TOC

Deep inside a wind tunnel, Jordan Racing test-drives its new Formula One racer using state-of-the-art measurement equipment.

Imagine you're behind the wheel of one of the fastest and most sophisticated cars in the world—a Formula One race car. High-rpm power plants are combined with an electrically shifted transmission. Shifting takes place in 25-30 µs for each of up to seven gears. You actuate gear changes via flipper switches located on the steering wheel: One switch is for up-shifting and the other is for down-shifting. Instrumentation, including rpm indicators, has been simplified to a row of LEDs on the steering wheel.

With approximately 1 hp/lb. of car, acceleration is blinding. Top speed is 200 mph. The V10 3-liter engine exceeds 15,000 rpm, using pneumatic valve return systems to reduce reciprocating mass.

Trade Secrets of the Racing World

The Formula One racing business is highly competitive. The rules are rigid, and minute differences in car and engine performance can decide who crosses the finish line first. Because of the proprietary nature of the work Jordan Racing does at its testing facility in the UK, we were unable to obtain detailed information on how the sensors are physically connected to the car under test or how indirect measurements are made on tire pressure.

Aerodynamic performance is a key factor; in fact, it accounts for 80% of the car's performance. Negative lift—wings near the front wheels and a spoiler at the rear create the necessary down force for improved cornering and traction. More drag means slower performance at high speeds. Variable-geometry wings are not allowed under Formula One rules. The tradeoff, then, is between maximum speed (mechanical performance) and cornering ability using down force (aerodynamic performance). Variables include the angle of the wings, the down force between the front wings and the rear wing, and the car's shape. Small variations in these variables determine which car gets into the winner's circle.

Good aerodynamics also has an effect on the driver in terms of reducing the variation between high-speed portions of a race track and the slower corners. Obviously, if the car performs predictably under different conditions, the driver will be more confident. Achieving a design with this type of winning balance requires extensive testing.

No one knows this better than Jordan Racing, one of the world's leading manufacturers of Formula One cars. Jordan is looking forward to an aggressive season thanks to big changes in its Formula One power plant. After its partnership with Peugeot ended this year, Jordan started a technical partnership with Mugen-Honda for its V10 power plants. This translates into a great deal of testing and monitoring of the chassis, suspension, engine, and aerodynamics—all necessary to achieve the perfect engine-chassis synergy required for winning on the track.

Jordan has also devised an indirect method of measuring tire pressure during testing. Formula One racing is governed by strict rules on tire size and even the type of groove used: pressure and compound are the only variables allowed.

First You Build a Wind Tunnel

To meet its testing needs, Jordan built a state-of-the-art wind tunnel (see Figure 1) that is capable of wind velocity of 40 mps (90 mph). The 40%-scale tunnel includes a moving road and an overhead balanced load that allows a model car to be placed on the road with a moving air stream, effectively simulating actual race conditions. The test facility also has a dynamic shaker table, which allows Jordan to accurately simulate the various track conditions with a full-size car.

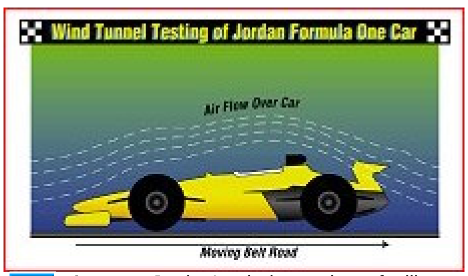

Figure 1. Jordan's wind tunnel test facility provides valuable data on a race car's aerodynamic performance.

Jordan turned to Hewlett-Packard to provide instrumentation and control tests for the facility. With HP concentrating on test solutions, Jordan engineers are now able to focus almost exclusively on the design of their vehicles.

Why Jordan Chose VXI

Jordan selected modular, standards-based VXI products for instrumentation because of an open architecture and the availability of upgrades for adding other measurement capabilities. The VXI system installed at the wind tunnel facility consists of a C-size mainframe with assorted cards linked to a Windows 95 PC via an IEEE 488 hookup (see Figure 2). To simplify the creation of programs for performing the multitude of measurements and control functions required, a graphical programming language (HP VEE) is also included, providing test engineers with a visual representation of how the various instruments are connected. The software allows test sequence changes to be implemented easily, even after programs are in use.

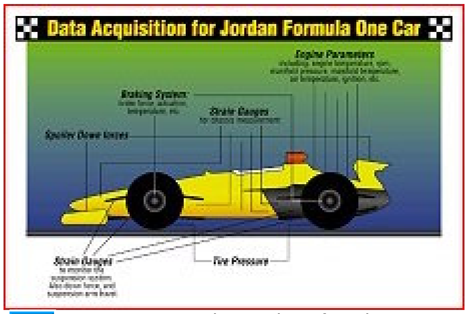

Figure 2. Extensive testing of engine-chassis synergy is required for optimum performance and a winning edge.

The footprint of a VXI mainframe—which is smaller than traditional rack-and-stack equipment, was considered a big advantage. The removal of displays and keyboards in favor of software drivers to create the feel of these physical features was another reason for selecting VXI.

The heart of the Jordan test system is a new-generation multifunction measurement and control VXI module. It not only provides multiplexing and A/D conversion, it also converts readings into engineering units. The motherboard is designed to accept up to eight signal conditioning plug-ons (SCPs). This flexible setup can measure the output of thermocouples and convert the readings directly to temperature.

The module also has a variety of strain gauge bridge-completion SCPs. Other SCPs were added to measure frequency (engine rpm), totalize, and accept a 16-bit digital input. A pressure-scanning ADC is used for aerodynamic testing. For general-purpose switching, power switching, and control over the process, a 32-channel Form C VXI switch-module is included.

The measurements required for testing include a dozen or more strain gauge channels and up to 20 pressure gauge channels. There are also 20 DAC channels and 32 thermocouple channels with type-K junctions. Pressure gauges are used to measure the aerodynamic forces on the car at various speeds. Temperature measurements are used for engine parameters, tires, and brakes, while the strain gauges measure chassis flexing and strain on suspension components (see Figure 3).

The extensive use of

instrumentation allows the rapid simulation of the engine-chassis combination under different race conditions. The effort requires constant adjustments in instrumentation since a single setting ripples to all other parts of the design; therefore, flexibility is key. HP VEE allows the test technician to rapidly change program sequences and to observe data coming in while a test is running.

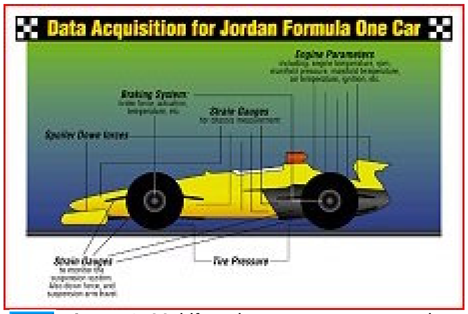

Figure 3. Multifunction measurement and control performance of VXI technology provides the Jordan team with state-of-the-art solutions for its car's race-day setup.

For Jordan, the result of all this leading-edge testing will be shorter times from design to track—and, the team hopes, faster times on the track itself.

Ken Jessen, was, until his retirement, a Senior Test Engineer at Hewlett-Packard Co. For more information, contact **Bill Porter**, Hewlett-Packard Co., 815 14th St. S.W., MS CU328, Loveland, CO 80537; 917-679-2739, fax 970-679-5984, bill_porter@hp.com

---