FLUKE®

Automotive testing drives changes under the hood

Application Note

Testing Functions
Case Study

Measuring tools: Fluke 189 True-rms DMM, Fluke 52 Digital Thermometer

Operator: Josh Winkelman, e-ride Industries and Bruce Leonard, Designer

Measurements: Current, range, pulse, temperature

For an industry that has seen little evolution in the architecture of the internal-combustion engine since its introduction in the 1920s, innovation is now running wild.

Monitoring motor temperature on an e-ride EXV-4.

The electric vehicle—once part of a thriving cottage industry that languished and then enjoyed an anemic resurgence—is today on the cutting edge of innovation. Its bipolar opposite, the turbo-charged racing car, is itself the subject of much new research devoted to squeezing even higher performance out of high-performance engines.

Neighborhood electric vehicles

For Josh Winkelman and his colleagues at e-ride Industries, a developer of zero-emission utility vehicles, a major effort revolves around tracking electrical regeneration in all-electric vehicles. E-Ride trucks and cars typically have a range of 50 miles on a charge, and energy regeneration is the company's preoccupation. "The question," he says, "is how to extend the vehicle's range in any way possible."

How does Winkelman attack the problem? "It all starts with measuring current draw on the motor in typical driving scenarios," he says. Winkelman uses a Fluke 189 True-rms Multimeter together with a Fluke i1010 Current Clamp. "We clamp on the meter and log data on energy regeneration as we drive the vehicle—how much the vehicle is regenerating, and how much current it is drawing as we drive it. We measure draw when we take off, the peak amperage, and the continuous amperage. We can also use the meter to calculate other factors such as the range we can expect to get on a charge."

Gathering current readings on an e-ride EXV-2.

It's the new regeneration

How does e-ride regenerate an electrical charge in a vehicle with no other power source than batteries? One other "source," it turns out, is the action of braking, which, when combined with an electronic controller, enables the brakes to regenerate as much as 30 % of the power that the batteries are drawing at the time. "It depends on how the controller is programmed," says Winkelman. "On the particular controller that e-ride is using, letting off the accelerator regenerates a small amount of amperage to slow the vehicle. Applying the brake causes an inrush of about 130 A, which drops to about 70 A as the vehicle comes to a stop, at which time no current will be going back into the motor."

In other systems, he says, engineers have used brake proportioning sensors—a form of transducer—to measure brake pressure. "Those systems convert braking pressure to a representative 0-5 V output, and the controller will read that output and regenerate charge according to how hard the driver brakes." He notes that the braking action can develop anywhere up to 130 A, which is fed back into the batteries to give the vehicle a longer range.

Winkelman and his colleagues use the Fluke 189 DMM to make and store continuous, instantaneous readings of current, and then output these readings in graphical format to show current generation as a function of time. "In a two-hour range test, I will record current draw through an entire course. Back in the shop I upload the data to the computer, and the graph shows me exactly at which point I was climbing a hill, or declining, or driving on a level surface.

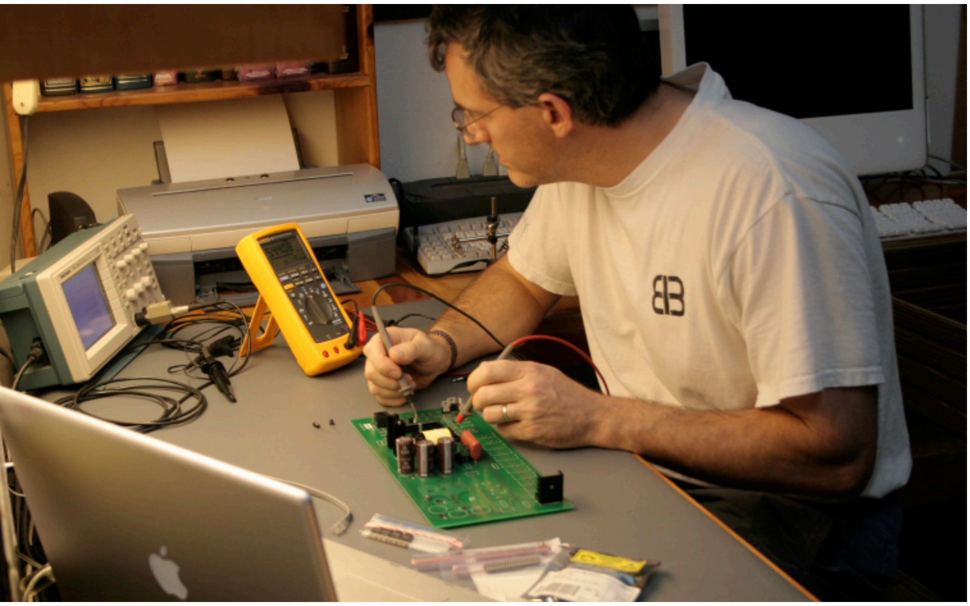
"Using the meter's math functions I can find the average amperage through the entire run, and that tells me how our much battery packs are capable of holding—and, furthermore, how many miles I should have gotten on a charge. Batteries take a number of charges to get up to full capacity, and this kind of testing can tell us if we are getting the full range expected from the batteries."

Winkelman is just as concerned about motor temperature as he is about current - a caution he takes to ensure that heat buildup does not burn out the motor controller. "We measure the temperatures of the motor, but controllers typically have an internal probe that provides a temperature reading." With a probe next to the brushes of the DC motor, engineers attach a thermocouple to the probe and then plug the thermocouple into the multimeter to make and store continuous temperature readings. Some applications, he says, require a second probe on the surface of the motor. On those occasions, the engineers connect thermocouples from the controller and motor probes to the Fluke 52 Digital Thermometer, which handles two temperature inputs.

On the speed circuit

Bruce Leonard, an independent designer of microcontroller-based ignition systems for automotive and marine use, gets a rush from the prospect of improving performance in high-performance engines. In one project, he set out to develop an SMPS-based high-voltage power supply for a coil driver circuit to be used in a turbocharged engine.

"I had hoped to use a coil driver from an existing company, but the price was too high, and I figured that the best option would be to develop my own. I learned that developing a coil driver is not a simple thing; designing the high-voltage analog engineering portion of the power supply and everything related to it was a challenge. Once I got beyond the coil driver, it was easy going. Essentially, the task was then an embedded application of a controller."



Bruce Leonard testing the Variable Spark Injection board for Engine Logic Systems LLC.

To help determine and specify the characteristics of the transformer he would eventually use in his power supply, Leonard turned to the Fluke 189 Digital Multimeter. "I had some transformers that I was playing with, but none of them were exactly what I wanted. I needed to come up with parameters that I could send to vendors for quotes on the specific transformer that I was looking for."

The signal that Leonard's power supply required would need to have a 300 µs period of 8 pulses. "I needed to know the current level on the output of the transformer. I couldn't use a standard DMM to do the job because, on most of them, the cycling period is measured in seconds. But the Fluke 189 DMM could cycle as fast as 250 µs. And that would pick up the peak current level on the output of the transformer easily within that 300 µs range."

According to Leonard, after the pulse was stored in a capacitor, and the capacitor was discharged, he was looking at a period of about 5 µs. "It was fascinating that the meter could catch that 5 µs output as long as I caught the sample right in the period of the discharge. The meter even picked up the output from the capacitor, as well as the long period of charging."

Missing data sheets and other challenges

With his transformer needs met, Leonard is now moving on to other applications. One is to develop a PCB prototype for a controller that will be able to adapt to sensors that are currently embedded on high-performance engines. "This essentially becomes an aftermarket application, in which I will need to sample the current level on engine sensors as the engine is running." The challenge, he says, is that data sheets on a number of those sensors are simply not available. "There is no way—other than to connect the 189 DMM to the engine, or to a test fixture using those sensors—to examine the real-time current output of the sensors. If the current output is too high, I may need signal-conditioning discrete components to be placed in line with the sensors."

But is the current itself the problem? With high currents comes noise, he says. But noise, or a current exceeding the input limits of the microcontroller, or even a high voltage, could be potential hazards. "I have to sample the signals rapidly. As the sensors are triggered, they have a peak output that could be as long as milliseconds or as short as microseconds—and a tool like the Fluke 189 DMM can capture samples that could be missed by other tools."

Leonard's latest project is to develop a test fixture for a marine outboard motor in which a number of sensors are embedded within the flywheel to trigger the ignition. "It's not always practical to run a device in order to test it," he says. "With the test fixture I can analyze the output of the sensors without actually running the motor. With that I can use the meter to measure the outputs from the sensors and read max current, pitch, and other parameters relating to performance."

On the one hand, a new generation of electrical vehicles are achieving higher ranges and higher performances than ever. On the other, the internal-combustion engine is being pushed to ever-higher performances. There may be no constants except change—and that change is being driven in part by innovative uses of familiar tools.

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