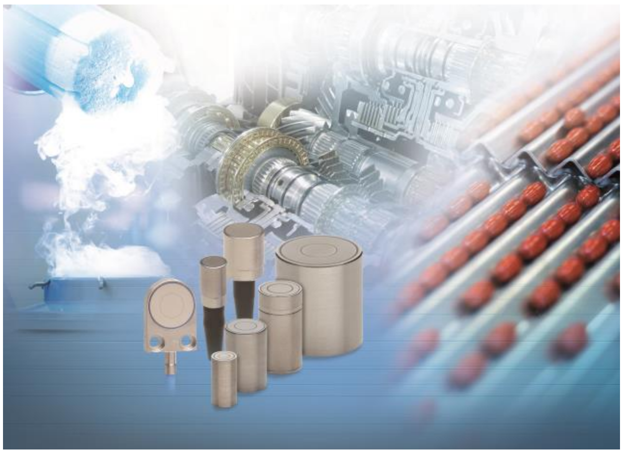
White Paper



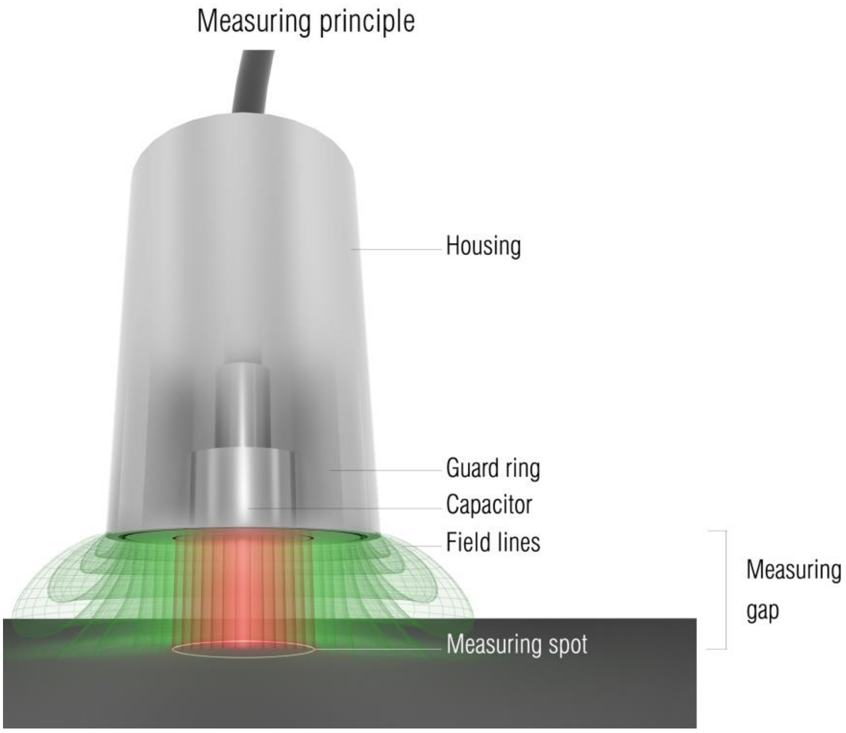
Learn how capacitive sensors open up new perspectives

Conventional capacitive sensors are known from simple tasks e.g. as proximity sensor or for fill level measurements. With corresponding design and evaluation electronics, these sensors can also be used for high precision displacement and position measurements, achieving resolutions well below one nanometer. Capacitive displacement sensors are typically used in applications where fast displacement changes have to be acquired, where no forces can be exerted on the measurement object, where highly sensitive surfaces do not allow any contact, or where a long service life of the sensor is required. Capacitive displacement sensors from Micro-Epsilon have proven themselves in various industries and measurement tasks.

Capacitive measuring principle

The principle of capacitive displacement measurement is based on how an ideal plate-type capacitor operates. The distance displacement of the plates (sensor and measurement object) leads to a change in the total capacity. If an alternating current of constant frequency and constant amplitude flows through the sensor capacitor, the amplitude of the alternating voltage on the sensor is proportional to the distance to the target (ground electrode). The distance change between the measurement object and the controller is detected, processed and output as measurement value by the controller via different outputs.

However, a continuous dielectric constant between sensor and target is required for a stable measurement, as the system does not only depend on the distance between the electrodes but also reacts to dielectric changes in the measuring gap. In order to achieve the highest possible measurement precision e.g. in the nanometer range, the environment should be clean and dry. Capacitive sensors from Micro-Epsilon provide high stability and resolutions in the micrometer range even in industrial environments. Therefore, sensors from Micro-Epsilon can be used successfully in different applications.



As an electromagnetic process, a capacitive measuring system measures on electrically conductive objects with constant sensitivity and linearity as standard. The system evaluates the reactance of the plate capacitor which changes in proportion to the distance. Capacitive sensors can also measure insulating material under certain conditions, in which the sensor grounding acts as ground electrode and the insulating material as coupling medium. An almost linear output signal for insulators is also achieved by using an electronic circuit.

Benefits of the measuring principle

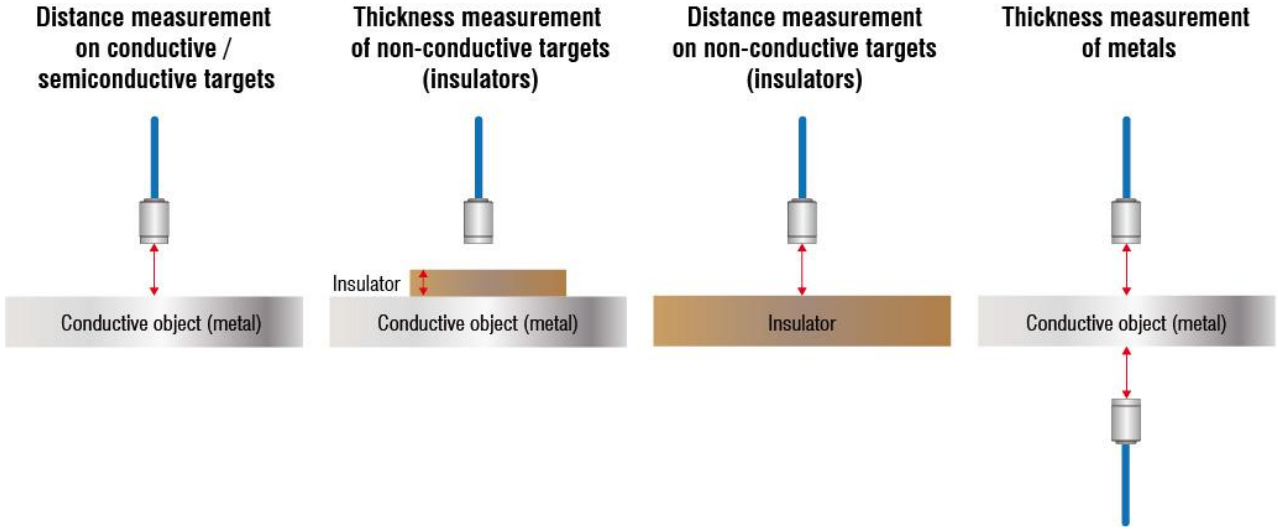
- Wear-free and non-contact measurement
- No interfering force on the target
- Robust against run out of electrically conductive measurement objects
- Unmatched accuracy and stability
- High bandwidth for fast measurements

High Performance

- Measuring Range: 0.05nm to 10mm
- Linearity: 0.025%
- Resolution: up to 0.0375nm
- Interfaces: Analog output, Ethernet, EtherCAT

Measurement on all objects

Since the measurement can be carried out conductive and non-conductive objects, there is no interference caused by e.g. the optical characteristics of the target. Therefore, even transparent and reflecting surfaces can be detected at maximum precision. Examples of conductive measurement objects are metals, graphite, silicon, CFRP and water. Examples of non-conductive measurement objects are plastics (also GFRP, glass fibre-reinforced plastic), ceramics, steatite, porcelain, glass, adhesives, resins, oils and gelatine.

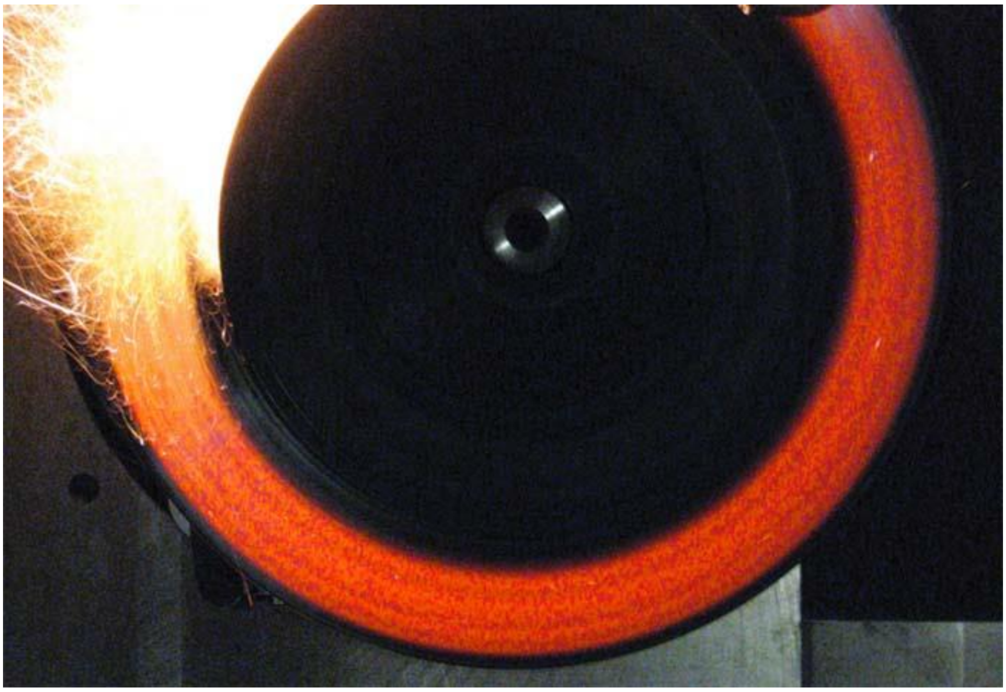


Wear-free measurement

During the measurement, a gap is required between the sensor and the target. As there is no physical contact, the measurement does not involve any load from the sensor applied to the target and is therefore completely wear-free. This means that materials can be measured reliably without any influence on the target surface. Unlike, for example, optical measurement techniques in which the light source must be changed from time to time, capacitive controllers from Micro-Epsilon do not contain any components that are subject to wear. This is why Micro-Epsilon’s capaNCDT systems represent the highest reliability and precision even over a long operating life. This means that maintenance and replacement costs are minimised. The capacitive measurement systems are also suitable for the detection of fast moving objects and processes, enabling fast, reliable measurement of motion sequences during operation. Another advantage is their resistance to magnetic fields and radioactive radiation. Magnetic fields do not influence the measurement which is why measurements in close proximity to strong magnetic fields are possible. Radioactive radiation does not affect the measurement.

High stability

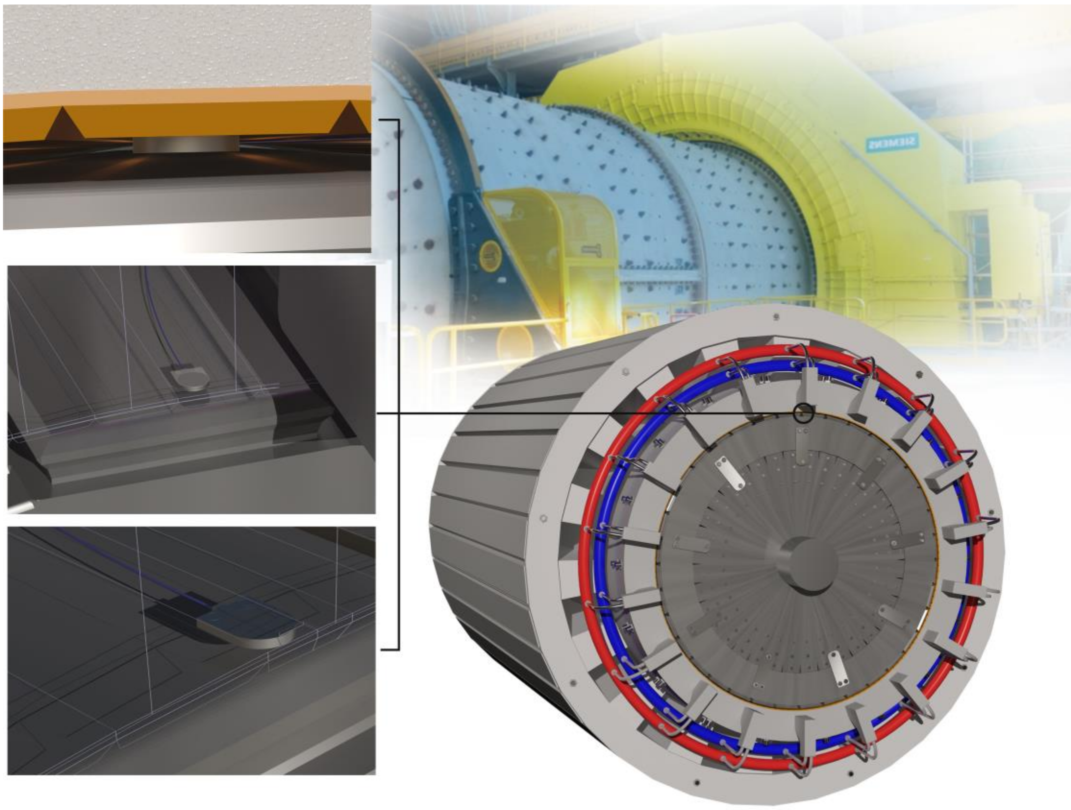
Compared to other non-contact measurement techniques, capacitive displacement measurement is characterised by extreme precision and stability of measurements. As thermally induced conductivity changes of the measuring object have no influence on measurements, the principle is also reliable even with fluctuations in temperature. This is also reflected by the temperature deviation per degree Celsius: the CS005 sensor model from Micro-Epsilon shows a deviation of only -0.5nm/°C, which is why this measurement technique is also suitable for fields of application where very low or very high temperatures occur. All measured values of the capaNCDT products were determined under practice conditions. Each sensor is calibrated before delivery and equipped with its own calibration protocol for the documentation of performance.



Capacitive sensors measure the deformation of glowing break disks

Application example: Air gap measurement in large electric motors

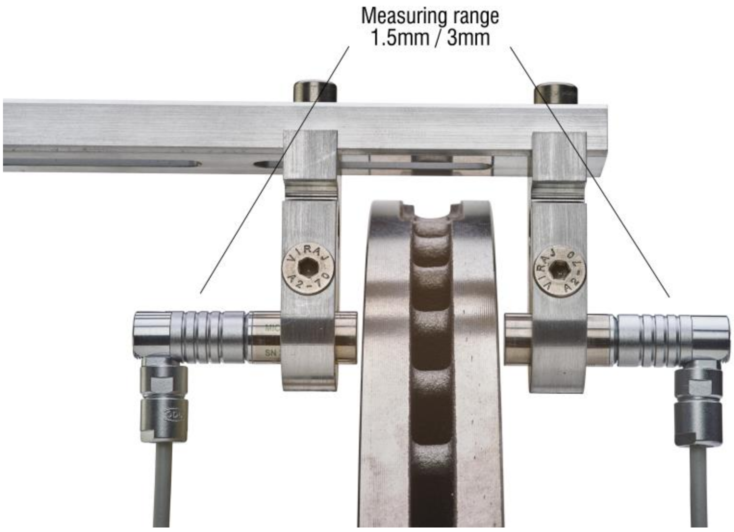
With very large electric motors (diameter larger than 10m) it is important for reasons of cost effectiveness and energy efficiency, to know the radial run out of the rotor from the stator inside the motor. These electric motors are intended for use in rock grinding mills for cement production or mining. Due to imbalances during operation, the rotor may touch the stator, which would cause much damage.



This is why sensors are used to measure the distance between the stator and rotor and to monitor the so-called rotor gap whilst the motor is in operation. For this application, capacitive sensors with a measuring range of approx. 30mm are used. Changing magnetic fields generated by the electric motor and the flat sensor design are challenges here. Due to the size of the motor, cable lengths of 8m or longer are necessary. In total, one motor normally has 8 sensor channels, but up to 16 channels can also be installed.

Application example: Measuring Disc Thickness Variation

With the capaNCDT DTV, Micro-Epsilon has developed a product range that is specifically used for non-contact detection of Disc Thickness Variation. Disc Thickness Variation (DTV) is the thickness deviation of brake discs. In order to achieve maximum efficiency of the braking system, the disc must have an even thickness. Unevenness, runout or abrasion on the friction surface of the disc cause the brake pads to lose contact with the rotating disc.

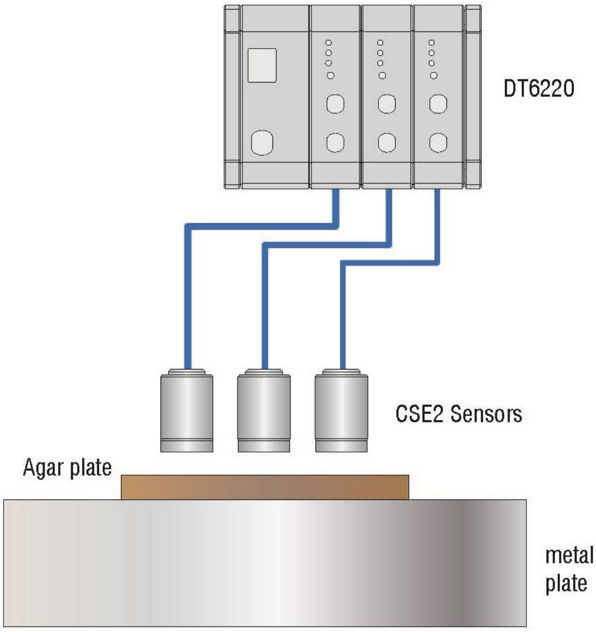


CSH1,4FL/4CH sensors enable robust and high precision multi-track measurements with very little installation effort

Thickness measurements can be performed in test benches, road tests and in car repair shops using non-contact, capacitive displacement sensors, which detect the thickness of the brake disc from both sides. The thickness is determined by using the difference principle. While the brake disc rotates, the thickness deviation is determined via the circumference of the entire disc. Using several sensors in pairs enables multi-track thickness measurements. Special DTV software calculates and delivers thickness values over time, providing real-time evaluation of measured results.

Application example: Height measurement of Petri dishes

In microbiology, cell cultures are used for the analysis of so-called agar plates. When producing this culture medium, liquid agar-agar is filled into plastic Petri dishes, where it hardens and forms a gel-like, transparent layer. The agar plate should be consistently as high as possible - this is a critical factor for later evaluation of the cell colony cultivated on it.



For the inspection of the fill level, the metrological control of the agar plate during the production process is invaluable. This measurement task is solved by using a three-channel version of the capaNCDT6220 capacitive measurement system.

Using three sensors with a measuring range of 4mm, the fill level can be determined over three tracks on the Petri dish. The basic requirement for a successful measurement is that the Petri dish is grounded during the measurement procedure i.e. the Petri dish must be on an electrically grounded, metallic surface. This measurement setup can be used to measure the thickness of insulators on metallic objects such as e.g. rollers. Therefore, measurements such as film thickness of plastics, application of the adhesive onto adhesive film and the thickness of gelatin are possible.

User-friendly operation without calibration

Micro-Epsilon’s capaNCDT components are completely interchangeable, without requiring complex calibration. Complex settings via jumper or rotary controller are unnecessary. The exchange of sensors, cable or controller is carried out within a matter of seconds. As all components are mutually compatible, even sensors with different measuring ranges can be connected to the controller quickly and easily.

Set up and configuration are carried out via a user interface on a web browser. The controller is connected to a PC via an Ethernet interface and a predefined IP address. Without any complex software to install, a clear user interface is carried out using a web browser, which enables the user to configure and set up parameters, data processing and the display. Set ups can be saved and loaded.

Customer-specific sensor development

Micro-Epsilon develops sensors and measurement systems for more than 45 years. Micro-Epsilon offers a wide range and depth of development and production expertise, with the flexibility to develop and manufacture tailor-made solutions, providing users with economical and technical advantages over competitor products. The entire implementation of customised sensors is delivered from Micro-Epsilon, starting from application consulting through to conception and product development, as well as production and after-sales service. Customers benefit from a reliable partnership between manufacturer and user, as well as sustainable technical support that is focused on stability and efficiency improvements. Changes requested include, for example, modified designs, target calibration, mounting options, individual cable lengths, modified measuring ranges or sensors with integrated controller.

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