Application solutions with PROFIsafe. Comparing conventional technology with safe bus systems.

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Abstract

Non-safe sensors and actuators are now connected to PLCs via fieldbuses. Safety technology usually involves the use of safety relays. Thus the two systems are controlled differently, leading to high programming and maintenance costs.

New fieldbus systems can handle both safety and non-safety information on a single fieldbus and in a single PLC.

A comparison between conventional technology and safety bus technology will be carried out on the basis of two application examples. The main advantage of using PROFIsafe is enhanced diagnoses – and thus shorter system downtimes.

1 Introduction

Larger machines and plants are usually controlled by programmable logic controllers (PLCs). A large number of sensors/actuators are distributed throughout the plant. Fieldbus systems are used to connect these devices for non-safe processing of this information. For this purpose, sensors/actuators are connected to decentralised peripheral units and the information is transmitted to the central control system via the bus cable. This allows a flexible and easily modified construction of automated plants. A further advantage is the possibility of expanded diagnosis right up to the connected devices, such as sensors and actuators.

Safe sensors/actuators are now processed and controlled either conventionally with safety relay combinations, or in separate safety bus systems and safety control systems. In this case, programming takes place separately from the non-safe control system in a new software environment. Further interfaces for diagnosis and data exchange must be inserted in order to achieve a linkage between the safe and non-safe signals.

1.1 Actuators

In addition to simple pneumatic and hydraulic valves, actuators include frequency converters for motors and robot drives. Complex systems like robots employ pneumatic valves for handling as well as having drives for axle control. The safe switching of drives is necessary to stop the hazardous movement of a robot. At present a safe or non-safe stop are switched along different paths, so that a double monitoring takes place via the standard control system (with integrated bus interfaces) on the one hand, and via the safety relay combinations on the other.

1.2 Sensors

Unlike standard sensors, safety-oriented sensors are almost exclusively located around the machine. They are used to detect impermissible access to the machine. From the point of view of the producers of safe electro-sensitive protective equipment (ESPE), autonomous modular safety applications for safe sensor processing take place in a machine and have an effect on appropriate actuators within the machine.

Complex safe sensors, such as light grids, are often only used at these plants for access safeguarding at insertion points, so that only one type of information is required: the current status of the light grid. More safe sensors are found in the direct vicinity of these complex safety sensors, such as emergency stop switches, door switches with and without interlock, and connection plugs for enabling switches. Entry/exit monitoring stations are installed in the area of automatic material transfer from one machine to the next. They distinguish between material and persons. This differentiation takes place by means of a number of further sensors (non-contact or tactile) in front of and behind a light grid. Inserted material must dampen these sensors in a defined sequence in order to mute the light grid.

This large number of safety signals is now transmitted to the non-safe control system for monitoring via either safety relay signalling outputs, or supplementary signalling contacts on the switches. Sensor signals that go straight to a separate unit for processing the safety technology (e.g. muting) must, if necessary, be executed in duplicate.

2 Application description: safeguarding access to a robot cell

Access safeguarding is necessary for a robot cell (pick-and-place robot) with a handling robot. Access to the hazardous area of the robot is required for insertion of the raw material and for removal of the finished material after the processing step.

As a result of the almost continuous access required, safeguarding is carried out using optoelectronic safety light curtains and a laser scanner to prevent the possibility of getting around the curtain. On the sides, there are protective doors monitored with safety interlocks for access to the robot and handling area for maintenance purposes. An Emergency Stop switch is also present. Start, Stop and Reset buttons are available for the operator for control of the work process. A human-machine interface (HMI) with a PROFIBUS DP connection is provided for visualisation.

2.1 Description of function

Infringement of the light curtain or movement into the scanner’s protective field immediately triggers a robot stop. Reset and then Start must be employed after release of the protective equipment. The same applies for the Emergency Stop and the protective doors. As the protective doors are provided with interlocks, the doors are initially unlocked after the robot has come to a stop and can only be opened thereafter. The Stop button triggers a robot stop after a full robot cycle has been completed – intended to provide a controlled running down of the robot movement before maintenance work. The plant can subsequently be restarted again with the Start button.

2.2 Components used

A SCARA robot with an appropriate control system is used. The optoelectronic safety equipment consists of one C4000 Advanced light curtain and a S3000 Advanced safety laser scanner. Both pieces of intelligent electro-sensitive protective equipment (ESPE) are equipped with a safety-oriented communication interface to allow, for example, operating mode switching or expanded diagnosis. Switches with interlock are employed on the protective doors. The operating elements Emergency Stop, Start, Stop and Reset are available for the plant operators. An IPC with visualisation software is provided for monitoring the plant processes and for diagnoses.

The above-mentioned components are independent of the control technology used for the safety technology.

2.3 Comparison of safety control system technology

2.3.1 Conventional safety technology with safety relays

Structure:
A PLC with the appropriate level of complexity and PROFIBUS DP is used to control the standard technology.

For the safety technology: safety relays are used for detecting the ESPE, protective door switches and Emergency Stop components. A supplementary standard relay for contact duplication of the Reset button is also employed.

Wiring of the components takes place centrally to a control cabinet. The long wiring distance from the control cabinet to the individual components results in high wiring costs.

Commissioning:
Commissioning costs are also high as a consequence of the expensive wiring. There are also more potential error points in the wiring because of the greater number of terminal connections involved.

Configuration of the intelligent C4000 and S3000 safety sensors takes place using CDS software from SICK. The necessary parameters are set through integration with local configuration connections. After successful configuration, the software's comprehensive diagnostic functions can be used to provide support for the initial commissioning.

Maintenance / diagnosis:
Further wiring costs arise because of connections to the PLC, necessary for transmitting plant status to the standard control system and for visualisation on the HMI.

The components generally offer an output for status diagnosis. If, for example, it is detected here that the switching output of a ESPE is switched, this means the protective field is free and no infringement has taken place. Conversely, a non-switched output at the ESPE does not necessarily mean that an infringement has taken place – the device must also be ready, correctly aligned, not contaminated, etc. Only the in-situ possibilities offered by the particular components (such as LEDs, 7-segment indicator, or diagnostic software) are available for this further diagnosis.

Early warning of faults, such as contamination, can only be detected at the ESPE with the help of a further diagnosis cable. Errors in the wiring or extended dropout times caused by hanging relays can only be reproduced with a plant test.

On replacement of a component with new parameterisation, the corresponding configuration tool must be connected locally and the parameters set there.

2.3.2 Safety technology with PROFIsafe safety bus system

Structure:
A failsafe PLC with an integrated PROFIBUS DP connection is used as the control system for both the safety and standard technology. Use of the failsafe PLC allows connection of safe PROFIsafe slaves and standard PROFIBUS DP slaves. Safety relays become completely unnecessary and two IP67 UE4155 bus nodes from SICK AG are used instead. A failsafe output module is used for safe switching off of the robot. The same safety components that were used with the safety relays can be connected to the UE4155. The IP67 enclosure rating brings about shorter wiring paths between the components and the bus connection. Pre-assembled cable reduces installation time to a minimum.

Commissioning:
The modular construction and short wiring paths minimise error sources in the wiring.

The UE4155 has special communication connections for intelligent ESPEs from SICK, such as the C4000 and S3000. Thus expanded functions such as the switching of protective fields and operating modes can be carried out directly via the PLC. SICK’s CDS software can be used for commissioning. As the UE4155 is also parameterised with this software, the connected devices and the UE4155 are considered as a single project and processed within a joint configuration. The remaining signals from the Emergency Stop, protective door switches, and Reset, Start, and Stop buttons, are connected to the UE4155 at the field signal inputs. Pre-configured function packages are available for parameterising the field signal connections for the various components, allowing simplified and consistent parameterisation of the entire system.

The CDS software can now be run via PROFIBUS for commissioning the entire system. When programming interface Step7 is used simultaneously, a comprehensive signal tracking from sensor to control system can be carried out from a central point via PROFIsafe. This centralised control of the plant, and the short wiring paths between sensors and bus connections, allow considerably shortened commissioning times.

Maintenance / diagnosis:
By integrating the signals in PROFIsafe, the complete plant status, triggered right down to the individual components, is available for the HMI via the PROFIBUS. No further wiring costs are incurred.

In addition to the status information, the UE4155 also has a PROFIBUS DP diagnosis available. Passing on this information to the HMI for visualisation immediately provides a deeper diagnosis for plant operators in clear text. So if a safety component becomes defective as a result of, for example, a short-circuit in the connection cable, this expanded information is immediately available.

The use of CDS software provides even deeper information on the intelligent safety components. Pre-fault warning signals, such as contamination, etc. are already signalled via the PROFIBUS DP diagnosis.

If a component requires replacement it can be newly parameterised via the PROFIBUS using the connected CDS software. The data set created during commissioning can be used for this purpose and transmitted via the bus system.

3 Entry/exit application description

3.1 Muting (bridging function)

With “classical” muting, in addition to an ESPE for safeguarding access, several muting sensors, a current-monitored muting lamp, and Restart, Override and Emergency Stop buttons are used. There is still supplementary safeguarding by swing doors with safety switches to reliably identify the muting-triggering material and prevent the risk of any entering with the material while the muting function is active.

3.1.1 Description of function

Given the arrangement as shown above, the muting sensors mounted in front of the station must be activated one after another in order to pass material through this safety equipment and carry out the assembly process. When both sensors have been activated, the muting lamp is activated and the photoelectric switch is muted. The safety function of the safety switches on the swing doors is not muted and remains permanently active. Muting is deactivated immediately if the muting lamp fails (detected by the current monitoring function). On continued throughput of the material, the muting sensors located behind are now activated so that the passage of the material is checked. The safety function is restored on deactivation of the sensors located in front of the safety photoelectric switch.

3.1.2 Comparison of the control system technology

<u>Conventional safety technology:</u>
Conventional solutions are implemented with local muting systems. In this case the monitoring of the muting sequences takes place in special muting evaluation units in situ. Only the release of the plant is available (switching outputs) for the safety output signal. All states, such as spurious muting conditions, defective muting lamp, infringement of the light curtain, etc. only bring about a need for a reset of the release of the plant.

Further error causes can be seen on the muting system in situ using the diagnostic LED or 7-segment indicator. Otherwise all that remains is the test of the individual functions of the safety equipment.

The PROFIsafe safety bus system:
All the signals necessary for muting can be connected locally when using safe bus systems with PROFIsafe and the safe slave UE4100 from SICK. The muting condition is either processed directly in the appropriate light grid or triggered in the PLC via software function modules.

CDS software is available for configuration of a local in-situ solution. All sensor status information, including error information on the muting conditions, is ready to be requested. As in the above application solution, the information can be called up via the bus system, thus considerably reducing downtimes if the system fails.

3.2 Entry/exit with laser scanner

With this solution a type S3000 safety laser scanner from SICK is used instead of the photoelectric switch. Muting sensors remain in use, as in the “classical” muting, and are employed for material detection. The swing doors and the associated protective door switches, however, are no longer required as a result of the vertical arrangement of the S3000. If the sensors are activated as described above, the laser scanner’s protective field is switched, and the contour of the material is monitored. The material itself can be fed in. The system’s safety function remains intact.

3.2.1 Comparison of the control system technology

This solution can be realised with conventional technology using special evaluation modules or with the UE4155 and PROFIsafe. In this case, there is a preliminary preparation of the muting sensor signals in the PLC before they are transmitted to the laser scanner. Switching of the protective field in the laser scanner is activated by the input conditions.

Errors can be specifically determined with the help of the PLC software or the CDS software. It is easy to arrange for the functions to be displayed on the HMI with diagnosis texts.

Control of the scanner protective field is possible from a central location via PROFIBUS DP and the CDS software.

4 Conclusions

As can be seen from the application examples, it is irrelevant for the safety sensors whether a solution is constructed with conventional technology or with the PROFIsafe bus system. The preferred solution exclusively affects the evaluation units for the safety technology.

At first glance, as in the standard technology, in a direct comparison of the components (i.e. between safety relay technology and safe bus system with failsafe PLC) the conventional solution still offers a cost advantage.

However, the costs in running operation are more than compensated for if the costs saved by the simplified commissioning plus the considerably expanded diagnostic opportunities (and, therefore, the reduced downtimes) are calculated into the equation. A detailed diagnosis can be carried out via the plant operator’s HMI so that no specialist personnel are required for the initial error localisation.

Diagnosis can be carried out right up to the sensor if the bus system is expanded with remote maintenance systems. Thus specially trained experts are not essential on site. Innovative solution approaches with new sensor systems therefore offer the key to using the new technologies of safe bus systems.