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Utilisation of Light and Laser Security Protection in the Commercial Security Industry

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Abstract: The paper presents some aspects of utilising light and laser technology in the commercial security industry. The paper focuses on issues related to using optical sensors in the field of active monitoring of areas by means of laser measurement sensors and scanners (LMS) and position location systems (PLS). The use of light and laser security in the commercial security industry (CSI) is primarily focused on monitoring facades of buildings, areas in 2D and 3D environments, inner spaces, security of persons and property, counting persons, as well as on detecting sizes and motions of vehicles.

Keywords: Laser scanner, Optical electric sensors, Laser measurement system, LMS, Position location system, PLS, Commercial security instruments, Commercial security industry, CSI

1. Introduction

The "Touch-Less Security Sensors" general denomination includes the light and laser security sensors used in the commercial security industry for securing persons and property in a secured zone. Thus, the sensors may be divided into two groups within the specified field: **light** and **laser** sensors. As per the principle they are based on and their design, the light (optical) sensor are grouped as shown in Fig. 1 and Fig. 2. The basic grouping shown belongs to the field of process analysis, automatic identification of bar and 2D codes, laser scanners (LMS – Laser Measurement Scanner), and vehicle motion detection with PLS sensors, and meets the basic standards IEC 61508 (SIL 3 – Safety Integrity Level), EN 954, EN 13849-1, and IEC/EN 61496-1, 2 and 3.

2. Optical electric sensors and their application

Up-to-date optical electric sensors are based on various physical methods, for instance triangulation, phase shift measurement, or pulse propagation techniques. The use of optical electric sensors, along with powerful digital processors, allows realisation of very efficient and economically effective measurements, sensing, and security tasks. Light beams as the instrument of measurement techniques are

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fascinating – they allow touch-less measurements in very fast sequences, their range is long and the resolution is still high; moreover, they are almost immune to any interference effects. Therefore, properties of any other measurement techniques are really very far from comparison with the range of applications using optical electric sensors. Any use of light for measuring distances, detection of objects and protection of persons is always based on reflection of a light beam from an object. For achieving excellent results, optical electric sensors use the method of **triangulation** combined with the Charged Couple Device (CCD) sensor technology. Optical electric sensors are equipped with a number of the high-resolution CCD sensors. Laser diodes are used as the light source for measuring in the range of 20 mm up to 250 m. Optical electric sensors allow measuring objects with the luminous intensity of 6% up to 90% in the entire measuring range and, thus, guarantee data almost independent of the luminous intensity. Measured values may be read in the analogue and digital form. The sensor itself can be comfortably "taught" either manually, or via a simple parameter setup through the RS-22, RS-485 or the Actuator/Sensor (AS) PC interfaces.

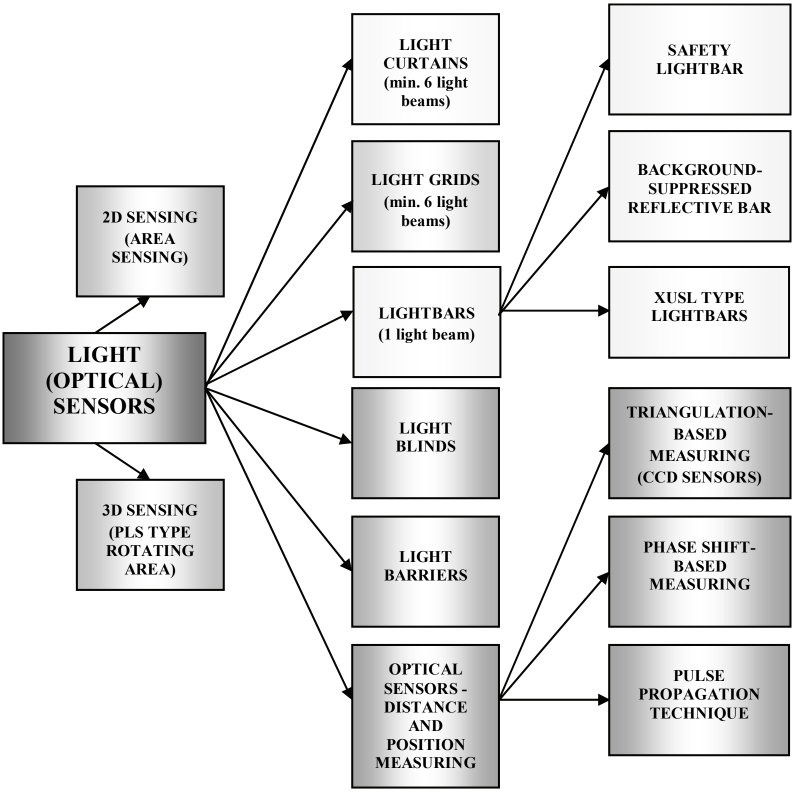

Fig. 1. CSI-Used Optical Electric Sensors Basic Grouping.

Optical electric sensors based on the **phase shift** measurement provide absolute measured values in the range of 0.2 m up to 170 m. The resolution can be continuously regulated whereas the scatter in repeated measuring is ± 2 mm. These optical electric sensors read newly measured values every one millisecond and, thus, establish optimal conditions for functioning in fast position control loops. The red laser used significantly reduces requirements for installing, adjusting, and setting the sensor's position. Thanks to this flexibility of their properties, optical electric sensors are the ideal instrument for distance measuring in location detecting and positioning.

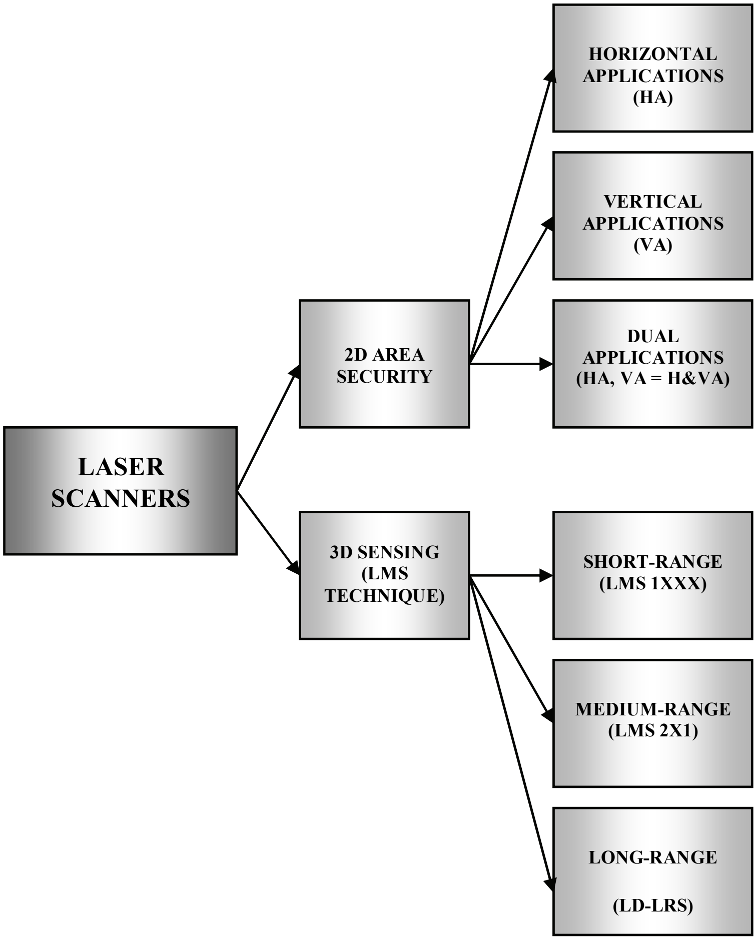

Fig. 2. CSI-Used Laser Scanners Grouping.

In order to meet increasingly stringent requirements related to security of persons, it is imperative to ensure reliable security for the critical areas. Laser security scanners based on the **pulse propagation** can offer a number of genuine security benefits. The pulse propagation technique principle consists in spreading of light pulses emitted by a laser diode by means of a rotary mirror over the entire work area. This principle of measuring is suitable not only for security but also for a number of measurement applications. The scanner allows definition of up to four different couples of security areas. For process-dependent activities it is, then, possible to activate and deactivate each couple separately.

3. Optical electric distance and position sensors

Light beams as the instrument for measuring techniques are remarkable: They allow touch-less measuring in fast sequences; their range is long with high resolution still maintained; moreover, they are almost immune to interferences. Therefore, properties of any other measurement techniques are really very far from comparison with the range of applications using optical electric sensors. Their combination with efficient digital processors and various types of devices can, then, be very beneficial in economically effective resolving of a number of variant measurement, detection, and security tasks.

4. Security light curtains, grids and bars

The basic task of Safety Light Curtains (SLC) is to protect a person or other persons in the security zone area. Therefore, they must quickly detect intrusion of a person into the secured area and issue a respective signal about it. In the CSI, this primarily applies to securing of areas adjacent to buildings, outdoor garages, indoor garages, access roads and others. Security light curtains consist of separate transmitting and receiving units between which a protected area is created. The transmitting unit is equipped with a number of infrared (red) light sources transmitting cyclically short light pulses that normally strike respective light-sensitive sensors in the opposite receiving unit. However, when an opaque object enters the protected area and at least one beam is interrupted, i.e. the light pulse emitted does not strike the corresponding sensor, the receiving unit generates an output signal from which it is very easy to derive an alarm command. The width of the protected area is determined by the maximum range of the light curtain in which the sensor reliably receives all the light pulses transmitted; this range varies from zero up to several tens of metres. The height of the protected area is given by the design height of the transmitting and receiving units, which is normally the function of the number of transmitted light beams and the pitch between each other. The pitch, or the distance between neighbouring light beams, defines the resolution rate of the security light curtain and its effectiveness. The shorter the light beams pitch is, the smaller the object entering the protected area of the light curtain that can be detected. The resolution of the light curtain must correspond to the security level required. The evaluation electronics of security light curtains are either integrated into the receiving unit, or built in a separate casing that can be fixed on the wall. Nowadays, the electronics are usually based on a microprocessor controller or the customer Application-Specific Integrated Circuit (ASIC), which allows the easy addition of a number of useful functions widening the application range or enhancing the comfort of the light curtain operators.

5. PLS and LMS systems

The PLS system is an optical electric sensor, which senses its surroundings by means of the infrared laser light beam. Regarding the scanning principle used, the PLS does not need separate receivers or reflectors. These features bring the following benefits:

- The secured field can be adjusted exactly according to the dangerous area;
- Since no receivers or additional reflectors are needed, the entire area is freely accessible and passable;
- Once the dangerous area is changed, the scanner can be easily reprogrammed without carrying out additional mounting operations;
- Different reflectivity of various materials has no impact on the sensor's function. Therefore, the PLS can be used in many quite different applications.

The sensor's function is based on the principle of measuring the time that elapses between the transmission and the receipt of the light beam being transmitted in short pulses. An electronic "stopwatch" measures the time. When the light beam strikes the object, it reflects and returns back to the sensor. The **distance** between the object and the scanner is then calculated from the time that elapsed from the instant of the light beam pulse transmission and the instant of its reception. A rotary mirror is placed in the sensor; this mirror makes the light pulse create a half-round surface (180° angle). By determining the mirror's shift, the PLS can recognise the **direction** of the object. The sensor then determines the exact **position** of the object from the distance and the direction measured. The area monitored by the sensor consists of the **protective** and **warning fields**. These two fields can be defined using the user software and then stored in the scanner's memory.

The **protective field** secures the dangerous area. If an object is detected in the protective field "vision" segment, the Output Signal Switching Device (OSSD) signals are switched to the "OFF" condition, which also stops the dangerous motion or the automatic shift. This protective field represents the safety function of the scanner, which complies with the safety requirements of Category 3 as per CSN EN 954-1 and Type 3 as per CSN EN 61496-3.

The **warning field** is defined as the area where the sensor is capable of recognising an object before the object reaches the protective field; in such a situation, the warning field can, for instance, issue a warning signal. Independently of the evaluation of the **warning**, or protective, field, the sensor keeps continuously monitoring the surroundings in its **measuring area**. The information obtained can be evaluated using additional data. Basically, two alternatives exist for specifying the place for installing the PLS as follows:

- The use of "teach-in". In this mode, the PLS takes the surrounding's outline and stores the data (after an automatic correction) in its memory as the outer limits of the protective field. For making sure that the safe distance, mounting height, and their feedback check are observed, the formula below should be used.

- The use of graphical or numerical values for the protective field specification. Here, the data for the observance of regulations must be specified first. This data is then used for programming the scanner.

The CSN EN 999 standard is the basis for planning the PLS mounting location. Here, the safe distance of the scanner from the dangerous area is defined as follows:

$$S = (K \times T) + C \quad [mm] \tag{1}$$

Where:

S The minimum distance in [mm] measured from the dangerous area to the detection point, border, plane, or space;

K Parameter in [mm/s] derived from the approach of the body or its part;

T The entire system run-out time measured in [s];

C The additional distance in [mm] that takes into account the entry towards the dangerous area prior to the protective device activation.

The approach speed of 1,600 mm/s is used for the K value in protecting the dangerous area. The T value is the sum of the sensor's response time and the time needed for stopping the dangerous motion. The C value describes the possibility of hand interference with the protective field area without deactivating the sensor; the C value depends on the protective field border height as shown in the formula below:

$$C = 1{,}2000\,[mm] - 0.4HD\,(HD = \text{detection height}) \tag{2}$$

Whereas: $C \geq 850mm$

Based on this:

If $HD = 0$ then $C = 1{,}200mm$

If $HD = 875$ then $C = 850mm$

The minimum height of the scanner placement is the additional condition given by the formula below:

$$HD = 15 \times (d - 50)[mm] \tag{3}$$

The scanner's resolution must always be determined in the longest length measured, $SL_{\max}$, i.e. in the outermost point in the protective field that can occur. The PLS function principle implies that the resolution goes down when the distance from the scanner goes up. When the protective field length $SL_{\max} = 2.9m$, the scanner must be placed higher to compensate for the lower resolution. The relations among the SL, HD, HS and C are graphically shown in Fig. 3. Here, the HS is the scanning plane height measured directly on the sensor.

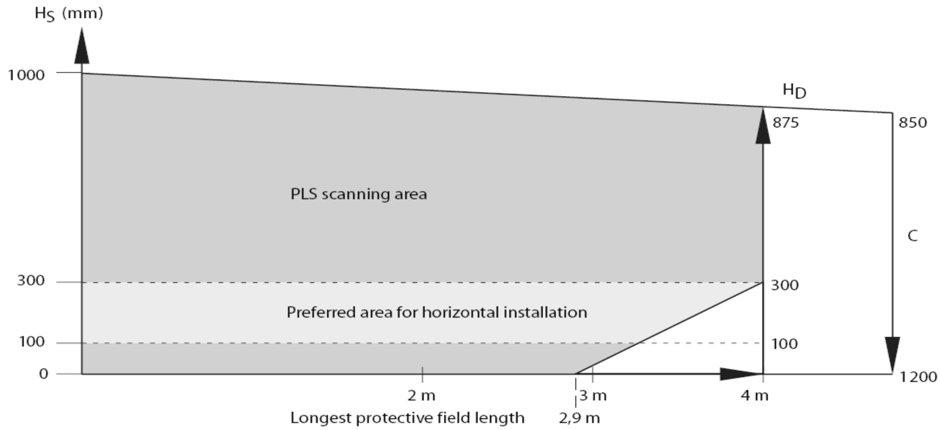

Fig. 3. Protective Field Length, Scanner Resolution and Scanning Plane Height Relation.

The PLS location selection also determines the value C of the protective field coefficient.

As per the basic relation, the following applies:

$$S = (1.600[mm/s] \times T) + C + Z_M + Z_R + Z_E \quad (3)$$

Where:

Z_M Additional coefficient for the PLS general measurement error;

Z_R Additional coefficient for the PLS eventual measurement error caused by reflection;

Z_E Additional coefficient for the PLS measurement error.

The Laser Measurement Scanner (LMS) for the areal security is mostly used for securing areas inside and outside of objects, primarily prison spaces, VIP buildings and strategic objects, such as nuclear power stations and others. The basic properties of the LMSs include:

- The **two-dimensional** scanning of the surrounding and detecting the object presence in the secured field;
- The **geometrical definition** of the secured field according to specific requirements;
- The scanner provides both data and switching signals as its output;

- The scanners are designed for both the indoor and outdoor environments.

The LMS systems can also be used in the area of spatial scanning and detecting the size of vehicles, and the speed and direction of passing vehicles. Physically, the LMS laser scanner is based on spreading the laser beam in the infrared spectrum and calculating the response (return) time of the beam transmitted. The possible spreading angles are 360°, 180°, and 100° with the range up to 150 m.

6. Conclusions

The use of the laser and optical electric sensors in the commercial security industry is presently astonishing. The technology deals with securing spaces in the area of horizontal and vertical orientation of the protective field, or securing spaces in 3D applications, such as monitoring entry into objects, guarding flat roofs, facades with the possibility of establishing alarm zones resistant to weather changes, or in applications utilising floating functions.

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