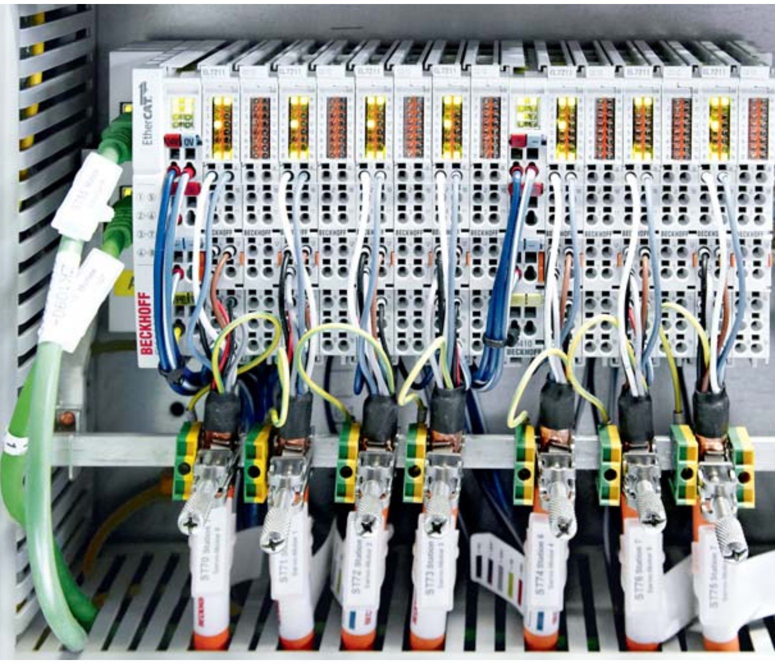
Simplifying complex test procedures

At the start of a test cycle, the operator subjectively examines the component to be tested in station 1 for obvious mechanical flaws and cosmetic deficiencies such as scratches. Once the device under test has been inserted, it is automatically clamped and contacted. After manual through-switching of the device and confirmation of the subjective inspection by the operator, the lift door closes and the rotary plate cycle starts.

The brightness of the LED symbol illumination can vary by more than 30 percent. In station 2, the brightness is calibrated by measuring light levels with a video camera. Correction values for the brightness control are written into the EEPROM of the device under test via a CAN telegram. In station 3, lift-off tests using suction grippers ensure that the decorative lids and covers are glued on correctly. Inductive analog initiators verify the presence of the bolts, and several sensors ensure the correct color combination of all buttons. The first haptic test in the form of a torque measurement follows in station 4. A torque sensor, which operates based on the piezo-electrical effect, provides torque data with a resolution down to 0.1 Nm at a rotational speed of up to 180 degrees per second. The goal of this measurement is to determine the notching as well as the minimum and maximum cogging torques. Cogging torques outside the permitted limits indicate a malfunction in the assembly process for the device under test. Andreas Borrmann explains: "We use the oversampling functionality with a factor of 20 to enable 20,000 measurements per second at a task cycle time of 1 ms. Therefore, each angle degree is resolved with more than 25 torque data sets."

Station 5 is uniquely configured for testing vertical pressure forces. Here too, a high-precision piezoelectric force sensor is used. Thanks to the oversampling functionality, a force resolution of 0.02 N can be achieved at an actuation speed of 10 mm/s, with a path resolution of 0.002 mm. At the same time, CAN and LIN telegrams are recorded during actuation and are exactly assigned to the actuation position, thanks to a task cycle time of 1 ms. Stations 6 and 7 are optimized for measuring horizontal tilting forces, utilizing the same measurement technology as in station 5. Because strictly horizontal actuation of tilting movements gives rise to lateral forces, these forces must be compensated through elaborate mechanical balancing components. The final writing of data, such as part number, serial number, production date and further product-specific information into the EEPROM takes place in station 8, which is the last station. If the results of all test parameters (up to 450) are within the specified limits, laser labelling of the device under test is approved. The labels contain information in plain text and in Data Matrix code (DMC). A DMC reader scans the code and checks the content and quality. In the subsequent rotary plate step, the fully checked module is transported to station 1, where the operator removes and packs it.

Communication with the test device according to the ISO 15765 standard is realized via seven EL6751 CANopen master terminals. This has reduced the costs by more than 80 percent when compared with existing solutions.



EL7211-0010 servomotor terminals with One Cable Technology (OCT) are key components to enable compact design and precise motion control.

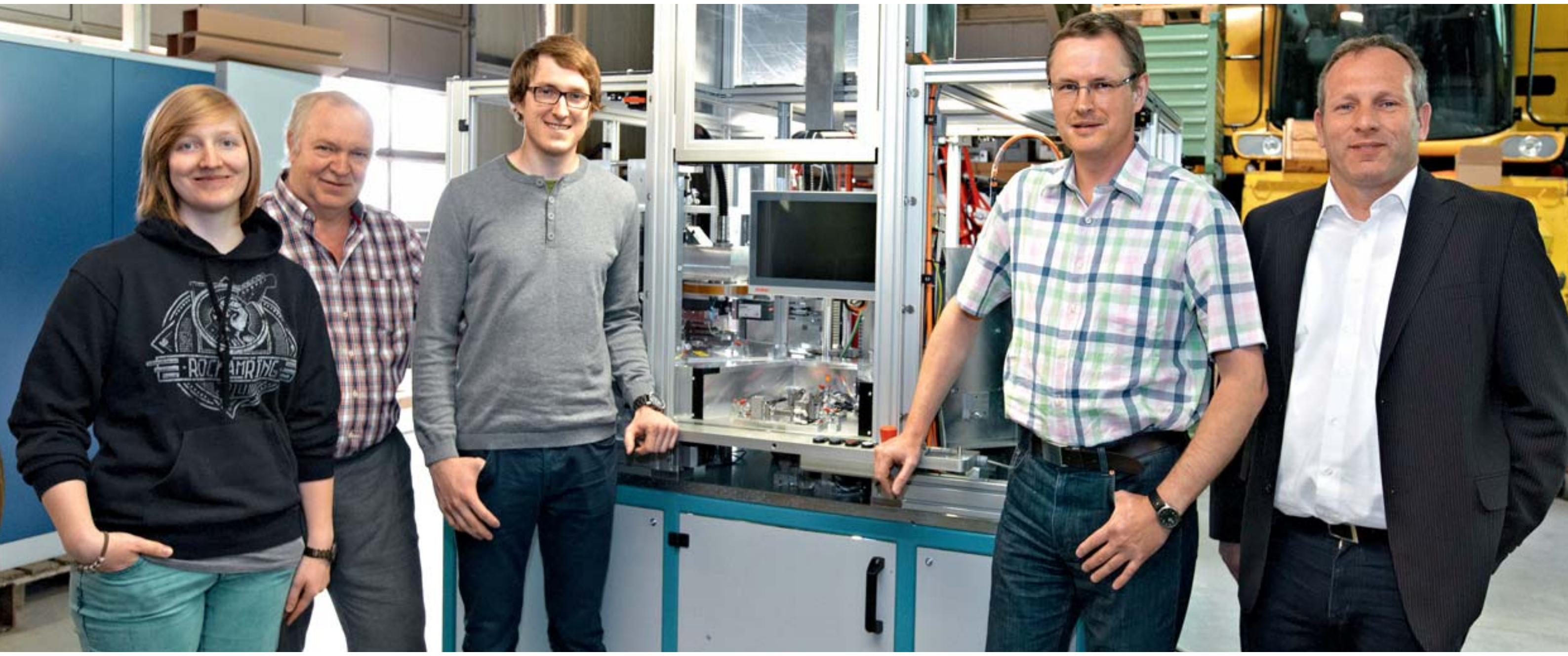
Speed and precision require PC Control solution

Without PC-based control technology from Beckhoff, the development of this end-of-line tester would have been virtually impossible, according to Andreas Borrmann: "Only PC-based control enabled us to meet the very stringent requirements in terms of speed and accuracy for the measurement and drive technology. The performance of existing solutions was limited by the lack of expandability of the PCs with measuring and control cards, which were used in the past. The modular, decentralized Beckhoff technology removes this limitation, facilitating a reduction in hardware costs by up to 70 percent, compared with existing solutions that have separate measurement technology."

Andreas Borrmann sees further benefits in the fact that the entire measuring and control system can be controlled centrally and conveniently from a single IPC. The additional PLC required in existing systems can be omitted, and the effort involved in numerous driver installations for the measurement technology from different manufacturers is a thing of the past: "The integrated system solution offers significant benefits in this respect, not least in view of the fact that PC-based control also includes high-performance, high-precision and very fast measurement technology. Moreover, it is easily possible to integrate the CAN protocol used in the vehicle for communication between operating elements and the control unit according to the ISO 15765 standard. The protocol is modelled in the TwinCAT PLC and processed via seven EL6751 CANopen master terminals. Compared with the technology used in the past, this results in cost savings of more than 80 percent. What's more, the CAN protocols can now be read and evaluated in real-time, synchronized with automatic actuation of the device under test. Previously, this was only possible with highly specialized and complex electronic measuring systems. The haptic data consists of three elements – the force sampled by analog means, the path determined directly via the motor and the contact determined via a CANopen master terminal – which can now be determined easily."

I/O system integrates advanced measurement technology

In addition to servomotor and CANopen master terminals, the I/O system that complements the control technology leverages 16 EL1008 digital input terminals and twelve EL2008 digital output terminals, each with eight channels. Measurement technology integrates directly via the corresponding EtherCAT Terminals. Four 2-channel EL3202 analog input terminals with an oversampling factor of 20 ensure time-synchronous, high-precision acquisition of force, path, torque and angle data. Seven 4-channel EL3104 analog input terminal process current, temperature and signal measurements. An EL3681 digital multimeter terminal also measures currents, while a high-precision, 2-channel EL3692 resistance measurement terminal provides contact resistance value determination.



Jasmin Schuhriemen, Managing Director Hans-Julius Schuhriemen and Stefan Schuhriemen, all from Schuhriemen Maschinenbau; Andreas Borrmann, Managing Director of Borrmann engineering consultants; and Jörg-Michael Vetter from the Beckhoff regional office in Frankfurt (left to right)

Servo drive technology with minimal space requirements

Servo drive technology is also integrated directly into the I/O system. The high-precision movements in the individual testing stations are realized via seven servo axes, consisting of EL7211-0010 servomotor terminals with a width of only 24 mm. These terminals also feature integrated One Cable Technology (OCT) and up to 4.5 ARMS output current, in addition to AM812x OCT servomotors with rated torques of 0.5 Nm and 0.8 Nm respectively. Andreas Borrmann continues: "Without the servo drives in the very compact Bus Terminal format, it would not have been possible to achieve such a small footprint for the machine. These products enabled us to minimize the size of the installation and do away with additional control cabinets. OCT was also very helpful, since it significantly simplifies the otherwise complex cable layout, based on linear and rotary bushings. Big advantages also arise from the absolute feedback system, which makes the previously required reference switches unnecessary, thereby significantly reducing the drive technology complexity."

Further information:
www.borrmann-gmbh.com
www.beckhoff.com/Scientific-Automation
www.beckhoff.com/Compact-Drive-Technology

At a glance:

Solutions for the automotive industry
End-of-line test facility for control elements in cars

Customer benefits
Minimum machine footprint and integration of cost-effective measurement technology

Applied PC Control
- Decentralized and integrated measurement and control solution reduces costs by up to 70 percent.
- EL6751 CANopen master terminals reduce the costs for communication according to ISO 15765 by more than 80 percent.
- EL3702 EtherCAT analog input terminals ensure high-precision force and torque measurement via oversampling.
- EL7211 servomotor terminals and AM81xx servomotors with OCT minimize space requirements.