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WHITE PAPER

IoT-Enabled Positioners Outperform Volume Boosters in Balancing Stroke Speed and Precision

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IoT-enabled smart positioners balance quick stroke speed and precision to maximize valve production and reliability

In many critical applications, such as compressor anti-surge applications, valves are required to both open quickly and maintain precision control to setpoint. But the balance between fast stroke speed and precision control is difficult to achieve. To achieve an acceptable balance, complex pneumatic systems are used. These systems utilize components originally developed in the 1940s. These 'dumb' components limit the effectiveness of the system, often resulting in poor performance.

To meet the unusually fast stroke speed requirements of valves in critical applications, many plants have relied on a complex arrangement of volume boosters, lock-up valves and solenoids. Or, they use positioners pieced together from a computer, electronic feedback stepper motor and custom spools. While these pneumatic systems can provide the fast stroke speeds required for these applications, they sacrifice precision control to achieve speed, or they may not be well suited to the demanding environments where these valves are located.

Figure 1: *To achieve fast stroke speeds and precision control, plants have used increasingly complex arrangements of volume boosters (circled).*

Setting up and tuning the complex pneumatic systems requires arduous and time-consuming procedures that delay start-up and frustrate plant technicians. Troubleshooting the many components of the pneumatic system is difficult, since most of the components cannot provide the plant technician with diagnostic feedback.

Advancements in smart positioner capabilities now make it possible to achieve capacities of up to 50 Cv through the positioner alone. With this ability, both fast speed and precision control are possible without the need for complex systems, tuning or even special training. Such new systems allow plants to maximize valve productivity and reliability without the drawbacks of volume booster-based control systems.

These smart positioner systems work by communicating directly with the characterized relay in real time to deliver proportional pneumatic output for both precision control for small step changes and high flow when fast stroking speeds are required.

In addition to balancing the needs for fast stroke speeds and precision control, these smart positioners also significantly simplify calibration and tuning, saving time. Tuning complex systems can take hours, whereas new smart positioner systems reduce this time to five minutes with the push of a button. These systems also enable advanced diagnostic capabilities that allow users to quickly check the status and health of both the positioner and the valve locally, or via a plantwide asset management system.

The problem with volume boosters

Since being introduced in the 1940s, volume boosters were among the few solutions available to plants that needed to increase valve stroke speed. Volume boosters receive a pneumatic control signal from an auxiliary device such as a transducer, valve positioner or other control means. This pneumatic signal controls the pressure into and out of the booster. Ingoing pressure applies force to one side of a diaphragm and changes the output pressure. As the diaphragm moves, it opens or closes the poppet, which controls the flow of air into the cylinder to stroke the valve.

Although volume boosters successfully increase stroke speed, they have significant drawbacks.

Lack of a feedback mechanism prevents precision

The positioner feeds compressed air in and out of the actuator to move it open and closed. The volume booster is intended to augment the volume of air going in and out of the actuator, making it stroke faster. Because the volume booster is a simple pneumatic device with no feedback mechanism, the positioner cannot read or precisely control the opening and closing of the volume booster. The result is poor precision and slower stroke speeds.

No micro-adjustment capabilities restrict responsiveness

Volume boosters use fixed components, and other than a bypass valve used to adjust the amount of deadband for stable control, there is no way for a user to tune the settings (see Figure 2). Since there is no ability to make small adjustments to the flow, volume boosters either provide a lot of flow or no flow. Further, the change between flow volume is nearly instantaneous, making it very difficult to precisely control the small flows needed to make minor step changes.

Volume boosters sacrifice precision for speed

The volume booster is a mechanical device containing no electronics, no sensors and no feedback. All tuning is done manually via a needle valve (bypass valve). Too far out and speed is lost. Too far in and precision control is lost.

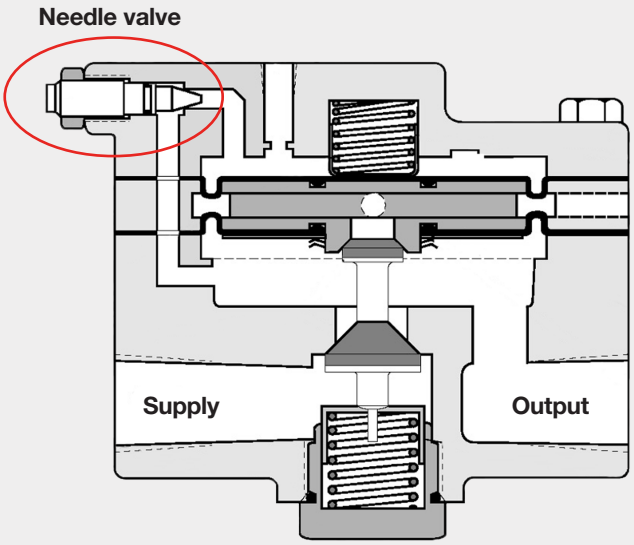


Figure 2: *Typical volume booster construction. Circled needle valve provides only means of tuning.*

Complex systems require more maintenance

As stroke speeds become faster or actuators become larger, more compressed air flow is required. This has led to plants using even more complex systems, including multiple volume boosters, lock-up valves, solenoids, tubing and air tanks, all working together to stroke a valve. These complex systems are cumbersome and have many moving parts that must be maintained. Since the failure of a single component can cause the whole system to go down, as the systems become more complex, failure is more likely.

Manual tuning introduces human error and increases labor

Volume boosters must be manually set up at installation and then tuned periodically to get the desired performance. Tuning, testing and re-tuning can take a skilled individual several hours, increasing maintenance labor and costs.

Smart positioners emerge as a more reliable alternative

For years, plants were willing to sacrifice stroke precision when using volume boosters to increase valve stroke speed because volume boosters were one of the few options available.

Now, by integrating IoT-enabled positioners and a relay, it is possible to achieve precision control and flow rates high enough to eliminate the need for pneumatic volume boosters. Smart positioners simplify the control systems, improve valve performance, and allow plants to monitor system performance in real time.

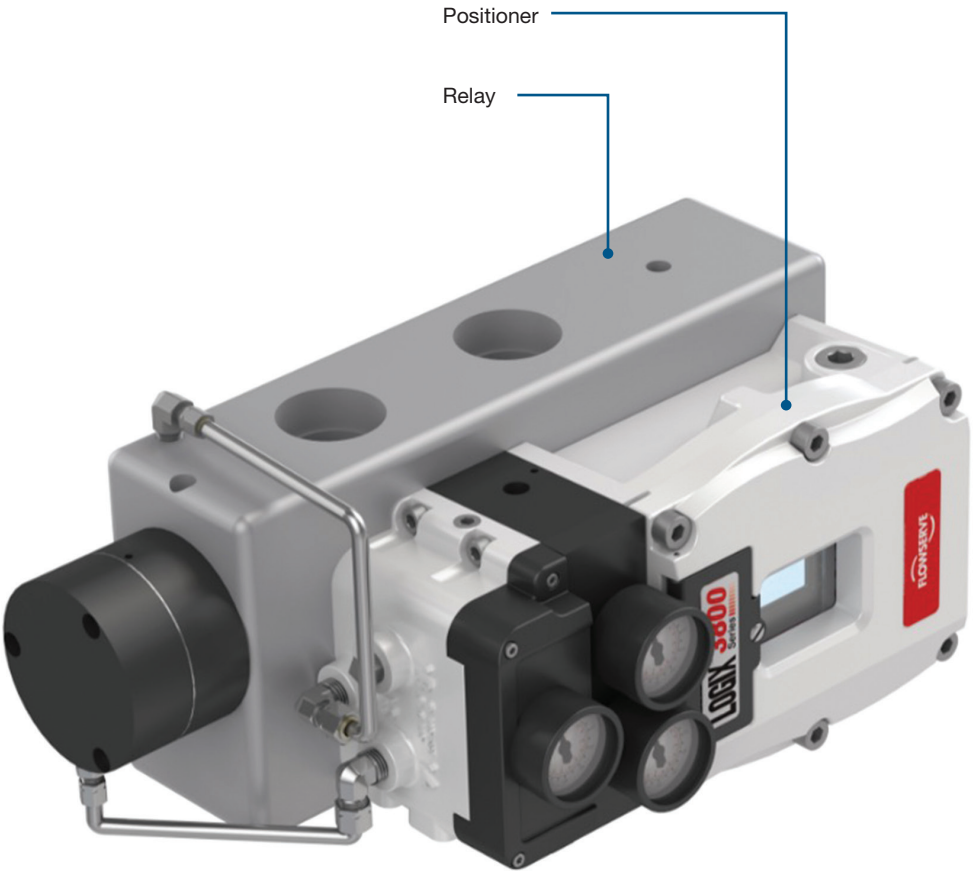


Figure 3: *By using a smart positioner paired with an integrated high-volume relay, you can achieve precision control and flow rates high enough to eliminate the need for pneumatic volume boosters.*

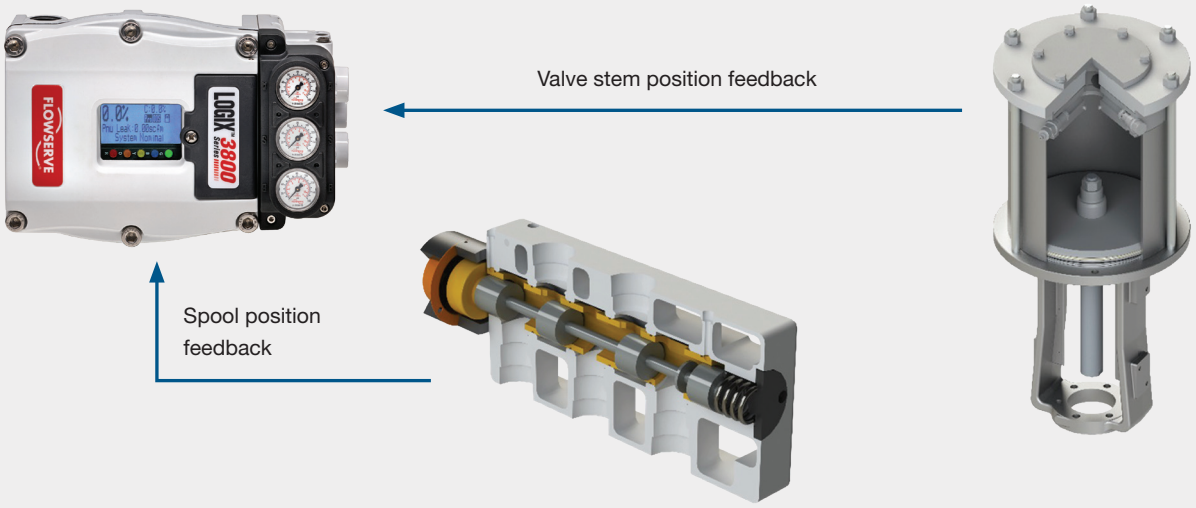
**Patents pending*

Three-stage, closed-loop position control balances speed and precision

A smart positioner using a three-stage feedback loop can overcome the longstanding compromise between stroke speed and precision (see Figure 4). The three stages consist of an inner loop (pilot relay control), a high-flow relay loop, and an outer loop for stem position control. The innermost loop controls the position of the high-flow relay. A sensor provides high-flow relay position feedback. The high-flow relay controls the position of the actuator. A separate position sensor provides stem position feedback.

In the outer loop, the final command is compared against the stem position. If any deviation exists, the high-flow relay loop sends a signal to move the relay in a direction, depending upon the deviation. The inner loop then quickly adjusts the relay poppet valve, which changes the high-flow relay position. The stem movement reduces the deviation between the final command and stem position. This process continues until the deviation is zero.

With two levels of continuous feedback and adjustment mechanisms, the smart positioner can rapidly stroke large actuators, opening valves in as little as one second.



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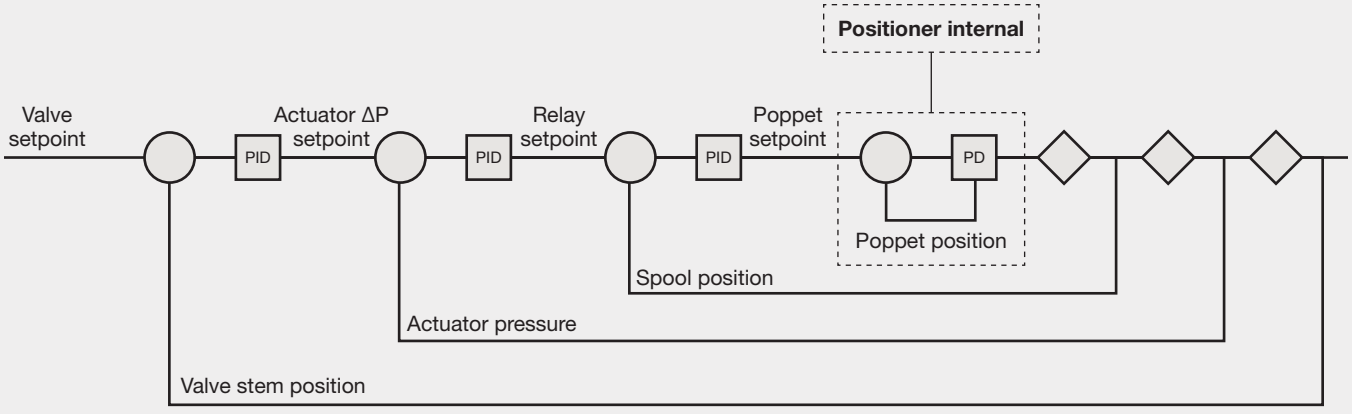

Figure 4: *A three-stage feedback loop is required to balance stroke speed and precision.*

Sensors enable system diagnostics for immediate response

IoT-enabled positioner systems feature advanced diagnostic capabilities that identify valve and actuator problems. Smart positioner systems can perform diagnostics to monitor the health status of a wide range of valve and actuator assemblies. These sensors can assess:

- Instrument air supply pressure
- Proper adjustment of the packing and seals
- Leak detection
- Friction and wear
- Poppet and spool stiction

Not only can a smart positioner system detect a problem, depending on the type of DTM the plant is using, the system can also advise which corrective action to take to fix the problem and prevent a failure. By alerting technicians when a valve or actuator experiences an issue and how to fix the problem, plants can increase uptime and keep small problems from turning into production-stopping failures.

One-button calibration and tuning

Smart positioners overcome the manual challenges found in volume boosters through one-button calibration and tuning. Both tuning and calibration are completed with the push of one button in as little as two minutes. Commissioning is simplified with a one-button setup that automatically configures the zero, span and gain of the positioner for most valves in less than five minutes.

Because of the one-touch tuning and calibration capabilities, plant maintenance technicians can tune the system without relying on factory experts, lowering operating costs and increasing uptime.

Because the system integrates with industry-leading communication technologies such as HART, 4-20mA or discrete I/O signals, plants can also calibrate and tune the positioner remotely, reducing the time technicians have to travel to sites.

Reduced total cost of ownership (TCO)

Replacing pneumatic control systems with smart positioner systems can also significantly reduce total cost of ownership. Flowserve has found that smart positioners can reduce the TCO by 20 to 40% compared to volume boosters. This savings includes the following:

- Reduces the startup and maintenance commissioning times by 80%
- With fewer components, failure modes are reduced
- Reduces preventative maintenance and on-site diagnostic times by 25%

Costs are lowered even further because smart positioners are “loop powered.” The system can run on 4-20 milliamps (the signal from the control room) and does not require a 110-volt or 240-volt DC power supply, which may not be available in some locations.

Conclusion

IoT-enabled smart positioners deliver precise control and exceptionally fast stroke speeds in a simple, easy-to-use, easy-to-tune and easy-to-maintain system. Smart positioners eliminate the need for problematic volume boosters and switching valves. They provide a simple user interface (UI) with a localized menu structure and quick-calibration functions that simplify setup and tuning. The advanced diagnostic capabilities of the positioners allow users to quickly check the status and health of both the positioner and the valve.

Flowserve can help

Flowserve manufactures the Logix 3800JF™ smart positioner and the pneumatic JetFlow™ relay, which provide high flow rates and fast stroke speeds. Together, they deliver proportional pneumatic output for both precision control for small step changes, and high flow when fast speeds are required. Additionally, the JetFlow relay eliminates the need for volume boosters and contains only two moving parts, which reduces complexity. Please contact your local Flowserve sales representative to learn how we can help maximize valve production and reliability.

About the authors

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Ken has more that 35 years of experience designing control valves and positioners as a development engineer, and as a director in engineering and product management. He earned a master's degree from Brigham Young University in engineering.

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R&D Engineer, Flowserve Corporation

Doug has more than 15 years of experience in research and development in addition to supporting and marketing positioners at Flowserve. He contributed to key developments in the Logix positioner product line and has patents pending on the Logix 3800JF positioner. Doug is an expert in FieldBus, HART, control systems, PID control, positioner electronics, embedded code and mechanical hardware relationships. He earned a bachelor's degree in computer engineering at Utah State University.

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Brad has more than 25 years of experience with Valtek® and Flowserve, contributing and leading as an application engineer, project manager and product manager. He holds numerous patents in the areas of control valve construction, anti-noise designs for control valves, and anti-cavitation designs for control valves. Brad earned a bachelor's degree in mechanical engineering from Brigham Young University.

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