MTS SENSORS

Magnetostrictive Position Feedback in Suspension Systems

TECHNICAL ARTICLE

Magnetostrictive Position Sensors offer many advantages for current suspension systems compared to traditional solutions. This article looks at how suspension systems operate, exploring the Mercedes Automatic Body Control System (ABC) example, a system that uses Temposonics® magnetostrictive technology to achieve advanced results.

LOOKING AHEAD

- Historical Look
- How Suspension Systems Work
- Linear Position Sensors
- Mercedes ABC Example

Temposonics®

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SUSPENSION HISTORY - PAST TO PRESENT

When thinking about suspension, my mind conjures an image you've probably seen a few times in old newsreels – that is a Model T bouncing down a deeply rutted road, the driver doing all he can do to hold on and not get ejected while simultaneously keeping the vehicle moving forward and out of both ditches. Though tough on the driver's comfort, ultimately, suspension failure was the likely result.

Albeit entertainingly reminiscent, the inputs to that vehicle's suspension system are still relevant today, but compounded by breakneck speeds (relative to then) and the need for all types off-road vehicles to go much faster than the on-road vehicles of back then. Or perhaps just as problematic, heavier machinery and vehicles, on and off road, moving loads un-thought-of back then.

C-Series Sensor embedded in JRI Damper
Photo courtesy of JRI.

Driver comfort and fatigue, road adhesion, load support and control, and response to operator input have made great strides with the continuingly improving suspension systems of the last 50 years. A good suspension system will address body roll and pitch, ride height, variable wheel rate (spring rate with lever arm consideration) and load leveling, all within a single package. What applies to wheeled suspension in cars and light duty trucks also applies, more or less, to motorcycles, bicycles, farm machinery, construction machinery, military vehicles, ATV's, motorhomes, freight trucks, trains – anything wheeled that moves over land.

Even better, suspension systems that have some form of adaptability to the current drive path conditions, load realities and equipment behavior at various speeds and forces are the penultimate solutions. Over the years names such as Automatic Body Control, Hydropneumatic suspension, Hydroelastic suspension, Hydragas suspension, electromagnetic voice coil suspension, magneto-rheological dampers, and numerous other unnamed suspension technologies that have appeared since those early days were, to varying degrees, adaptive. But those that have some form of electronic wheel suspension velocity and position feedback, four corner on board electronic control units (ECU's),

and rapid electronically commanded suspension rate and height adjustment generally have had the greatest degree of adaptability. The best of those "close the loop" with the ECU by measuring position and motion of the unsprung components relative to the chassis.

DETERMINING POSITION FEEDBACK

Electronic motion and position feedback to the ECU can take a number of forms, depending upon the variable needing measurement and control. Load (in the form of pressure or deflection to balance a load between suspension points), position (in the form of continuous linear position to determine height, rate of change in height, inclination relative to other suspension points and deflection for overall load) and acceleration (for damping measurements and overturning moments) may be the most common on each suspension point. Pressure, temperature, and others may also be used to put another performance envelope around really sophisticated or specialized systems.

LINEAR FEEDBACK SENSORS

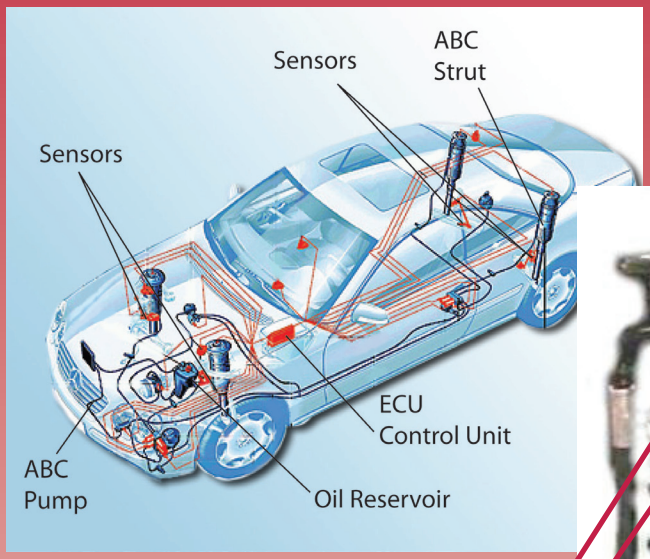
The most frequently used measurements - position and its derivatives, velocity and acceleration - can be determined with a linear feedback sensor. Linear position sensors can be mounted in myriad ways, depending upon the vehicle type, the suspension type and the space available. Potentiometers, inductive devices, proximity switches, and other discreet or continuous devices have been around for a long time and available to the suspension designers as economical methods of getting position indication.

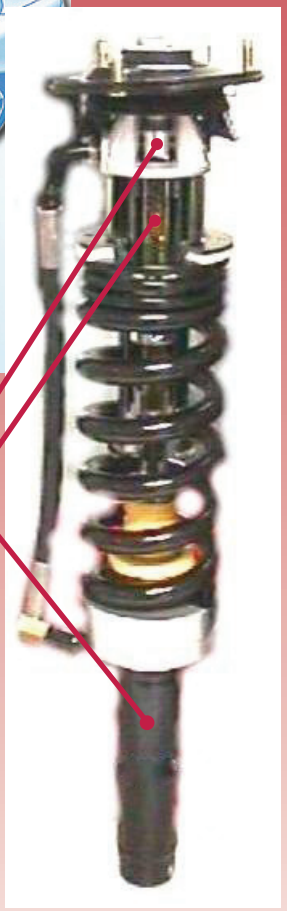
MAGNETOSTRICTIVE TECHNOLOGY

In the industrial tools market, a not-so-new technology, magnetostriction, has been carving a niche in position and velocity control of the large capital equipment machines. For over 30 years, magnetostricitive sensors have been applied to multiple axes of mid to higher end injection molding machines, sawmills and other general hydraulically-powered machinery. Chief among the technology's attractions has been non-contact operation, repeatability in the 0.002% range, non-linearity in the ± 0.02% range, and, more recently, resolutions in the 2-micron range or less. Sensor models support voltage or current analog, or CANbus and other serial bus structure communications allowing their use in many control architectures.

Mercedes Benz ABC System

Mercedes has successfully deployed a suspension known as the Active Body Control system (ABC). This system consists of struts which have sensors for measuring wheel input motion relative to the body and an actuator for adjusting spring preload, and an ECU (controller).





Mercedes strut cutaway showing hydraulic line to the preload actuator. In the cutaway section, the Temposonics magnetostrictive sensor and its associated circuitry is shown.

Each wheel strut has an integrated magnetostrictive sensor, as part of the overall system that also contains accelerometers, pressure sensors, and temperature sensors.

The magnetostrictive sensors provide measurement of the body relative to the unsprung wheels. Four corner measurement provides height and angle measurement for roll and pitch.

MTS® SENSORS

NEW LOW COST/SMALL FOOTPRINT VARIATIONS

Though industrial versions of these sensors range in price from several hundred dollars to several thousand dollars to fit within the budget of capital equipment machines, they mostly did not necessarily fit price objectives of high end mobile machines with relative high-dollar price tags. What's more, these sensors were totally out of contention for position feedback use on other consumer-type products and they tended to be too large both in cross section and in length to be considered for space constrained machines. But that's changed...

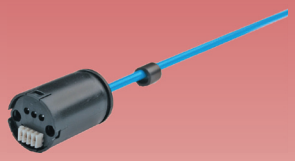
One modular magnetostrictive product line allows embedding of the sensor into vehicle and mobile equipment applications such as agricultural machines, construction machinery, cars, trucks, off-road recreational and rescue vehicles, farm implements, construction equipment, consumer ATVs, military equipment and even low cost conveyances. Their smaller size and embeddable nature allow their use in compact actuator and damper devices, or even liquid level uses, with smaller footprints than could have been addressed with their larger forefathers. Plus, taking advantage of the application's natural protective architecture removes the extra cost protective environmental housings that might otherwise have been necessary. Their substantially lower installed cost allows them to be considered against other contemporary sensing technologies for highly cost sensitive OEM equipment manufacturers.

Though successfully deployed in automotive, construction and agricultural applications for suspension control, the earliest and largest volume application has been in automotive body control which serves as a good example of what can be accomplished with this type of technology.

Key Features of Magnetostrictive Suspension Sensors

Due to a highly efficient automated manufacturing process, the magnetostrictive sensor implementation costs have become very competitive with other technologies normally associated with high volume applications but with some very significant advantages.

The new totally automated manufacturing process allows production of fully-tested core sensors every 17 seconds. This hands-off process is designed to verify that each sensor conforms to the very high standards of quality and control required by automotive and other vehicular industries.



- Complete integration is possible
- No additional wearing parts
- Well-proven, long term measurement principle
- High accuracy
- High temperature stability
- Choice of communication protocols

The sensor is an absolute positioning device. Its electronics measures the interval of a sound wave's travel from the location of the magnet to the tip of the sensor using the known speed of sound in a waveguide material. In fact, the sensor's resolution is primarily a function of its electronics and can be as fine as 50 microns, at rates that allow excellent velocity derivatives.

OTHER SUSPENSION APPLICATIONS

In large heavy equipment found in agricultural, construction and heavy duty off-road machinery, such as military vehicles, magnetostrictive sensors have been used to develop responsive control of body motion to increase operator comfort, reduce fatigue and make the machines safer and more efficient and faster. One suspension application for light military vehicles uses a sensor mounted parallel to the suspension damper. It's ruggedized package allows precious intra-damper real-estate to be used for valve control while providing easy access to the sensor. Internal integration in this particular case wasn't practical due to the damping components occupying space needed for an internal mount.

Lighter machines also can benefit from information feedback, such as ATVs and purpose-built off-road light vehicles for remote site services, firefighting or rescue to maintain vehicle stability, increase load capability and leveling, while potentially increasing the speed of the vehicle over rough terrain.

For further information on Temposonics Linear Position Sensors, visit us at www.mtssensors.com or email us at sensorsinfo@mts.com.

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