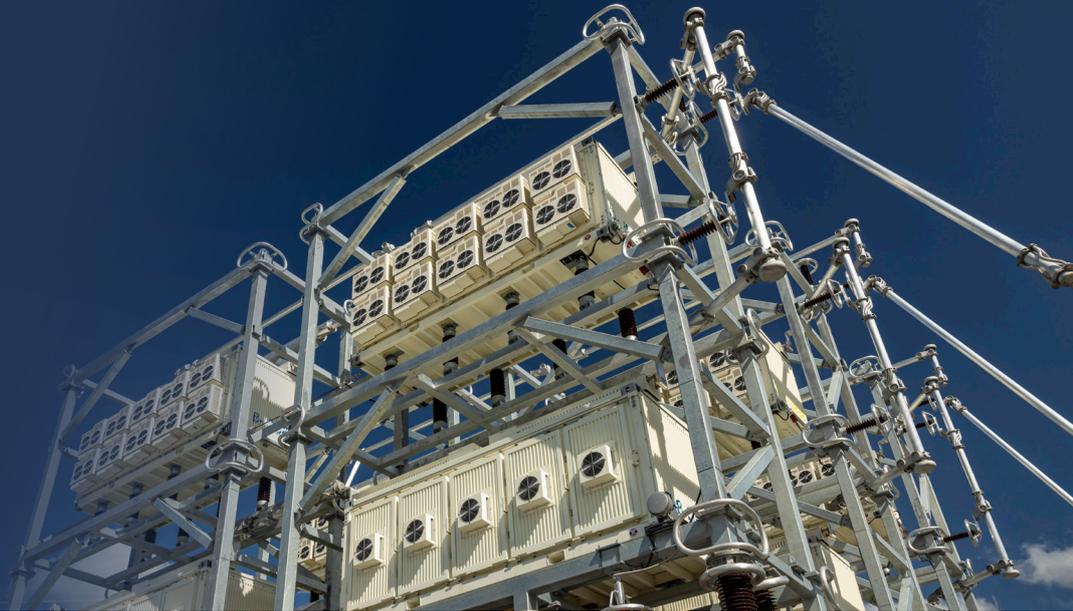


SmartValve™

v1.04



SmartValve is an advanced power flow control technology that quickly solves overloads and other grid issues to unlock extra capacity on the existing network. It is a patented, award-winning, single-phase, modular Static Synchronous Series Compensator (m-SSSC) that injects a voltage in quadrature with the line current to synthesize a capacitive or inductive reactance. This means it can increase or decrease power flows on a circuit and perform dynamic services including improving voltage stability and transient stability.

SmartValve is the next logical step in the progression of series-connected FACTS (Flexible Alternating Current Transmission Systems). SmartValve employs voltage-source converter (VSC) technology, and its power electronics use insulated-gate bipolar transistors (IGBTs) that have been widely used for utility-scale VSCs, including StatComs and HVDC systems. Unlike physical series capacitors or inductors, the injected voltage can be controlled independently of the line current, allowing the series reactance produced by the device to be varied in real time. Also, SmartValve does not have the negative characteristics of these passive devices, such as high risk of sub-synchronous resonance (SSR) with series capacitors and the constant VAR consumption of series reactors.

Previous SSSC technologies required site-specific designs, series injection transformers, water cooling across a high-voltage gradient, circuit breaker bypass protection, and considerable substation space – all driving significant solution cost and extending project timelines. SmartValve leverages a modular, transformerless approach, sealed cooling systems at line potential, integrated fast-acting semiconductor bypass switch, and deployment flexibility to deliver greater solution value. This move towards a modular, standard offering eliminates many disadvantages of previous devices, providing a flexible and scalable technology with high reliability, faster delivery and installation, with multiple network applications.

SmartValve solves critical grid challenges:

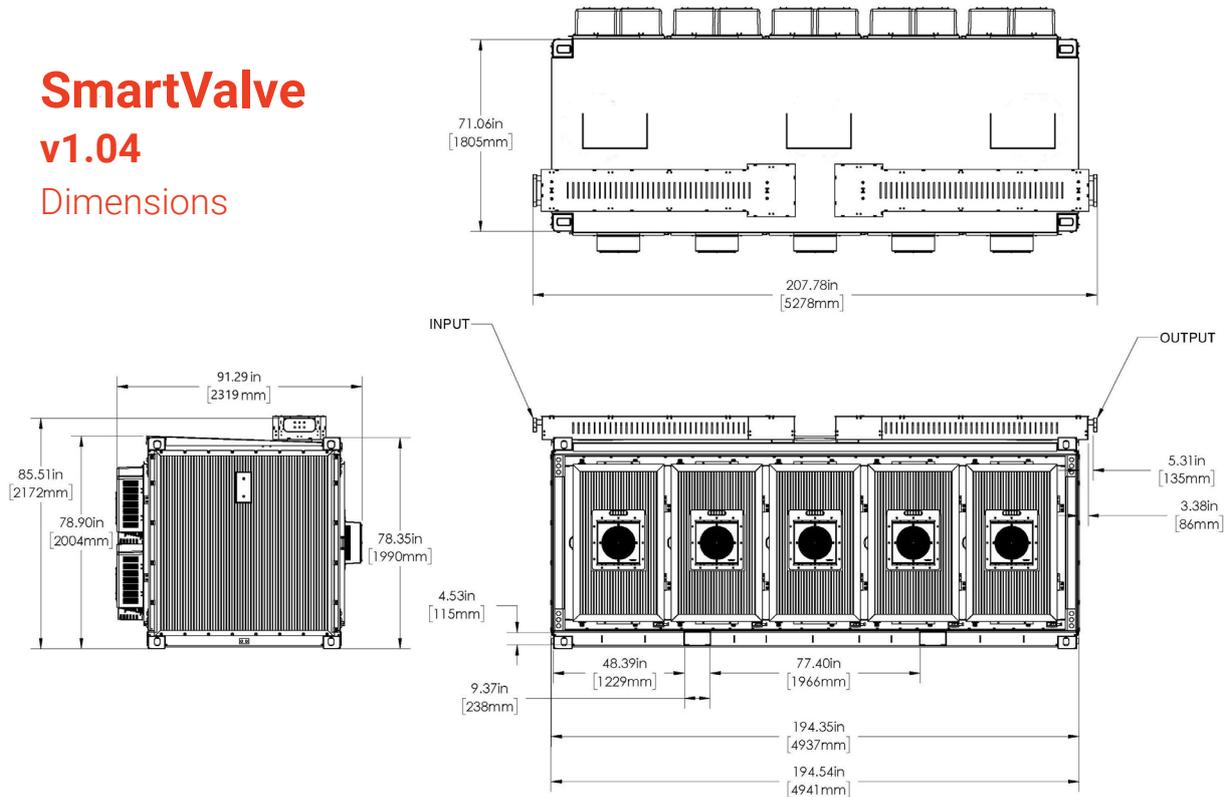
- Unlock extra capacity on the grid
- Quickly connect new renewables and demand
- Deliver critical projects on time and on budget
- Enable greater power flows between regions
- Lower cost of energy for consumers

Technical specifications

The SmartValve v1.04 devices are available with a maximum continuous power rating of 10 MVAR and a maximum continuous current rating of either 1800 A RMS or 3600 A RMS. The SmartValve devices are equipped with an integrated bypass and can withstand fault currents up to 63 kA for 1 second.

SmartValve devices and corresponding communication equipment are typically installed as part of a SmartValve System. The SmartValve System enables a continuous range of control between the minimum injection voltage of a single device per phase up to the aggregate maximum injection voltage rating of all devices in the system.

SmartValve v1.04 Dimensions



Electrical

Peak Fault Current Rating⁽¹⁾	164 kA @ 60Hz 158 kA @ 50 Hz	Maximum Rate of Change of Frequency (RoCoF) Withstand	2 Hz/s for up to 0.5 s 1 Hz/s for up to 1 s
Max Ramp Time from 0% to 90% of Maximum Injection Voltage⁽²⁾	200 ms	Maximum Corona-Free Voltage⁽³⁾	550 kV RMS line-to-line
Minimum Current for Monitoring⁽⁴⁾	70 A RMS	Power Source	Powered by line current
Minimum Current for Injection⁽⁴⁾	100 A RMS	Operational Frequency Range	47.00 Hz to 52.00 Hz 57.00 Hz to 62.00 Hz
Fault Current Rating	63 kA RMS for 1 s	Lightning Impulse Rating⁽⁵⁾	15 kA 8/20 μ s wave

Physical

Dimensions	See Figure Above
Mounting	Supported by ground-mounted insulators
Cooling	Liquid-cooling interface between power semiconductors and fan-equipped liquid-to-air heat exchangers using redundant fans and pumps all at line potential. Sealed enclosure coolers for controlling internal ambient temperature.
Intrusion Protection	IEC 60529, Designed to IP 55, Tested to IP X5
Snow Loading	50 lbs/ft ² (244 kg/m ²)
Corrosion Rating⁽⁷⁾	Class 3 (1440 hours)

Environmental

Operating Temperature Range⁽⁶⁾	-40°F to 104°F (-40°C to 40°C)
Maximum Sustained Rain	4.0 in/hr (102 mm/hr)
Condensing Operating Humidity Range	5% to 100%
Maximum Wind Speed	127 mph continuous (57 m/s) 150 mph gust (67 m/s)
Ice Loading	50 lbs/ft ² (244 kg/m ²)



Communication

Communication Architecture

SCADA integration via PowerLine Gateway™ and PowerLine Coordinator located at the substation

Communication Method

Fiber-optic communication between the communication system and the SmartValve devices

Telemetry

Sampling rate: 2 - 10 s
Typical number of SCADA points used for a 3-device SmartValve System: 110

Other

Electrical Connections

Joints that carry current during faults and Monitoring Mode tested to IEC 61284.
Joints that carry current during Injection Mode tested to ANSI-C119.4

Communication Security Features

The communication protocol uses SHA-256 to ensure cryptographic integrity of all messages while supporting full observability by utility firewalls

EDR

1,200,000 max samples per event
Sampling rates:
· HSR (High-Speed Recorder): 0.97 kHz - 1 MHz
· LSR (Low-Speed Recorder): 0.97 kHz - 31 kHz
· FSR (Fixed Sampling Rate): 0.97 kHz
Max duration single capture:
1200 ms (HSR) and 120 s (LSR and FSR)

Sensor Accuracy

AC Line Current ⁽⁸⁾ ± 3 %

Model-specific

Model	Maximum Mass	Nameplate Current Rating ⁽⁹⁾	Maximum Continuous Voltage Injection at 50 Hz or 60 Hz ⁽¹⁰⁾	Minimum Injection Voltage at 50Hz or 60Hz ⁽¹¹⁾
10-1800	16535 lbs (7500 kg)	1800 A RMS	± 5660 V RMS	± 566 V RMS ⁽¹²⁾
10-3600	17196 lbs (7800 kg)	3600 A RMS	± 2830 V RMS	± 283 V RMS

Model	Monitoring Mode Continuous Current Rating ^(4,13)	Injection Mode Continuous Current Rating ^(4,13)	Injection Mode 15-Minute Emergency Current Rating ^(4,13,14)	Injection Mode 1-Hour Emergency Current Rating ^(4,13,14)	Injection Mode 4-Hour Emergency Current Rating ^(4,13,14)
10-1800	2250 A RMS	1700 A RMS	2160 A RMS	2100 A RMS	1950 A RMS
10-3600	4320 A RMS	3500 A RMS	4320 A RMS	4250 A RMS	3920 A RMS

- Notes:**
1. Tested in accordance with IEC 62271-1:2017 Ed 2.1 (Clause 7.6) and IEC 62271-100:2021+AMD1:2024 CSV (Clause 5.104).
 2. The value shown is for an individual device upon receipt of the command to enter injection from the PowerLine Coordinator. This timing applies only to Fixed Voltage Mode injection commands. Fixed Reactance Mode and Current-Control Mode may have slower ramp times. For currents below 750 A RMS for the 10-1800 and 2000 A RMS for the 10-3600, ramp times may be slower. For a SmartValve System with n devices in series per phase, the maximum ramp rate of the set is n times the Maximum Ramp Rate listed.
 3. Tested in accordance with IEEE C37.30.1-2022 (Clause 7.8 and 7.9) and IEC 62271-1 Ed 2.1 (Clause 7.3, 7.9.1.1, 9.1 and Table 3). The value shown can only be reached with corona shield attachments.
 4. In Monitoring Mode, the SmartValve is bypassed and does not inject voltage, but telemetry data are still transmitted. In Injection Mode, the SmartValve injects voltage in series with the line, and telemetry data are transmitted.
 5. Tested to a maximum peak and impulse speed of 9.5 kA and 16/45 µs respectively due to laboratory limitations.
 6. Tested in accordance with IEC 61936-1 Ed 3.0 (Clause 4.4.2.2) and IEC 62271-1 Ed 2.1 (Clause 4.1.3 and 7.5). The device can operate in a de-rated mode at temperatures up to 122°F (50°C). Ratings on these conditions are available upon request. Smart Wires anticipates that the -40°C capability will be available by Q3 2025.
 7. Tested in accordance with IEC 60068-2-52:2017.
 8. Applicable for line currents between 1440 A RMS and 2160 A RMS for the 10-1800 or 2880 A RMS and 4320 A RMS for the 10-3600.
 9. A newly-manufactured standard device fulfills this rating at 104°F (40°C), 1000 W/m² of solar radiation, and 1000 m elevation when operating at maximum fan speed.
 10. Maximum RMS AC of the output voltage for an individual device. Maximum voltage injection of a SmartValve System of n devices in series per phase is n times the Maximum Voltage Injection of an individual device.
 11. Minimum RMS AC of the output voltage for an individual device. Minimum voltage injection per phase of a SmartValve System consisting of n devices per phase is the Minimum Injection Voltage of a single device as the other n-1 devices per phase can be operated in Monitoring Mode.
 12. The minimum injection voltage for an individual device is 120 V RMS in Fixed Voltage Mode and 566 V RMS for all other control modes.
 13. The standard device fulfills this rating at 104°F (40°C), 1000 W/m² of solar radiation, and 1000 m elevation when operating at maximum fan speed with a fully degraded external coating. Ratings for other environmental conditions (e.g., 122°F (50°C)), durations (e.g., 10 minutes), or fan speeds are available upon request.
 14. Assumes continuous operation in Injection Mode at 1700 A RMS for the 10-1800 or 3500 A RMS for the 10-3600 prior to the start of the 15-minute, 1-hour, or 2-hour window. Ratings for alternate preload conditions are available upon request.

About Smart Wires

Smart Wires is a global provider of advanced power flow control technology and services. We work with electric utilities to solve their most critical grid challenges, helping them build a more flexible, reliable, and affordable transmission system. Our solutions offer a faster, lower-cost path to meet growing electricity demand, support the integration of new load, and improve overall system performance.

Headquartered in the Research Triangle of North Carolina, Smart Wires has a global team of power system experts working across four continents. In partnership with utilities around the world, we've helped deploy over 3.8 gigawatts of capacity by making better use of existing infrastructure and delivering meaningful cost savings to consumers.



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This document has been carefully developed and reviewed by Smart Wires, but deviations cannot be completely ruled out. In case any errors are detected, the reader is kindly requested to notify the manufacturer. Other than under explicit contractual commitments, in no event shall Smart Wires be responsible or liable for any loss or damage resulting from the use of this document or the application of this equipment. All technical specifications above apply to the SmartValve 10-1800 v1.04 R1.1 and 10-3600 R1. Previous versions of these models may not comply and may have different specifications.

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