USER STORY

Pacifica Group Technologies Advances Brake-by-Wire Technology with Simulink® and xPC Target

THE CHALLENGE

To design an innovative brake-by-wire system without building and testing costly hardware prototypes

THE SOLUTION

Use Simulink and xPC Target to design, prototype, and rigorously test a safety-critical brake-by-wire system for aggressive production schedules

THE RESULTS

- Huge savings in design and testing costs
- Holistic testing
- Faster prototyping and fewer field tests

With brake-by-wire technology, we may soon be driving cars that decelerate automatically in hazardous situations, such as skidding on wet roads. Part of a larger trend in the automotive industry, brake-by-wire technology replaces mechanical linkages with electric signals, thereby reducing manufacturing costs and environmental concerns associated with hydraulic brakes. To date, however, implementing this technology has required building and testing costly and labor-intensive hardware prototypes.

Pacifica Group Technologies (PGT), the R&D arm of Pacifica Group Limited, has bundled their resources into RABiT, a Victorian State Government-supported collaborative venture for advanced by-wire research. PGT used Simulink® and xPC Target to design and test an innovative brake-by-wire system, greatly reducing their dependence on physical prototypes.

"With the progress we are making in this area, it is very likely we will be buying future cars with brake-by-wire technology features, and it wouldn't be happening without MathWorks tools," says Jaap Overschie, senior control systems design engineer at PGT.

THE CHALLENGE

To preserve driver safety, brake-by-wire systems must be thoroughly reliable and fault-tolerant. PGT needed a way to test their technology under a broad range of driving conditions, and in the context of the entire vehicle system.

"Designing and testing brake-by-wire technology requires a scalable, integrated environment in which each part aligns with all other mechanisms of the vehicle," says Overschie. "Our challenge is to match the physical model of the new brake components with a real vehicle, and calibrate the model to identify any irregularities."

Hardware-in-the-loop testing environment.

PGT faced intense global competition in developing these production-ready systems, so they needed a more cost-effective and faster way to test the system than traditional approaches. Typically, engineers developed a physical prototype and tested it in the field with real vehicles. After every test run, they adjusted or rebuilt the prototype, then tested it on the road again. This method was too costly and caused long time delays.

Moreover, purchasing and customizing a commercial off-the-shelf simulator with proprietary hardware and software would cost several hundred thousand dollars.

THE SOLUTION

Instead of relying on conventional field testing approaches or expensive vehicle simulators, PGT designed, prototyped, and tested their brake-by-wire systems with MathWorks tools for Model-Based Design. They used Simulink for modeling, simulation, and analysis, and xPC Target for hardware-in-the-loop testing.

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>
> Jaap Overschie, Pacifica Group Technologies

"We chose MathWorks products because they enable us to simulate and test every aspect of the brake system operation," says Overschie. "If we can simulate it, we can control it in real time."

PGT used Simulink to design a vehicle dynamics model that simulates vehicle response to the brake-by-wire products that they are developing. PGT used Real-Time Workshop® to automatically generate C code that they ran on standard, low-cost personal computers with xPC Target. They used the PCs to simulate all vehicle components in real-time by running hardware-in-the-loop simulations with xPC Target.

"Using xPC Target is a very cost-effective way to test the internal software for model coverage, and external real-world influences through scenario testing," explains Overschie. "Conducting tests outside of such an environment is complicated, dangerous, and expensive."

If the tests run well, simulated components, such as a front right wheel, will be replaced with real components. They are integrated with the remaining simulated components through a real-time data link for hardware-in-the-loop testing. PGT can simulate the effect of a wheel hitting a curb, for instance, and the reaction of the real electromechanical brake.

PGT uses the Optimization Toolbox and the Genetic Algorithm and Direct Search Toolbox to automatically optimize and calibrate the design parameters of the new braking system. They evaluate these parameters on a real car, and then bring results back into MATLAB® to further test and optimize a new set of parameters.

After rapid prototyping and verification, the team uses Real-Time Workshop Embedded Coder to transfer the desktop simulation into production C code for their ECU.

General Motors (GM) has incorporated PGT's brake-by-wire technology into the Sequel, a fuel cell car that debuted at the 2001 North American International Auto Show. GM says that the Sequel's state-of-the-art, by-wire systems will offer better control and more responsiveness than a conventional vehicle by slowing vehicles from 60 to 0 MPH in one car length, a stopping distance of about 5 meters shorter than conventional hydraulic brakes.

THE RESULTS

- **Huge savings in design and testing costs.** "Simulink and xPC Target give us an enormous cost savings," explains Overschie. "What we are designing and testing now would have cost 100 times more without MathWorks tools for Model-Based Design."
- **Holistic testing.** "With Simulink and xPC Target, we can take a holistic approach to the car's operation, rather than viewing the components as separate units," Overschie says. "Now, we can truly assess the effect of our brake design changes on the entire vehicle."
- **Faster prototyping and fewer field tests.** "MathWorks tools help us to prototype more rapidly," Overschie explains. "Field testing is now only required in the final stages of vehicle development."

APPLICATION AREAS

- Automotive
- Automatically generated code
- Control design
- Hardware-in-the-loop simulation
- Model-Based Design
- Rapid prototyping

PRODUCTS USED

- MATLAB
- Simulink
- Real-Time Workshop
- Real-Time Workshop Embedded Coder
- xPC Target
- Optimization Toolbox
- Genetic Algorithm and Direct Search Toolbox

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