

# Drive & Control profile

## New simulation rig helps “tighten” racecar performance



The semi-dynamic chassis and suspension testing rigs allow crews to conduct testing in a controlled environment that provides high-speed simulation data acquisition.

Tune in to a NASCAR race at any time and you’re certain to hear the announcers repeatedly talking about how different cars are “handling.” In today’s highly competitive world of racing it takes more than driver skill and engine/drive train performance to cross the finish line first. Suspension and chassis design can be the deciding factor in winning the race.

Until recently, fine-tuning a racecar’s chassis and suspension was done

at the track through a process of trial-and-error. The K-RIG and the KD-RIG allows the crew to conduct testing in a controlled environment that provides high-speed simulation data acquisition.

Livingston & Haven (L&H), a leading industrial technology provider with extensive experience supplying the automotive industry, partnered with Accelerating Developments International (ADI) in developing these

### Challenge:

Create groundbreaking chassis and suspension simulation rigs to improve racecar performance control

### Bosch Rexroth Solution:

- AA10VSO pump
- 4WREE6 valves
- CDT4 cylinders
- VT-HACD controller
- Linear Ball Rail
- Ball screw
- EcoDrive
- WinStudio

### Benefits:

- Enables simulation of racetrack conditions on racecar chassis and suspension configurations
- Lets race teams replace trial-and-error adjustments with real-world data to optimize racecar handling before race
- Race teams can measure and adjust settings such as coil bind and force over position suspension curves
- Rigs let teams visually inspect underside of vehicle during simulation

semi-dynamic rigs that meet the extreme requirements necessary for testing in the motor sports industry.

Getting the right power and motion control solutions were key to the success of this innovative technology. ADI and L&H turned to the leading drive and control company, Bosch Rexroth ([www.boschrexroth-us.com](http://www.boschrexroth-us.com)).

### **A new generation enters the pits**

The world of auto racing is an evolving mix of high-tech engineering tools and practices, combined with traditional skills, customs and “tricks of the trade” handed down from one generation of race teams to the next.

Now, a more scientific, engineering-oriented approach to managing vehicle performance is becoming common. With this new approach, new tools are needed. L&H and ADI designed and developed its semi-dynamic testing systems to broaden the spectrum of diagnostic scenarios for suspension, alignment and chassis on today’s racecars. Teams are now able to tune vehicles ahead of time, so they are tighter and easier for the driver to control and race at peak performance.

### **Simulation delivers a winning edge**

L&H and ADI developed two versions of its chassis and suspension testing systems. The first version, called the K-RIG, is a four-post system that uses sensors and Bosch Rexroth hydraulics to provide motion and capture detailed data about chassis and suspension functions.

Vehicles are driven onto the rig, so that each wheel rests on one post or “tower.” The car is held rigid via tie-downs between the rig frame and the car chassis. The vehicle is then lifted high enough off the floor that



The K-RIG uses a hydraulic pump, and four Rexroth proportional directional valves and cylinders in each leg of the rig to lift the vehicle and provide the independent movement that simulates changes in the road surface.

technicians can view the underside of the car during testing.

To test, each corner of the rig can be actuated—independently, in combination, or all four synchronously—to measure the effects of different forces on the position of suspension components such as springs and tie rods.

The newest version of the testing system is called the KD-RIG, which uses a combination of Bosch Rexroth linear Ball Rails®, ball screws and servo motors and drives for each leg of the rig to provide the movement simulation.

“Simulation is the key—the watchword of the day at NASCAR right now,” explained Clifton Vann IV, president of Livingston & Haven. “The new generation of crew chiefs and crews have gone from an attitude of ‘feels good, let’s see how it works’ to a different mindset—they want to see the data.”

Using the rig offers major savings: race teams can gather more data about chassis and suspension setup without

the time and expense of taking the vehicles to the track. It also reduces risks—safety risks for the driver, and extremely expensive risks of damaging the car in testing.

Simulation also provides repeatability, which is necessary for true engineering control of any mechanical system—including a racecar.

### **1st generation rig uses hydraulic power**

Both the K-RIG and KD-RIG count on advanced Bosch Rexroth technology components to create the racetrack simulations.

The K-RIG uses the Rexroth AA10VSO hydraulic pump, and four 4WREE6 proportional directional valves and CDT4 cylinders in each leg of the rig to lift the vehicle and provide the independent movement that simulates changes in the road surface.

The AA10VSO proportional control pump electronically controls both hydraulic flow and pressure with exceptional speed and precision. The 4WREE6 valves provide a low-cost design that’s perfect for manual and

open loop applications like the K-RIG, and the CDT4 cylinders are rugged, proven components built around a one-piece extra long bearing for reduced wear and long service life.

A Rexroth VT-HACD force/position digital hydraulic controller controls the motion sequences. Each tower can be moved as little as 1/1000 of an inch, for very precise simulation. VT-HACD controllers deliver extremely responsive control, smooth transitions from velocity to pressure regulation, and unmatched repeatability to fractions of an inch.

Vann said the Rexroth HACD controller provides the proportional hydraulic control the K-RIG needed. In addition, its built-in recipes for position and force control simplified building and commissioning the K-RIG, so they could bring it to market much faster.



A digital hydraulic controller enables each tower of the K-RIG to be moved as little as 1/1000 of an inch, for very precise simulation.

“Using hydraulics for force control was easier because we can maintain hydrostatic balance in the cylinder,” he said. “This also lets us measure the pressure in the hydraulics as we

are moving through various force and load simulations.”

### **Electric drives and linear Ball Rail® systems expand simulation**

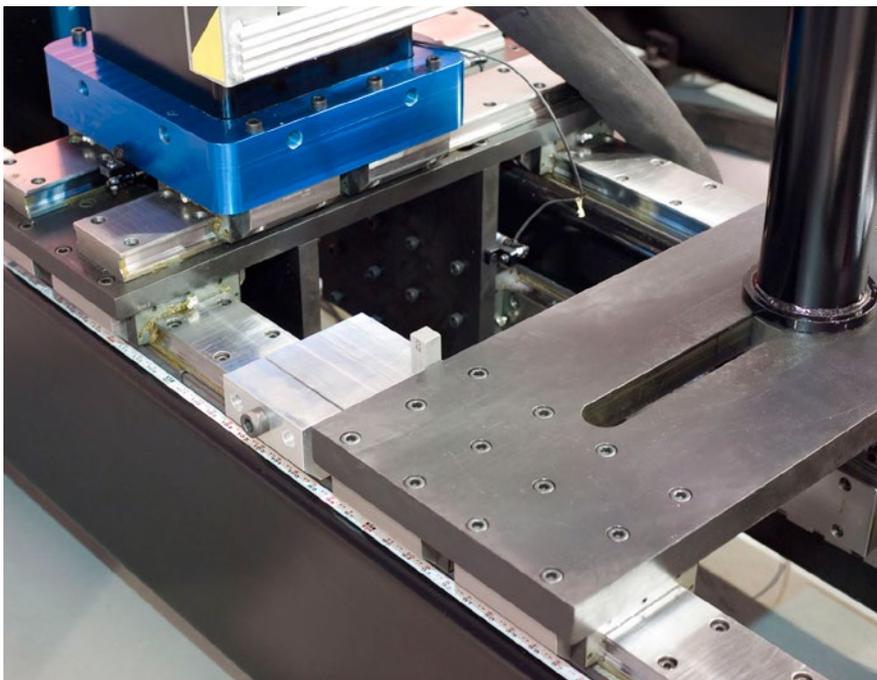
L&H and ADI developed the second-generation simulation machine, the KD-RIG, to provide faster motion, increase the range of diagnostic simulation scenarios, and enhance high-speed control and data acquisition.

To accomplish these goals, they chose a combination of Rexroth electric drives and linear Ball Rail® and ball screw systems to build the new rig, which has a total of 12 motion axes.

The four KD-RIG towers are each powered by a Rexroth EcoDrive MKD synchronous servomotor with absolute feedback and DKC EcoDrive 03 drive unit. The EcoDrive system provides a compact and versatile drive solution with integrated technology functions, multiple power ratings, and simple assembly and easy operation features, and integrates very efficiently with Rexroth ball screw and linear guide products.

The EcoDrive system in each tower drives a Rexroth ball screw, which lifts the vehicle to the desired height for simulation. Each tower is also mounted on a Rexroth Ball Rail linear guide system.

This unique mounting provides independent, multi-axis tracking of suspension and alignment: if any binding of springs or other suspension components occurs on any test point as the vehicle goes through a simulation, the “floating” towers track the binding, for improved measurement of chassis conditions.



The EcoDrive system in each tower of the KD-RIG drives a Rexroth ball screw, which lifts the vehicle to the desired height for simulation. Each tower is also mounted on a Rexroth Ball Rail linear guide system (shown here).



can measure such things as force over position curves: Relative to the compression of the tire, the rig can simulate and measure the forces that specific points in the suspension are experiencing. This helps the teams understand how vehicle suspensions are performing, compared to original design and engineering assumptions.

To make the simulations as accurate as possible, the teams can run a test car equipped with sensors for multiple laps at a specific racetrack. Road surface condition data captured in this way can be loaded into the KD-RIG and used to re-create how that raceway's surface will impact the car's suspension—its attitude in the straight-aways, in the turns, high up in the curve or down low.

The rigs raise the car off the ground, allowing race teams to stand under the vehicle and examine the car as it goes through various simulations, helping to identify and correct issues they weren't able to see before.

The crew can inspect all the suspension elements—coils, rocker bars, etc—and truly understand what's happening and the best way to adjust the settings for the starting line, and throughout the race.

Rexroth Ball Rail systems were specially developed for applications requiring compact, rolling-element linear motion guideways. Available in various accuracy classes, they come in 9 common sizes (15 mm – 125 mm) and offer extremely high load capacity and high rigidity in all four major planes of load application.

“Just putting the car up on the rig and being able to stand under it and look at the suspension, the springs, the rocker bars as the car goes through various simulations has been a major benefit,” says Vann.

Teams have been using the rig to understand and refine a critical suspension component called “coil bind.” Coil bind is achieved when the spring coil is fully tightened—the metal coil essentially becomes a rigid member, like a solid tube.

Precision ball screws from Rexroth utilize enclosed ball-circulation systems for smooth operation, high rigidity, high axial load capacity, and low friction to achieve exceptional repeatability and precision.

“They've discovered things such as suspension rocker arms rubbing brake lines—a potentially fatal condition for the vehicle; if the line gets broken, that could take the car out of the race in the first 20 laps.”

“You don't want to go into coil bind too early in the race,” according to Vann. The simulation rig helps the teams identify how loose the coils should be at the start of the race, and the adjustments they should make throughout the race to reach coil bind at the right time.

### **Rigs help uncover unseen problems**

Both rigs have given the race teams a whole new view of their vehicles—in many cases, helping identify and correct issues they weren't able to see before.

During a simulation, each tower moves up and down and side to side to subject springs, suspension components and chassis frame to accurately captured track surface conditions at a specific raceway.

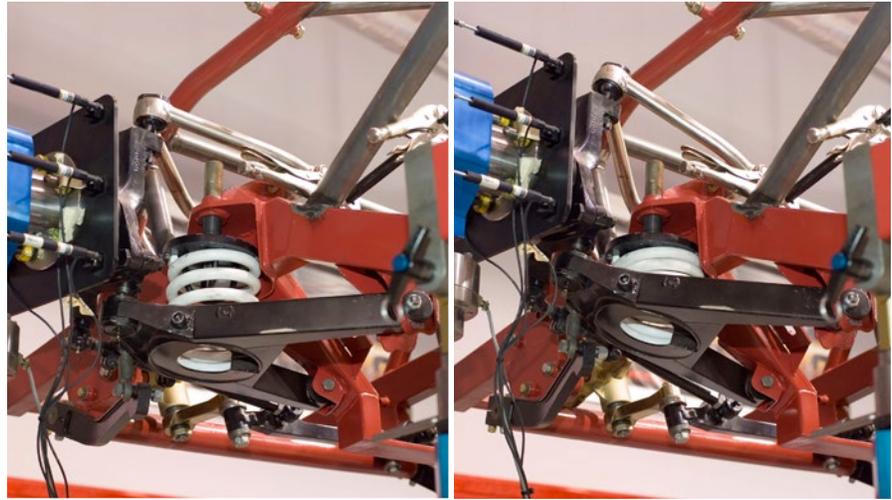
Sensors in each tower can capture data on various conditions. The rigs

The KD-RIG's flexibility, ease of use, and fast operation are enabled by the Rexroth WinStudio visualization

software tool. It provides a much more efficient platform for develop the rig's motion control, force control, HMI and front-end data reporting functions.

WinStudio offers the project engineer all functionality for creating system-specific operating screens in a simple drag-and-drop, point-and-click development environment. In addition to access to libraries with mathematical functions and graphical objects, WinStudio also supports different graphics formats and interfaces such as Active-X. Standardized hardware and software interfaces integrate the functions needed for fast, flexible, cost-effective automation.

According to Vann, WinStudio offers more efficient integration with the rest of the simulation rig's sensors and data reporting functions, and faster machine commissioning.



Teams have been using the rig to understand and refine a critical suspension component called "coil bind." They can identify how loose the coils should be at the start of the race, and the adjustments they should make throughout the race to reach coil bind at the right time. (Left: coil at rest, Right: coil in "coil bind")

"WinStudio was generally easier to use for commissioning and day-to-day application elements," he said. "There was more functionality on-board, and that enabled us to program control

loops better, reducing handshakes and making the entire application more efficient."

### Expanding opportunities for simulation

Due to the success with its test rigs, Livingston & Haven and Accelerating Developments International provide the K-RIG and KD-RIG, along with other engineering tools and advanced technology solutions, to the motor sports industry, OEM and aftermarket businesses.

According to Vann, interest in the rigs is expanding beyond motor sports; current plans include offering the KD-RIG for purchase, and creating a facility where race teams and other users can lease time on either rig for simulations.

Vann also said that bringing both rigs to market was made much easier by the engineering support and high quality of all the Bosch Rexroth products used.



Visualization software tools provide a much more efficient platform for develop the rig's motion control, force control, HMI and front-end data reporting functions.

“One reason we partnered with Bosch Rexroth is that they have the crucial drive and control components we needed,” he said. “We really appreciated the innate compatibility of the Rexroth products across all the technologies they offer. Because they have such a large breadth of products, we were able to work with them as the main automation supplier to build the whole thing.”

**Story update:**

*Bosch Rexroth congratulates ADI for earning the Testing Technology of the Year Award at the 2007 Professional Motorsports World Expo in Köln, Germany, for the KD-RIG's revolutionary technology. ADI was chosen for the award by an industry panel of motorsports professionals, including Michael Andretti, CEO of Andretti Green Racing.*

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