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WHITEPAPER

CONTRAST READERS DETECT THE FINEST DIFFERENCES

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1 INTRODUCTION

Contrast scanners are versatile and are therefore suitable for a whole range of applications, e.g. as pulse generators for counting devices, for non-contact position detection, for position and orientation detection of fast-moving objects, for high-precision detection of object edges, for position control of print or color marks, for discrimination of brightness deviations on objects, or for intensity control of so-called self-illuminators, such as LEDs, displays, etc.

Contrast scanners are high-resolution optical sensors that distinguish objects or marks according to the reflectivity or contrast of their surface. For the devices to function smoothly, it is crucial that there is a sufficient difference with respect to the environment or the marking substrate, whether this tends to be bright (higher reflectance) or dark (lower reflectance).

This white paper describes how ipf electronic‘s contrast scanners work and provides an overview of both the compact devices, which operate primarily with visible laser light, and the high-end solutions for connecting fiber optics. Finally, an application example gives an impression of the potential of these devices in industrial practice.

2 FUNCTIONAL PRINCIPLE OF CONTRAST READERS

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3 COMPACT DEVICE OR HIGH-END SOLUTION

The portfolio of contrast readers from ipf electronic can generally be divided into compact devices that can be set via teach-in or potentiometer and high-end devices that can be parameterized via special software. These solutions are described in more detail in the following chapters.

3.1 HIGH PRECISION SENSORS WITH RANGES UP TO 300MM

The compact devices from ipf electronic that work with laser light currently include a total of four solutions with a switching output (**PK140470** (laser class 2), **PK140475** (laser class 1), **PK170220** (laser class 1) and **PK430170** (laser class 2). These contrast readers are flanked by the **PK170020** (laser class 1), which integrates an analog output in addition to a switching output.

All devices work with a very small laser light spot or a fine laser line (**PK140475**) and can thus detect even the smallest marks or markings. The installation of the sensors does not cause any problems in practice, as they work with visible red light. Due to the laser protection classes 1 and 2 applicable to the devices, no special safety precautions need to be taken during installation.

Fig. 1: Selection of compact devices from ipf electronic: Except for the OK500320 (far left), which operates with white light, the other devices (PK170220, PK430170 and PK140470) (from left) integrate a laser diode with laser protection class 1 or 2.

The contrast readers in plastic or zinc die-cast housings (protection class IP67) with M8 or M12 connection plugs have ranges from 3mm to 300mm and are designed for ambient temperatures from-10°C to +50°C. The portfolio of compact devices is supplemented by the **OK500320**. This sensor in a zinc print housing works with point-shaped white light instead of a laser diode and has a scanning range of 30mm.

3.1.1 ADVANTAGES OF LASER CONTRAST READERS

Contrast readers operating with laser light enable large ranges and can be adjusted very easily in an application after mounting due to the visible red light. Commissioning of the devices is also simple, as they can mostly be parameterized via teach-in (in a few exceptions via a potentiometer). The point or line-shaped laser beam of the respective device solution is capable of detecting even the smallest marks, among other things due to its extremely small diameter or beam width.

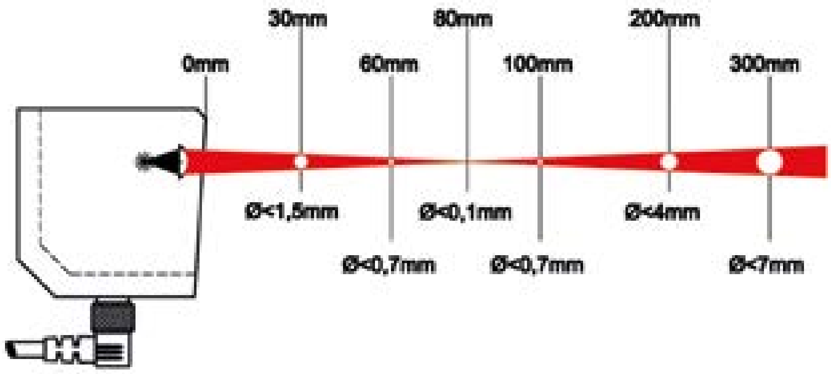

Fig. 2: Laser beam path of a contrast reader (compact device): In the area of the largest laser beam focus (Ø<0.1mm), the smallest marks or marks can be detected. At this point, the device also has the greatest positioning and repeat accuracy.

3.1.2 DISADVANTAGES OF LASER CONTRAST READERS

Despite all their positive properties, however, transparent objects are difficult to detect with contrast readers. This is mainly due to the transmittance, i.e. the permeability of transparent materials to visible light. Very rough surface structures, e.g. of raw castings or sand-blasted components, can in turn scatter the laser beam to such an extent that the receiver of the device hardly receives any reflected light for evaluation, thus impairing the sensor in its function.

In general, when using contrast readers, care should be taken to ensure that the marking or mark to be detected is not smaller than the light spot of the device itself, as otherwise the sensor may malfunction due to any interfering influences prevailing in the immediate detection environment.

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3.2 HIGH-END DEVICES SOLVE SPECIAL TASKS

In addition to the compact devices described, ipf electronic offers the **OK630180**, **OK630181**, **OKSI0276** and **OKSI0289** contrast readers as high-end solutions with digital switching outputs and two analog outputs that provide a grayscale-dependent analog signal (0...10V and 4...20mA). These solutions, intended for the connection of optical fibers, were developed for very special requirements or challenges. For the light guides, therefore, a wide variety of optics are available, among other things, for determining the light spot or the detection range required in each case.

Fig. 3: The high-end devices from ipf electronic are designed for the connection of fiber optics and are also suitable for particularly demanding tasks due to the powerful parameterization software.

3.2.1 POWERFUL PARAMETERIZATION SOFTWARE

These high-end devices are as flexible as they are versatile, thanks in particular to their extremely powerful parameterization software. Unlike the compact devices, it allows the user to virtually look inside the sensor, as the software visualizes the signal strength (intensity) of the light reflected from a background as well as a mark, and thus also their relationship to each other, as detected by the device.
In this context, the software offers an extremely wide range of options for adjusting the sensor and visualizing the signal curves. The image in Fig. 4 therefore offers as an example only a very small section of the potential range of applications.

The fine blue dashed line at the very top of the right window of the figure here marks the reference that was previously taught. The long dashed black line represents the value for the hysteresis (also adjustable via the software) and the red line the so-called switching threshold. Both values are determined automatically by the software in the mode selected for this example. The green curve shows the signal curve when the sensor detects the background and the mark to be detected. In this specific case, the sensor reacts in the previously selected threshold mode „Low“ in the event of a signal drop caused by a mark, i.e. that in this example the mark reflects less light to the sensor than the background on which the mark is located. Alternatively, however, it is also possible, among other things, to evaluate a signal increase, to control two references (control of different marks) via the two digital outputs of the sensor, or to control a switching window (control when two thresholds are exceeded or undershot).

Ideally, the delta (δ), i.e. the signal distance between background and mark, should be as large as possible during detection to ensure reliable detection at all times. In this context, the parameterization software can be used to very quickly determine whether a system solution delivers the desired results for a specific application. If this is not the case, in addition to the setting options via the software, it may still be possible to achieve better results by using a different fiber optic design with the appropriate optics.

The use of the high-end devices also makes sense whenever, for example, several objects with varying markings or marks are to be detected, because one of the analog outputs is suitable for this purpose. The intensity-proportional signal can be evaluated on a control system (PLC), whereby product-dependent limit values previously defined on the PLC can be called up in the event of a product change without having to re-parameterize the device specifically for this purpose.

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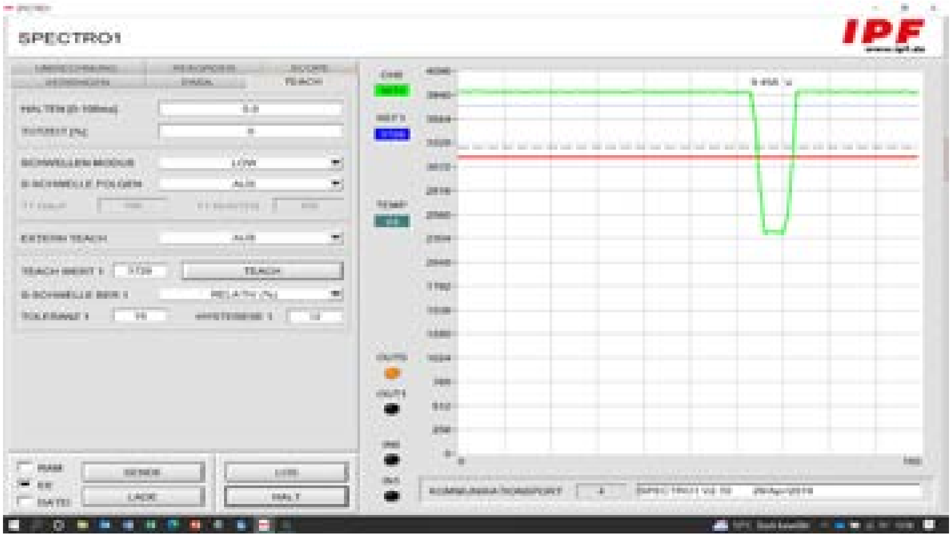

Fig. 4: The parameterization software for the high-end contrast readers offers an extremely wide range of options for setting the sensor and visualizing the signal curves.

3.2.2 MORE FLEXIBILITY AND HIGH SPEED

Since the fiber optics transmit the intensity of the light reflected from a mark or marking to the high-end contrast reader, another advantage is that the fiber optics can be installed independently of the actual sensor, even in very difficult-to-access areas for detection. Ambient temperatures of up to +180°C are also no problem for the fiber optics.

The outstanding features of ipf electronic‘s sensors also include the high speeds at which the solutions operate. For example, the **OK630180** has a switching frequency of 200kHz. Since the device is thus capable of detecting up to 200,000 signals per second, such contrast readers are particularly suitable for reliable detection in extremely fast-running processes. At high speeds and small marks, the sensor signals are naturally very short. To ensure that in such cases the downstream control system is able to detect the sensor signals without any problems, the switching signal length of the outputs can be freely set in the software.

The outstanding technical properties of such sensors are certainly impressive. But in the end, it is often ipf electronic‘s task in practice to recognize the actual potentials for an optimal system solution and to consistently exploit them by selecting the appropriate system components, as the following practical example show.

4 APPLICATION EXAMPLE SMOKE DETECTION

Smoke can provide valuable information, as one automotive supplier discovered in the production of flexible tubes. These products are in demand for vehicle construction mainly because of their small bending radii. The company described here manufactures such tubes, for example, for air-conditioning technology, or more precisely for the distribution of hot and cold air in caravans and mobile homes, as they make optimum use of the limited installation space in the interior of the vehicles.

4.1 INDICATOR FOR TOO MUCH WARMING

The flexible tubes are made of aluminum and kraft paper. To firmly bond these two materials together for the end product, the tube is passed through an induction coil where it is heated. However, process-related fluctuations can cause the aluminum and thus also the paper to heat up too much in the induction coil. In extreme cases, this can cause a fire at the induction coil, which should be prevented at all costs.

4.2 EARLY WARNING SYSTEM FOR CRITICAL PROCESS CONDITIONS

In order to be able to immediately detect such critical processes during the production of the flexible tubes, the automotive supplier decided to use the smoke intensity at the induction coil as an indicator. For this purpose, a solution was needed to control the smoke development in the manufacturing process directly downstream of the induction coil and thus act as an early warning system, so to speak. Specifically, this solution was to transmit a signal to the plant control system as soon as a certain smoke intensity was reached, so that the ongoing production process could be stopped and the induction coil could also be switched off.

4.3 HIGH-END CONTRAST READERS WITH SPECIAL REFLEX OPTICS

ipf electronic suggested a high-end device with a fiber optic cable in combination with special reflex optics to the company for the described task. Specifically, this is the OK630180 contrast reader, which is insensitive to extraneous light and operates with clocked, point-shaped white light as the transmission source. In addition, a light guide is used on which the special optics are located.

Fig. 5: The combination of the OK630180 contrast reader, which is insensitive to extraneous light, and special reflective optics enables monitoring of a relatively large area in which smoke can occur.

The sensor, which is equipped with a very bright white light LED, has a range of 1mm to 500mm depending on the light guide used and the selection of the attachment optics. In this application, the operating range of the system solution extends from 80mm to 150mm due to the light guide used with the reflex optics. The **OK630180** is parameterized with the parameterization software already presented in chapter 2.2.1. In addition to an RS232 interface, the contrast reader has a total of 4 outputs:
2 digital outputs (0V/+Ub) with a switching frequency of up to 200kHz as well as 2 analog outputs (0...10V and 4...20mA).

4.4 WIDE VIEW OF THE DETECTION AREA

Since the contrast reader cannot be installed in the immediate area of the smoke development and is therefore not located at the actual measuring point, the fiber optic cable transmits the send and receive signals between the sensor and the reflex optics. Accordingly, the white light generated by the sensor emerges from the optics. At the same time, it picks up the white light reflected by the smoke and transmits it back to the sensor via the light guide. The special optics of the lens cover a detection range of 180°, which in turn allows a relatively large area at the end of the induction coil to be monitored for smoke development.

Fig. 6: A fiber optic cable transmits the transmission signals from the sensor (bottom right) to the reflex optics (top, center)

In order to determine the necessary sensitivity at which the contrast reader should output a signal, a kind of „worst case“ scenario with corresponding smoke development was simulated. In this simulation, the power of the induction coil was gradually increased until a light fire was generated. The reference for the sensor response and thus the threshold for a potentially critical process state was then set far below this via the parameterization software.

Accordingly, if the smoke development becomes stronger, the intensity of the light reflected by the smoke also increases until the intensity threshold previously determined via the software is reached. In this case, the sensor outputs a switching signal to the plant's PLC so that the production process can be stopped immediately and the induction coil switched off.

Fig. 7: The special optics of the lens located above the induction coil enable a 180° view into the smoke. The lens used here was specially developed for fiber optic scanners and has an operating range of 80 to 150mm. The light spot (center of image, right) of the reflex optics on the flexible tube at the exit opening of the induction coil can be seen clearly.

4.5 MANUFACTURING WITH A CLEAR PLUS IN SAFETY

Since the installation of ipf electronic's solution, the company says it has gained a significant plus in safety in the production of flexible pipes. For smoke detection, only one threshold value determined via simulation is used, as this is completely sufficient even in the case of a product change. To date, no more problems have been observed in this area of the plant, so that the risk of fires is finally a thing of the past.

5 SUMMARY AND CONCLUSION

Contrast readers from ipf electronic open up diverse potentials for use in a very wide range of applications. The sensor specialist offers both extremely precise and powerful compact devices for easy installation and commissioning, as well as high-end devices that are particularly suitable for very special requirements. Especially when using the high-end contrast readers, the extensive experience of ipf electronic's application specialists can be valuable, as there is a wealth of possibilities for designing an optimal system solution with regard to a specific application. In this context, the parameterization software for the high-end devices alone offers an immense number of options for setting the sensors and evaluating the corresponding signals.

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