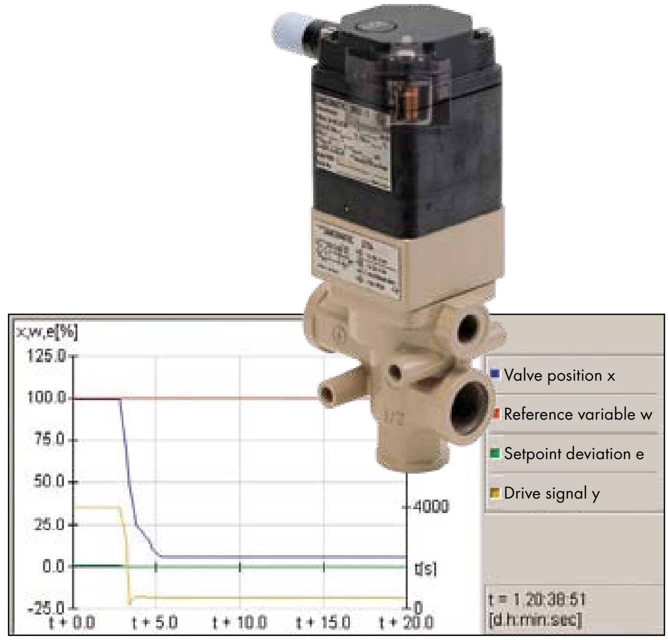
SAMSON

Smart and reliable whether on or off – valve automation trends



Special print from
„Industrial Valves"
2008

By:
Dr. Jörg Kiesbauer, SAMSON AG
Guido König, SAMSON AG

Smart and reliable whether on or off – valve automation trends

Dr. Jörg Kiesbauer and Guido König, SAMSON AG

Smart automation is increasingly becoming the benchmark for field instruments in process engineering. Following the success of microprocessor and communication technology in transmitters and valve positioners, digital systems are now conquering the on/off valve sector, including safety-related valves, formerly the domain of conventional systems. The historical developments and the current state-of-the-art are examined, and the opportunities for digital systems in binary automation are outlined and evaluated.

Historical developments and background

Operation and the degree of automation of process engineering systems have undergone continuous changes since the beginning of the previous century. Owing to long intervals between individual innovations, sometimes decades passed until the next significant technological step was made.

Self-operated temperature and pressure regulators allowed certain control loops with fixed set points to be automated first.

In any case, monitoring process variables used to be possible only by reading the respective values directly from the instruments on site. The technological leap forward brought about by the introduction of process control systems and programmable logic controllers with flexible processing of binary electric signals paved the way for pneumatic limit switches being replaced by electric limit switches (Figure 1).

In addition, the electropneumatic interface in the form of a solenoid valve (Figure 2) moved into the immediate vicinity of the actuator in many industries.

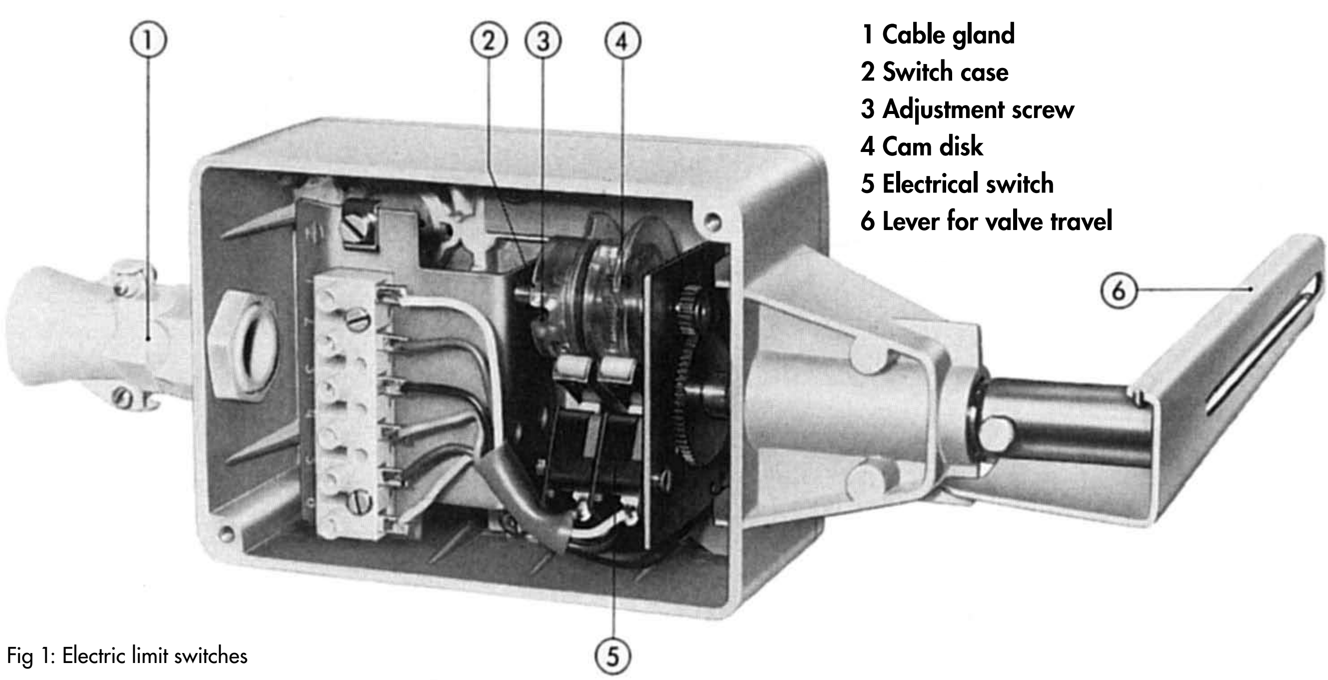


Fig 1: Electric limit switches

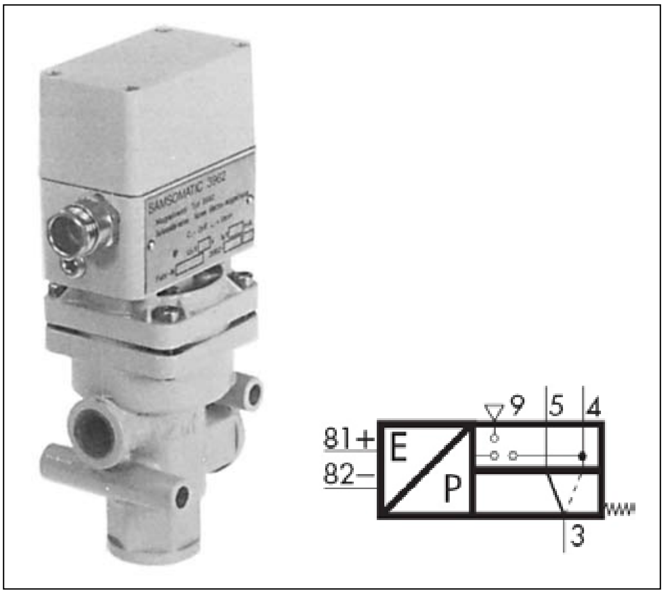


Fig 2: 3/2-way solenoid valve to control an actuator plus circuit diagram

It was – and still is – usual on the throttling valve market that the entire control valve assembly consisting of actuator, positioner and further accessories was delivered as a ready-mounted unit by a single supplier. For on/off valves, however, the individual components, mostly by different manufacturers, were habitually assembled by engineering services providers. They faced the tricky challenge of combining diverse makes of valves, actuators, limit switches, mounting kits, adapters and possibly solenoid valves to form reliable and safe units.

Missing interface standards caused comparatively high costs and inevitably increased the risk of mounting errors due to the number and complexity of individual components (Figure 3).

The attachment of limit switches and solenoid valves using mounting brackets, in particular, increased the possibility of the valves getting damaged during transport or start-up. This also raised the question of who would be responsible if such valves did not comply with the customer's specifications. Finding the reasons for a non-compliance was further hindered by a large number of manufacturers being involved.

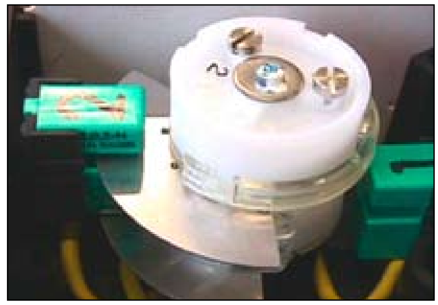


Fig 4: Valve monitor with proximity switches complying with IEC 60947-5-6

For many years, mechanically actuated electric make-and-break contacts, mostly used to indicate the valve end positions, have been considered the benchmark in the industry.

In terms of safety and reliability, the use of electric switches as the output stage of a limit switch meant that no other signal was issued in normal operation to indicate a breakage or short circuit in the cable. As a result, such faults could not be detected. A solution was provided by the signaling of switching states according to the biasing principle, which was initially defined in DIN 19245 and has meanwhile been established in EN 50227 and finally IEC 60947-5-6. The principle allows both kinds of faults mentioned – cable breakage and short circuit – to be detected (Figure 4).

These limit indicators also known as "NAMUR proximity switches" required a suitable device for evaluation. By definition, they were not able to directly switch higher electrical capacitances. The inclusion into DIN 19245, however, did not have any effect on the mounting of the associated limit switches, nor did it influence the mechanical/pneumatic interface.

The VDI/VDE 3845 standard contained solutions to these issues: Two mounting levels, interface patterns for different actuator sizes and stem connections were defined for attaching accessories, mainly limit switches.

VDI/VDE 3845, however, focused on rotary valves (Figure 5). By including the main points of VDI/VDE 3845 into part 6 of IEC 60534, a standard was created that covered control valves with both linear and rotary actuators. NAMUR working sheet NA19 contains a corresponding bore pattern (Figure 6) for at-


Fig 3: On/off valve with conventional fullscale automation


Fig 5: Attachment according to VDI/VDE 3845

tachment of solenoid valves to pneumatic actuators without piping. The bore pattern was incorporated into VDI/VDE 3845 as well.
This incorporation facilitated mounting and start-up, and made complex customized mounting kits redundant. The automated valve became more compact and rugged in design.

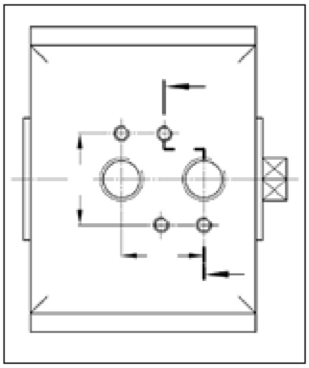


Fig 6: NAMUR bore pattern for solenoid valve mounting without piping

State of the art and current solutions

Applying the existing standards permits easy integration and modular setups.
Limit switches and solenoid valve(s) are combined to form a control and feedback unit. By putting together the electrical connections in one component (fewer connection and junction boxes, fewer cable glands, fewer cables), this functional unit reduces the cost for installation. Especially for control valves installed in hazardous areas, where very specific regulations for installation and types of protection apply, valve monitors (Figure 7) with an integrated solenoid valve offer the greatest cost advantage.
A vast number of functions can be integrated, yet retaining a modular design. It is possible, for example to include more limit switches so that the valve's end positions and further intermediate positions can be indicated. Additional solenoid valves can also be included for pulsed control, for connection of a bus for integral digital control and for bidirectional data exchange, e.g. using AS-interface (Figure 8).

Fig 7: Valve monitor with integrated solenoid valve

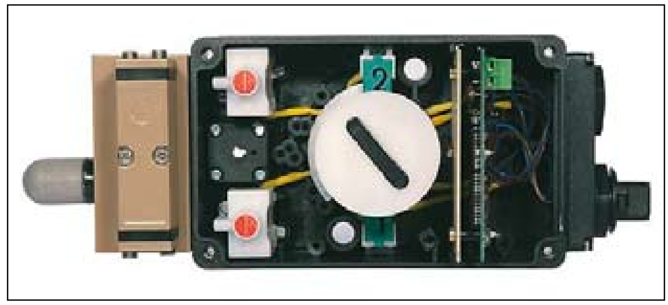


Fig 8: Valve monitor with AS-interface bus control, pulse switching

However, the components outlined above generally require a hook-up between the pneumatic output stage and the actuator. The standards do not prescribe a fixed location or orientation for the NAMUR interface; nor do they lay down that this interface must be integrated into the VDI/VDE fixing levels. Particularly for large-volume pneumatic actuators, the standardized flange pattern is insufficient due to the defined connection diameters. Some valve monitor designs offer an integrated electric solenoid valve connection, thus avoiding pneumatic connections.
Conventional solenoid valves typically have a power of 10 Watt and call for appropriately sized output components and safety features. The use of solenoid valves or pilot-control stages with a reduced power consumption, however, presents a number of advantages: When using 0.5 W valves, the component density can be increased. Optimized designs even allow solenoid valves with a power consumption of 5 mW to be built (Figure 9). For them, flexible multi-channel input and output units are available. Their channels can be configured individually to function as inputs for inductive limit switches or as outputs for solenoid valves. The low power consumption also allows limit switches and solenoid valves to be made intrinsically safe throughout, so that it is no longer necessary to have several types of protection on the same automated control valve.

Fig 9: Intrinsically safe solenoid valve (K_{VS} 4.3) with low power consumption

Fig 10: Fieldbus control unit including four on/off valves

This is a major benefit in modern processes that use fieldbus technology and where the control valves can be powered directly by the bus. In systems complying with IEC 61158 and powered by PROFIBUS-PA or FOUNDATION ™ fieldbus, each bus device is able to control and handle feedback signals by up to four on/off valves. Controlling valves in this way (Figure 10) also allows diagnostic functions to be performed, e.g. monitoring the valve's transit time and counting switching cycles.
However, in newly built plants where all components are interlinked digitally, a different approach is being taken: To reduce the cost of operation and maintenance, all valves are equipped with identical bus-powered positioners (Figure 11). This also creates opportunities for predictive maintenance and diagnostics on the entire control valve.
Admittedly, the share of on/off valves used in safety-instrumented systems is rather small. Nevertheless, limit switches, solenoid valves and valve monitors with integrated solenoid valves complying with IEC 61508 are available for them. Conventional control of the safety equipment is supplemented by approved safety-related fieldbus systems, such as PROFISafe for PROFIBUS or ASinterface Safety.

New fields of application for digital positioners in binary automation

The IEC 61508 and IEC 61511 standards set down extended requirements on monitoring on/off valves in safety-instrumented systems. As a result, new fields of application with pure on/off valves have opened up for smart digital positioners, which were initially developed for throttling valves. These fields are mainly protective circuits in safety-instrumented systems, increasingly also non-safety-related circuits to improve plant availability or reliability.
Clearly, positioners are used to monitor the process with their diagnostic and test functions in this case rather than perform actual control operations.
DIN IEC 60534 or VDI/VDE 3845 can serve as the standards for positioner attachment to automated control valves (Figure 12). Thanks to the moving parts being encapsulated, connections using the standardized interface are much more reliable than the classic counterparts.
A major benefit of positioners is their integral, continuous pick-up of the valve position. Positioners certified according to IEC 61508 safely vent the actuator in cases of emergency when the safety system cuts off the power supply. The valve is thus moved to its fail-safe position. In normal operating position (not fail-safe position), the positioner is powered and can perform diagnostic functions, e.g. run the valve through a partial stroke test. Consequently, the positioner combines diagnostic and safety functions in a single unit.
Alternatively, a safe solenoid valve can be integrated into the positioner or an external solenoid valve can be mounted the classic way. These solenoid valves are responsible for the valve reaching its fail-safe position. The positioner merely carries out diagnostic or test functions, e.g. it performs partial

Bild 11

Fig 11: Automated shut-off valve with fieldbus positioner

Bild 12

Fig 12: Safety-related valve with integral positioner attachment for binary control

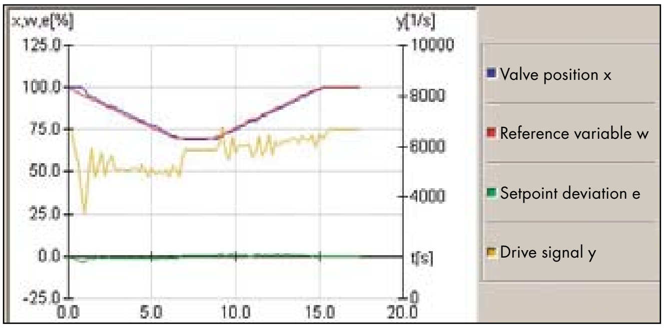


Fig 13: Partial stroke testing of a smart positioner (from 100 % to 70 %)

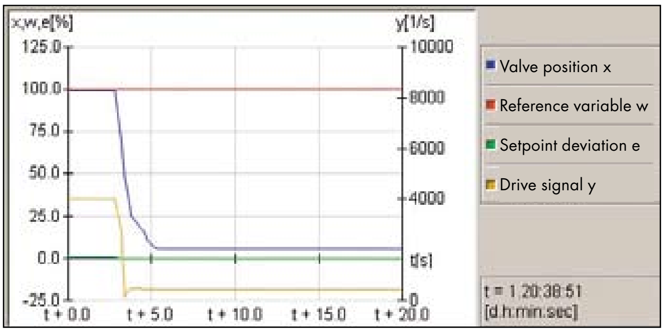


Fig 14: Documentation of full stroke test using data logger

stroke and/or friction tests. Solenoid valves integrated into the positioner use the common output stage of the pneumatics section, which is required for and tested during a partial stroke test. When failsafe action is triggered, the microprocessor also records how the safetyrelated valve reached fail-safe position over the course of time (course of travel over time recorded during full stroke testing).

The end positions can be indicated as binary signals issued by limit switches complying with IEC 60947-5-6, which are coupled to the analog travel sensor in the positioner and can thus be adjusted easily. As an alternative, the positioner can be equipped with inductive limit switches.

Partial stroke testing is utilized to check whether the valve stem can still be moved. A major benefit is that fail-close valves can be caused to open by a certain percentage of travel, e.g. in a step change from 100 % valve opening to 90 % and down to 70 % (Figure 13). In combination with internal cancellation conditions based on the valve position, the transit time and the drive signal, performing stroke tests with a predefined ramp function allows them to be stopped more quickly, e.g. when the initial breakaway torque has increased considerably. From a practical point of view, regular partial stroke tests (e.g. carried out once a day) keep the initial breakaway torque from increasing too much and thus improve the valve's reliability.

Using a data logger integrated into the positioner, the results of a full stroke test can be recorded, as can the course of the valve position over time (Figure 14) in case the valve is closed when its failsafe action is triggered. In addition, the data logger automatically traces unintentional shutdowns.

Summary and outlook

Automation of "binary" on/off valves is currently undergoing considerable changes. Integration has advanced thanks to new attachment options and standardized interfaces stipulated, e.g. in VDI 3845. Limit switches, mounting kits, adapters and solenoid valves are increasingly combined into single units, moving further and further away from the Christmas-tree-like setups common in the past.

Due to stricter requirements placed on safety and availability, smart, communication-enabled positioners are used more and more often. They permit bidirectional communication over a bus, include diagnostic and testing functions (e. g. partial and full stroke tests), can be equipped with a single unit carrying solenoid valve and limit switch, are suitable for integral attachment to the control valve, and offer convenient operation both directly on site and remotely using software.

This trend towards smart on/off valves is just beginning to evolve and is definitely set to continue. Advanced integration of actuators and accessories, simpler power supply and more convenient start-up procedures are areas that offer room for improvement in the future.

Dr. Jörg Kiesbauer,
Director of Research & Development
SAMSON AG, Frankfurt am Main, Germany
Phone: +49 69 4009-0
E-mail: drjkiesbauer@samson-ag.com

Guido König,
SAMSON AG, Frankfurt am Main, Germany
Phone: +49 69 4009-0
E-mail: gkoenig@samson.de

SAMSON AG · MESS- UND REGELTECHNIK · Weismüllerstraße 3 · 60314 Frankfurt am Main · Germany
Phone: +49 69 4009-0 · Fax: +49 69 4009-1507 · E-mail: samson@samson.de · Internet: www.samson.de

2008-10 ST · WA 196 EN