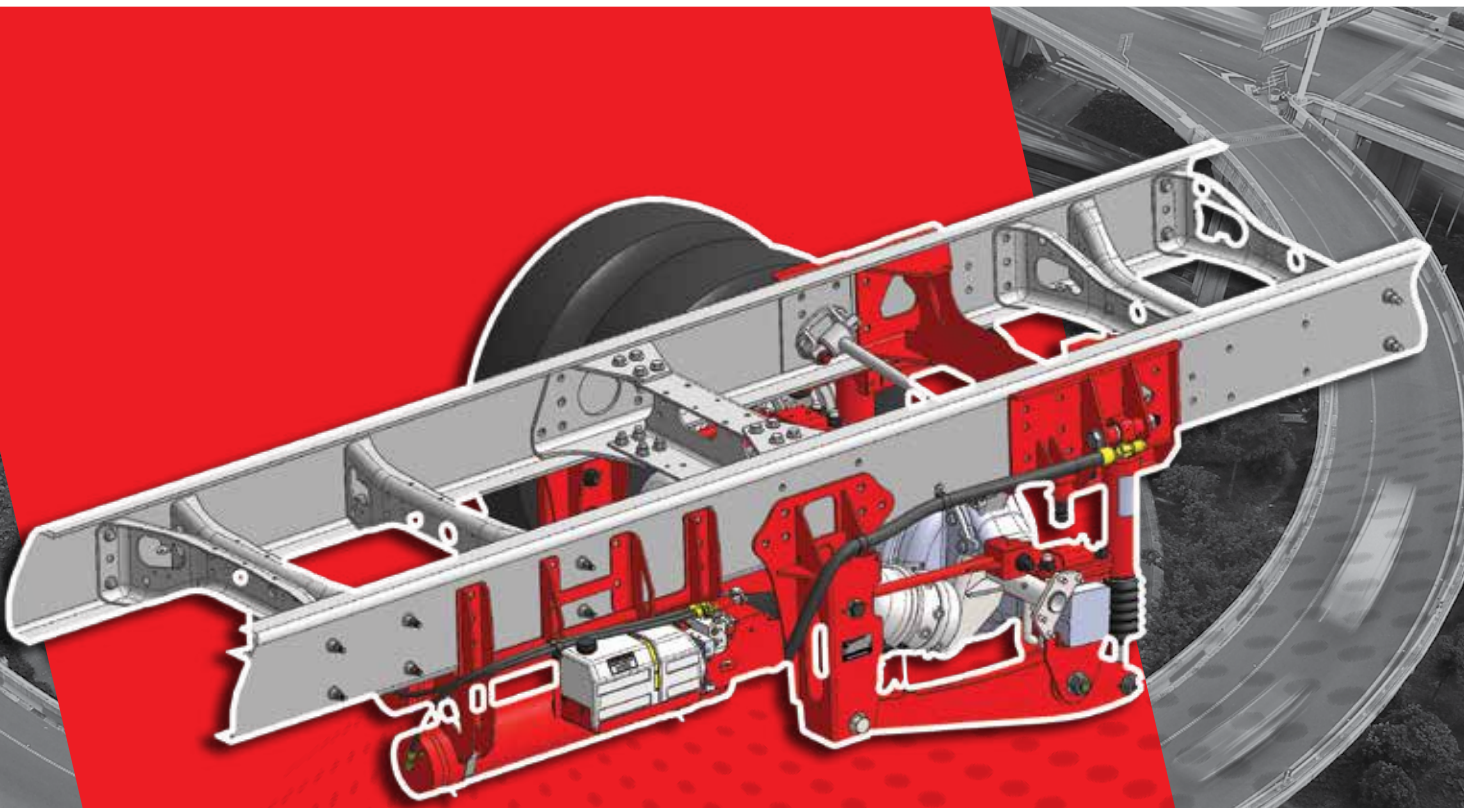


HOW AN ACTIVE SUSPENSION HELPS IMPROVE BUS DRIVER RETENTION



An active suspension is the smoother, safer, smarter way to ride in today's buses. It brings comfort and enhanced performance to drivers, passengers, and assistants.

OVERVIEW

In this whitepaper, you will be introduced to the following:

- What is an active suspension?
- An example of how standard suspensions react to road conditions
- Compare with how an active suspension's response is different
- What does an active suspension do for you?
- Specific benefits of an active suspension for buses and the transport industry
- Practical benefits provided to drivers, passengers, and to fleet managers

WHAT IS AN ACTIVE SUSPENSION?

While most other elements of a modern vehicle have received powered upgrades, the suspension has been a notable holdout, remaining unpowered. Power steering, antilock brakes, lane change warnings, traction control, and automatic collision avoidance are just a few powered options available on consumer vehicles. This is without considering the self-driving car, a whole new level of computerized system.

Yet the suspension, a fundamental aspect of a vehicle's handling and ride, is almost always a set of shocks and springs which have only one setting in one of the most dynamic areas of a vehicle. An active suspension is different. It automatically and instantaneously changes the spring stiffness and damping at each individual wheel in response to road and driving conditions. When the road's rough, the ride is soft and smooth. When the vehicle makes sharp turns, corners, or emergency evasive maneuvers, the suspension stiffens to provide superior stability and eliminates roll. Thanks to the onboard processor, the suspension adapts and adjusts without driver intervention. This provides better handling and control when you need it, and a smoother, softer ride when you want it.

A PRACTICAL EXAMPLE, THE POTHOLE, WITH A STANDARD SUSPENSION

The pothole or any sudden dip in the road is an uncomfortable fact of driving. We all know the faster you hit them, the worse it gets. What is happening with a standard suspension in this case? There are three phases. Let us consider them one at a time:

First phase: Entering the pothole. With a standard suspension, the vehicle drops into the pothole, and so does everyone inside. It is all simple gravity, everything is falling. The suspension has extended somewhat to compensate, but you still drop. It is a fast change, more than it can handle. The vehicle sinks, and if it is a big pothole, you may feel yourself having a floating feeling from this sudden drop.

Second phase: Exiting the pothole. As the wheel goes upwards to leave the pothole, this compresses the suspension. The vehicle is still heading downward, diving down into the pothole. Simultaneously, the wheel and its shock absorber must do the opposite and head up and out. Pinched between two forces, the suspension compresses deeply.

Third phase: Returning to normal. Newton's laws of motion say that for every action, there must be an equal and opposite reaction. In this case, the standard suspension has been pushed close to the limit. It quickly decompresses and returns to normal height. This change rockets the vehicle upwards and results in the painful meeting of chair and your tailbone. This effect can be especially strong with the rear suspension of a bus and a light passenger load. Tuned to work effectively for a heavy load of passengers, this single-size solution can be over-energetic when few passengers are present, reacting too fast and with an uncomfortably strong force.

But the one affected wheel is not the only part of the suspension. The energy of this sudden change is now passed through the frame to the other wheels, setting up a swaying and rocking action as the force echoes through the vehicle.

THE MODERN POWER SOLUTION: ACTIVE SUSPENSION AND THE POTHOLE

Active suspension systems have differing methods by which they work, but all share the core idea that the stiffness of the suspension can be altered to provide an optimal adjusted spring stiffness at each moment by using smart controls. Note that all these responses are automatically part of the smart controls system. It requires no input from the driver, so there is no distraction, just improved driving to enjoy.

Here is the better way to handle a pothole:

First phase: Entering the pothole. The active suspension system is monitoring each wheel independently. In an imperceptible few thousandths of a second, the smart control system notices the downward drop because of the pothole. Adjustments are made to that wheel alone, effectively increasing the ride height to maintain road contact. This fast response keeps the vehicle relatively level instead of falling into the hole. However, the vehicle did sink slightly, so the smart system works to return the vehicle slowly and comfortably to normal height without the jarring sudden reaction of the standard suspension.

Second phase: Exiting the pothole. This is the same situation, but in reverse. The active suspension dynamically becomes a softer spring after sensing the vehicle is rising. This allows full absorption of the upward travel needed to insulate the vehicle from the sudden change and prevents a considerable amount of shock being passed to the vehicle itself.

Third phase: Returning to normal. Because of the optimized reaction to the pothole itself, there is less force required to return to normal level road conditions. By optimizing the speed of the return, the process is slower and more pleasant. Because of the smart control system, rocking and swaying is considerably reduced, ending the back and forth echoing cycle seen in standard suspensions. All wheels work in concert to return to optimal conditions.

This is the real advantage of active suspension technology, reacting at the appropriate speed. A standard suspension has only one speed of reaction. Active suspension reacts fast to absorb road shock, and when some still gets passed on the smart systems work to prevent the jerking and head-snapping that the standard suspension often produces.

ACTIVE SUSPENSION EXAMPLE

To see how much an active suspension can dampen the effects of the road, see this example video shot at a bumpy test track. Notice the level nature of the bus cabin, and the soft and slow return to level running when needed.

COMFORT VS SAFETY – ACTIVE SUSPENSION CAN DO BOTH

While the pothole example is mostly about comfort, let us consider another scenario where active suspension really shows the true value of the system. During sharp turns or emergency evasive maneuvers, traditional suspensions are prone to roll as the vehicle digs into the turn. An active suspension can counteract this by optimizing suspension stiffness to compensate. By using leveling sensors and speed as inputs, the smart controls can instantly switch to optimize for safety over comfort.

But more than the avoidance itself, the aftereffects are also a concern. Just like in the pothole scenario, the echoing sway caused by the sudden decompression of the suspension can create a secondary issue for the driver to address. The reverberating sway pulls the vehicle alternately left and right, an especially dangerous situation in poor road conditions such as rain. The smart controls will quickly optimize for flat level travel and return to standard comfort driving.

PRACTICAL BENEFITS OF ACTIVE SUSPENSION UPGRADE

An active suspension allows buses to drive and operate more like luxury cars. At first this can sound like an unneeded extravagance, but it has many practical benefits which may not be immediately obvious. It's not only comfort that you are buying, there's more.

LESSENS DRIVER FATIGUE

What are the improvements beyond school bus and bus handling? The active suspension also gives increased stability and comfort to drivers and passengers alike. There is a substantial reduction in bouncing compared to stiff standard bus suspensions, especially in the rear seats.

Drivers experience less fatigue because a smoother ride is not just a luxury. The practical advantage is that longer shifts are possible when the driver stays comfortably in his or her seat, and upright. With a traditional suspension, the constant fight against sway and neck-snapping induced by the road has proven to be very tiresome.

COMFORTABLE DRIVERS STAY ON THE JOB

Increased comfort pays off in increased driver retention. As a highly physically demanding job, it can force hard decisions on drivers who may no longer be up to the challenge the job presents. Even the healthiest of drivers may weigh the discomfort while thinking of changing careers.

- Retain older workers who might retire due to physical complaints
- Allows workers to continue with other physical issues
- Reduces one of the largest complaints in the profession

One of the earliest adopters of active suspension technology were retiree drivers of bus-sized Class A motorhomes. Being more prone to fatigue issues, some have had to limit their time on the road to a small handful of hours a day. This means what would normally be a single day's travel in a car could be days of short hops and overnights in sub-optimal locations chosen only for their distance.

INCREASES PASSENGER COMFORT

This enhanced comfort is also appreciated by special needs passengers, especially those with reduced motor function and less ability to fight these forces. With multiple chassis to choose from, there are options for both standard-sized and smaller mobility buses. Active suspension upgrades have a proven track record of increasing comfort in EMS/ambulance suspension systems where performance and comfort are key deciding factors.

INCREASES LOADING/UNLOADING ASSISTANT RETENTION AS WELL

The loading and unloading assistants in school buses often spend their day in the back of the bus, where the stiff rear suspension amplifies the effects of the road on fatigue. Improving the lives of the students will also improve the comfort and energy for the workers in this physically demanding job position.

REDUCES MAINTENANCE

For regions with poor or rural roads, an active suspension upgrade can also improve school bus and bus maintenance issues. The same comfort provided to passengers is also at work to reduce vibration and frame flexing of the bus chassis and body. An active suspension greatly reduces chassis frame torque and twist. Due to the riveted body construction of many buses, frame flex can be transmitted to body panels from this repeated movement. Reduced wear and tear keeps buses out of the shop and on the road longer.

This reduction of maintenance has been a key selling feature for recreational vehicle customers. For full-time campers or when far from home, maintenance on the vehicle means having to leave your house behind while it is in the shop.

“By the time we had traveled from North Carolina to Missouri, the freeway ride had been so rough that the front grill had broken free from three of its four mounting points and was dangling inches away from the radiator. And before we reached Colorado, the vibrations and bouncing had sheared the four screws that keep the dashboard cover mounted to the coach frame,” Bill Goldman, owner and blogger on Open Roadscapes, said of his motorhome. After his upgrade to an active suspension, he stated that there was a remarkable improvement.

“The first hint, just shortly after starting my trip, was a seat-of-the-pants sensation that there was less vibration, even on smooth roads. Then, as I drove at higher speeds, this became obvious to my ears—I wasn’t hearing the usual rattles and creaking from the back of the coach,” he said. “As the day wore on, my hands registered the most surprising difference of all—they remained relaxed!”

BETTER SUSPENSION FOR BETTER RESULTS

In short, an active suspension adjusts in milliseconds to work towards keeping the floor of the bus leveled. This counteracts the forces which cause sway and frame flex for an improved experience at all levels for drivers, passengers, and even the bus itself. Active suspension makes believers quickly, as the following test drive report shows.

“I have to say that I was impressed with the handling differences,” explained Nancy Geesey, director of transportation for Kingman Academy of Learning. “I noticed right away when I pulled out of the driveway. There was not the rocking movement typical for the passengers. The bus was smoother when going over the ‘great’ streets around RWC, off of Central Avenue. As I pushed the limits, going around corners fast and making aggressive lane changes. I wanted to see if the body roll was different—it was! I couldn’t get my test passengers to slide out of their seats, which had happened when I was a new driver back in 1997. I was so impressed with the handling of the bus with active suspension, with sharp maneuvering and in and out of driveways.”

“I feel that with the smoother ride, there would be a lot less adjustments needed with the wheelchair lift and all the other components. Other problems like air conditioner lines that have broken before, and heater covers where screw heads have literally popped off. That vibration is mostly gone.” Geesey added.

LIQUIDSPRING – A LONG HISTORY OF ACTIVE SUSPENSION INNOVATION

Conceived over 20 years ago, LiquidSpring is the industry leader in active suspension technology. The company began designing active suspensions for large off-highway mining equipment. LiquidSpring pioneered a suspension system to reduce operator injury from extreme conditions found in rugged off highway use and mining. The new strut was filled with a unique pressurized compressible liquid capable of supporting vehicle load and damping in a single element. Today, LiquidSpring continues to develop products for other Class 3-7 on-highway trucks, buses and RVs, as well as providing sales, application, manufacturing, distribution, and service of their products. To learn more, visit their website at [LiquidSpring.com](https://www.liquidspring.com).

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