Baumer

Sensor Solutions
Motion Control
Vision Technologies
Process Instrumentation

Application report:

With distance – measurably better

An efficient selection of the proper sensor technology for distance measurement becomes more and more important. Continuously increasing requirements to machine capacity and reduced budgets requires a lot of experience especially as regards the selection of the proper measurement process to be able to achieve a solution fitting the application. Several contact-less measuring processes are available for an optimum solution; each principles has its strength.To start with it is very helpful to look at several technological measurement terms and then assign them to the respective current function.

Technological measurement basics

The *resolution* corresponds to the smallest possible distance change, which effects a measurable change on the output signal. Linearity is the deviation from an ideal linear function (straight line). It is mostly shown in percent of the measurement range final value (Full scale). Response time is the time a sensor requires to rise from 10% to 90% of the maximum signal level. For sensors with digital signal processing this time corresponds to the time required to calculate a firm measurement value. A temperature change of the surroundings involves a definite shifting of the measurement value. This temperature drift is mostly proportional to the temperature change and is specified for example in 0.08%/K (ΔT) *Repeat accuracy* (R) is the difference of the measurement data of consecutive measurements within a duration of 8 hours at $23^0C \pm 5^0C$ ambient temperature.

The sensors discussed below (Illustration 1, chart) supply an analog output signal proportional to the measurement distance.

The measuring sensor technology from Baumer covers a wide area of application with different models – these should however be selected exactly for the particular application

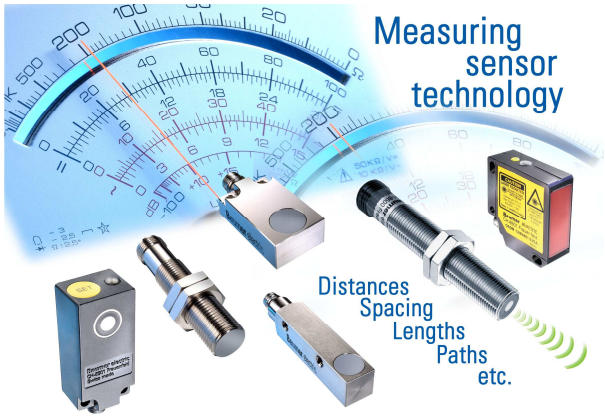

Figure 1: Measuring sensors

Inductive sensors

This product group is best suited for the distance measurement of electro-conductive objects, such as steel, aluminum or other metallic alloys. The measuring cycle method is based on the evaluation of induced eddy currents. Therefore this physical principle is especially insensitive to all non-metallic contamination. Inductive sensors are an outstanding choice when high demands, as far a resolution and measurement precision are concerned, are expected from the application. The currently possible resolution is at $\leq$0.1 µm; this corresponds to approximately 1/500 of a human hair.

Due to innovative manufacturing technology a measurement range of 0 to 2 mm can be realized reliably and precisely starting with an overall size of 6.5 x 40 mm. For applications where the standard range specification (FS) is not sufficient, Baumer offers the possibility to further specify the measurement value with the supplied polynomial function (mathematical description of the characteristic sensor probe line). With the help of the polynomial very precise measurement- and standard algorithms can be programmed to commercially available controls.

Alternatively sensors with integrated microprocessor are also available. Application of digital signal processing allows considerable linearization of the characteristic probe line. With a Teach-function these sensors can easily be used for the correct application. This is especially

evident with an absolute distance measurement. For example: a linearized sensor with the overall size M12, with a measuring range from 0 to 4 mm obtains a maximum linearity error of less than + 0.4%, which corresponds to an improvement around the factor 10. The following characteristics are the most important characteristics of inductive sensors:

- Suitability for electro-conductive materials (Steel, aluminum, etc.)
- High resolution
- Short response time
- Insensitive to contamination
- Small design
- Low cost

	Inductive	Optical	Ultrasonic
Resolution	0.1 µm	2 µm	0.3 mm
Measurement precision	1 µm	2 µm	0.5 mm
Linearity	0.4 … 4%	0.1 … 1.2%	0.5%
Response time	0.35 ms	0.9 ms	50 ms
Teach-in	Yes	Yes	Yes

Chart: Typical sensor parameter with three measurement principles

Optical sensors

Laser distance sensors are especially well suited for measuring cycles on small and quick moving objects. It is also possible to safely measure parts with frequently changing colors over a distance of up to 1 m.

Optical sensors predominantly function in accordance with the principle of triangulation. At this principle an appropriate light source, particularly a laser, produces a visible point or line on the measurement object. With the help of a lens the light, mostly complex reflected by the object, is reflected on a position-sensitive receiver. A change of distance between sensor and object also leads directly to a change of the position of the image spot on the receiver. The CCD-line as receiving element and the intelligence of the micro-controller provide that output of the measurement data is nearly independent from the color and wit only a very small error are output as analog signal.

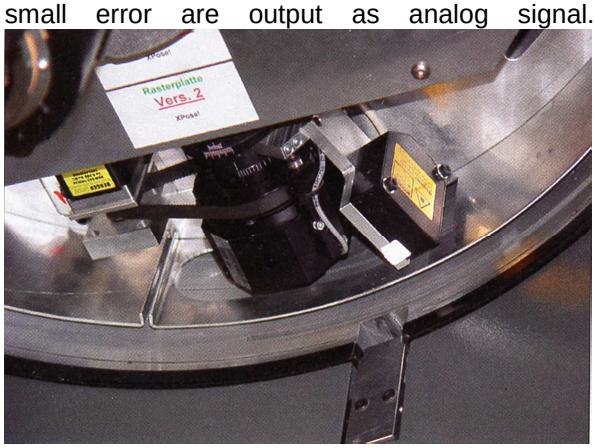

Figure 2: Laser light meter

Sensors with special light geometry are available for porous or very rough surfaces. Because of the use of a fine laser-line changing surface finishes of the objects have very little or no influence on the reliability and precision of the measurement process. An additional synchronization input is available for chronologically synchronized measurement functions, such as thickness measurement of objects. With the help of an external signal the measurements of different sensors can be started simultaneously. The very favorable price-capacity ratio of optical sensors permits a wide range of application, starting with the coordination of the chassis of a Formula-1-Boliden up to the tracking assembly (Illustration 2) of a laser light meter for the digital pressure with a resolution of 5 µm. The main characteristics of the sensors are:

- Suitable for different materials
- Suitable for small, quickly moved parts
- High resolution
- High linearity
- Short response time

Ultrasonic sensors

These sensors use the transmission from ultra sound to measure distances instead of optical irradiation. The most important measurement is the velocity of sound or the run-time of ultrasonic impulses, which are transported by the medium air. With the use of converters, which are based upon the reversible piezo-electric effect, single-head systems can be realized, at which a converter is utilized as transmitter as well as receiver. A short burst packet activates the ultrasonic converter to emit an ultrasonic packet. An internal clock is started simultaneously to measure the run-time. The sound packet reflected from the measurement object again generates an

electrical signal in the converter. The measured time between the transmission packet and the echo received serves as basis for the calculation of the distance to be measured. The integrated micro-controller assumes complete control of all cycles

Sound waves are reflected on different surfaces. The objects to be detected can be solid, liquid, granular or in powder form. Even transparent and other objects difficult to identify optically, are detected quickly and absolutely reliable with ultra sound. Sound absorbing objects or media with rough, porous surfaces reflect sound diffusely. The maximum measurement distance is thereby reduced. Nevertheless optimum utilization can be warranted for surface roughness up to 0.2 mm.

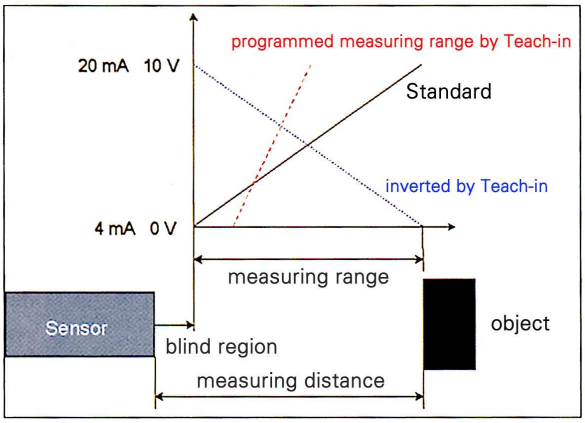

Figure 3: Programmable characteristic probe line

The converters are constructed such that a directional irradiation with small angle of beam is the result. The newest technologies thereby permit sound beams of $\leq 6^0$, which opens up completely new application possibilities. With consistent use of minituarization technology the smallest sizes were made possible, which allow the use of ultrasound even with restricted space. Measurement distances up to 3 m with constant resolution of $\leq$ 0.3 mm are now an every day occurrence. The latest generation of Baumer sensors with dimensions of only 20 x 42 x 15 mm and integrated Teach-function can with small space requirements reliably measure through the smallest openings, for example: at test tubes.
In general the most important characteristics are:

- Alternative to optical distance sensors
- High linearity
- Constant resolution
- Large measurement distance
- Insensitivity to contamination

Teach-in-functions and interfaces

A special highlight of the Baumer analog-sensors is the uniform Teach-in process for all measurement principles. Laser distance sensors, miniaturized ultrasonic sensors, as well as high precision inductive sensors can simply be programmed for the respective measurement function. The Teach-in function allows to freely configure the measurement range within the preset limits. For example: if a small measurement range with large signal deviation is desired, it now possible to limit the measurement range to a few millimeters and to thereby obtain a resolution of, for example: 2 µm (laser distance sensor). The complete signal range of for example: 4 to 20 mA is available at the analog output for the measurement range configured this way (Illustration 3). In addition an automatic switching output with two optional switching thresholds can be freely defined.

The most different requirements of an industrial environment are taken into consideration with three different interfaces. Besides the standard voltage interface (0 – 10V) a current interface (4 … 20 mA) is available as well. It is sensible when signals have to be transmitted over large distances or if high interference resistance (EMV) is required. The product group of laser distance sensors is also available with a digital interface as option. The RS485-interface affords maximum data security with 11 bit resolution.

Multifunctional application

Due to the increasing variety of products and quality requirements in the processing industry products and processes require increased and reliable monitoring. Increasingly positioning- and measurement functions are solved with the help of Baumer's extensive product program, which has been inconceivable up to now or cold have been solved only by expensive sensor systems. This pertains to the areas absolute distance measurement, thickness measurement, slack control, linear path measurement, positioning control, profile detection and sorting of products, as well as centering monitoring functions.