MACHINE DESIGN

ELECTRICAL/ELECTRONIC

DAQs track race-car moves

Onboard dataloggers make possible the traction-control and digital track-mapping systems that help racers keep the accelerator on the floor.

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Alex Tagliani's CART car rounds a turn at last year's Marconi Grand Prix of Cleveland. Onboard traction control systems help reduce wheel spin which lets drivers go faster. (Photo by: Paul Webb/Autostock)

Professional auto racers agree that even a thousandth of a second edge over the competition can make a huge difference. But gaining that 0.001 sec, lap after lap, is not the driver's responsibility alone. It's also the job of modern electronics, sensors, and telemetry equipment.

That is why many racing teams today, from Formula One to go-carts, use onboard data-acquisition (DAQ) equipment to gather and store information on vehicle dynamics during races and practice laps. The data helps teams more rapidly test chassis settings and develop new components. Data typically include steering angle, suspension movement, wheel speed, yaw (the rotation of the body around its center-point when cornering), tire pressures, fuel consumption, shock absorber displacement velocities, throttle position, engine speed, and brake pressure.

Some race series permit telemetry, the relaying of data by radio back to PCs in pit areas. Using the data, crewmembers often dubbed data-acquisition geeks may suggest changes to wing angles, suspension settings, and driving style, all in real time. Where telemetry is not allowed, DAQ systems typically include a 100 Base-T Ethernet link for quick downloads to laptop computers during pit stops and after practice runs.

Feedback from an inductive sensor and toothed reluctor ring mounted on each wheel hub accurately measure wheel speed. An onboard computer uses this information to calculate tire slip.

Data-acquisition systems from Pi Research include a steering-wheel-mounted display, transmitter, and processor.

Traction control gains purchase
One of the biggest players in data acquisition for racing is Pi Research in Cambridge, England (www.pireseach.com). And one of the hottest applications for the equipment is traction control. Daniel Bryars, a Pi engineer working with CART (Championship Auto Racing Teams), explains: "Wheel spin can be problematic, especially in cars making 900 hp at 16,000 rpm. Traction control improves driver consistency. And consistency wins races."

Regardless of how teams implement traction control, the basic input comes from ferrous, toothed reluctor wheels mounted on each wheel hub. The reluctors are read by active npn inductive sensors. The sensors deliver square-wave pulses, with a frequency proportional to wheel speed, to a data-acquisition system and to an engine controller by serial link. The system measures the falling edge of each wave and averages the signal for each wheel revolution to determine wheel speed. Speeds of all four wheels are compared to one another to identify wheels losing traction. Slipping wheels make the engine-management system reduce engine power and stop wheelspin.

Race-series rules mandate cars meet certain design specs, but each team can implement traction control however they want. Some teams retard ignition timing to reduce power while others drop spark firing from alternating cylinders. And though no traction-control system has proven better than another, keeping the playing field level is constantly on rule-makers' minds. In fact, there is some doubt that CART will permit traction control at all in 2003. Fortunately, CART now has a single engine supplier, Ford-Cosworth, instead of three, which means all teams could use a "standard" traction-control system.

"But even standard systems can be tailored to suit driver's tastes using reluctor wheels with more or fewer teeth," Bryars says. For example, Pi began with eight-tooth wheels but some teams wanted more resolution so it raised tooth count. There is, of course, a point of diminishing returns. More teeth can better map wheelspin. However, signal noise creeps in when tooth counts exceed the ability of the sensor to pick up teeth edges at car speeds exceeding 225 mph. It's also a question of cost, packaging, and durability, adds Bryars.

"We use reluctors with 12 teeth on rear wheels and 18 teeth on the front," says Brandon Fry, a data-analysis engineer with Team Herdez racing, a CART racing team. "We tried as many as 20 teeth on the rear wheels but found the added resolution wasn't necessary for accurate track mapping. Using fewer teeth also lets us use lower-cost sensors and boost system reliability."

Team Herdez uses Pepperl+Fuchs NBB1.5-8GM40-E2 inductive sensors to monitor wheel speed. A fast 1.5-kHz response time lets the sensors work at high wheel speeds. The cylindrical, industrial-type sensors readily mount on most suspension parts and are simple to adjust during races when heat makes suspension components move around and change clearances. Herdez replaces the sensors every three races though Fry claims sensor failures are rare, despite being run at temperatures exceeding their design specs (130°C). "Actually, the thin cabling between sensors and the controller takes the most abuse," Bryars adds. Herdez and other teams have experimented with other, more-expensive sensors that respond faster, but say they've found no obvious advantage to doing so.

Digital track mapping
Another related application for onboard data-acquisition systems is digital track mapping. Such mapping can ease the task of car setup. Rather than using a "best guess" based on experience and notes from previous sessions, a team can use actual data to accurately predict chassis combinations, tire pressures, and wing angles. "We can get setup almost dead-on right off the trailer," Fry says. "This saves valuable time during

practice so we can concentrate on fine-tuning the combination for track and weather conditions instead of trying to get the big stuff right first. It's made the cars much faster and more consistent." Fry claims his setup predictions based on DAQ information are accurate to within +/-2.5%.

And such predictions will only improve as logging and transmission rates rise, predicts Bryars. Team Herdez has already reaped the benefits of such improvements. The math channel in Pi Research's DAQ, for instance, is capable of calculating maximum wheel slip for each wheel and beaming it to a trackside receiver. But the onboard processor in earlier models had trouble keeping up with the data stream so sampling rates had to be throttled back. Processors in newer units are much faster which lets the team raise sampling rate and boost resolution without upgrading other equipment.

Next-generation data-acquisition systems promise to be even more powerful and compact. Cutting weight is critical to any racing application, and smaller, easier-to-place, more capable packages are in the works. "The biggest performance improvements in DAQ systems will likely come from the sensor side in the form of smaller, more durable packages," says Bryars. "Probably the most difficult part will be tailoring the DAQ equipment to meet race-series rules."

Inductive sensors from Pepperl+Fuchs provide wheel-speed data for race-car traction-control and track-mapping systems.

A data-acquisition processor (red box) mounted in a CART car.