**Fail-safe sensors SIMATIC FS:**

**Protective Field Monitoring with the Laser Scanner LS4**

**Possibilities of a protective field switch at the laser scanner in practice**

With its continuous detection of the environment, its long range and four switchable field pairs, the laser scanner LS4-4 is suitable even for difficult applications.

However, often the question arises on how the four field pairs can be switched by the process in practice. The following documentation illustrates how a protective field switch is possible for the various application areas of the laser scanner and which hardware can be employed for this.

The required field pair outlines can be conveniently defined with the application software "LS4soft".

The field pairs are activated by applying 24 V to the respective inputs, which are available from the X1 plug of the scanner.

- X1-4 (FP1)
- X1-6 (FP2)
- X1-7 (FP3)
- X1-8 (FP4)

*When switching field pairs, note that the new field pair has to be activated first before deactivating the previous one.*

The process must take no more than 1 second. If this time is exceeded or the previous field pair is deactivated first, it has to be assumed that the application or the sensing unit for the field pair switch is faulty.

This results in the immediate deactivation of the two safety semiconductor outputs (OSSD) of the laser scanner LS4. In addition, the LEDs at the LS4 will indicate a malfunction, which can be verified and assigned by the software "LS4soft".

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**Here, the protective/warning field switch can be carried out in several ways:**

- **Mechanically**, e.g. position switch
- **Inductively**, e.g. inductive proximity switch
- **PROFIsafe**, e.g. CPU 315F
Mechanical Switching employing Position Switches

With position switches, mechanical positions of movable machine elements are converted into electrical signals. SIGUARD position switches can be used to:

- Monitor protective devices with swivel joints such as revolving doors, hatches, lids, etc.
- Monitor sideways moving protective devices such as sliding doors, protective guards, etc.
- Detect dangerous movements of machine elements

Through the application of SIGUARD position switches in safety circuits, any safety category can be achieved. Here, it is important to properly select and use the devices in combination with the failsafe analysis units 3TK28 or SIMATIC S5-95F, S7 300F, S7 400F/FH and SINUMERIK/SIMODRIVE.
Application Example for Safeguarding a horizontal Danger Zone with multiple Protective Fields by means of Position Switches

A machine area with one machine possesses 2 danger zones that are automatically switched depending on the machine position.

The position switches for the field pair switch can, for example, be installed at the machine foot. Through cam lobes at the machine foot (swivel joint), the position switches can precisely determine the position of the grasping arm at any time, activating the corresponding protective field.

During the configuration of the cam lobes, it has to be ensured that the already mentioned time overlap is maintained when switching from the protective field 1 (PF 1) to the protective field 2 (PF 2). In this example, this is achieved by overlapping the cam lobes: for a brief period, both protective fields (PF 1 + PF 2) are active at the same time.

If the grasping arm is operating at a very high speed, it is recommended to configure an additional protective field for the switching process, which then monitors the entire machine area (SF 1 + SF 2).
Inductive Switching employing Inductive Proximity Switches

The comprehensive range of proximity switches offers a right sensor solution for the most diverse applications. Regardless what the automated processes are running, the proximity switches hear, see and feel everything – they are the sensory organs of the automation.

- **Sonar Proximity Switches**
  The application possibilities of the ultrasound sensors are almost unlimited. Whether fill level or height detection, distance measurement, bottle count, etc. - at distances ranging from 6 cm to 10 m, sonar proximity switches recognize objects of any composition.

- **Optical Proximity Switches**
  Operating with either infrared, red or laser light, the comprehensive series of optical proximity switches covers ranges up to 50 m. Via teach-in process or potentiometer, they can be adjusted quickly and conveniently.

- **Capacitive Proximity Switches**
  Capacitive proximity switches also operate contactlessly and detect conductive as well as non-conductive materials of solid, liquid or powdery form. Typical applications include fill level reporting and monitoring functions.

- **Inductive Proximity Switches**
  Inductive proximity switches are the economical way for contactlessly detecting metallic objects. They are favored by the automotive industry, machine construction firms, the robot industry, materials handling firms and the paper/printing industry.

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**Application Areas for Inductive Proximity Switches:**

- **High repeat accuracy**
  - Positioning, e.g. in production machines

- **Wide frequency range**
  - Counting, e.g. sorting machines, conveyor systems

- **Contactless**
  - Sensing, e.g. doors, gates, elevators

- **Speed sensing**
  - Impulse sensing, e.g. downtime monitoring, speed measuring
Application example for
Safeguarding a horizontal danger zone with multiple protective fields by means of Inductive Proximity Switches

A machine area with one machine possesses 2 danger zones that are automatically switched depending on the machine position. The inductive proximity switches for the field pair switch can, for example, be installed at the machine foot.

Through metallic cam lobes at the machine foot (swivel joint) – which are programmed as reference points for the inductive proximity switches by means of a teach-in process – the position of the grasping arm can be precisely determined at any time, activating the corresponding protective field. During the configuration of the cam lobes, it has to be ensured that the already mentioned time overlap is maintained when switching from the protective field 1 (PF 1) to the protective field 2 (PF 2). In this example, this is achieved by overlapping the cam lobes: for a brief period, both protective fields (PF 1 + PF 2) are active at the same time.

If the grasping arm is operating at a very high speed, it is recommended to configure an additional protective field for the switching process, which then monitors the entire machine area (SF 1 + SF 2).
PROFIsafe Protective Field Switching via PROFIBUS employing a CPU 315F

While the parameterization of the laser scanner LS4 is carried out via the PC software LS4soft, the PC adapter and the optical interface at the PROFIsafe adapter, the scanner on the side of the master – in most cases a safety PLC with PROFIsafe master – has to be integrated into the application program.

What is PROFIsafe?

PROFIsafe is a functional expansion of the PROFIBUS DP and enables the operation of safe bus components together with non-safe standard components on the same bus.

PROFIsafe devices do not require any changes to existing hardware components and seamlessly integrate into existing systems.

Principle of Operation:

The safety-oriented S7 CPU (F-CPU) and laser scanner LS4 communicate via PROFIBUS. In this case, the LS4 supplies cyclical input data with a length of 1 Byte to the S7 CPU. The LS4 in turn expects cyclical output data with a length of 1 Byte from the S7 CPU. This input and output data can then be processed or analyzed by the application-oriented and safety-oriented STEP7 program.

The designations input data and output data refer to the point of view of the DP master (F-CPU):

- Input data is read by the DP master, it is the output data of the LS4
- Output data is written by the DP master, they are the control signals for the LS4

The safety-relevant output signals OSSD1 and OSSD2 and the warning signal of the LS4 are transmitted to the PROFIBUS master (normally a safety PLC) via the PROFIsafe adapter as a Bit of a safety telegram. The deactivation of the dangerous movement has to be implemented through the program of this safety sequential circuit.

The switching of the protective field pairs during runtime takes place via the output Bits of the safety PLC, which are transmitted via PROFIBUS and the PROFIsafe adapter to the LS4 (PF 1...4). The restart signal for the LS4 can be provided via a pushbutton locally connected to jack 1 or via PROFIBUS as a bit of the cyclical output byte.

[Diagram of PROFIBUS DP with PROFIsafe protocol, including a robot, emergency stop, light curtain, and SIMATIC S7-300 with CPU 315F]
Application example for Safeguarding a horizontal danger zone with multiple protective fields by means of a Safety PLC

The actuator used in this example consists of a contactor, which is turned on and off via a safety-oriented output (F-DO of the ET 200S). If the (active) protective field of the LS4 is violated while the contactor is on, the contactor will automatically be turned off. A restart is only possible after acknowledgment.

The status of the sensors is defined by the protective field number (Bits 0 to 2 of the cyclical output data). This determines which protective/warning field is active.

In this example, the following can be active:
- Field Pair 1 (Protective Field 1 and Warning Field 1) or
- Field Pair 2 (Protective Field 2 and Warning Field 2)

The sensors for switching the protective fields are routed to a safety-oriented input module of the ET 200S. If a malfunction occurs at this input module, a switch between the protective fields can no longer take place. This malfunction will be detected and put the safety-oriented output module into the fail-safe state (actuator contactor K1 drops off).
Overview of Hardware Setup

The laser scanner LS4-4 is operated just like the ET 200S as a DP slave on the PROFIBUS DP. A safety-oriented S7 CPU acts as the DP master.

<table>
<thead>
<tr>
<th>HW component</th>
<th>Symbol</th>
<th>Signal (Default value)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pushbutton (Open Contact)</td>
<td>START</td>
<td>&quot;0&quot;</td>
<td>turns ON contactor K1</td>
</tr>
<tr>
<td>Pushbutton (Break Contact)</td>
<td>STOP</td>
<td>&quot;1&quot;</td>
<td>turns OFF contactor K1</td>
</tr>
<tr>
<td>Pushbutton (Open Contact)</td>
<td>Acknowledgement</td>
<td>&quot;0&quot;</td>
<td>Acknowledges a corrected error</td>
</tr>
<tr>
<td>Contactor Auxiliary Contact</td>
<td>READBACK</td>
<td>&quot;1&quot;</td>
<td>for locking the start conditions</td>
</tr>
<tr>
<td>(Break Contact)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position Switch (Break Contact)</td>
<td>Protective field 1</td>
<td>&quot;1&quot;</td>
<td>defines, which field pair is active</td>
</tr>
<tr>
<td>Position Switch (Break Contact)</td>
<td>Protective field 2</td>
<td>&quot;1&quot;</td>
<td></td>
</tr>
<tr>
<td>Contactor K1</td>
<td>K1</td>
<td>&quot;0&quot;</td>
<td>Actuator</td>
</tr>
</tbody>
</table>
Configuration/programming:

- S7 Distributed Safety V5.2 for the configuration of the hardware and the programming of the safety-oriented application using LAD or SFC in the familiar STEP7 environment (option package to STEP7)

- Integrated F command library with ready-made and TÜV-certified programming examples and function blocks – individually modifiable:
  - EMERGENCY STOP
  - Two-hand control
  - Muting
  - Door monitoring
  - …

Further information on fail-safe sensors

www.siemens.com/simatic-sensors/fs

Author:

Uwe Schumann
E-Mail: uwe.schumann@siemens.com

Provided by

Siemens AG
Automation and Drives
Factory Automations Sensors
Postfach 48 48
90327 NÜRNBERG
GERMANY

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