

Taking precise measurements

There are a wide variety of non-contact displacement sensors available, but how do you go about selecting the correct technology for the task?

The use of non-contact displacement technologies in the field of precision measurement is rapidly growing. Two factors for this include the drive to measure much more accurately to sub micron or even nanometer resolutions; and the need to measure against fragile surfaces or surfaces that cannot be touched during the measurement process – for example silicon, glass, plastics, miniature electronic components, medical components and even food based surfaces.

This growth has pushed the development of new technologies, and the adaptation of those which already exist, to meet the new measurement requirements and to improve accuracies and resolutions. It is therefore more important than ever to have a greater level of understanding of the strengths and limitations of each non contact measurement principle when selecting the correct sensor technology for the measurement task.

Besides eddy current and laser triangulation sensors, capacitive and confocal sensors are becoming more prevalent in this field of measurement. But, non-contact displacement sensors come in a wide variety of shapes, sizes and measurement principles. The key is selecting the most appropriate technology for the task.

The eddy current principle

The eddy current measurement principle is an inductive measuring method based on the extraction of energy from an oscillating circuit. This energy is required for the induction of eddy currents in electrically conductive materials.

A coil is supplied with an alternating current, which causes a magnetic field to form around the coil. If an electrically conducting object is placed in this field, eddy currents are induced, which form an electromagnetic field according to Faraday's Induction Law. This field acts against the field of the coil, which also causes a change in the impedance of the coil. The controller calculates the impedance by considering the change in amplitude and phase position of the sensor coil.

Advantages of this

technology include: it can be used on all electric conductive metals with ferromagnetic and non-ferromagnetic features; small sensor size; high temperature range due to the resistance measurement of sensor and cable; it is immune to dirt, dust, humidity, oil, high pressures and dielectric materials between the measuring gap; and it is highly accurate. Restrictions in the application include: output and linearity depend on the electric and magnetic features of the target material; individual linearisation and calibration is necessary; cable length is 15m maximum; and the diameter of the sensor, and therefore the effective measuring diameter, rises as the measuring range increases.

The capacitive principle

With the capacitive principle, the sensor and target operates like an ideal parallel plate capacitor. The two plate electrodes are formed by the sensor and the opposing target. If an AC current with constant frequency flows through the sensor capacitor, the amplitude of the AC voltage on the sensor is proportional to the distance between the capacitor electrodes. An adjustable compensating voltage is simultaneously generated in the amplifier electronics. After demodulation of both AC voltages, the difference is amplified and output as an analogue signal.

Because the sensor is constructed like a guard ring capacitor, almost ideal linearity and sensitivity to metals is achieved. These offer constant sensibility and linearity against all metals; high temperature-stability, because changes in the conductivity have no effect; and they are also possible for isolators.

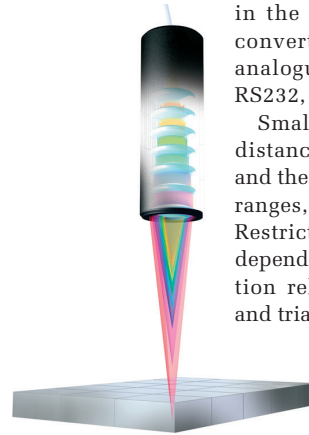
These, however, only have a short sensor cable length, due to the effect of the cable capacity on the oscillating circuit tuning; and the diameter of the sensor, and therefore the effective measuring diameter, rises with increasing measuring ranges.

The laser triangulation principle

In the laser triangulation principle, a laser diode projects a visible point of light onto the surface of the object being measured. The back scattered light reflected from this point is then projected onto a CCD- / CMOS array by a high quality optical lens system. If the

target changes position with respect to the sensor, the movement of the reflected light is projected on the CCD array and analysed to output the exact position of the target. The measurements are processed digitally in the integral controller and then converted into a scaled output via analogue (I/U) and digital interface RS232, RS422 or USB.

Small beam-spot, high reference distance between sensor and target, and the possibility for large measuring ranges, are some of the advantages. Restrictions include: kind of surface dependence, and big sensor construction related to confocal, capacitive and triangulating sensors.



The confocal principle

This technology works by focusing polychromatic

white light onto the target surface using a multi-lens optical system. The lenses are arranged in such a way that the white light is dispersed into a monochromatic light by controlled chromatic deviation. A certain deviation is assigned to each wavelength by a factory calibration, and only the wavelength that is exactly focused on the target surface or material is used for the measurement.

This light reflected from the target surface is then passed via a confocal aperture to the receiver, which detects and processes the spectral changes. This measuring principle enables displacements and distances to be measured very precisely.

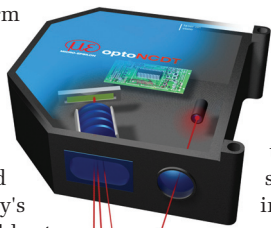
Both diffuse and spectral surfaces can be measured and, with transparent materials such as glass, a one-sided thickness measurement can be accomplished along with the distance measurement. Because the emitter and receiver are arranged in one axis, shadowing is also avoided.

Advantages of confocal sensors range from nanometer resolution, they are nearly material independent, a tiny constant spot, and compact course of beam, to one-sided thickness measurement on transparent materials. Restrictions in the application include limited distance between sensor and target, and the beam requires a clean environment.

Selecting the technology

All measurement technologies have different advantages and limitations. So, when it comes to selecting a suitable technology, it is a good idea to compare common performance criteria.

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Left:
The laser triangulation principle