Implementation of the safety components base on industrial networks

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Abstract. Capabilities of modern automation systems, especially in the field of industrial networks applications, encouraging them to favor during the process of developing the automation project [2,3,5]. Extensive network topologies and simplicity and clear structure causing displacement of the classic wiring. The article presents: project workflow for creating laboratory stand based on industrial network and base on it implementing the safety system. The individual steps of the process are described. In addition, the paper presents the main concept for controlling the safety functions of the system.

1. Introduction
A perfect example is the comparison of classical topology and wiring distribution automation equipment in relation to a modern industrial network topology of the AS-interface. Topology simplification is not the only benefits that we get through the selection of industrial networks. Built control systems must often provide the required level of safety. Thus, the designer of the automation system is required to enable the handling of so-called safe I/O modules, safety light curtains, emergency stop buttons, pull-wire switches, etc. This article describes the application possibilities of industrial network such as AS-interface in the implementation of safety at work technology. The authors presents the process of creating a simple application, which includes: the position limit switches, actuators, electro-pneumatic control units, modules of analogue inputs and outputs, push buttons modules, the frequency converter and its controlled asynchronous 3-phase motor. Figure 1 shows the test application designed to simulate a simple industrial system. Cyclic operation is controlled actuators in accordance with the adopted histogram, the work of an asynchronous motor with different speeds and possible pressure drop in the pneumatic system. It is possible to choose the manual control mode and fully automatic. Once launched, the authors present the basic functionality of the implementation process, on the existing structure of hardware, security components. The sample safety program, security restarting the system after the breach of security, in a development environment ASIMON, has been written.

2. General description
To simulate a simple industrial process [1,6], the electro-pneumatic laboratory system of the drink production line has been assembled. The main control program consists of a series of sequences written in sequential function chart (SFC). The whole process from activation by choosing glasses,
pour a drink, provide the glasses on the tray can be divided into certain stages. Each of them is assigned to individual steps in the main program in the SFC with the same name. Beneath it lies for each step of the program written in functional block diagram (FBD), which carries out the tasks assigned to the stage. All variables, both parts programmed in SFC and FBD, are in the main program. The program contains three sub-programs, also written in FBD. To clarify the whole process steps simple figures has been created. The first, choosing the glass, is shown on figure 2.

![Laboratory application designed to simulate drink production line](image1)

**Figure 1.** Laboratory application designed to simulate drink production line.

Whole process starts from magazine of glass (first subsystem). In the project it was program challenge to create the matrix of variable of glasses positions and adequate algorithm for searching the first available glass. Authors uses electro-pneumatic system based on suspended transport system with vacuum griper.

![Drink production line – subsystem of glass matrix](image2)

**Figure 2.** Drink production line – subsystem of glass matrix.
System is ready to start the next step after it download the glass and give it to the transport tray. Then the glass is transported to the drink distribution area. As soon as the glass is transported to the drink distribution area pneumatic cylinder with vacuum griper should base the glass under the rotary distributor. Six drinks are available to choose. Algorithm of control allow to prepare mixtures of maximum two liquids. Proportions are freely set via the HMI panel. Figure 3 shows the next subsystem – six liquids rotary distributor. Figure 4 shows the photo of real implementation.

Figure 3. Drink production line – subsystem of rotary distributor.

Figure 4. Drink production line – real photo of subsystem of rotary distributor.

When this subsystem confirm that the mixture is ready then the next conveyor starts working. This part consist of barrel conveyor system and one long range pneumatic cylinder with griper. Glass filled of liquid is gently pushed in to direction of belt conveyor system. As soon as the optical sensor sense the glass pneumatic cylinder goes back, and the belt conveyor system starts his movements. Laser diffuse reflection sensor determines the distance on which the glass should stop traveling. This
subsystem is also equipped with condition monitoring of the bearings of the drive motor. For this task the VE1001 sensor of ifm electronic have been chosen. If of some circumstances the vibration of this laboratory set will increase and reach the unacceptable level of RMS then this information will effect in changing the safety input state [4]. Glass stack on the path of belt conveyor will also be trade as non-safety situation (stopping the glass movements in area between start point and end point of travel is equal to error situation). In normal situation the glass on this subsystem should reach the end point as soon as possible, without any unnecessary stopping. As it is shown on the figure 5 – on the end of belt conveyor system the last pneumatic cylinder responsible for glass movements is located. When the glass stops on the end point on the conveyor, the vertical gates will be opened (goes up) and the arm of pneumatic cylinder will push the glass to final position – glass collection point. The view of this subsystem – real photo shows figure 6.

![Figure 5. Subsystem of belt conveyor with distance and vibration monitoring.](image)

![Figure 6. Drink production line – real photo of subsystem of belt conveyor.](image)
2.1. Implementation of safety functions
The functional task of the AS-interface safety monitor is to continuously specify the state(s) of the OSSD in accordance with the configuration specified based on the states of the configured devices and to activate or deactivate the assigned safe switching outputs or safe actuators (the main concept is shown on figure 7). The ASIMON software automatically arranges the devices in the respective windows during configuration.

Each device can take on two states: ON state (switched on, logical "1"). This state means that the device has agreed to validate the circuit, i.e. to activate the safe switching outputs. Depending on the device type, various conditions must first be met. OFF state (switched off, logical "0"). This state means that the device has not agreed to validate the circuit, i.e. it results in the switching off of the safe switching outputs. In the first step of the evaluation, the states of all monitoring, logic and EDM devices are linked to one another by means of a global logic AND function, i.e. only when all configured monitoring, logic and EDM devices have the ON state is the result of the AND function equal to ON. In principle, the device states are evaluated in the same way as in an electrical safety

Figure 7. Main structure of the safety management in AS-interface Safety Monitor.
circuit in which all safety switch elements are connected in series and validation is possible only when all contacts are closed.

In the second step, the start devices which determine the startup behaviour of the OSSD are evaluated. A start device enters the ON state when the result of the global AND function from the first step of the evaluation is equal to ON and when the respective start condition is fulfilled. With regard to the start condition, the start devices have a lock. The start condition must therefore only be fulfilled once. A start device is reset (OFF state) when the result of the global AND function from the first step of the evaluation returns the OFF state. The states of the start devices used are linked to one another with an OR function, i.e. only one of the start devices needs to be in the ON state in order for the internal validation of the circuit to occur.

In the third step, the output device is then analyzed. If the circuit has been internally validated (result of the OR function from the second step of the evaluation is equal to ON), the output device switches the message and safe switching outputs of the OSSD in accordance with its function characteristics and time behaviour, i.e. the relays trip and the switching contacts close or the safe AS-interface output is set.

3. Conclusions
This approach simplifies the maximum number of components in the way of industrial automation from sensor to PLC. Instead of: multi-core cables, intermediate boxes, connectors, terminals, hundreds of cable descriptions, automation systems integrator chooses increasingly clear industrial network bus. With the adoption of the proposed safety monitor, to prepare for the process automation project development, it is possible to implement a safety system based on AS-interface industrial network, as well as a significant acceleration of the final run of the application.

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