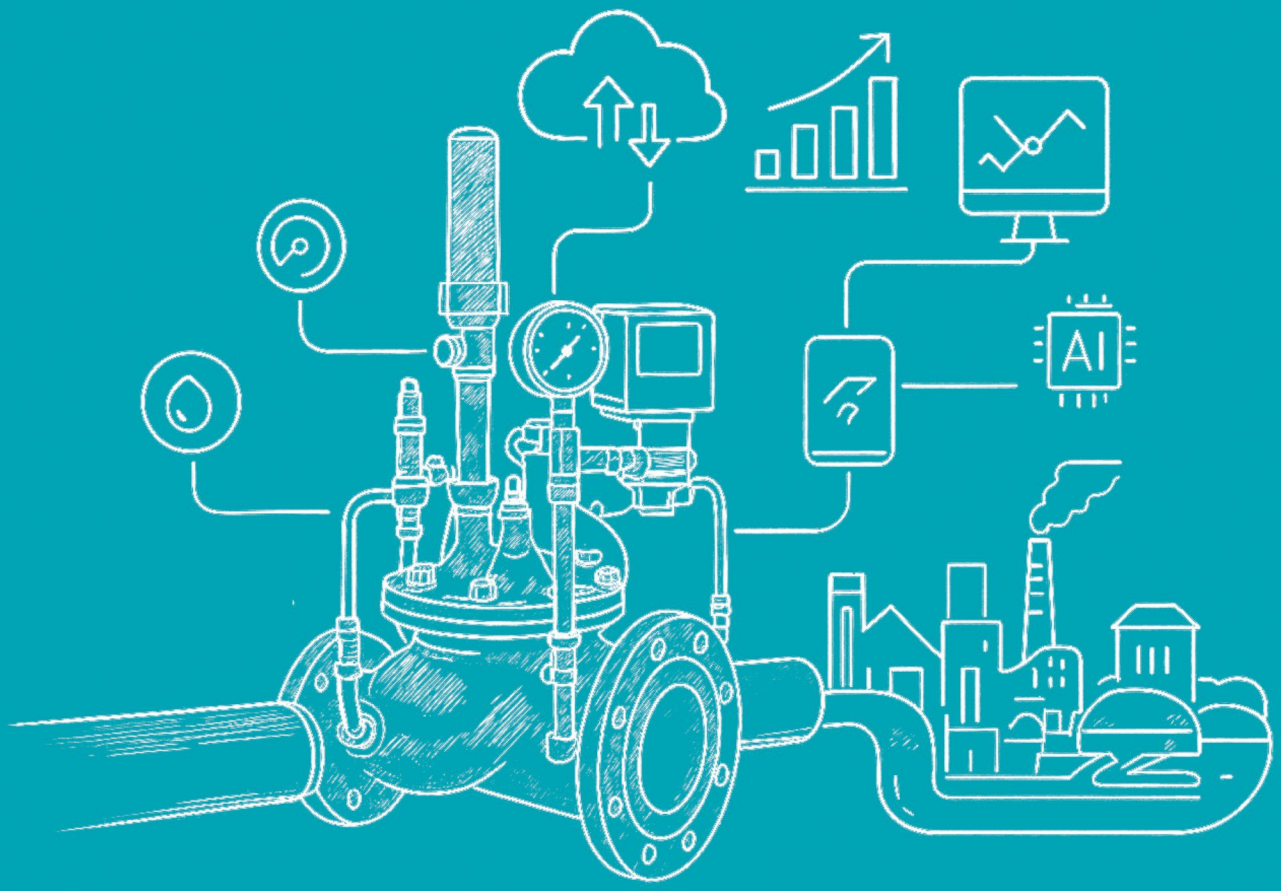
ALTON

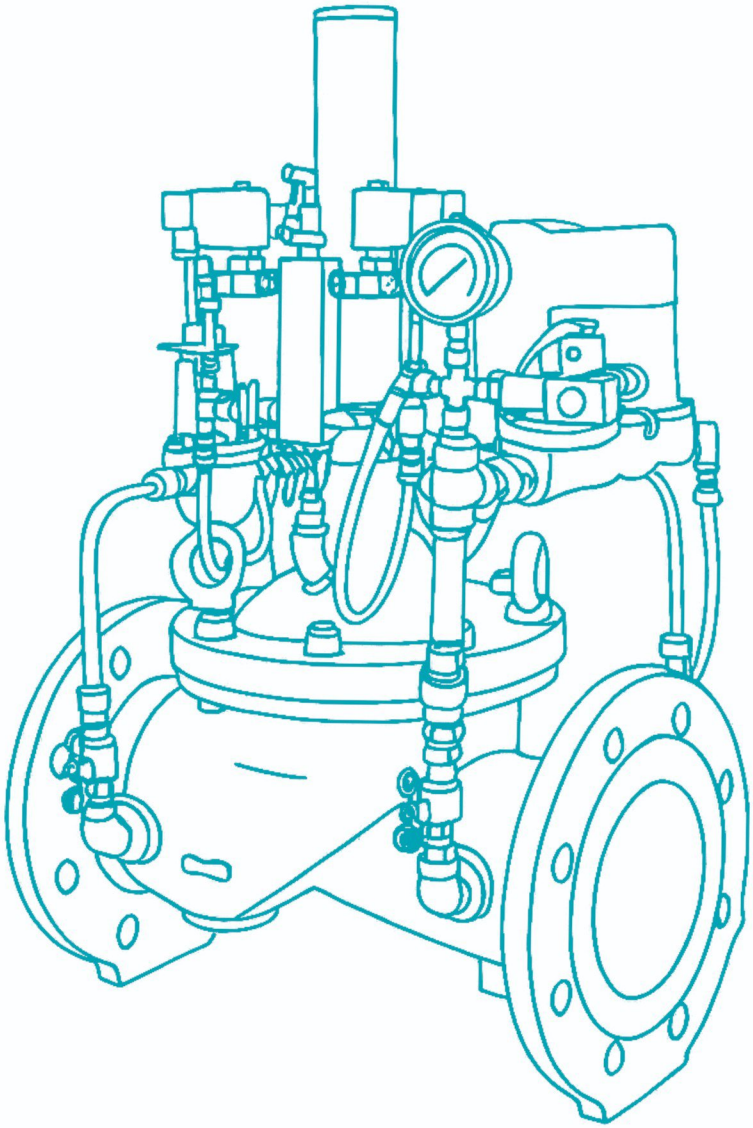
Smart Valve Controller



1.Introduction

The **Smart Valve Controller** is an advanced retrofit and AI-enabled platform that transforms conventional hydraulic valves into fully autonomous and intelligent control devices. Designed for water distribution and transmission systems, it enables utilities to achieve precise pressure regulation, optimized flow control, and predictive network management—without the need to replace existing infrastructure.

Unlike traditional controllers, our solution integrates **multi-layer pressure management, advanced alarm handling, cloud-based analytics, and strong cybersecurity**. This makes it suitable not only for leakage reduction but also for comprehensive digital transformation of water networks.



2.System Overview

The solution consists of three integrated layers:

2.1 Hardware Layer

-Controller Board:

- ARM Cortex-A53 processor
- Secure boot and encrypted storage
- Low-power consumption (<6W average

-Sensors & Inputs:

- Pressure transducers (accuracy is 0.5% FS)
- Flow sensing (virtual and external pulse or analog input)
- Valve position feedback
- Expansion for vibration, acoustic, seismic, flood, or intrusion sensors

-Actuators:

- Electro-hydraulic or motorized valve actuation
- Fail-safe design with emergency shutoff capability

-Power Supply:

- 9–48 VDC with surge and polarity protection
- Backup battery option for uninterrupted operation

-Enclosure:

- Industrial-grade IP68 rugged housing
- Wide operating range: –20°C to +70°C

2.2 Software Layer

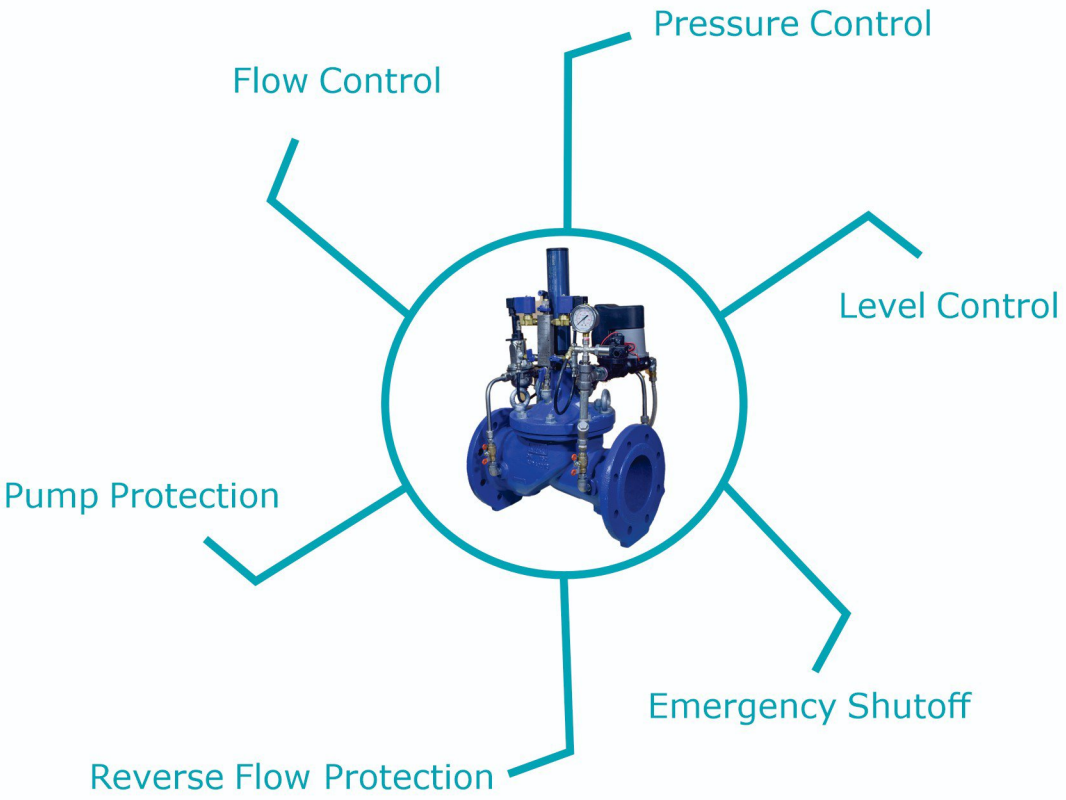
- Embedded multithreaded architecture
- Real-time closed-loop control with adaptive self-learning algorithms
- Virtual flow sensing (no need for external flow meter)
- Configurable safety logic (pause control if abnormal conditions persist for >30s)
- Local event logging and data buffering in case of communication loss

2.3 Communication Layer

- Protocols Supported: MQTT, OPC-UA, Modbus RTU/TCP, HTTPS, IEC 101/104, DNP3
- Interfaces: Wi-Fi, Ethernet, 4G LTE, NB-IoT, LoRaWAN, RS-485
- Cybersecurity: Encrypted communication, role-based access, server authentication
- Cloud Integration: Secure link to centralized analytics and monitoring servers

3.Control Modes

The Smart Valve Controller supports six advanced control modes. Each mode combines real-time sensing, adaptive algorithms, and safety mechanisms to ensure reliable operation under different hydraulic conditions.



1.Pressure Control (3-layer approach):

In this mode, the Alton Smart Valve Controller is installed on an automatic control valve and regulates the downstream pressure to a predefined setpoint. This functionality is critical for urban water supply zones, regional distribution lines, and pressure reduction points at the entry of consumer areas.

The main control parameter is the outlet pressure, while other variables such as flow, valve opening percentage, inlet pressure, and reverse flow are managed as auxiliary conditions or protections. The setpoint can be set in the following three modes:

Fixed Setpoint Mode: Maintains constant pressure.

Flow-Compensated Mode: Adjusts pressure dynamically according to real-time flow.

Time-Scheduled Mode: Applies user-defined pressure profiles based on time of day or season.

3.Control Modes

2.Flow Regulation Mode:

In this mode, the Smart Valve Controller regulates the flow rate through the valve according to operator requirements. It can operate under two distinct working modes:

Fixed Setpoint Mode: The operator defines a constant flow setpoint, and the controller continuously adjusts the valve to maintain this target.

Timetable Mode: The operator provides a schedule (timetable) with different flow setpoints for different times of day, allowing dynamic flow management based on demand zones or consumption patterns.

3.Level Control Mode:

In this mode, the Alton Smart Valve Controller is used to maintain a target water level in downstream storage tanks or elevated reservoirs. A level transmitter installed in the tank continuously sends water level data to the controller. The controller then adjusts the valve opening to regulate inflow and maintain the desired level.

This mode is particularly useful for remote reservoirs, gravity-fed systems, and tanks where overflow or low level could disrupt operations.

4.Pump Protection Mode:

In this mode, the Alton Smart Valve Controller plays a vital role in protecting pumps. It is specifically designed for applications where the valve is installed in the pumping line, and sudden valve movements or pressure changes can affect the pump's performance or cause damage.

The controller monitors pressure sensors, diaphragm feedback, and learned patterns to detect pump-critical conditions such as dry-run operation, water hammer events, and reverse flow. It automatically adjusts the valve to a safe position or sends alerts to the control center.

5.Reverse Flow Protection Mode:

This mode ensures that flow is prevented from reversing through the valve, a critical protection especially in distribution zones connected to multiple supply lines or pumping systems. Reverse flow can result in back-siphonage, contamination risks, and pressure disturbances in upstream pipelines.

The controller monitors flow direction using its internal logic or optional flow sensors. Upon detecting any unauthorized reverse flow, it commands the valve to fully close, while also logging the event and sending alerts to operators.

6.Emergency Shutoff Mode:

In this mode, the Alton Smart Valve Controller acts as an automatic rapid shutoff unit in emergency situations. Such events may include earthquakes, floods, severe leakage, unauthorized access to the valve chamber, or other critical incidents requiring immediate flow isolation.

The controller connects to external safety and environmental sensors—such as vibration detectors, flood alarms, or intrusion sensors—and instantly commands valve closure upon receiving a trigger signal. A simultaneous alert is sent to the central control system or local operator.

This protection mode, like Reverse Flow Protection, can be enabled in parallel with other operational modes.

4.Alarm & Safety System

A robust alarm management system ensures operational safety and proactive response:

- **Alarm Thresholds:** Configurable high/low limits for input and output pressures, flow, and valve position.
- **Timed Response Logic:** If a threshold violation persists for more than 30 seconds, control is paused until normal conditions are restored.
- **Sensor Expansion:** Optional vibration, acoustic, seismic, or intrusion sensors can be integrated for advanced monitoring.
- **Automatic Logging:** Alarms, warnings, and system events are logged with timestamps.
- **Downloadable Reports:** Operators can download logs from the web dashboard.
- **Real-Time Notifications:** Alarms are sent instantly to the server for central monitoring and decision-making.



5.Web Dashboard & Server Analytics

The system is complemented by a **dedicated analytics server** and **user-friendly web interface**:

- **Real-Time Monitoring:** Live visualization of input and output pressure, flow, level, and valve positioner.
- **Historical Analysis:** Graphs of daily and long-term performance (All parameters over 24h).
- **Alarm Visualization:** Timeline and event-based charts for quick incident tracking.
- **Downloadable Logs:** 30-minute interval reports available in CSV.
- **Remote Reconfiguration:** Update setpoints, control phases, or switch modes remotely.
- **Cybersecurity:** Multi-level user authentication, encrypted data channels, and intrusion protection.
- **Predictive Insights:** AI-driven leak detection, abnormal pattern recognition, and failure prediction.

The controller stores multi-day operational data that can be visualized in detailed trend charts. On the server interface, daily analytics provide a clear overview of network conditions within a 24-hour window, while the controller retains extended historical records for long-term performance evaluation.

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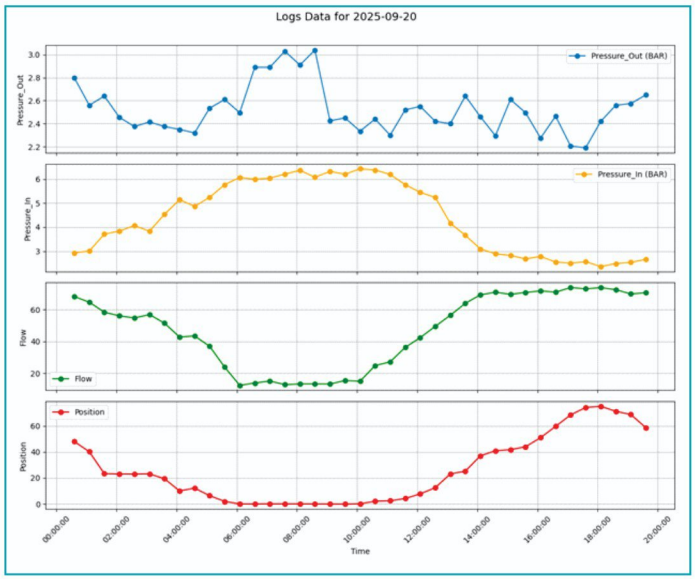
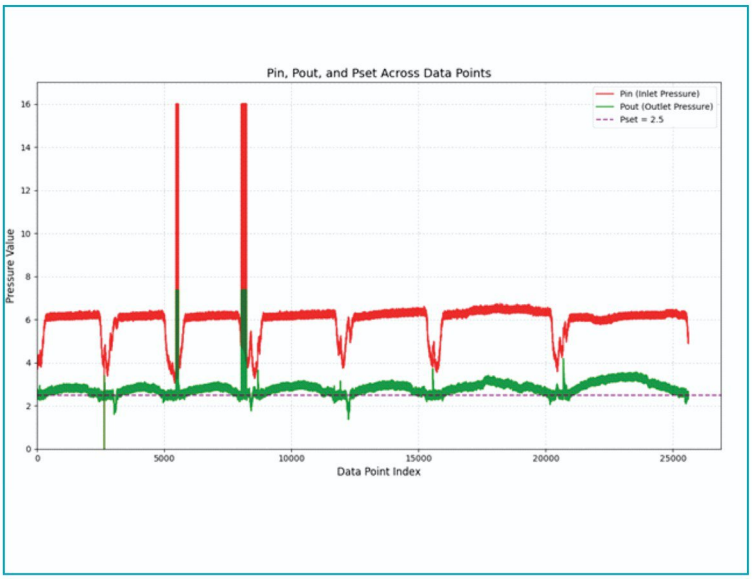




6.Flow Internal Analysis

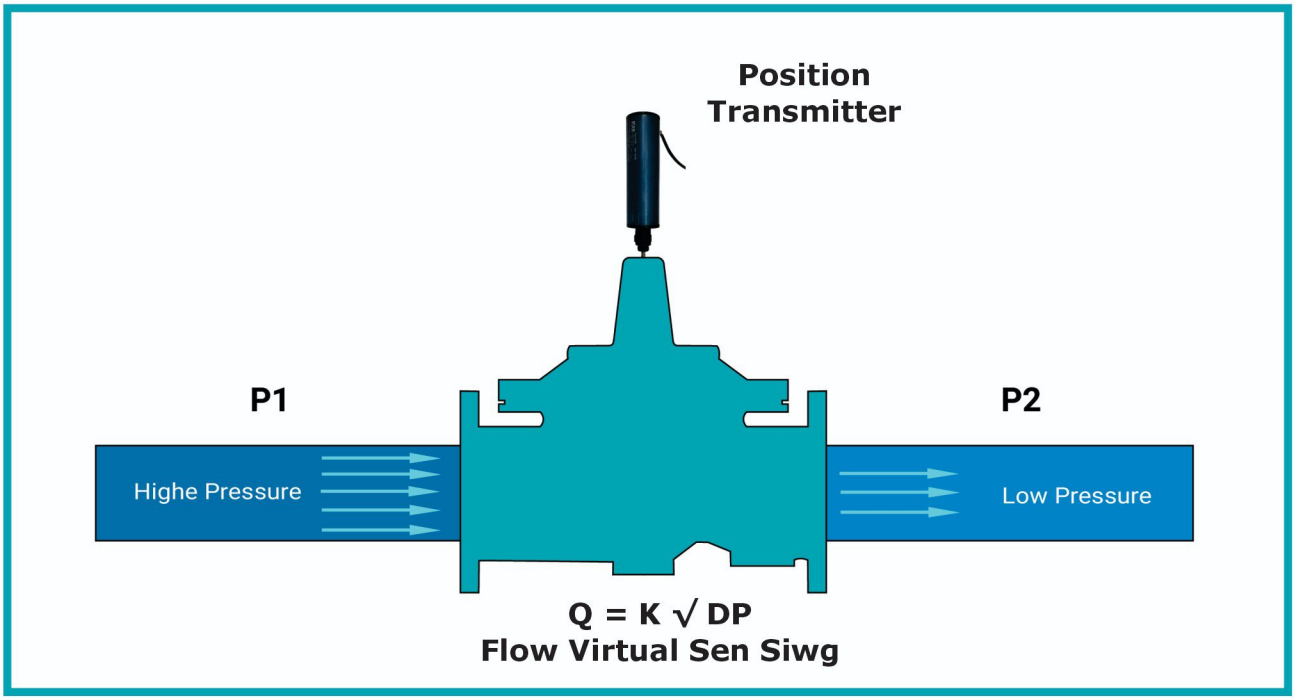
The Smart Valve Controller integrates an **internal flow estimation module** that enables accurate flow calculation without relying solely on external flow meters. This functionality is achieved through continuous learning of the valve's hydraulic behavior and analyzing the relationship between pressure, valve position, and flow dynamics.

To ensure data reliability, the system applies advanced preprocessing and filtering steps, including:

- **Outlier Detection and Removal**: Abnormal spikes or noise in pressure/flow readings are automatically excluded.
- **Data Smoothing**: Rolling averages and exponential filters are used to minimize fluctuations while preserving real-time responsiveness.
- **Consistency Checks**: The algorithm prevents unrealistic flow jumps by validating new measurements against recent historical trends.

As a result, the controller achieves the **lowest error margin to date** in internal flow estimation, ensuring accurate performance even under varying hydraulic conditions. The learning algorithm is continuously improved, making the model adaptive and more robust over time.

This internal flow module not only enhances control accuracy but also reduces dependence on external instrumentation, lowering deployment costs while enabling predictive and reliable operation.



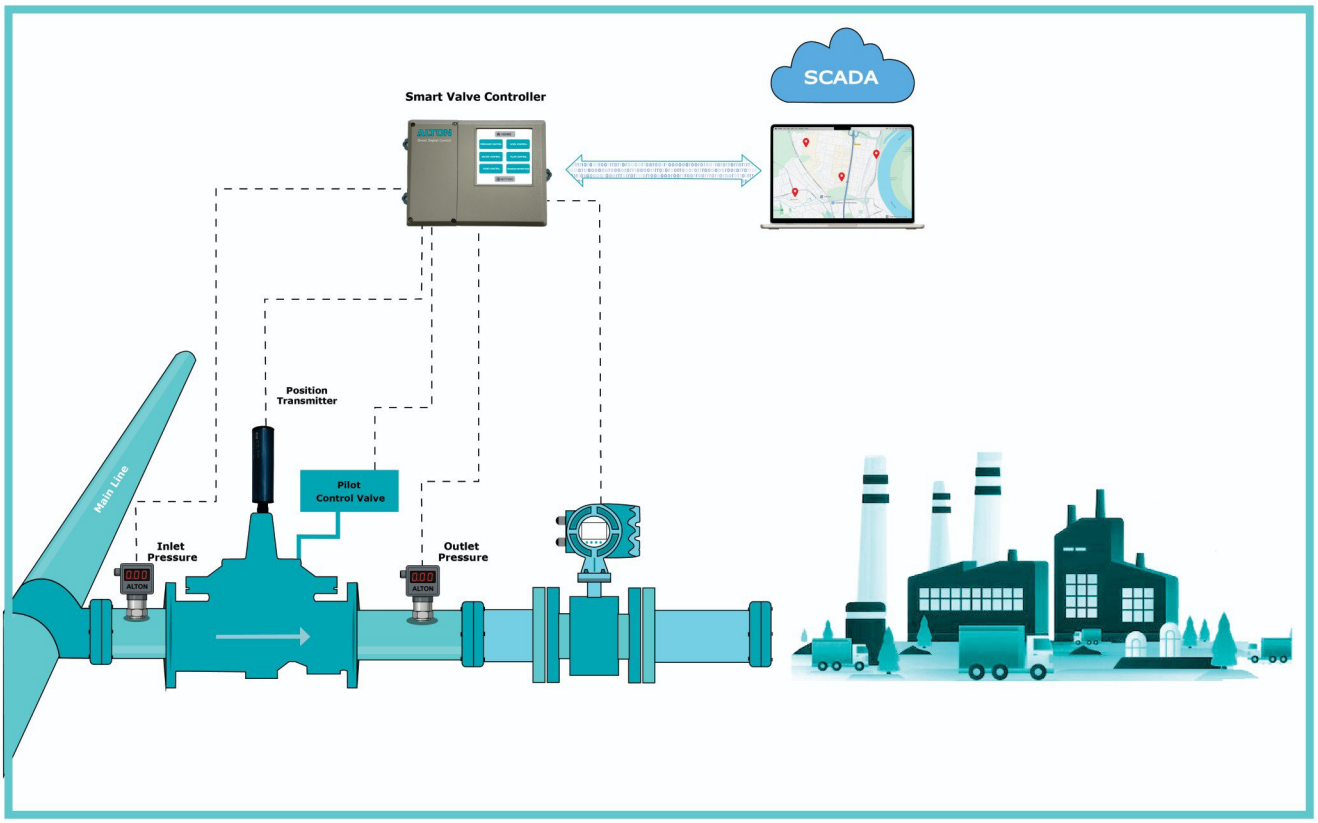
7.Features & Benefits

Features

- Six advanced control modes including hybrid adaptive operation
- Three-layer pressure management strategy
- AI-based diagnostics and predictive maintenance
- Integrated alarm safety logic with timed shutdown
- Expandable sensor ecosystem for complete situational awareness
- Cloud-based analytics with real-time and historical charts
- Web dashboard with remote monitoring and configuration
- Secure multi-protocol communication (MQTT, OPC-UA, Modbus, HTTPS, etc.)
- Fail-safe design with automatic fallback setpoints

Benefits

- **Leakage Reduction:** Dynamic pressure management minimizes bursts and NRW.
- **Energy Efficiency:** Optimized pumping and reduced operational costs.
- **Reliability:** Alarm-driven protection prevents system damage.
- **Scalability:** Modular design adaptable to municipal or industrial networks.
- **User Empowerment**: Easy-to-use dashboard with full remote access.
- **Cybersecurity:** Secure operation against unauthorized access.



8.Technical Specifications8

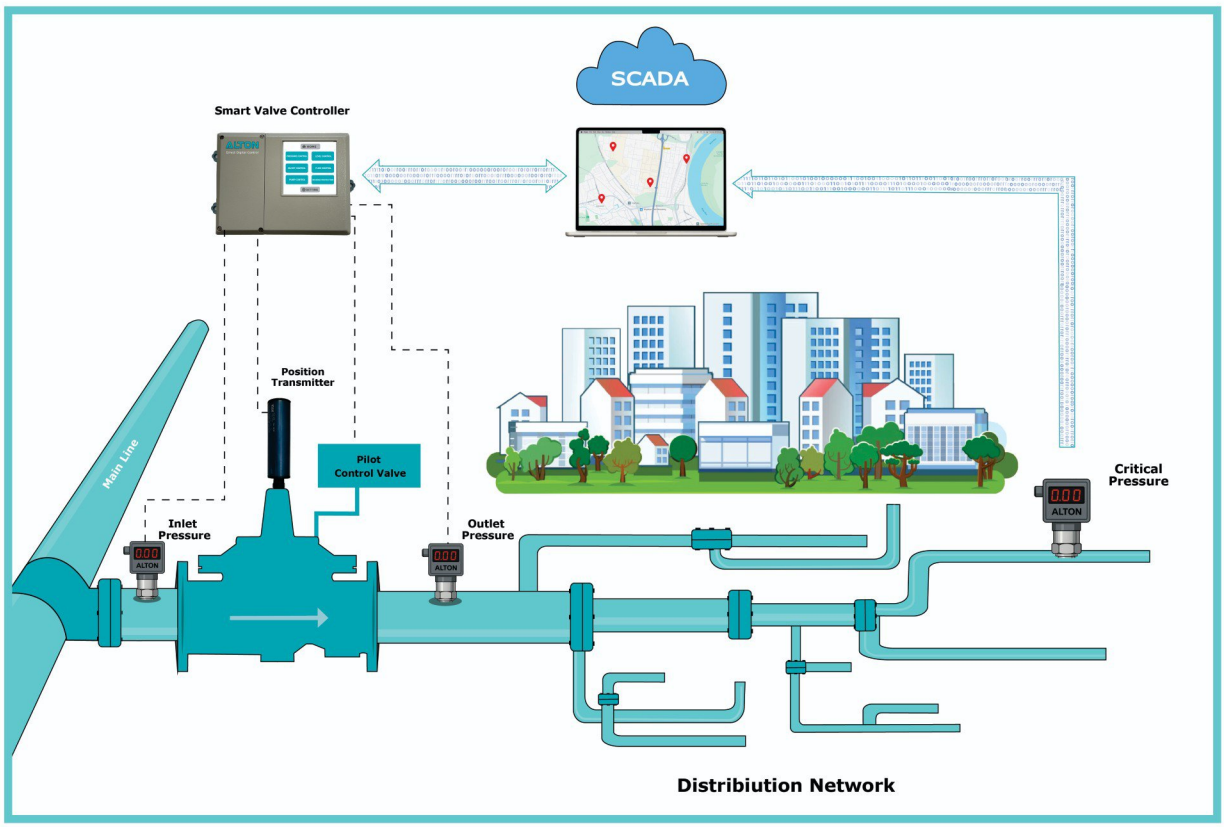
- **Processor:** ARM cortex-A53
- **Memory/Storage:** MicroSD
- **Power Supply:** 9–48 VDC, surge/polarity protection, <6W
- **Operating Range:** –20°C to +70°C
- **Enclosure:** IP68-rated, rugged industrial design
- **Sensors:** Pressure, flow, diaphragm position, optional acoustic/seismic/intrusion
- **Communication:** Wi-Fi, LTE, NB-IoT, LoRaWAN, RS-485, Ethernet
- **Protocols:** MQTT, OPC-UA, Modbus RTU/TCP, HTTPS, IEC 101/104, DNP3
- **Security:** End-to-end encryption, secure boot, role-based access



9.Conclusion

The Smart Valve Controller is a next-generation, AI-driven water network management platform. It delivers unmatched control flexibility, predictive intelligence, and operational safety—outperforming traditional and modern competitors alike.

By enabling real-time monitoring, data analytics, and remote control, it ensures smarter, safer, and more efficient water distribution for municipalities and industries worldwide.



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