Wolverines Don’t Usually Run This Fast
The wolverine is a powerful animal that can run as fast as 30 miles per hour (mph). However, some wolverines can go much faster. Michigan Electric Racing (MER) is a student-run team at the University of Michigan, home of the Wolverines. The team’s mission is to design, build, test, and finance a high-performance, all-electric Formula-style race car that accelerates from 0–60 mph in just over 4 seconds. The team competes at Formula SAE competitions each summer against teams from all over the world. This intense design and build project allow students from around the university to engage in real-world engineering. It challenges them to further their classroom education on a student-run team.

**Organization**
- Michigan Electric Racing

**Challenges**
- move from hybrid to full electric vehicle
- improve previous year’s electrical drive system

**Solutions**
- N7900 advanced power supply
- BenchVue
- 14585A control and analysis software
- 34465A Truevolt DMM
- RP7933A regenerative power system

**Results**
- second overall finish in the 2019 Formula SAE North Electric competition
Challenge: Build a Faster, More Powerful Electric Vehicle

The team, founded in 2011 as the Michigan Hybrid Racing team, moved from hybrid vehicles to full electric in 2019 in response to trends in the automotive industry. Many carmakers are turning to electric vehicles to help them address consumer demands for better fuel efficiency and cars that have less environmental impact.

MER includes the following divisions:

- **Vehicle Dynamics and Chassis** is responsible for all vehicle dynamics components of the car. They design and tune the chassis and suspension.

- **Drivetrain** is responsible for delivering mechanical power to the ground from the motors. They conduct vehicle simulations and design and manufacture gearboxes, corners, and the cooling system.

- **Aerodynamics** is responsible for all vehicle aerodynamics and body panels. They design and manufacture the front, rear, and side wings; undertray; nose cone; and side panels.

- **Ergonomics** is responsible for any component the driver interacts with on the car. They design and manufacture components such as the seat, steering wheel, and pedal box.

- **Controls** is responsible for all low-voltage wiring and vehicle software. They design the software and vehicle dynamics programs that make the car drive. Controls is also responsible for the data logging system to tune the performance of the car.

- **Powertrain** is responsible for power delivery to the motors and most of the safety systems. This includes designing and manufacturing a custom battery pack, battery, high-voltage safety systems, and custom motor inverters.

*Figure 1. MER 19 electric race car burning rubber in a test session*
Solution: Testing at Keysight’s Automotive Customer Center

MER consists of about 50 students and one faculty advisor. About half the students study electrical engineering, while the rest come mainly from mechanical engineering. Keysight provided technical support and electronic test instrumentation to the Controls and Powertrain divisions to help them design and optimize battery algorithm, battery-pack safety features, and motor controller performance.

Keysight’s Automotive Customer Center in Novi, Michigan, partnered with the Powertrain lead engineer, Spencer Hansen, a fourth-year electrical engineering student at the university. Hansen’s Powertrain division is responsible for designing and manufacturing the custom battery pack and motor controllers for the MER race car. “Keysight’s equipment has allowed us to collect our team’s most accurate battery data ever, which has been invaluable in designing the cooling of our car’s battery pack,” he said.

Each year, the team starts with the prior year’s electrical drive system and tries to make it more efficient, more powerful, and faster. Team members use actual data from the previous year and compare it to recent design simulations to create the improved battery design. Hansen wanted to test the 18650 lithium-ion cells members planned to use in their next-generation battery pack for the 2020 season (MER 20 race car). The team needed an easy way to measure discharge curves and battery temperatures under various operating conditions with something that could dissipate more than 30 amps at normal lithium cell voltages.

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Spencer Hansen, Student Engineer, MER Powertrain
One option we had available in our Automotive Customer Center was our N7900 advanced power supply family of products, together with BenchVue and 14585A control and analysis software. I wrote a few example test automation sequences in BenchVue that allowed them to set a fixed discharge rate and cutoff voltage and then log the battery voltage, current, and temperature using the 34465A Truevolt digital multimeter connected to a thermocouple.

Joshua Love, a Keysight power applications engineer located in Novi
Keysight offers a variety of test solutions through its Scienlab battery test systems, but they were not available at the Automotive Customer Center when the MER team did its testing.

The MER team then created custom test scripts to test the exact parameters it wanted to analyze. They used this setup to import captured current draw data from last year’s race car to see how the new batteries would perform under real-world conditions. Analyzing actual test data allowed the MER team to determine that it would need battery pack cooling to keep the batteries from overheating during the endurance portion of the competition.

The MER team also looked for help testing laminated aluminum bus bars for use as fuses on each battery in the pack. Since the bus bar was a MER custom design, the company that made it didn’t have an easy way to estimate the fusing performance. The MER team tested various designs and chose the one that would best meet its needs. It submitted this test data for Formula SAE approval. For the current levels needed in this test (100+ amps), MER used Keysight’s RP7933A regenerative power system with the 14585A control and analysis software to act as a datalogger.

With Keysight’s equipment, we developed an advanced state-of-charge algorithm for our batteries, which will greatly improve our car’s performance.

Colin Bott, Student Engineer, MER Controls
“With the testing data collected, our battery model allows us to safely push the performance of our battery pack,” Hansen said. “By testing the fusing performance of the laminated bus bars in our battery pack, we were able to tune in the main fail-safe in our battery pack to make it safer.”

The team uses parking lots at the University of Michigan for testing, as well as the Chrysler Proving Grounds in nearby Chelsea, Michigan. This testing allows the team to quickly evaluate performance and design changes to make sure the car is faster and more efficient each time. A Formula SAE race event includes a series of design, presentation, cost, and performance events:

- acceleration (0–60 mph)
- skidpad
- autocross
- endurance (22 km), including energy efficiency results
Result: A Top Contender

MER 19 finished second overall in the 2019 Formula SAE North Electric competition in Barrie, Ontario, Canada — not bad for a wolverine that is only supposed to run 30 mph.

The MER team expected to complete and unveil the MER 20 model in the spring / summer of 2020, but the COVID-19 pandemic and its impact on education and manufacturing prevented the team from doing so.

Find out more about the University of Michigan’s electric racing program and Keysight Technologies and its automotive test program:

- University of Michigan Electrical Engineering
- Michigan Electric Racing Revs Up
- Michigan Electric Racing
- Keysight Technologies
- Keysight’s E-Mobility Solutions
- Scienlab

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