R&S®Scope Rider RTH – FAST DEBUGGING OF ELECTRIC VEHICLES

The Elefant Racing Team of the University of Bayreuth, Germany, needs a reliable, multipurpose handheld oscilloscope for developing and verifying its FR19 Loki electric racing car. The focus is on monitoring and analyzing CAN bus sensor data, EMC measurements and measurements on the vehicle electrical system and the high-voltage electrical system. The fully isolated R&S®Scope Rider RTH handheld oscilloscope from Rohde&Schwarz, featuring comprehensive trigger and decoder options for SPI, CAN, CAN-FD and SENT bus signals, is the ideal T&M instrument for this task.

Reference Card
Version 01.00

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Endurance testing of electric vehicles

Every year, student teams from numerous universities compete in the Formula Student motor racing competition, racing on world-renowned tracks such as the German Hockenheimring, the Czech Autodrom Most or the Dutch TT Circuit in Assen. These competitions are not only about racing, but also about static disciplines such as evaluating electrical designs and business plans.

The most prestigious discipline is the endurance race, for which nearly a third of all competition points are awarded. Up to seven vehicles compete against each other over a distance of 22 km. The jury also evaluates the energy efficiency of the vehicles. Endurance is a particular challenge for Formula Student participants driving electric vehicles. Even a minor loose contact can quickly mean the end to their race.

Requirement: verifying and debugging

To develop and optimize their racing car for the 2018 season, the Elefant Racing Team of the University of Bayreuth was looking for an instrument to measure EMC and debug voltage supplies and CAN bus connections. The instrument had to be equally suited for verifying PCBs and measuring the high-voltage supply system. It also should have a rugged and portable design that allows measurements to be conducted both in the lab and on the test and race tracks.

Fig. 1: The rugged R&S®Scope Rider RTH survives even violent shocks without a trace of damage. Source: Elefant Racing Team

At a glance

Before an electric car can hit the track, the electronics must be thoroughly tested. This also applies to the Formula Student E racing cars. The Elefant Racing Team of the University of Bayreuth developed the FR19 Loki, an electric racing car equipped with an epicyclic gear designed by the team and the latest four-wheel drive technology. Using the R&S®Scope Rider RTH handheld oscilloscope, the team captured the comprehensive sensor data and analyzed it using the CAN bus decoding function. Thanks to its isolated inputs, the instrument reliably measures currents and voltages up to 1000 V. The rugged handheld oscilloscope is ideal for fast debugging of the vehicle electrical system and the high-voltage electrical system. Because it is battery-operated, the R&S®Scope Rider RTH is the right choice for work in the lab and on the race track.

The solution: the R&S®Scope Rider RTH

The Elefant Racing Team opted for the R&S®Scope Rider RTH handheld oscilloscope, which meets all the requirements. The R&S®Scope Rider RTH is highly ruggedized and features isolated inputs for voltage measurements up to 1000 V (RMS) in measurement category III as well as special analysis functions for automotive applications.

Extremely rugged and versatile

The robustness of the Rohde&Schwarz handheld oscilloscope was demonstrated in an accident the team had during a return transport from the training track in 2018. The trailer carrying the racing car overturned, and the car and most of the tools and accessories were hurled across the road. The racing car was a total write-off, but the R&S®Scope Rider RTH survived the severe impact without any trace of damage. The instrument complies with protection class IP51 (IEC 60529) and the applicable military standards for shock and vibration resistance.

The R&S®Scope Rider RTH can be used to quickly check whether the correct voltage has been applied and the associated communications protocols such as I^2C, SPI or CAN bus are transmitted correctly when verifying devices and modules or during debugging on the track. For automotive applications, the oscilloscope's triggering and decoding options support not only the conventional CAN and LIN bus protocols, but also protocol analysis functions for single edge nibble transmission (SENT) – a point-to-point protocol used for sensor data transmission. This allows users to acquire specific events, data or error states of the fast and slow protocol channels for SENT transmissions. It also supports the short and enhanced message format and the various CRC check methods.

With the R&S®RTH-K9 CAN-FD triggering and decoding option based on the R&S®RTH-K3 CAN triggering and decoding option, users can also analyze CAN-FD signals. At transmission rates of up to 15 Mbit/s, the CAN-FD serial bus is significantly faster than the standard CAN bus (up to 1 Mbit/s) and is gaining in importance. The fully digital triggering and decoding unit operates at a sampling rate of 1.25 Gsample/s, irrespective of the analog or digital channel sampling rates used for signal acquisition. This makes it easy to decode serial protocols even when very slow time domain signals are displayed at the same time. At the push of a button, the oscilloscope displays the analyzed protocol in table format, together with additional protocol-specific information. Another benefit is support for symbolic labels. Decoded control signals are displayed in plain text, making it especially easy to work with the instrument.

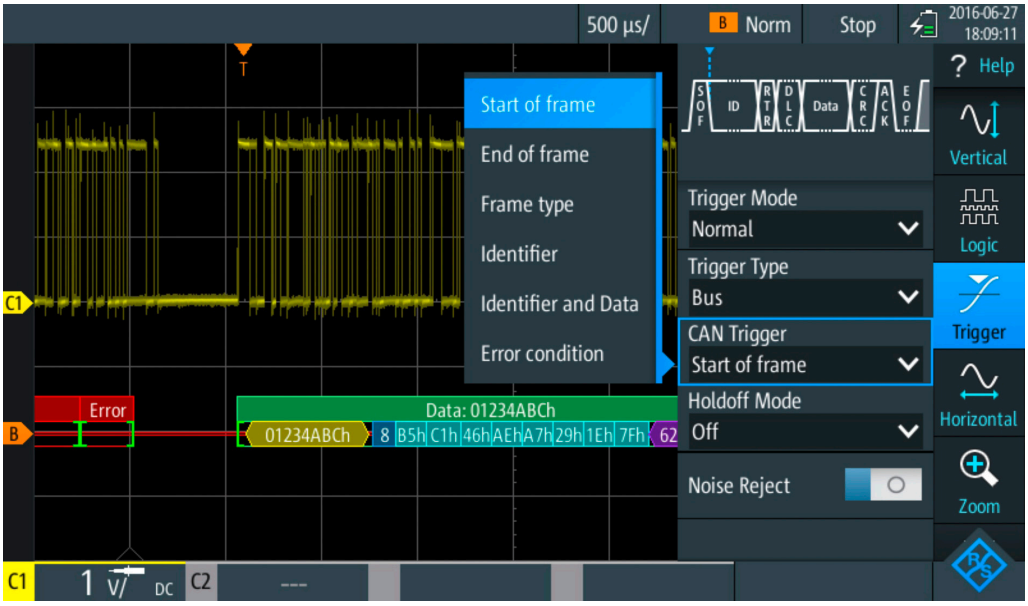
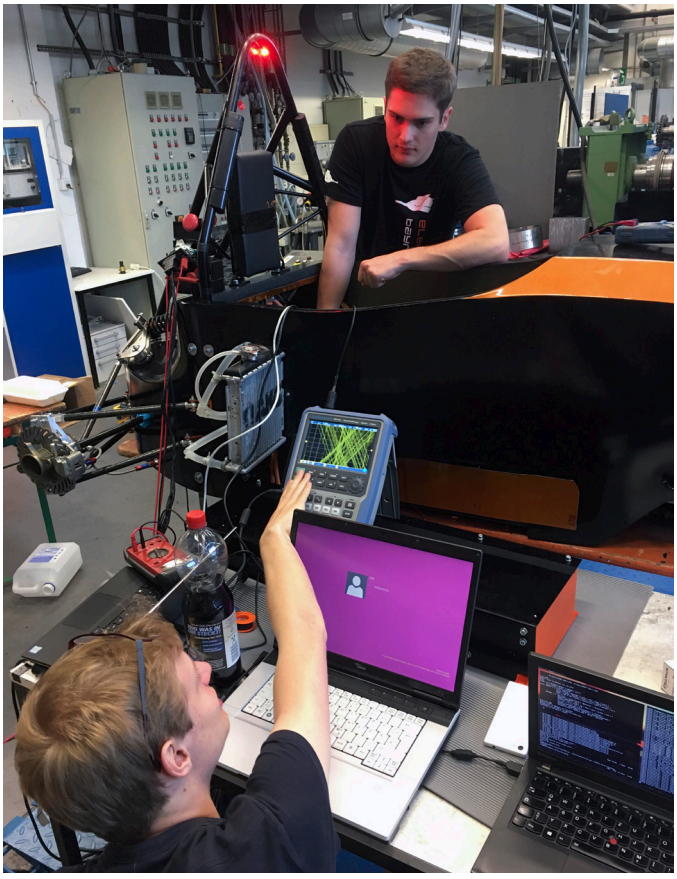


Fig. 2: The user menu for the R&S®RTH-K3 triggering and decoding option for CAN bus signals.



Example measurements during PCB verification

The R&S®Scope Rider RTH repeatedly helped reduce the time the team had to spend on debugging. Long before the racing season began, the handheld oscilloscope greatly simplified PCB verification. It took far less time than with a typical multimeter for the team to verify whether the correct voltage was applied everywhere and whether bus communications was error-free. This mostly involved SPI and CAN bus debugging. Once the electronics were integrated into the vehicle, testing within the vehicle started.

A red warning light is attached to the highest point of the vehicle and it must light up reliably whenever high voltage is applied outside of the battery box. During verification, a CAN bus transmission fault was detected. It became clear that a terminal resistance had been forgotten during implementation.

Fig. 3: During a CAN bus transmission, a missing terminal resistance led to a CAN signal fault. Source: Elefant Racing Team

Example measurement on the race track

The FR19 Loki is currently the Elefant Racing Team's fastest car. The new epicyclic gear permits extremely efficient power transmission. The all-wheel-drive system with wheel hub motors (each 35 kW) and actuation via torque vectoring delivers optimal road traction in curves.

The vehicle won fifth place during the endurance test at the Dutch Assen race track. Three weeks later on the Hockenheimring in Germany, the high-voltage system repeatedly switched off, forcing the team to withdraw from the race. To compete at the Autodrom in Most just a few days later, the technicians immediately began searching for the cause. The first analyses did not reveal any software errors. Then the team used the R&S®Scope Rider RTH to analyze CAN bus communications. Nothing. Only measurements on the low-voltage electrical system revealed a voltage drop on the safety line. The high-voltage system can be activated only when the safety line carries voltage. Everything pointed toward a short circuit, which the team found on a wheel suspension. It had been caused by a poorly routed safety line wire chafing against the linkage, and that was easy to fix. The Elefant Racing Team came in fourth in the endurance test and overall at the next competition in Most.

Fig. 4: Debugging at the side of the track using the triggering and decoding option for CAN bus signals.
Source: Elefant Racing Team

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