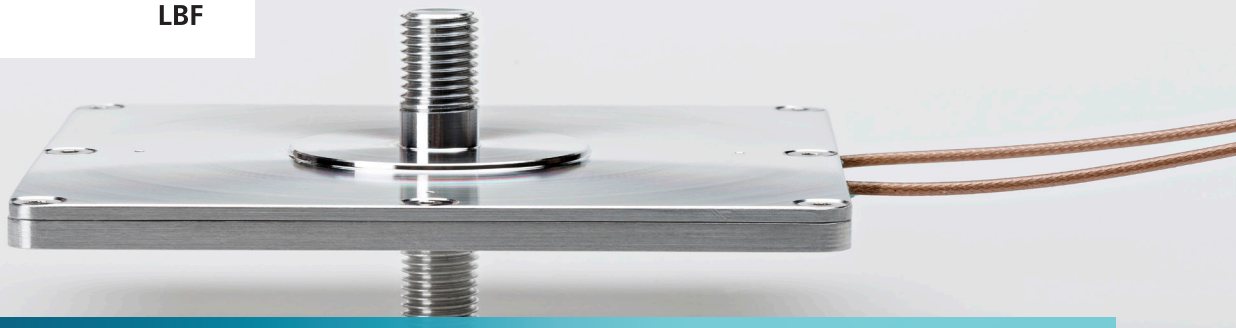
Fraunhofer LBF



Flexible, cost-effective, efficient

CUSTOMIZIBLE FORCE SENSOR SYSTEM FOR THE LIGHTWEIGHT CARGO BIKE "L-LBF"

Driven by trends and technologies such as Industry 4.0, IoT and predictive maintenance, continuous monitoring of conditions in machines and plants is becoming increasingly important in an industrial context. For the implementation of such intelligent systems, the need for inexpensive sensor technology with good integration capability is increasing. Individually designed force measurement modules were developed within the "L-LBF" project, measuring the payload and its distribution in the transport box when loaded and also monitoring its position while driving.

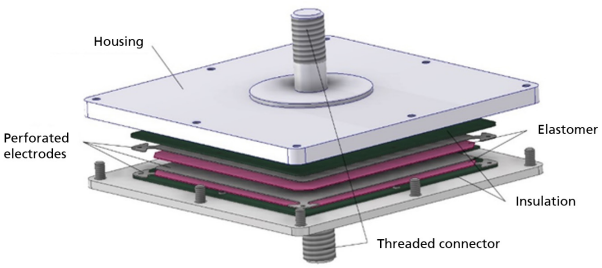
The sensor module: Layered capacitive force sensor design

A layer arrangement of elastomer foils and microstructured metal foils is located between the two halves of the housing to form the capacitive sensor structure.

Many force sensors are based on complex deformation bodies whose strain is measured using the piezoresistive measuring principle (strain gauges), whereas the so-called DELTA sensor technology developed and patented by Fraunhofer LBF uses this capacitive measuring principle of thin elastomer and metal foils. What makes it so special is the microstructuring of the metal electrodes, which enables high sensitivity and linearity of the sensor system. Thin electrodes feature a sub-millimeter hexagonal hole pattern fabricated by an etching process. These are separated by elastomeric sheets made of natural rubber, which serve as an elastic dielectric. This layered composite, integrated into milled aluminum housings, results in robust force sensors that have an overall height of only eight millimeters.

The prototype shown, for example, has a maximum hysteresis of only 2.7 percent of the measuring range. Through the design of the electrodes and the housing, both the measuring range and the sensitivity can be easily scaled.

Inherent hysteresis effects of the material can be further minimized on the evaluation side with AI algorithms. Doing so is particularly efficient because the electronics are inexpensive compared to the hardware.



Schematic diagram of the sensor build-up for capacitive force measurement

Sensor module integration into the “L-LBF” for continuous monitoring of transported goods

By their design, the sensor modules bring the great advantage of acting as connecting elements between the transport box and the front frame. With this, four of these sensor modules fix the four corners of the transport box with the cargo bike. The load application by the goods to be transported is measured locally at these four points. Drivers thus even receive information about the payload distribution in their box on a display directly on the steering wheel while driving. The measurement data is displayed in real time.

As a result, the loading of the cargo box can be optimized and monitored during the journey, without significantly increasing its center of gravity.

As the sensors also detect high-frequency forces, information can also be obtained, for example, about the condition of the roads being traveled.

Additional application as handhold sensors

Featuring good dynamic performance, this capacitive sensor system can be applied to simply curved structures in a wide range of sizes. For this reason, it is virtually predestined for integration into existing handle structures. As a technology demonstrator, the bicycle handles of a cargo bike were chosen, which have a tight curvature, a low wall thickness and require elasticity necessary for haptics. The structure of the bicycle grip was adapted to integrate one-millimeter-thin sensor layer systems enabling continuous grip contact force measurement during operation. The resulting measurement data is shown in real time on a display.

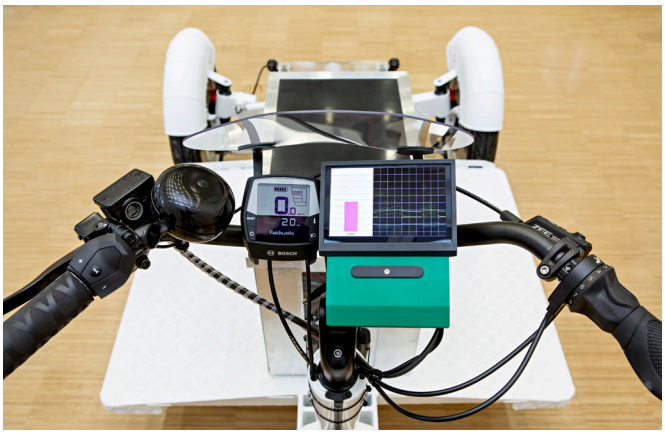
High transfer potential

The DELTA technology is of particular interest to manufacturers in the field of mechanical and plant engineering, as it allows the detection of static and dynamic forces for condition monitoring and facilitates the integration of force sensors in previously inaccessible places. In addition, the technology allows an economical production of the sensors, as both the starting materials and the automatable production on an industrial scale result in low costs.

By integrating a force sensor system into elastomer components, the DELTA technology also opens up further possible applications, such as in the automotive and shipbuilding industries. Applications in vibration control technology, household appliances, medical technology and consumer electronics are also useful.

Additionally, the fact that the technology can be used as an actuator can open up further potential in the future, such as active vibration reduction: When the sensor is excited with AC voltage, targeted dynamic forces can be introduced into the coupled structures and can work against disturbing vibrations.

Experts at Fraunhofer LBF will use their know-how and experience to answer outstanding scientific and technological questions in cross-disciplinary research teams, thus increasing the technological sophistication of the sensors.



The handlebar display shows the measurement data of the sensors in real time

More information

https://www.lbf.fraunhofer.de/en/projects/lightweight-cargo-bike.html

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