Brake safely with the iBOB

Control units for brake systems must meet the most stringent safety requirements. The automotive supplier ZF sought a suitable test option for testing the safety-critical components of an Electronic Control Unit (ECU) for car brakes. MicroNova has developed the perfect solution in the intelligent breakout box for SPI buses (iBOB).

TEXT: David Hirschhäuser, Christian Stangl **PICTURE: © Olaf Naami / Shutterstock.com**

The brake system is arguably the most crucial of all vehicle components when it comes to the safety of the driver and other road users. Even classic cars from early automotive engineering days usually came with two independent braking systems, so that if one failed, the other could still bring the vehicle to a stop safely. Since then, not only has the relevant technology come on in leaps and bounds, the legal requirements have become increasingly complex, with numerous DIN standards, ISO standards and the safety integrity levels for automobiles. Both developments mean the test requirements for brake systems are becoming ever more extensive and complex and constantly require new test solutions.

Automotive supplier ZF sought a special way to test communication between two independent microcontrollers connected via an SPI bus as part of work to develop a new control unit for car brakes. These microcontrollers are on the same board and monitor each other via a serial peripheral interface (SPI). The SPI signals were intended to be specifically manipulated by test engineers to test the behavior of both chips in the event of an error and verify their error-handling algorithms.

As well as SPI communication, they wanted a test solution capable of recording all analog and digital signals from the hardware connected to the two microchips. As well as being needed to substantiate the test implementation, it also allows further error sources to be identified.

A new development for optimal test

Given the lack of any system on the market that could meet these demanding requirements, ZF asked MicroNova to develop an intelligent breakout box (iBOB). One criterion for the choice was the previous experience of employees from the Testing Solutions division in recording SPI communication with hardware-in-the-loop (HiL) systems.

Solving the task set by ZF meant overcoming a number of different challenges for the MicroNova team: Firstly, the bus frequency of 10 megahertz required very fast signal manipulation at 20 nanoseconds. Secondly, the cable lengths between the breakout box and the PCB had to be minimized to avoid signal delays and distortions. Furthermore, the iBOB had to be able to record large volumes of data of up to 13 megabytes per second, generated by up to five SPI buses operating in parallel

Against this backdrop, MicroNova used the fastest analog switching technology, a high-performance FPGA (Field Programmable Gate Array) and a microcontroller with real-time operating system to make the project happen. The results speak for themselves: The intelligent breakout box supports up to five SPI interfaces with a total of twelve slaves, which use their own specific SPI protocols and are individually selectable via separate cables.

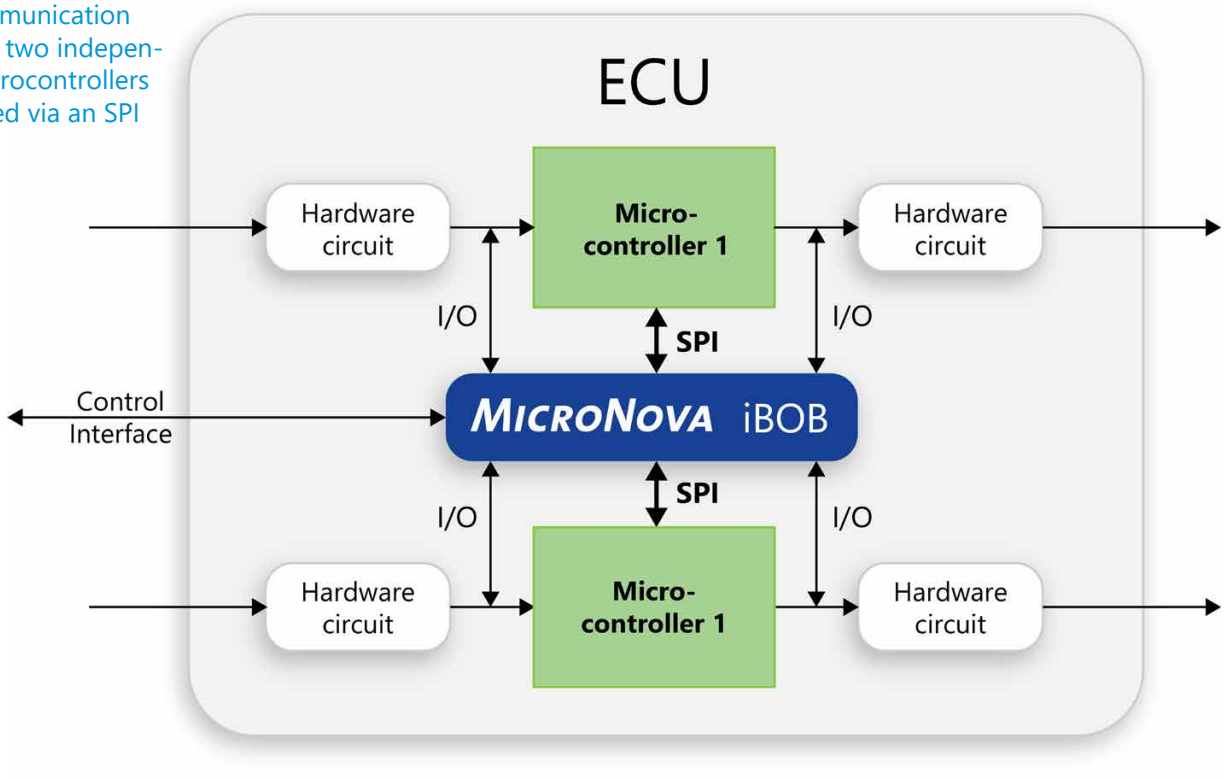
Recording the signals

Integrating the iBOB into the communication between master and slaves allows test engineers to record all data traffic easily, including manipulated signals (known as tracing). This process can be controlled either manually or via a digital trigger line. The iBOB stores the data in MDF format and records the current values of the digital and analog inputs for each SPI frame. All analog and digital signals can also be recorded at a sample rate of 10 kilohertz, independent of SPI communication.

Technical details of the iBOB

- 5 SPI interfaces with up to 12 slaves
- A separate SPI protocol for each slave (64-bit frame length)
- Max. clock frequency: 10 MHz
- 9 possibilities for data manipulation for MOSI/MISO lines
- Optional automatic recalculation of the CRC checksum of a manipulated frame
- Clock line manipulation for fault simulation
- Trigger-controlled (digital/analog) manipulation possible

1 The iBOB makes it possible to test communication between two independent microcontrollers connected via an SPI bus.



As well as recording data, the iBOB also enables the manipulation of signals to test the error behavior of masters and slaves or the error algorithms, for example. Messages can be varied in nine different selectable ways. The data can also be manipulated, for example, depending on the frame content or with a time delay to the next frame („Out of Frame Protocol"). New data can be imported into the iBOB in millisecond increments for this purpose. Test engineers can use tables with up to 20 values, to accelerate updates even further. This allows the user to simulate alive counters during manipulation, for example. There is also scope to switch the digital outputs individually while manipulating an SPI frame.

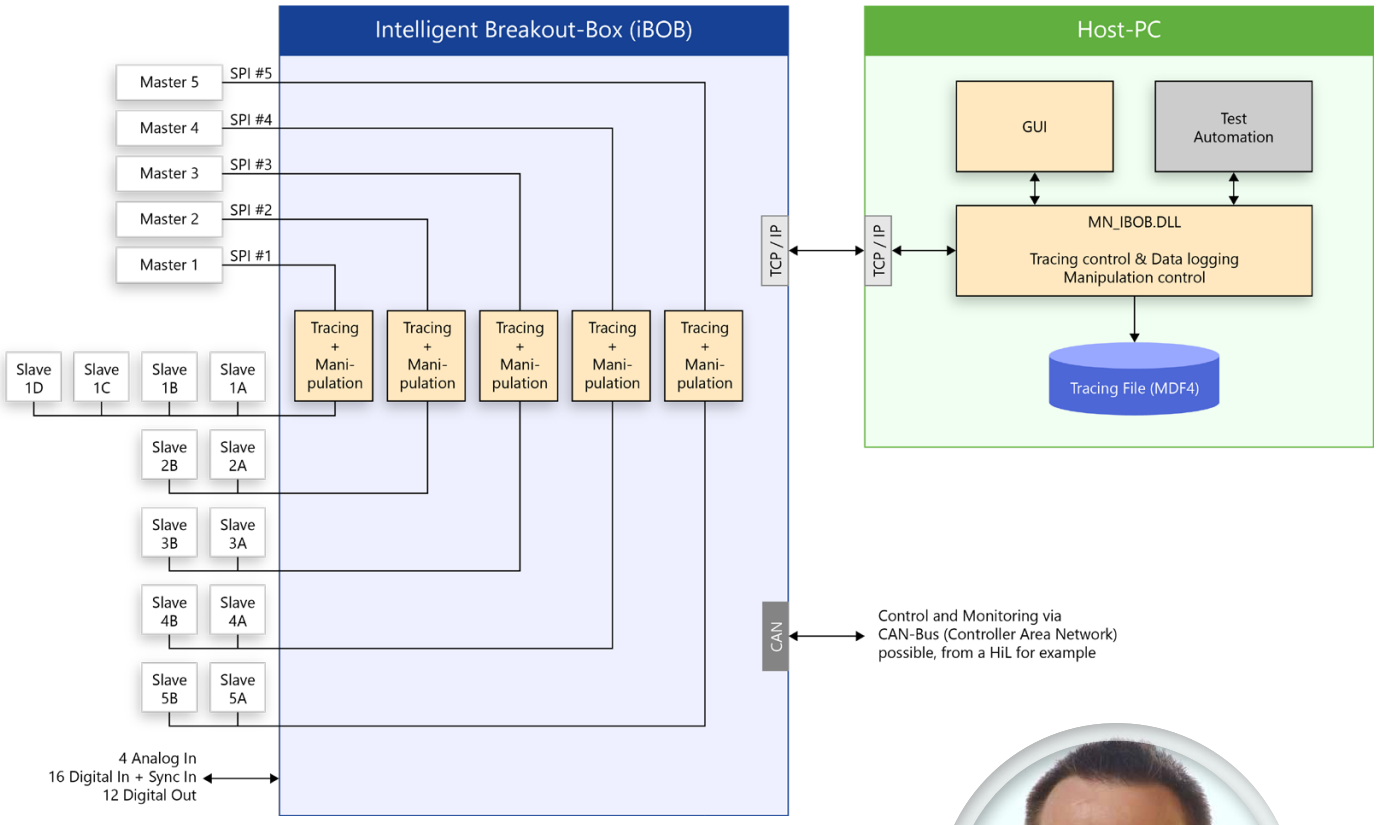
To make the operation as user-friendly as possible, the intelligent breakout box includes a graphical user interface for controlling and displaying signals. Alternatively, a DLL interface means the system can also be controlled via other software applications such as MATLAB/ Simulink. Many functions are also available via an integrated CAN interface, making it easier to use the iBOB in existing environments without much training.

Serial Peripheral Interface (SPI)

The Serial Peripheral Interface is a bus system that combines digital circuits according to the master-slave principle. The SPI bus operates synchronously and is used – normally by PCB components – to communicate over short distances.

Inputs and outputs

The iBOB has twelve digital outputs (8 push-pull, 4 open-drain), which can be switched either via the user interface, the API or a CAN message. As well as four analog (0 - 20 V) inputs, 17 digital inputs are also available, including one trigger line (sync). The measured analog and digital signals can optionally be transmitted cyclically to the CAN bus. The signals are displayed on the user interface and are also provided by the API.



2 Overview of the iBOB's functions

Quickly interpretable data

With performance in mind, iBOB records all data in a raw format, convertible to readable information swiftly and simply. Various options exist to simplify the task of data analysis further: For example, the user can define the SPI frame structure in a file and choose from up to ten file types. The individual signals are then extracted from the raw data during post-processing. The user can also define which of the synchronously recorded analog and digital signals should be stored together with the interpreted frames.

A bonus for safety

MicroNova's iBOB makes it possible to now test and validate the communication of safety-critical systems via an SPI bus. This not only improves the respective product and makes it safer, it also supports companies in complying with legal safety requirements: In the case of the ZF control unit, such tests are even mandatory to comply with the safety concept of the brake and constitute the only way to ensure maximum safety. Consequently, further intelligent breakout boxes will be used at ZF in future to expand the test scope.

„Thanks to MicroNova, the intelligent breakout box now gives us an opportunity to test what is – in this case – safety-critical SPI communication of the controller in a targeted and comprehensive manner. The solution is technologically convincing, and the close cooperation of the teams involved was exemplary and extremely productive."

– Matthias Roos,
Senior Controls Engineer, ZF