A complete range of solutions for dynamic vehicle testing.

APPLICATION NOTES:

Laser Triangulation Sensors for Dynamic Vehicle Testing

Optical sensors have been integral to dynamic vehicle testing for many years. In fact, it is difficult to imagine vehicle testing without this powerful technology.

As the driving force behind optical measurement technology, CORRSYS-DATRON literally changed the course of vehicle dynamics measurement with its CORREVIT® Optical Sensors. CORREVIT® Single-Axis, L-Series Sensors are widely considered as the industry standard for braking distance measurement and performance testing. Similarly, CORREVIT® 2-Axis S-Series Sensors are universally recognized to represent the benchmark for accuracy in the measurement of slip angle.

CORRSYS-DATRON also offers the CORREVIT® HS-CE Sensor, which enables simultaneous measurement in 3 axes. The highly accurate HS-CE Sensor provides all the functionality of CORREVIT® S-Sensors, plus precision optical height measurement capability. CORREVIT® HS-CE Sensors are optimized for pitch and roll measurement, as well as for other specialized testing applications, such the measurement of dynamic tire flattening.

New from CORRSYS-DATRON

Now, CORRSYS-DATRON adds another proven technology to its comprehensive line of vehicle testing solutions: Laser Triangulation. This established technology provides a more accurate and robust alternative to mechanical sensors, such as wire potentiometers. As the name implies, Laser Triangulation Sensors utilize the process of triangulation to measure distance.

Like CORREVIT® Sensors, CORRSYS-DATRON Laser Triangulation Sensors (including the HT-250 and HT-500 Height Sensors) utilize a high-intensity light source to illuminate the measurement surface. This allows the optical component of both sensor types to observe the stochastic microstructure of the surface via an objective lens. The acquired signal is projected onto an optical component within each system, where it is used to generate the measurement value.

Rather than using halogen or IR-LED illumination sources, as found in CORREVIT® Sensors, CORRSYS-DATRON Laser Triangulation Sensors use a laser to illuminate the measuring field. With a diameter of approximately 1 mm, the laser focuses light energy onto a very small measuring spot.

The intensity of the illumination produced by the laser can be compared with that of standard CORREVIT® Sensors, but requires considerably less power. However, the price of reduced power consumption is a more pronounced influence of surface roughness of the measurement field. CORREVIT® Height Sensors, on average, illuminate a measurement field of 30 mm in diameter. Because laser sensors illuminate a much smaller measuring field (1 mm), each small grain of sand – in a manner of speaking – influences the measurement.

The advantage of laser technology is that it can detect even the most minute variations surface detail. This is especially advantageous when measuring on very smooth surfaces.

How does it work?

As shown in Figure 1, the beam of the laser is projected onto the measurement surface and then reflected by the measurement surface onto the photo receptor component of the sensor. This receptor component is a CCD array (Charged-Coupled Device).

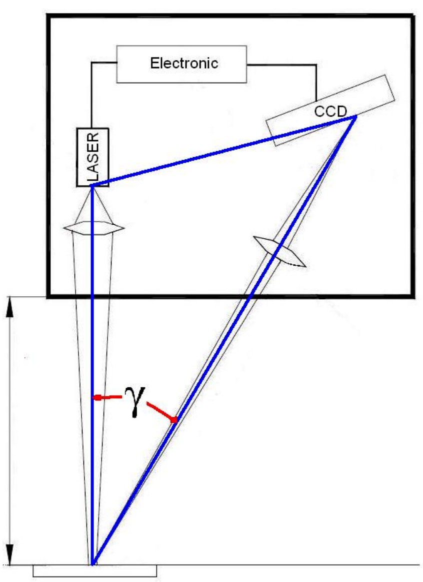


Figure 1. The laser triangulation principle

The CORRSYS-DATRON HT-250 Sensor uses laser triangulation technology to measure dynamic vehicle ride height.

The angle γ between the illuminating laser beam and the perspective of the receptor optics varies as a function of height. As height increases, the angle decreases, vice versa. As this angle changes, the optical signal (laser beam) moves across the surface of the CCD array.

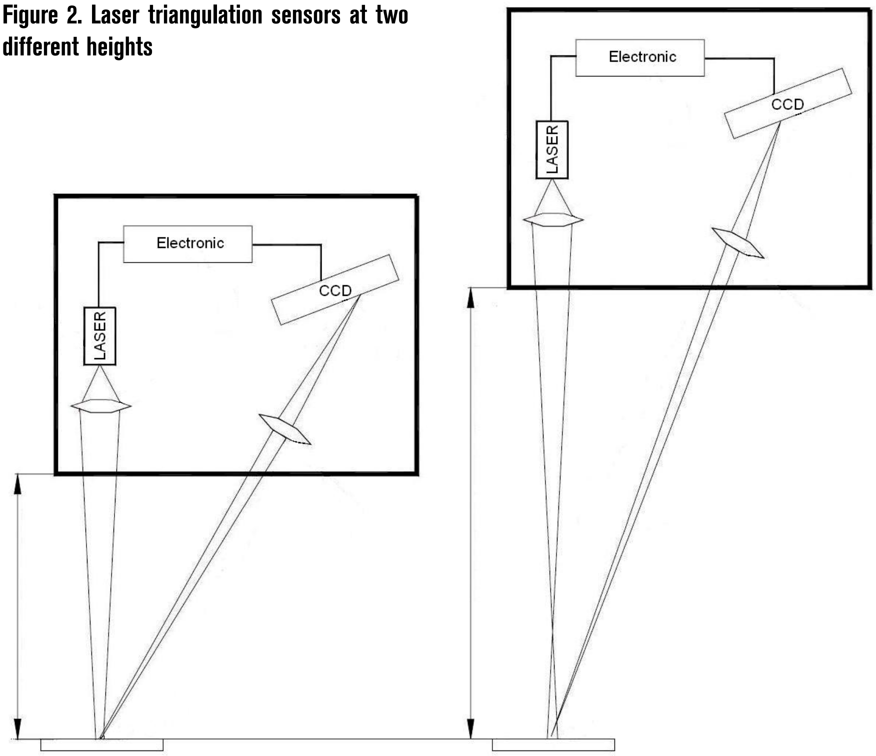
The integrated signal processing component of the sensor then uses the information it acquires about the position of the beam on the CCD array to calculate the angle γ, and from this value it determines height.

Understanding the CCD

Figure 2. shows the sensor at two different measuring heights. Regardless of height, the laser illuminates the measurement field from above, with the beam traveling in a vertical orientation. A lens system in the receptor optics focuses the image onto the CCD array.

A CCD array consists of multiple cells, which convert light energy into an electrical charge. Increasing the amount of that light falls on a cell increases the charge that it is stored within it.

Figure 2. Laser triangulation sensors at two different heights



The CCD array functions via the bucket brigade principle. When light strikes the surface of the CCD, a charge is created. The charge is then emptied from one cell of the CCD into the next, until it reaches the end of the array. When the charge reaches the last cell in the array, the voltage signal is sent to the processing component of the sensor, as shown in Figure 3.

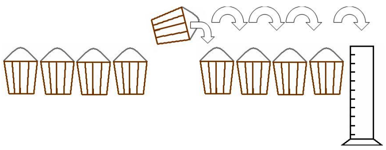


Figure 3. The CCD array functions via the bucket brigade principle.

In a CCD array that has 1024 cells (pixels), a charge that is created in the first cell of the array must be passed on 1024 times to it reaches the end cell.

In the CORRSYS-DATRON HT-500 and HT-250 Sensors, internal software (HT-firmware) determines angle by identifying the point at which the laser strikes the surface of the CCD (as shown in Figure 4). The CCD and software in the sensors enable accuracy at the sub-pixel level, by calculating the center of the spot that is projected onto the CCD.

Laser types and accuracy

Two types of lasers can be used in Laser Triangulation sensors: punctiform and dash-form. The beam of the punctiform laser is delivered to the CCD as a precise point, whereas dash-form lasers deliver the beam in the form of a dash. Punctiform lasers require very accurate adjustment to ensure that the beam always falls exactly onto the CCD array.

Dash-form lasers do not require this costly adjustment, as the direction of the dash alone assures the illumination of the CCD array. The laser energy is distributed over the length of the dash; only the part of the dash that falls onto the CCD array contributes to the signal.

The diffusion of light energy (and resultant weakening of the charge that can be generated in the CCD) inherent to dash-form lasers renders them less effective for precision measurement applications. Consequently, the stronger laser signal produced by punctiform lasers used in the CORRSYS-DATRON HT-250 and HT-500 Height Sensors provides significantly better results, even when the sensors are used in extreme environmental conditions.

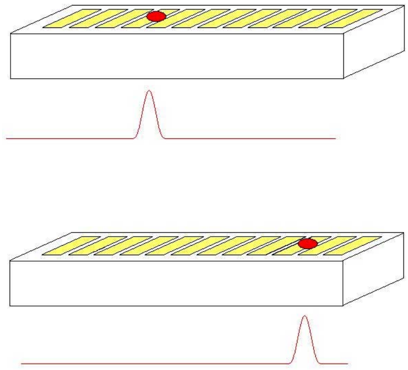


Figure 4. CORRSYS-DATRON HT-firmware determines angle by identifying the point at which the laser strikes the surface of the CCD.

Measurement conditions

Laser Triangulation Sensors have been used successfully in industrial measurement applications for many years, and for a multitude of tasks. However, until now, laser sensors have not been widely used in vehicle testing applications.

The primary reason is that the operating conditions encountered in industrial applications tend to be reasonably consistent. Ambient lighting and temperature, as well as the surface characteristics of the measurement subject tend to be consistent. In contrast, dynamic vehicle testing requires sensors to withstand constantly changing environmental conditions, and to produce accurate results despite very significant variations in the measurement surface.

In vehicle testing applications, it is common for the test surface to vary between extremely dark asphalt and white markings, all within the span of a few milliseconds. Blue basalt or epoxy coverings are also commonly encountered. Additionally, test surfaces can vary from being absolutely dry to being covered by a film of water several millimeters in depth.

Further, in vehicle testing, ambient temperatures can range from the sub-zero chill of winter testing in Finland to the scorching heat of India or the American desert. The intensity of ambient light can also change as a vehicle moves from areas of bright sunlight (which is often far brighter than even high-quality industrial sensors can tolerate) to areas of deep shadow.

Applications

In the field of dynamic vehicle testing, Laser Triangulation Sensors can be applied to numerous testing applications. Primary among these are the measurement of vehicle body movement, and the measurement of the relative movement between wheels and car body.

Laser Triangulation Sensors are also well suited for non-contact measurement of spring travel, pedal travel and movement of the engine block in its suspension. In motor sports, Laser Triangulation Sensors like the CORRSYS-DATRON HT-250 are used in combination with the smallest CORREVIT® SF-II Slip-Angle Sensor to optimize vehicle balance.

Other vehicle testing applications include:

- **Dynamic Tire Flattening Measurement** – Mounted on the vehicle wheel, CORRSYS-DATRON HT-500 and HT-250 Sensors accurately measure dynamic tire flattening, and with it, the suspension and damping qualities of the tire.

- **Dynamic Wheel Camber Measurement** – Using two CORRSYS-DATRON HT-250 Sensors and a special, lightweight wheel mounting system (as shown in Figure 7), dynamic wheel camber angle can be measured accurately in real time.

- **NHTSA Rollover Testing** – The NHTSA Rollover Test can be accomplished using two CORRSYS-DATRON Height Sensors per wheel to reliably perceive wheel lift-off when running through the so-called Fishhook Test.

IPW Automotive in Isernhagen, Germany, has compared the CORRSYS-DATRON HT-500 Sensor with high-quality industry sensors with extremely positive results. As did CORRSYS-DATRON test engineers working in Arizona and India, IWP tested the CORRSYS-DATRON HT-500 Height Sensors on various track surfaces and under extreme environmental conditions as glaring sunlight and wet track.

Dr. Otto Bode of IPW Automotive states, "Always when surrounding conditions got to be extreme, the HT-500 satisfied us. IWP Automotive successfully applies the HT-500 in utility vehicle testing, for example, for the determination of track-related roll behavior."

Figure 7. The new CORRSYS-DATRON Dynamic Camber Angle Measurement System acquires dynamic wheel camber values by comparing the relative change in height between two HT-250 Sensors.

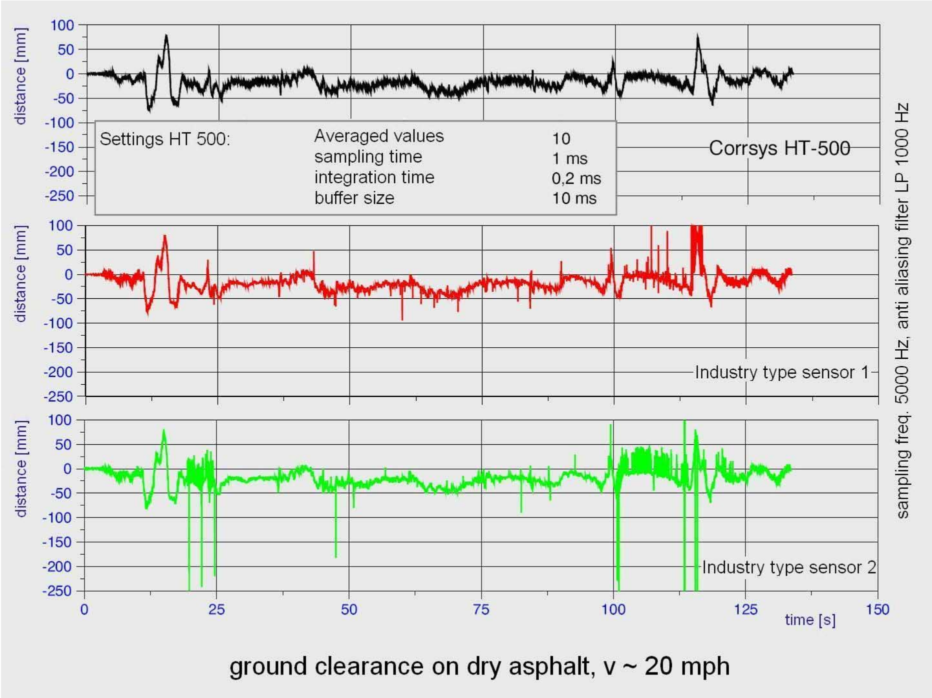


Figure 5. CORRSYS-DATRON HT-500 Laser Triangulation Sensor vs. industrial sensors (dry pavement)

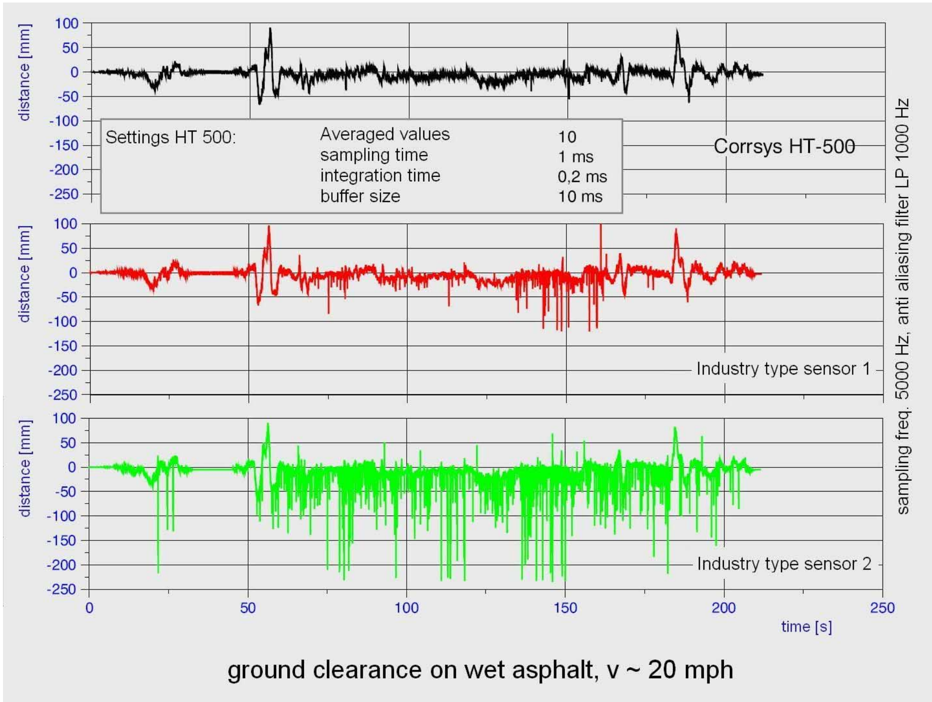


Figure 6. CORRSYS-DATRON HT-500 Laser Triangulation Sensor vs. industrial sensors (wet pavement)

For more information, please contact us today.

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