

Start - Contents Application Note 100419

Each Safety Application Notes considers one aspect of a safety circuit. Therefore, implementing a safety circuit in a specific application always requires several documents that are linked in the application note.

Important notes

- Please unzip the zip file and save it in a folder. Some programs used cannot open files in compressed folders.
- Certain programs are required to open some files, see section → “Recommendations for the Required Software”

Contents of the Application Notes

Normally contains every application note the following files:

- **Application Note (in pdf format)**
Document with the description, circuit, required features of components and product recommendations from Festo.
- **Sistema project (in Sistema format and as Sistema report in pdf format)**
Sistema project for the evaluation of the sub-circuit for the safety sub-function according to the block diagram in the application note. As a rule, this is only the safety-related output of the pneumatic safety circuit.
- **FluidDraw Project (in FluidDraw format and in pdf format)**
FluidDraw project with the subcircuit for the safety subfunction according to the description in the application note.
- **FluidDraw Translation Table DE – EN (in FluidDraw format)**
The FluidDraw project was created with a translation table in order to be able to select and display different languages (German and English). To integrate the translation table into a FluidDraw project, see → “Instructions Translation Table for FluidDraw”.
- **FluidSim Project (in FluidSim format)**
FluidSim project with a possible electrical circuit and the pneumatic sub-circuit for the specified safety sub-functions. This project file can be used to test and explain how the circuit works using a simulation.

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Our Reference

100419

Legal form:
Limited partnership
Registered office: Esslingen a. N.
Registry court Stuttgart
HRA 211583
Value added tax id. number:
DE 145 339 206
General partner:
Festo Management SE
Registered office: Esslingen a. N.
Registry court Stuttgart
HRB 782421
Management Board:
Dr. Sebastian Beck
Dipl.-Ing. (FH) Thomas Böck
(Chairman)
Dipl.-Ing. (FH) Frank Notz
Dr. Jaroslav Patka
Prof. Dr.-Ing. Tomas Smetana
Chairman of the Supervisory Board:
Dr. Friedrich Eichiner

Festo SE & Co. KG

Ruiter Straße 82

73734 Esslingen

Phone +49(711)347-0

GERMANY

www.festo.com

This simulation shows valve Q2 in detailed view, i.e. with a pneumatically actuated main stage and the electrically actuated pilot valves. With this simulation, the mode of operation and the fault exclusion “spontaneous change of the output switching position of the main stage without input signal” can be better explained.

- **Video**

The video shows and explains the simulation of the pneumatic part of the circuit. There are also two videos of the simulations, one with the usual symbol for the bistable valve and one with the detailed representation.

Recommendations for the Required Software

The following software is required to make full use of this application note:

- **Reader for files in pdf format**

We recommend the free ➤ [Adobe Acrobat Reader](#).

- **Sistema**

Sistema is a software assistant for the evaluation of safety circuits of machines according to the ISO 13849-1 standard. This is a free software provided free of charge by the Institute for Occupational Safety and Health (IFA) ➤ [Software-Assistant SISTEMA](#).

- **FluidDraw**

FluidDraw makes it quick and easy to create pneumatic, hydraulic and electrical circuit diagrams. This is a paid program that can be ordered from Festo ➤ [FluidDraw 365](#).

- **FluidSim**

FluidSim can be used to simulate pneumatic, hydraulic, and electrical circuits at circuit diagram level. For the simulation of this application note, the Windows version with licenses for pneumatics and electrical engineering is required. For the licenses ➤ [FluidSim](#).

- **Video player for MP4 files**

A video player is required to play the video showing the simulation of the pneumatic circuit. The Media Player, which is suitable for playback, is normally available for Windows.

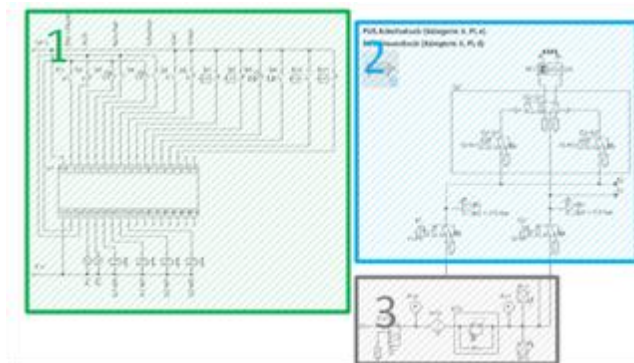
Instructions Translation Table for FluidDraw

The translation table can be loaded with the following steps:

1. Select the "Manage" menu
2. Select the "Translation tables" menu item
3. Select the "Open..." button
4. Select the file "... FluidDraw Translation Table DE - EN.xmltt"
5. The columns TextID, German and US-English are displayed in the "Words" table
6. The "Manage translation tables" window can be closed with the OK button
7. Select the "Project" menu
8. Select the "Language" menu item
9. Select the file "... Translation Table DE - EN.xmltt" in the "Translation table" selection list (usually the lowest file in the list)
10. Select the desired languages in the "Project / Page / Report" and "Translation language" selection lists.

Instructions for Simulations with FluidSim

Overview



Important Notes

- The circuit of the simulation shows a safety-related circuit that is not complete and must always be adapted to the application.
- The programming of the safety controller K1 in the simulation is adapted to the FluidSim simulation program and is not complete. For example, it is only single channel, there are no test pulses, no internal diagnostics, etc.

This simulation is intended to demonstrate the operation of the PUS safety sub-function with bistable valves in a safety circuit. The behavior of the circuit can be examined by actuating the various buttons and switches. By changing the settings of the sensors, controllers and switching times, it is also possible to simulate other operating states and faults.

The simulation circuit consists of the following parts

1. Circuit of the safety controller
The safety controller circuit is partially located in the control cabinet and the valve solenoids, switches, push buttons and sensors are connected to the safety PLC K2.
2. Pneumatic circuit
The components required to implement the PUS safety sub-function are shown in the pneumatic circuit. Valve Q2 is shown with its main components, i.e. a pneumatically actuated, bistable 5/2-way valve and two electrically actuated 3/2-way valves as pilot valves. This explains the behavior of the valve and the

application of the fault exclusion “Automatic change of the output switching position without input signal”.

3. Service unit

The service unit is used to implement certain safety principles.

Functions push buttons and switches

- **S1 – Push button ON/Reset**

The machine is switched on. In the simulation, the working pressure valve Q1 and the pilot pressure valve K1 are switched on. This means that the working pressure and the pilot pressure are available for the valve Q2.

Valve Q2 is controlled in the initial position.

The preconditions for this are

- The minimum pressure at pressure switch B10 is exceeded, the maximum pressure at pressure switch B11 is not exceeded.
- Emergency stop S3 is not activated.
- The safety door S4 is closed.
- OFF button S2 is not actuated.

- **S2 – Push button OFF**

The machine is switched off. In the simulation, the working pressure valve Q1, the pilot pressure valve and the valve Q2 are switched off. This means that the working and pilot pressure are no longer available and the machine function cannot be started.

- **S3 – Emergency stop switch**

Emergency stop is requested, i.e. PUS is executed with valve Q2 for the application. The working pressure valve Q1 is switched off so that the working pressure supply is interrupted and exhausted. The pilot pressure valve K1 is also switched off so that the pilot pressure supply is interrupted and exhausted. This means that working and pilot pressure is no longer available. Valve Q2 is also switched off so that the main stage of the valve can no longer leave its actual position. As long as the emergency stop S3 is activated, it is not possible to start the normal machine function with S5 or to reset it with S3.

To acknowledge the emergency stop, the emergency stop switch S3 must be moved to its initial position and acknowledged with the push button S1 ON / Reset button.

- **S4 – Safety gate switch**

The safety sub-function PUS is requested for valve Q2. The pilot pressure valve K1 is also switched off so that the pilot pressure supply is interrupted and exhausted. This means that pilot pressure is no longer available. Valve Q2 is also switched off so that the main stage of the valve can no longer leave its actual position. As long as the safety gate S4 is open, it is not possible to start the normal machine function with S5 or to reset it with S3.

To acknowledge the safety gate, the safety gate S4 must be closed and acknowledged with the S1 ON / Reset button.

- **S5 – Push button Start**

If the start button S5 is pressed, the normal machine function is executed, i.e. the pneumatic drive M1 extends and retracts continuously. It is controlled via the simulation of the fieldbus. The prerequisite for this is that no safety function (emergency stop, safety gate) is active, no faults have been detected by the diagnostic measures (B1, B2, B3, B4, B10, B11) and the stop button S6 has not been pressed.

- **S6 – Push button Stopp**

The stop button S6 stops the normal machine function, i.e. the pneumatic drive is functionally stopped and remains in the activated end position.

Functions circuit safety PLC

- **B1 - Pressure switch**

Diagnosis for the working pressure valve Q1. With the pressure switch B1, the safety controller K2 monitors the switching of valve Q1 for plausibility and whether the switching times do not exceed certain values.

- **B2 - Pressure switch**

Diagnosis for the pilot pressure valve K1. With the pressure switch B2, the safety controller K2 monitors the switching of valve K1 for plausibility and whether the switching times do not exceed certain values.

- **B3 - Limit switch pneumatic drive retracted**

Diagnosis for the working valve Q2. With the limit switch B3 monitors the safety PLC K2 the switching of valve Q2 for plausibility and whether the switching times do not exceed certain values.

- **B4 - Limit switch pneumatic drive extended**

Diagnosis for the working valve Q2. With the limit switch B4 monitors the safety PLC K2 the switching of valve Q2 for plausibility and whether the switching times do not exceed certain values.

- **B10 – Pressure switch minimum pressure (setting 0.3 MPa)**

The pressure switch monitors the minimum working pressure required for the application. If the set minimum pressure is not reached, the valves are switched off. The valves then move to their normal position and perform the following safety sub-functions:

- Q1 performs SDE for the working pressure and then PUS in the normal position of the valve.
- Q2 executes PUS in the current position of the valve.

- **B11 – Pressure switch monitoring maximum pressure (setting 0.5 MPa)**

The pressure switch monitors the maximum working pressure permitted for the application. If the set maximum pressure is exceeded, all valves are switched off. The valves then move to their normal position and perform the following safety sub-functions:

- Q1 performs SDE for the working pressure and then PUS in the normal position of the valve.
- Q2 executes PUS in the current position of the valve.

- **K2 - Safety PLC**

In the simulation, the safety PLC K2 is simulated by a digital module. This digital module is programmed with logic elements, which is similar to programming with function blocks. The outputs are controlled according to the signals from the buttons, switches and sensors so that a safe state can always be maintained.

- **P1 - Lamp safety request**

The P1 lamp shows whether there is a safety request.

- **P2 – Display failure detected by diagnostics**

If P2 lights up, a failure has been detected by one of the diagnostic measures. This signal may not light up visibly, e.g. if a failure is detected by a signal edge.

- **Q1 - Working pressure valve**

In its normal position, the working pressure valve executes the safety sub-functions SDE and PUS. If there is no safety request and no failure, it can be acknowledged with button S1 and the working pressure valve is switched on and the downstream pneumatic system is pressurized.

- **K1 - Pilot pressure valve**

In its normal position, the pilot pressure valves executes the safety sub-functions SDE and PUS. If there is no safety request and no failure, it can be acknowledged with button S1 and the pilot pressure valve is switched on and the pilot pressure supply for the downstream valves is pressurized.

- **Q2 - Working valve**

The working valve controls the pneumatic drive as a machine function and is also a channel for the safety sub-function PUS.

Functions service unit

- **S10 - Manual on/off valve**

The manual on/off valve can be used to interrupt the compressed air supply and exhaust the directly downstream pneumatic system. This valve can be used to simulate a pressure failure.

- **P10, P11 - Pressure gauge**

The pressure gauges can be used to monitor the supply pressure and the regulated working pressure.

- **K10 – Pressure regulator (setting 0.4 MPa)**

As long as a sufficient volume flow is available, the pressure is regulated to 4 bar. The pressure regulator can be used to simulate too low or too high a pressure.

- **H10 - Filter**

Filter should ensure the required compressed air quality for the downstream pneumatic system.

- **B10 – Pressure switch minimum pressure (setting 0.3 MPa)**

The pressure switch monitors the minimum working pressure required for the application. If the set minimum pressure is not reached, all valves are switched off. The valves then move to their normal position and perform the following safety sub-functions:

- Q1 performs SDE for the working pressure and then PUS in the normal position of the valve.
- Q2 executes PUS in the current position of the valve.

- **B11 – Pressure switch monitoring maximum pressure (setting 0.5 MPa)**

The pressure switch monitors the maximum working pressure permitted for the application. If the set maximum pressure is exceeded, all valves are switched off. The valves then move to their normal position and perform the following safety sub-functions:

- Q1 performs SDE for the working pressure and then PUS in the normal position of the valve.
- Q2 executes PUS in the current position of the valve.

Functions Pneumatic Circuit

- **B3 - Limit switch pneumatic drive retracted**

Diagnosis for the working valve Q2. With the limit switch B3 monitors the safety PLC K2 the switching of valve Q2 for plausibility and whether the switching times do not exceed certain values.

- **B4 - Limit switch pneumatic drive extended**

Diagnosis for the working valve Q2. With the limit switch B4 monitors the safety PLC K2 the switching of valve Q2 for plausibility and whether the switching times do not exceed certain values.

- **M1 - Pneumatic drive**

Double-acting pneumatic drive controlled by valve Q2.

- **Q2 - Electrical actuated 5/2 directional control valve, bistable**

The working valve controls the pneumatic drive as a machine function and is also a channel for the safety sub-function PUS.

In this simulation, valve Q2 is separated into its main components:

- Q2-Q1: pneumatically actuated 5/2-way valve, bistable (main stage)
- Q2-K1, Q2-K2: electrically actuated 3/2-way valves, monostable (pilot valves)

This makes it easier to explain the behavior of the valve and the application of the fault exclusion “Spontaneous change of the output switching position without input signal”.

- **B2 - Pressure switch**

Diagnosis for the pilot pressure valve K1. With the pressure switch B2, the safety controller K2 monitors the switching of valve K1 for plausibility and whether the switching times do not exceed certain values.

- **K1 - Electrical actuated 3/2 directional control valve, monostable**

In its normal position, the pilot pressure valve executes the safety sub-functions SDE and then PUS. If there is no safety request and no failure, you can acknowledge with button S1 and the pilot pressure valve is switched on and the pilot air supply for the downstream valves is pressurized.

- **B1 - Pressure switch**

Diagnosis for the working pressure valve Q1. With the pressure switch B1, the safety controller K2 monitors the switching of valve Q1 for plausibility and whether the switching times do not exceed certain values.

- **Q1 - Electrical actuated 3/2 directional control valve, monostable**

In its normal position, the working pressure valve executes the safety sub-functions SDE and then PUS. If there is no safety request and no failure, you can acknowledge with button S1 and the pilot pressure valve is switched on and the pilot air supply for the downstream valves is pressurized.

Instruction Simulation

1. Press button S1: The machine is switched on, i.e. the valves K1 and Q1 are controlled and activate the pilot and working pressure for valve Q2 and the other parts of the pneumatic system.
2. Press button S5: Machine function is started, i.e. drive moves.
3. Open safety door S4: The valves K1 and Q2 are no longer controlled, i.e. PUS is executed.
4. As long as the safety door S4 is open, the button S5 can be pressed as desired without starting a movement.
5. Close safety door S4: Safety request reset by the safety door. The button S5 can be pressed as desired without starting a movement.
6. Press button S1: The safety request is acknowledged and the machine function is allowed to start.
7. Press button S5: Machine function is started, i.e. drive moves.
8. Press emergency stop S3: The valves K1, Q1, Q2 are no longer controlled and move to their normal position.
9. For the other parts of the pneumatic system (X1, X2) is SDE executed. For Q2 is PUS executed.
10. As long as the emergency stop S3 is actuated, the button S5 can be pressed as desired without starting a movement.
11. Release emergency stop S3: Safety request reset by the emergency stop. The button S5 can be pressed as desired without starting a movement.
11. Press button S1: The safety request is acknowledged, and the machine function is allowed to start.
12. Press button S5: Machine function is started, i.e. drive moves.
13. The sticking of a valve can be simulated by holding down the "Shift" key and then clicking with the mouse on an actuator of valve Q2. The valve remains in the switched position. An error is detected by the diagnostics and all valves are no longer actuated and go into normal position. Clicking on an actuator of valve Q2 cancels the blocking.
14. The failure is acknowledged by pressing button S1 and a restart is possible by pressing button S5.