

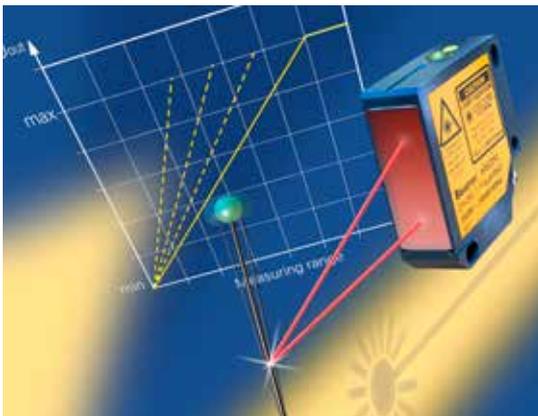
Technical Report

Small unit (sensor) tackles large jobs.

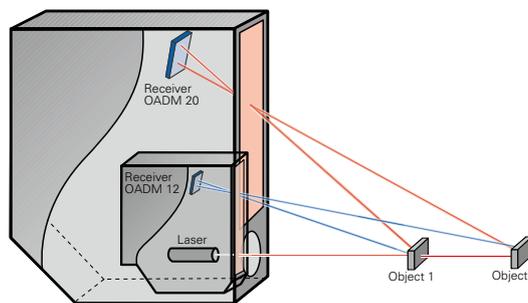
To some extent today's technical systems and instruments are extremely complex configured puzzles of individual parts. Automobiles consist of dozens of subsystems with a multitude of activators, sensors, control electronics and mechanical elements. Cell phones are small miracles – so small that they can no longer be operated with normal fingers and digital cameras, filled with functions, now fit into vest pockets.

Automated assembly of such systems also makes high demands on sensors, whether it concerns measuring or switching processes – they are required for adjustment and control. To be able to place these closer to the processes they are also required to be smaller in size. They not only have to be smaller, but also more precise. They have to zero in more precise and supply higher resolution readings than their larger brothers. In addition they have to be able to measure very quickly because modern manufacturing- and assembly processes are very fast.

gulation principle. A laser or LED illuminates the object and an observer-optics "looks" at the object in an angle to the lighting. With the optics in the sensor the light-spot on the object is transmitted to a light-sensitive receiver. Sufficient space in the sensor assures that the light-spot travels a great distance on the optoelectronic receiver when the object moves through the measurement range. In this instance a small error in the position of the receiver or movement of the receiver, due to pressure or temperature only has a slight impact on the measurement result.



Probably the currently smallest available completely integrated, measuring laser distance sensor



Principle of a triangulation-distance-sensor. It has to be possible to evaluate a smaller distance in a small casing and the same measurement range.

Development of small measuring Triangulation Sensors

Development of a distance sensor of comparable size to today's miniature sensors, able to exactly measure to micrometer and has the complete complex evaluation electronics, presents quite a challenge.

The distance from the sensor and receiver is smaller with a small sensor and therefore the angle of observation as well. The changes of the angle for the same distance changes are smaller, so are the distances to be recorded on the receiver. Small errors thereby have a much more grave impact. If not only the customary accuracy has to be achieved with small sensors, but if the accuracy has to be increased with a small sensor, high demands are made as far as the design of the optics, the mechanical system and the evaluation electronics are concerned.

Let's look at an optical sensor working with the trian-

Of course optics designers would like to have as much

room as possible, thereby they increase accuracy. For example; the distance between receiver and sender is decisive for the measurement accuracy of the sensor. Mechanics designers would like a sturdy casing, which can easily be attached.

There is not much room left for the electronics. However the complete signal evaluation has to take place in the sensor as well, so that the signals do not have to be transported over cables to the remote signal evaluation unit and thereby impairs the quality of the measurement. In addition these external evaluation units increase the price. The small and quick moving objects, which have to be measured, also require extremely fast evaluation.

Team work is required

The solution for this optimization task is only possible with team work of the individual designers. With analog measuring laser distance sensors of the series 12, as well as 12 mm wide casings, this difficult task has been solved by Baumer Electric. As far as we know, with its 35x37x12 mm dimensions the new "12" is the smallest completely integrated laser distance sensor presently available. With a measurement range of 16-26 mm at resolutions of 2 μ m up to 5 μ m and linearity deviations of 6 – 10 μ m the sensor satisfies the demands for exact positioning functions. But also with a larger measurement range of 16 m- 20 mm the accuracy described above is available for close-up range.

The optics:

With a diameter of only 0.6mm (@ 16mm) and 0.25 mm (@ 26 mm) the laser beam is very fine and well suited to measure small objects. The beam is adjusted such in each beam that the casing is always precisely vertical. An array of diodes is utilized as receiver. With a specially designed short focal distance optics the point of the laser is displayed exact and sharp onto the diode array; this characteristic is also not left to chance, all components of each sensor are synchronized with one other.

The mechanics:

A sturdy metal casing with massive wall thickness in the range of mounting screws provides the required exterior stability for the sensor. Depending upon which mounting method is selected by the user; he is able to mount the sensor exactly and in a reproducible man-

ner or the user is able to align the sensor to an object. A fiber-reinforced plastic frame houses all optical and electronic components precisely, securely and firmly, that they are not subject to exterior factors and warranty precise optical images.

The electronics:

The electronics is attached to a flexible circuit board. It is snaked around the mechanical and optical components and fills the residual space. The position of the individual electronic components was optimized in close cooperation of the layout designer with the mechanical design engineer. Highest accuracy was compulsory, as even displacement of a small SMD component on the flexible circuit board can lead to collisions and in the worst scenario requires tooling changes for the frame. A very small, but extremely efficient

micro controller of the latest generation assumes signal processing and output of the analog signal.

The software:

Optimized software is essential for the application of micro controllers in the sensor technology. In this example the controller is able to read the diode array more than 2500 times per second, to exactly determine the position of the laser spot and to linearize the measurement value and issue it as 4-20 mA-value. It thereby corrects all small optical errors and supplies a correspondingly precise signal. In addition the controller adjusts the laser illumination such, that the same signal quality is obtained on dark and light surfaces and is thereby "colorblind", meaning that all colors are measured equally well. In addition, the controller monitors the Teach-in-key and -circuit. If the sensor has been trained for a smaller measurement range, the controller then additionally calculates the measurement values with the same high accuracy utilizing the higher optical resolution.

The production process:

A precise manufacturing process is required for best performance; therefore the axis of the beam is aligned vertically for each sensor. The last few small production tolerances are then www.baumer.com October 2004 compensated for, in that the sensor "learns" its measurement range on a precision measurement path. It is aligned such, that the measurement range starts exactly at 16 mm before the leading edge of the casing

and ends at 26 mm and inbetween the output is highly linear to the distance.

Development Results

The laser distance sensor Type OADM 12164xx with 12 mm width is small and can easily be added".

- Precisely aligned laser beam for the same measurement position at all times, aligned focus for the same beam quality at all times.
- The metal casing with solid mounting area enables safe mounting.
- When the casings are placed close on top of each other, for example to measure the contours, there is no mutual interaction.
- Resolution up to 2 μm , linearity to $\pm 6 \mu\text{m}$, up to 2.5 kHz measurement rate on light objects and 1.1 kHz on dark objects.
- Due to the line receiver no black / white differences.
- The sensor can be set to the required measurement range with key or cable, including characteristic line return.
- Plug and Play: screw-on, connect power, done, no additional settings, besides teaching the measurement range.
- Two ranges: besides the short measurement range of 16-26 mm there is an additional range of 16-120 mm with lower resolution

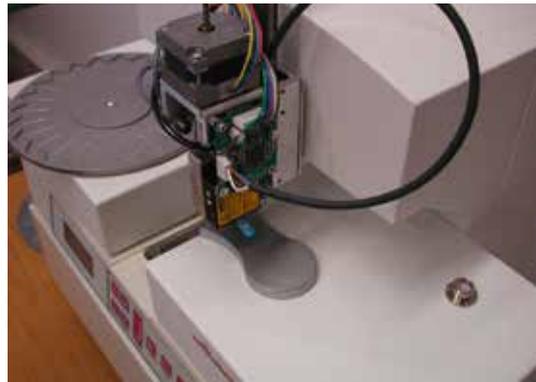
Large application range for the little one

An application in the pharmaceutical industry by Dr. Schleuniger Pharmatron AG shows that the small laser distance sensor is able to provide completely new solutions. Currently known devices measure the thickness of pills mechanically by touching the pills. However there is some uncertainty connected with this process, which is caused by "crushing" softer pills during the measurement process.

The objective of the new development of the test station for the pills was to replace the thickness measurement, which to date has been performed with calipers, with a contact-free alternative. An accuracy of <0.03 mm had to be achieved thereby, independent of the color of the pills. In addition, the capacity was to be significantly increased through automated measurement of the pills, which had been placed onto a turntable. This required integration of the sensor directly into the handling unit, which takes the pills from the turntable and deposits these at different test locations

(weight, tensile strength).

The solution for all these requirements was the OADM 12. Due to the favorable dimensions the laser-distance-sensor could be integrated directly into the movable handling unit. In addition to the thickness it is now also possible to precisely incorporate the profile in the X- and Y-axis and to determine the length and width of the pill. For this the handling unit moves over the pill and takes several measurement values from which the profile can be calculated. High accuracy for the length- and width measurement is also achieved due to the high measurement rate. Similar applications are feasible in other miniaturized handling-, testing- and assembly machines used for production in the watch industry-, assembly of electro-mechanical components or manufacture of medical instruments. In short, where small parts have to be measured precisely, but only little space is available.



Thickness measurement of pills with a repeat accuracy of <0.02 mm

Conclusion

With this only 12mm wide, very small sensor Baumer electric is able to raise miniaturization of optical sensors to a higher level. This development does however not dispense of larger sensors with, for example 65 x 50 x 20 mm. If sufficient space is available these should be used because of their wider triangulation base. For medium distances of 100 mm up to 1000 mm they still cannot be replaced.

More information:
www.baumer.com