

Foreword

Thanks for your selection of SVG series independently developed by us. This Manual (version 2.3) is applicable to cascaded SVG devices that work at 6kV, 10kV, 27.5kV and 35kV. It provides adequate information for users to properly use the products. You are strongly recommended to deeply read all information provided in this Manual, especially information about safety and warnings if you would like to safely and reliably use these devices and experience the advanced design concept.

Despite of all-around reviews have been made on this Manual, it is unavoidable that omissions and errors exist in this Manual. If you find any omission, please contact us.

This Manual does not cover all functions of SVG series. Please contact us if you find any function not mentioned herein. We will make improvements in later updated versions to include the proposals you give.

We reserves the right to further upgrade and change the products, which may result in changes in this Manual without further notice. Please call us to get the latest revised User Manual.

You can also get complete and valid information through the following channels:

Local Office

Please contact the local office in your region for information about relevant services, pricing and commissioning.

Technical Support Center

We provide comprehensive technical services with respect to our products and systems.

Please contact us through the said contact information if you have any difficulty in understanding this Manual and we will offer you help readily.

Definitions and Warnings

 **Danger.** "Danger" signs presented in this Manual and on the SVG devices mean it is probable to cause death or severe personal injury if relevant requirements are not observed or required actions are not taken.

 **Warning.** "Warning" signs presented in this Manual and on the SVG devices mean it is possible to cause death or severe personal injury if relevant requirements are not observed or required actions are not taken.

 **Caution.** "Caution" signs presented in this Manual and on the SVG devices mean it is possibly to cause slight or medium personal injury if relevant requirements are not observed or required actions are not taken.

Caution. "Caution" without a triangle sign presented in this Manual and on the SVG devices means it is possible to cause property loss if relevant requirements are not observed or required actions are not taken.

Hint. "Hint" presented in this Manual means it is possible to cause undesirable outcomes or conditions if the user do not pay attention to the hinted problem.

Notice. "Notice" presented in this Manual indicates important information about the product. All bold texts in this Manual require special notice from users.

Certified Person. A "certified person" mentioned in this Manual means the person who works on the device must be familiar with the installation, commissioning and production of the device and able to

avoid and solve emergencies that occur during production.

Certified persons must also meet the following criteria:

1. they must have received special training and passed the evaluation, and be able to operate the electric circuit and the device by following the safe steps generally accepted and set forth in this Manual, such as powering on, powering off, cleaning, grounding and wiring.

2. they must have been trained and able to correctly maintain and use the device by following the safe steps generally accepted and set forth in this Manual.

3. they have received first-aid training.

Limited to designated fields. The device can only be used in the fields specified in this Manual and must work in combination with components and parts recommended and accepted by our Company.

"Warnings", "Cautions" and "Hints" as below are provided for your safety and show some actions necessary to avoid the damage of the device and relevant parts. In dealing with matters relating to SVG devices, you will generally meet circumstances described in the "Warnings", "Cautions" and "Hints" which cover general circumstances, transportation and storage, commissioning, operations, repairs, and dismantling and waste disposal.

Special "Warnings", "Cautions" and "Hints" are applicable to special operations, shown at the beginning of relevant chapters, and be repeated and supplemented as necessary.

Please carefully read these "Warnings", "Cautions" and "Hints" because they help keep your safety and elongate the useful life of the SVG device.

General Circumstances

 **Warning**

This device is with dangerous high voltage; death, severe personal injury or major property loss may be caused if the requirements in the "Warning" or this Manual are not observed.

Only certified persons are permitted to operate this device and must get familiar with all instructions about safety, installation, operation and maintenance as described in this Manual before using the device. Proper handling, loading/unloading, positioning, installation, and operation and maintenance reliably guarantee the safe and successful performance of the device.

This device works at high voltage. All high voltage operations must be performed in correct procedures by the high voltage operator under the supervision of safety administrator, both of whom are designated by the user. Otherwise, death, severe personal injury or major property loss may be caused.

Protection against electric shocks must be underscored. Except for the door of the control part, all other cabinet doors and the container door are prohibited to be opened at high voltage. Otherwise, death, severe personal injury or major property loss may be caused.

Protection against electric shocks must be underscored. Except for the door of the control part, all other cabinet doors and the container door are prohibited to be opened at high voltage. Otherwise, death, severe personal injury or major property loss may be caused.

Protection against electric shocks must be underscored. The power supply of the power system is changed from AC to DC. Residual dangerous DC voltage remains on the DC capacitors even if the control system is powered off. It is not allowed to check and maintain the control system until 15 minutes after the power is cut off.

Protection against electric shocks must be underscored. In the event of grounding failure, once the part or system connected to the ground fails, it may generate a phase-to-phase voltage over the device enclosure and ground. In this case, several personal injury or even death may be caused if one touches the enclosure and the ground simultaneously.

 **Caution**

Prevent children and the public touching or approaching this device!

This device can only be used for the purposes recommended by the manufacturer. Unauthorized change of this device or use of parts and accessories not sold or recommended by the manufacturer may result in fire, electric shock or other injuries.

Hint

Please keep this Manual in an accessible place near this device to ensure all users can get it readily.

Measurements or tests required to be made on the device that is working must be performed by following relevant safety requirements and using proper electronic tools.

Please carefully read these safety requirements and warnings, and all safety signs attached to the device before you install and commission the SVG device. Safety signs must be placed on places that are easily identified. Signs that have fallen off or are damaged must be replaced.

Transportation and Storage

 **Warning**

Correct transportation, storage, positioning and installation and careful operation and maintenance are vital for the proper and safety performance of the SVG device.

 **Caution**

SVG devices must be protected against physical impacts and vibrations, and weathering and high temperature during transportation and storage.

Commissioning **Warning**

Persons who are not fully trained work on components/systems of this device or persons who do not follow requirements set forth in "Warning" may cause severe personal injury or major property loss. Only certified professionals who have received adequate training on design, installation, commissioning and operation of the device are permitted to work on components/systems of the device.

Input power supply cables must be permanently connected by fasteners. The device must be grounded (in accordance with IEC 536 Class 1, NEC and other applicable standards).

The following terminals may have dangerous high voltage even if the SVG device is not working:

——high voltage power supply terminal

——DC bus bars and DC capacitors connected thereto within the cabinet

 **Caution**

Power supply cables and control cables connected to the device must be wired as required in the user drawings to avoid any interference caused by working of the SVG device.

Operation **Warning**

SVG devices operate at high voltage:

Dangerous voltages are over some parts of an SVG device that is working.

Parameters that reflect actual circumstances must be input through the industrial controller's display to ensure the SVG device's compensation effect. The transformation ratios of potential transformer and current transformer, if configured by the user, must properly reflect the actual circumstance.

In a well-ventilated place, the fan of the SVG unit is started normally to provide good heat dissipation effect for the SVG device, thereby prevent overheat and even fire.

Repairs **Warning**

Repairs of the device must be performed by our service department or a service center authorized by us or certified persons who are authorized by us. These persons must be extremely familiar with all warnings and operation steps presented in this Manual. Any defective part or component must be replaced with another part or component of the same model and specification.

For opening the cabinet door for repairing the device, the following steps must be followed: **cut off the high voltage power supply; 10 minutes later, cut off the control power supply; open the cabinet door at least 15 minutes after the high voltage power is cut off because at least 15 minutes is required to discharge all the residual charges in the DC capacitors in the power unit.**

Dismantling and Waste Disposal **Caution**

Please keep the packing box for further use or return it to the manufacturer.

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Chapter 1 SVG Overview

1.1 Overview

Developed independently by us, SVG device integrates overseas and Chinese technologies and concepts and ranks high in terms of technology among electric and electronic products in China. Staying true to the ideas of "innovation, quality and service" which has been embodied into the business blood, We pursues growths and breakthroughs and strives for the long-term goal of "saving energy, serving the society and building a China's energy efficient product manufacturing base", with a commitment to making higher contribution to China's strategy of energy saving and emission reduction for building a low-carbon and harmonious society.

Expansion of modern electric grids, the vast number of new energy generation systems that are connected to the grids, and wide application of non-linear loads and impulse loads such as large-capacity electric and electronic devices severely impact the electricity quality:

- ◆ Lowered power factor, increased grid consumption, higher production cost and reduced productivity.
- ◆ The resulting reactive power impulses cause fluctuation and flickering of grid voltage, and in some cases, even prevent the proper performance of transmission and protection.
- ◆ Unbalanced three-phase distribution grid generates a negative sequence current which causes rotor vibration.
- ◆ High harmonic current that is generated due to the above factors causes grid voltage distortion.
- ◆ Amplified harmonic resonance and harmonic current of the capacitor bank subjects the capacitors to overloading or over-voltage, and even burn them up.
- ◆ Increased transformer load causes transformer to get hot.
- ◆ Electric equipment get hot, which may cause unstable motor torque or even damage the motor.
- ◆ Accelerated the insulation aging, which makes the electric equipment prone to breakdown.
- ◆ Lowered arc furnace productivity which increases electricity consumption.

- ◆ Communication signals are interfered.

As the electric grids is developed continuously, it is increasingly necessary to control and compensate the reactive power.

- As the transmission grid requires increasingly high efficiency, reactive power must be compensated locally in order to effectively use transmission and transformation capacity.
- Since power supplies (in particular for water power, photo-voltaic power and other new energies) are far from load centers, long-distance electricity transmission requires flexible control of reactive power to support the stability and voltage control.
- Distribution grid has a great number of inductive loads which need a high reactive power for their performance, which greatly increases the electricity consumption in distribution system.
- DC power transmission system requires reactive power control at the AC side of a converter.
- As users put higher requirements for electricity quality with increasingly specific goal for economic benefit, it is greatly essential to compensate reactive power, especially locally, in electricity transmission and distribution system.

Currently, the most ideal solution to these problem is SVG (Static Var Generator), the short name of STATCOM (Static Synchronous Compensator) which mainly works to increase electric grid stability, enhance electricity transmission capacity, eliminate the negative impact of reactive power, inhibit harmonic waves, balance three-phase grid, lower electricity loss, save energy and reduce emission. The underlying working principle is to parallel an AC bridge circuit to the electric grid through a reactor and properly adjust the phase and amplitude of the output voltage of the circuit or directly adjust its output current, so that the circuit absorbs or generates such reactive power as required, thereby compensating the reactive power.

SVG for reactive power compensation and harmonic control is the most advanced dynamic technology for reactive power compensation and the most developed voltage source converter technology, making a qualitative change in reactive power compensation equipment. Instead of utilizing high-capacity capacitors and inductive components, reactive power compensation transforms reactive energy through the high frequency switching of high-power electric and electronic

components.

The SVG device provided by us is a reactive power compensation system with IGBT as the core and able to rapidly and continuously provide capacitive or inductive reactive power for controlling constant reactive power, constant voltage and constant power factor at the targeted point, ensuring stability, efficiency and quality of the electricity system. In electricity distribution system, medium and small capacity SVG products installed near to some special loads (e.g., electric arc furnace) can significantly improve the electricity quality at the point at which the loads are connected to the public grid. Such improvements include, for example, increasing power factor, balancing the three-phase distribution, eliminating voltage flickering and fluctuation, and inhibiting harmonics contamination.

1.2 Characteristics of SVG Series

With modern electric and electronic technologies, automation, microelectronics and network communication, using advanced instantaneous reactive power theory and synchronous coordinates transformation-based power decoupling algorithm, the SVG series provided by us is designed to control the nature and level of reactive power, power factor and grid voltage as preset, dynamically trace the change in quality of grid electricity and adjust the reactive power output, thereby enhancing the grid quality.

SVG series, which is easy to use and highly reliable with high performance, is specially designed to meet the urgent needs of users for increased power factor of the transmission and distribution grid, reduced harmonics and negative sequence current compensation, with the following :

- Modular design facilitates installation, commissioning and setting.
- Fast dynamic response $\leq 5\text{ms}$.
- The total harmonics distortion (THD) subject to sufficient compensation is $\leq 3\%$.
- To satisfy user's needs to the largest extent, there are several operating modes, i.e., unit reactive power mode; targeted point reactive power mode; targeted point power factor mode; targeted point voltage mode and targeted point reactive power 2, with targeted

values that can be changed in a real-time manner.

- Real-time tracking of load change helps dynamically compensate reactive power, increase system's power factor, immediately control harmonics and compensate negative sequence current, thereby improving the grid's power quality.
- Voltage flickering can be inhibited to improve voltage quality and stable system voltage.
- Deliberately designed circuit parameters allow low heat generation, high efficiency and low operating cost.
- Compact structure requires a small space.
- The main circuit is a series chain of H-bridge power units consisting of IGBT circuits, whose each phase is composed of many same power units; the output is a square wave generated from PWM waveforms that approximates the sine waveform, and performs much more similar to the sine waveform after filtered by the output reactor.
- Redundancy and modular design makes the SVG device meet the high reliability requirement of the system.
- Modularized design of power circuit guarantees easy maintenance and good interchangeability.
- Full protections, i.e., over-voltage, under-voltage, over-current, unit over-heating and voltage unbalance, and recording the transient waveform at failure, can help locate the failure point, provide easy maintenance and high operating reliability.
- Friendly display human-machine interface and communication interfaces including RS485 and the Ethernet are provided, with standard Modbus communication protocol. Apart from real-time display of digital and analog quantities, inquiry of operating history records and history curves, monitoring of the unit status, inquiry of system information and inquiry of history failures, the device can provide system self-test after powered-on, one-key on/off, time-shared control, oscilloscope (AD channel mandatory wave-recording), and recording of the transient voltage/current at the failure time.
- SVG is designed to have interfaces that go with FC, a way that can effectively combine static

and dynamic compensation, providing more economical and flexible compensation options.

- No switching transient impulse, no switching surge and no arc restriking exist, and no discharging is needed before switching again.
- The phase sequence in AC system is not a factor that needs consideration when the device is connected to a larger system, which eases the connection work.
- Parallel installation is allowed, which makes it is easily to extend the capacity. Fiber communication used for parallel operation can ensure faster communication and better real-time compensation.

Chapter 2 SVG Series Description

2.1 Underlying Principles for SVG Reactive Power Compensation

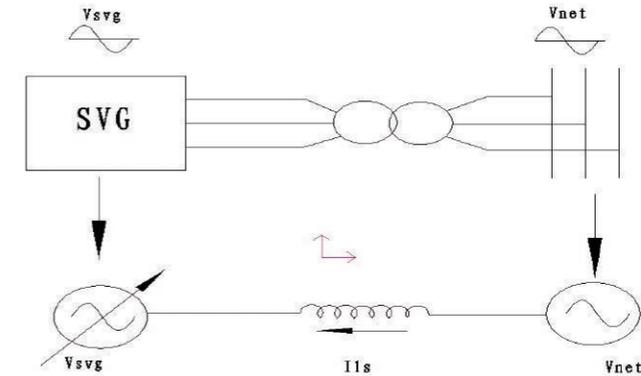


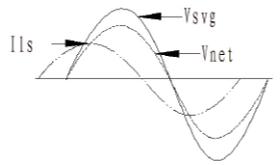
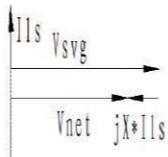
Figure 2.1 Principle Diagram

The diagram of principles for SVG series is shown in Figure 2.1. In an AC circuit, there are three kinds of phase relationships between voltage and current: voltage and current are in the same phase in the case of a pure resistive load; voltage leads the current in the case of an inductive load; the voltage lags the current in the case of a capacitive load.

The basic principle for SVG series is to parallel a self-commutated bridge circuit to the grid through a transformer or a reactor, then properly adjust the amplitude and phase of the output voltage at the AC side of the bridge or directly control the AC side circuit to make it absorb or generate the satisfactory reactive current, thereby compensating the reactive power, as shown in Table 2.1.

Table 2.1 Principles for Different Operating Modes

Operating Mode	Waveform	Phase	Description
Zero load			If $V_{svg} = V_{net}$, $I_s = 0$, equivalent to an adjustable resistor
Inductive load			If $V_{svg} < V_{net}$, I_s is the lagging current, equivalent to a continuously adjustable inductor.

Capacitive load			<p>If $V_{svg} > V_{net}$, I_s is a leading current, equivalent to a continuously adjustable capacitor.</p>
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2.2 SVG Series Introduction

2.2.1 Main technical parameters

- rated working voltage: 6kV, 10kV, 27.5kV, 35kV;
- rated capacity: $\pm 1 \sim \pm 100$ Mvar;
- output reactive power range: continuous change from the rated reactive power in an inductive circuit to the rated reactive power in a capacitive circuit;
- response time: ≤ 5 ms;
- over-load capacity: 1.2 times of the rated load for 1 minute;
- output voltage THD (before parallel): $\leq 5\%$;
- output current THD (at rated power): $\leq 3\%$;
- voltage unbalance protection and setting range: 4% \sim 10%;
- efficiency: $\geq 99\%$ (at rated operating condition);
- operating temperature: $- 20^{\circ}\text{C} \sim +40^{\circ}\text{C}$;
- storage temperature: $- 30^{\circ}\text{C} \sim +70^{\circ}\text{C}$;
- human-machine interface: color tough panel with Chinese display;
- relative humidity: monthly average value is not higher than 90 % (25°C), without condensation;
- applicable elevation: < 2000 m (customized product is needed for elevation of higher than 2000m).
- seismic intensity: \leq scale 8.

2.2.2 Some standards referenced for SVG

SVG series satisfies the following standards or applicable provisions thereof. For dated references, only the edition cited applies, neither amendment (including corrections) or revision thereof applies.

For undated references, the latest edition of the reference document applies.

GB 311.1-2012	Insulation co-ordination - . Part 1: Definitions, principals and rules
GB/T 3797-2005	Electrical control assemblies
GB 4208-2008	Degree of protection provided by enclosure (IP code)
GB/T 11022-2011	Common specifications for high-voltage switchgear and controlgear standards
GB/T 14048.1-2012	Low-voltage switchgear and controlgear - Part 1: General rules.
GB/T 12325-2008	Power quality—Deviation of supply voltage
GB/T 12326-2008	Power quality--Voltage fluctuation and flicker
GB/T 14549-1993	Quality of electric energy supply-- Harmonics in public supply network
GB/T 15543-1995	Quality of electric energy supply-- . Admissible three-phase voltage unbalance factor.
GB/T 15945-2008	Power quality - Frequency deviation for power system
GB/ T 18481-2001	Power quality--Temporary and transient over-voltages
GB/T 3859.3-2013	Semiconductor converters—General requirements and line commutated converters. Part 1-3: Transformers and reactors.
GB/T 3859.1-2013	Semiconductor converters— General requirements and line commutated Converters. Part 1-1: Specification of basic requirements.
GB/T 3859.2-2013	Semiconductor converters— General requirements and line commutated converters. Part 1-2: Application guide.
GB 3906-2006	Alternating-current metal-enclosed switchgear and controlgear for rated voltages above 3.6 kV and up to and including 40.5 kV
GB1985-2014	High-voltage alternating-current disconnectors and earthing switches
GB/T 7261-2008	Basic testing method for relaying protection and security automatic equipment
GB/T 17626.5-2008	Electromagnetic compatibility - Testing and measurement techniques - Surge immunity test.
GB/T17626.11-2008	Electromagnetic compatibility--Testing and measurement techniques-- Voltage dips, short interruptions and voltage variations immunity tests.
GB/T 17626.3-2006	Electromagnetic compatibility—Testing and measurement techniques—

	Radiated, radio-frequency, electromagnetic field immunity test
GB/T 17626.2-2006	Electromagnetic compatibility - Testing and measurement techniques— Electrostatic discharge immunity test
GB/T 17626.4-2008	Electromagnetic compatibility—Testing and measurement techniques— Electrical fast transient/burst immunity test
GB/T 11032-2010	Metal-oxide surge arresters without gaps for a.c. systems (amendment 1 attached)
Q/GDW 480-2010	Technical rule for connecting distributed generation systems to power grid
Q/GDW 617-2011	Technical rule for connecting photovoltaic power station to power grid
NB/T 31003-2011	Design regulations for connecting large-sale wind power to the power grid (with provision explanations)
DL/T 620-1997	over-voltage protection and insulation coordination for AC electrical installations
DL/T 672-1999	Ordering specification for controlling device of adjusting voltage and reactive power in substation
DL/T 1215.1-2013	Chain-circuit static synchronous compensator. Part 1: Guide for the functional specification
DL/T 1215.1-2013	Chain-circuit static synchronous compensator. Part 2: Testing of converter chain
DL/T 1215.1-2013	Chain-circuit static synchronous compensator. Part 3: Control protection and monitoring system
DL/T1215.1-2013	Chain-circuit static synchronous compensator. Part 4: Field tests guide
DL/T 1215.1-2013	Chain-circuit static synchronous compensator. Part 5: Guideline of operation and maintenance
DL/T 1216-2013	Technical regulation for distribution static synchronous compensator

2.2.3 SVG models and specifications

The rules for naming SVG models and specifications are shown in Figure 2.2:

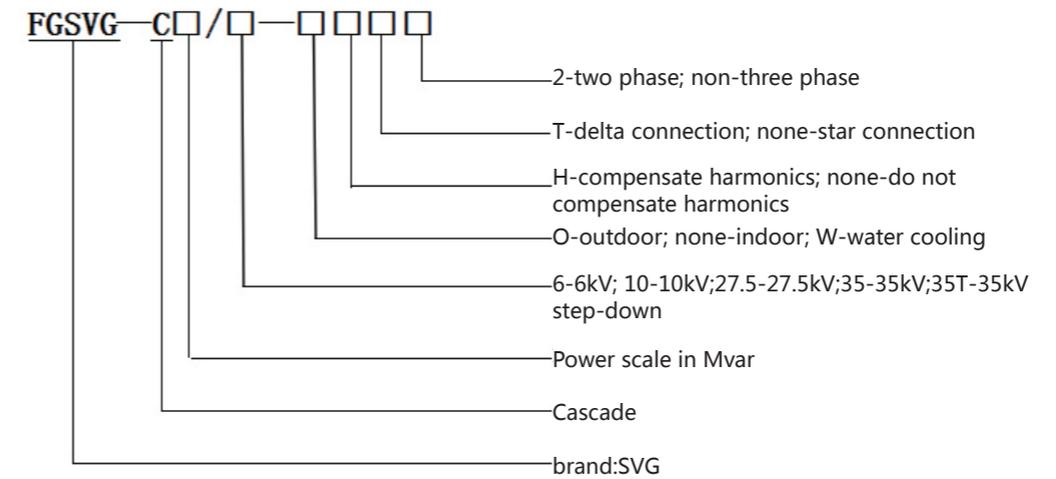


Figure 2.2. Product Naming Rules

Note: Capacity (Mvar) means the rated maximum adjustable capacity from an inductive reactive power to a capacitive reactive power. For example, C2.0/10 means a direct-mounting device with a capacity of ±2Mvar at 10 kV. It can smoothly adjust the reactive power within the range of +2000 kvar (inductive) and -2000 kvar (capacitive). An SVG product either uses air cooling or water cooling. The models and specifications of products with each cooling form at different voltage levels are described as below.

Table 2.2 Models and Dimensions of 6kv-G31 Indoor Air Cooling SVGs

Model	Cooling Method	Voltage Level (kV)	Rated Capacity (Mvar)	Dimensions			Remarks	Weight (kg)
				Total Width (mm)	Height (mm)	Depth (mm)		
FGSVG-C1.0/6	air cooling	6	1.0	3300	2405	1400	iron core reactor	2290
FGSVG-C2.0/6			2.0					2850
FGSVG-C3.0/6			3.0	iron core reactor			3140	
FGSVG-C4.0/6			4.0				3850	
FGSVG-C5.0/6			5.0				4590	

Model	Cooling Method	Voltage Level (kV)	Rated Capacity (Mvar)	Dimensions (mm)	Weight (kg)			
FGSVG-C6.0/6	air cooling	6	6.0	3600	2650			
FGSVG-C7.0/6			7.0		3700			
FGSVG-C8.0/6			8.0	5600	2405	1400	air core reactor	4600
FGSVG-C9.0/6			9.0					4700
FGSVG-C10.0/6			10.0					4800
FGSVG-C11.0/6			11.0					4900
FGSVG-C12.0/6			12.0					5000

Table 2.3 Models and Dimensions of 10kV-G31 Indoor Air Cooling SVGs

Model	Cooling Method	Voltage Level (kV)	Rated Capacity (Mvar)	Dimensions			Remarks	Weight (kg)
				Total Width (mm)	Height (mm)	Depth (mm)		
FGSVG-C1.0/10	air cooling	10	1.0	4000	2405	1400	iron core reactor	2750
FGSVG-C1.5/10			1.5					2970
FGSVG-C2.0/10			2.0					3150
FGSVG-C3.0/10			3.0					3600
FGSVG-C4.0/10			4.0					4000
FGSVG-C5.0/10			5.0	4500				
FGSVG-C6.0/10			6.0	3000			air core reactor	2500
FGSVG-C7.0/10			7.0	6100				iron core reactor
FGSVG-C8.0/10			8.0	6350			air core reactor	3900
FGSVG-C9.0/10			9.0	4900				4050
FGSVG-C10.0/10			10.0	5000				4350
FGSVG-C11.0/10			11.0					4550
FGSVG-C12.0/10			12.0	8200				7000
FGSVG-C13.0/10			13.0					7200
FGSVG-C14.0/10			14.0					7400
FGSVG-C15.0/10			15.0					7500
FGSVG-C16.0/10			16.0					7700
FGSVG-C17.0/10			17.0					
FGSVG-C18.0/10			18.0					
FGSVG-C19.0/10			19.0					
FGSVG-C20.0/10			20.0					
FGSVG-C21.0/10	21.0							

Table 2.4 Models and Dimensions of 35kV-G31 Indoor Air Cooling SVGs

Model	Cooling Method	Voltage Level (kV)	Rated Capacity (Mvar)	Dimensions			Remarks	Weight (kg)
				Total Width (mm)	Height (mm)	Depth (mm)		
FGSVG-C8.0/35	air cooling	35	8.0	14500	2105	1800	air core reactor	9550
FGSVG-C9.0/35			9.0					9600
FGSVG-C10.0/35			10.0					9650
FGSVG-C11.0/35			11.0					9700
FGSVG-C12.0/35			12.0					9750
FGSVG-C13.0/35			13.0					9800
FGSVG-C14.0/35			14.0					9850
FGSVG-C15.0/35			15.0					9900
FGSVG-C16.0/35			16.0					9950
FGSVG-C17.0/35			17.0					10000
FGSVG-C18.0/35			18.0					10050
FGSVG-C19.0/35			19.0					10100
FGSVG-C20.0/35			20.0					10150
FGSVG-C21.0/35			21.0					10200
FGSVG-C22.0/35			22.0	26200				15580
FGSVG-C23.0/35			23.0					
FGSVG-C24.0/35			24.0					
FGSVG-C25.0/35			25.0					
FGSVG-C26.0/35			26.0					
FGSVG-C27.0/35			27.0					
FGSVG-C28.0/35			28.0					
FGSVG-C29.0/35			29.0					
FGSVG-C30.0/35			30.0					
FGSVG-C31.0/35			31.0					
FGSVG-C32.0/35			32.0					
FGSVG-C33.0/35			33.0					
FGSVG-C34.0/35			34.0					
FGSVG-C35.0/35			35.0					
FGSVG-C36.0/35			36.0					
FGSVG-C37.0/35			37.0	17140				
FGSVG-C38.0/35			38.0					17560

FGSVG-C39.0/35	air cooling	35	39.0	26200	2105	1800	air core reactor	17980	
FGSVG-C40.0/35			40.0						
FGSVG-C41.0/35			41.0						
FGSVG-C42.0/35			42.0						
FGSVG-C43.0/35			43.0	52400				19200	
FGSVG-C44.0/35			44.0					36000	
FGSVG-C45.0/35			45.0						
FGSVG-C46.0/35			46.0						
FGSVG-C47.0/35			47.0						
FGSVG-C48.0/35			48.0						
FGSVG-C49.0/35			49.0						
FGSVG-C50.0/35			50.0						36800
FGSVG-C55.0/35			55.0						37200
FGSVG-C60.0/35			60.0						
FGSVG-C65.0/35			65.0						
FGSVG-C70.0/35			70.0						
FGSVG-C80.0/35			80.0	40000					
FGSVG-C90.0/35			90.0	72000					
FGSVG-C100.0/35			100.0	72000					

Table 2.5 Models and Dimensions of 10kV-G31 Indoor Water Cooling SVGs

Model	Cooling Method	Voltage Level (kV)	Rated Capacity (Mvar)	Dimensions			Remarks	Weight (kg)
				Total Width (mm)	Height (mm)	Depth (mm)		
FGSVG-C1.0/10-W	water cooling	10	1.0	5200	2405	1400	air core reactor	2850
FGSVG-C2.0/10-W			2.0					
FGSVG-C3.0/10-W			3.0					
FGSVG-C4.0/10-W			4.0					
FGSVG-C5.0/10-W			5.0					
FGSVG-C6.0/10-W			6.0					
FGSVG-C7.0/10-W			7.0					
FGSVG-C8.0/10-W			8.0					
FGSVG-C9.0/10-W			9.0					
FGSVG-C10.0/10-W			10.0					
FGSVG-C11.0/10-W			11.0					

FGSVG-C12.0/10-W	water cooling	10	12.0	5800	2405	1400	air core reactor	3050	
FGSVG-C13.0/10-W			13.0						
FGSVG-C14.0/10-W			14.0						
FGSVG-C15.0/10-W			15.0	8100				3850	
FGSVG-C16.0/10-W			16.0						
FGSVG-C17.0/10-W			17.0						
FGSVG-C18.0/10-W			18.0						
FGSVG-C19.0/10-W			19.0						
FGSVG-C20.0/10-W			20.0						
FGSVG-C21.0/10-W			21.0						
FGSVG-C22.0/10-W			22.0						
FGSVG-C23.0/10-W			23.0						
FGSVG-C24.0/10-W			24.0						
FGSVG-C25.0/10-W			25.0						4450

Table 2.6 Models and Dimensions of 35kV-G31 Indoor Water Cooling SVGs

Model	Cooling Method	Voltage Level (kV)	Rated Capacity (Mvar)	Dimensions			Remarks	Weight (kg)	
				Total Width (mm)	Height (mm)	Depth (mm)			
FGSVG-C5.0/35-W	water cooling	35	5.0	10100	2405	10000	air core reactor	9000	
FGSVG-C6.0/35-W			6.0						
FGSVG-C7.0/35-W			7.0						
FGSVG-C8.0/35-W			8.0						
FGSVG-C9.0/35-W			9.0						
FGSVG-C10.0/35-W			10.0						
FGSVG-C11.0/35-W			11.0						
FGSVG-C12.0/35-W			12.0						
FGSVG-C13.0/35-W			13.0						
FGSVG-C14.0/35-W			14.0						
FGSVG-C15.0/35-W			15.0						
FGSVG-C16.0/35-W			16.0						
FGSVG-C17.0/35-W			17.0						
FGSVG-C18.0/35-W			18.0						
FGSVG-C19.0/35-W			19.0						10200

FGSVG-C20.0/35-W	water cooling	35	10100	2405	10000	air core reactor	10200
FGSVG-C21.0/35-W							10800
FGSVG-C22.0/35-W							11400
FGSVG-C23.0/35-W							
FGSVG-C24.0/35-W							
FGSVG-C25.0/35-W							
FGSVG-C26.0/35-W							
FGSVG-C27.0/35-W							
FGSVG-C28.0/35-W							
FGSVG-C29.0/35-W							
FGSVG-C30.0/35-W							
FGSVG-C31.0/35-W							
FGSVG-C32.0/35-W							
FGSVG-C33.0/35-W							
FGSVG-C34.0/35-W							
FGSVG-C35.0/35-W							
FGSVG-C36.0/35-W							
FGSVG-C37.0/35-W							
FGSVG-C38.0/35-W							
FGSVG-C39.0/35-W							
FGSVG-C40.0/35-W							12600
FGSVG-C41.0/35-W							
FGSVG-C42.0/35-W							
FGSVG-C43.0/35-W							
FGSVG-C44.0/35-W							
FGSVG-C45.0/35-W							
FGSVG-C46.0/35-W							
FGSVG-C47.0/35-W							
FGSVG-C48.0/35-W							
FGSVG-C49.0/35-W							
FGSVG-C50.0/35-W							
FGSVG-C50.0/35-W	13800						

Table 2.7 Models and Dimensions of 10kV-G40 Indoor Air Cooling SVGs

Model	Voltage Level (kV)	Rated Capacity (Mvar)	Dimensions			Remarks	Weight (kg)
			Total Width (mm)	Height (mm)	Depth (mm)		
FGSVG-C0.5/10	10	0.5	2300 or 2000	2405	1400	iron core reactor	2000
FGSVG-C0.6/10		0.6					
FGSVG-C0.7/10		0.7					
FGSVG-C0.8/10		0.8					
FGSVG-C0.9/10		0.9					
FGSVG-C1.0/10		1.0					
FGSVG-C1.5/10		1.5					
FGSVG-C2.0/10		2.0					
FGSVG-C3.0/10		3.0					
FGSVG-C4.0/10		4.0					

Notes about indoor models:

- 1) In the case of air cooling, the indoor device's height does not include the fan height (about 500mm).
- 2) For a 35 kV device, the three phases can be arranged in three rows as convenient.
- 3) The above dimensions are only for reference; We reserves the right to upgrade and improve its products without further notice.

Table 2.8 Models and Dimensions of 6kv-G31 Outdoor Air Cooling SVGs

Model	Voltage Level (kV)	Rated Capacity (Mvar)	Dimensions			Remarks	Weight (kg)
			Total Width (mm)	Height (mm)	Depth (mm)		
FGSVG-C1.0/6-O	6	1.0	5200	2591	2438	iron core reactor	6500
FGSVG-C1.5/6-O		1.5					
FGSVG-C2.0/6-O		2.0					
FGSVG-C3.0/6-O		3.0					
FGSVG-C4.0/6-O		4.0					
FGSVG-C5.0/6-O		5.0					
FGSVG-C6.0/6-O		6.0					
FGSVG-C7.0/6-O	7.0	6700	air core reactor	6450			

FGSVG-C8.0/6-O	6	8.0	6700	2591	2438	air core reactor	6600
FGSVG-C9.0/6-O		9.0					6700
FGSVG-C10.0/6-O		10.0					6800
FGSVG-C11.0/6-O		11.0					6900
FGSVG-C12.0/6-O		12.0					7000

Table 2.9 Models and Dimensions of 10kv-G31 Outdoor Air Cooling SVGs

Model	Cooling Method	Voltage Level (kV)	Rated Capacity (Mvar)	Dimensions			Remarks	Weight (kg)	
				Total Width (mm)	Height (mm)	Depth (mm)			
FGSVG-C1.0/10-O	air cooling	10	1.0	5200	2591	2438	iron core reactor	5500	
FGSVG-C2.0/10-O			2.0					5850	
FGSVG-C3.0/10-O			3.0					6100	
FGSVG-C4.0/10-O			4.0					6300	
FGSVG-C5.0/10-O			5.0					6700	
FGSVG-C6.0/10-O			6.0					6850	
FGSVG-C7.0/10-O			7.0	6200			6700	air core reactor	9000
FGSVG-C8.0/10-O			8.0						9200
FGSVG-C9.0/10-O			9.0						9400
FGSVG-C10.0/10-O			10.0						9500
FGSVG-C11.0/10-O			11.0						9700
FGSVG-C12.0/10-O			12.0						9700
FGSVG-C13.0/10-O			13.0	9700			9700	air core reactor	9700
FGSVG-C14.0/10-O			14.0						9700
FGSVG-C15.0/10-O			15.0						9700
FGSVG-C16.0/10-O			16.0						9700
FGSVG-C17.0/10-O			17.0						9700
FGSVG-C18.0/10-O			18.0						9700
FGSVG-C19.0/10-O			19.0						9700
FGSVG-C20.0/10-O			20.0						9700
FGSVG-C21.0/10-O			21.0						9700

Table 3.0 Models and Dimensions of 35kv-G31 Outdoor Air Cooling SVGs

Model	Cooling Method	Voltage Level (kV)	Rated Capacity (Mvar)	Dimensions			Remarks	Weight (kg)		
				Total Width (mm)	Height (mm)	Depth (mm)				
FGSVG-C8.0/35-O	air cooling	35	8.0	12700	2591	2438	air core reactor	11900		
FGSVG-C9.0/35-O			9.0					12000		
FGSVG-C10.0/35-O			10.0					12100		
FGSVG-C11.0/35-O			11.0					12500		
FGSVG-C12.0/35-O			12.0					12600		
FGSVG-C13.0/35-O			13.0					12700		
FGSVG-C14.0/35-O			14.0					12800		
FGSVG-C15.0/35-O			15.0					13300		
FGSVG-C16.0/35-O			16.0					13400		
FGSVG-C17.0/35-O			17.0					13500		
FGSVG-C18.0/35-O			18.0					13600		
FGSVG-C19.0/35-O			19.0					14100		
FGSVG-C20.0/35-O			20.0	14200						
FGSVG-C21.0/35-O			21.0	14300						
FGSVG-C22.0/35-O			22.0	26000				25000	25400	
FGSVG-C23.0/35-O			23.0							25000
FGSVG-C24.0/35-O			24.0							25000
FGSVG-C25.0/35-O			25.0							25000
FGSVG-C26.0/35-O			26.0							25000
FGSVG-C27.0/35-O			27.0							25000
FGSVG-C28.0/35-O			28.0							25000
FGSVG-C29.0/35-O			29.0							25000
FGSVG-C30.0/35-O			30.0							25000
FGSVG-C31.0/35-O			31.0							25000
FGSVG-C32.0/35-O			32.0							25000
FGSVG-C33.0/35-O			33.0	25800						

FGSVG-C34.0/35-O	air cooling	35	34.0	26000	2591	2438	air core reactor	25800
FGSVG-C35.0/35-O			35.0					
FGSVG-C36.0/35-O			36.0					
FGSVG-C37.0/35-O			37.0					26000
FGSVG-C38.0/35-O			38.0					
FGSVG-C39.0/35-O			39.0					27000
FGSVG-C40.0/35-O			40.0					
FGSVG-C41.0/35-O			41.0					
FGSVG-C42.0/35-O			42.0					

Table 3.1 Models and Dimensions of 10kv-G31 Outdoor Water Cooling SVGs

Model	Cooling Method	Voltage Level (kV)	Rated Capacity (Mvar)	Dimensions			Remarks	Weight (kg)	
				Total Width (mm)	Height (mm)	Depth (mm)			
FGSVG-C1.0/10-OW	water cooling	10	1.0	6058	2591	2438	air core reactor	8200	
FGSVG-C2.0/10-OW			2.0						
FGSVG-C3.0/10-OW			3.0						
FGSVG-C4.0/10-OW			4.0						
FGSVG-C5.0/10-OW			5.0						
FGSVG-C6.0/10-OW			6.0						
FGSVG-C7.0/10-OW			7.0						
FGSVG-C8.0/10-OW			8.0						
FGSVG-C9.0/10-OW			9.0						
FGSVG-C10.0/10-OW			10.0						
FGSVG-C11.0/10-OW			11.0						9200
FGSVG-C12.0/10-OW			12.0						
FGSVG-C13.0/10-OW			13.0						
FGSVG-C14.0/10-OW			14.0						
FGSVG-C15.0/10-OW			15.0						
FGSVG-C16.0/10-OW			16.0	9300	13000				

FGSVG-C17.0/10-OW	water cooling	10	17.0	9300	2591	2438	air core reactor	14000
FGSVG-C18.0/10-OW			18.0					
FGSVG-C19.0/10-OW			19.0					
FGSVG-C20.0/10-OW			20.0					15000
FGSVG-C21.0/10-OW			21.0					
FGSVG-C22.0/10-OW			22.0					
FGSVG-C23.0/10-OW			23.0					
FGSVG-C24.0/10-OW			24.0					
FGSVG-C25.0/10-OW			25.0					

Table 3.2 Models and Dimensions of 35kv-G31 Outdoor Water Cooling SVGs

Model	Cooling Method	Voltage Level (kV)	Rated Capacity (Mvar)	Dimensions			Remarks	Weight (kg)
				Total Width (mm)	Height (mm)	Depth (mm)		
FGSVG-C5.0/35-OW	water cooling	35	5.0	14000	2896	2700	air core reactor	19000
FGSVG-C6.0/35-OW			6.0					
FGSVG-C7.0/35-OW			7.0					
FGSVG-C8.0/35-OW			8.0					
FGSVG-C9.0/35-OW			9.0					
FGSVG-C10.0/35-OW			10.0					
FGSVG-C11.0/35-OW			11.0					
FGSVG-C12.0/35-OW			12.0					
FGSVG-C13.0/35-OW			13.0					
FGSVG-C14.0/35-OW			14.0					
FGSVG-C15.0/35-OW			15.0					23000
FGSVG-C16.0/35-OW			16.0					
FGSVG-C17.0/35-OW			17.0					
FGSVG-C18.0/35-OW			18.0					
FGSVG-C19.0/35-OW			19.0					
FGSVG-C20.0/35-OW			20.0					

FGSVG-C21.0/35-OW	water cooling	35	14000	2896	2700	air core reactor	23000
FGSVG-C22.0/35-OW							
FGSVG-C23.0/35-OW							
FGSVG-C24.0/35-OW							
FGSVG-C25.0/35-OW							
FGSVG-C26.0/35-OW							
FGSVG-C27.0/35-OW							
FGSVG-C28.0/35-OW							
FGSVG-C29.0/35-OW							25000
FGSVG-C30.0/35-OW							
FGSVG-C31.0/35-OW							
FGSVG-C32.0/35-OW							
FGSVG-C33.0/35-OW							
FGSVG-C34.0/35-OW							
FGSVG-C35.0/35-OW							
FGSVG-C36.0/35-OW							27000
FGSVG-C37.0/35-OW							
FGSVG-C38.0/35-OW							
FGSVG-C39.0/35-OW							
FGSVG-C40.0/35-OW							
FGSVG-C41.0/35-OW							
FGSVG-C42.0/35-OW							
FGSVG-C43.0/35-OW							
FGSVG-C44.0/35-OW							
FGSVG-C45.0/35-OW							
FGSVG-C46.0/35-OW							
FGSVG-C47.0/35-OW							
FGSVG-C48.0/35-OW							
FGSVG-C49.0/35-OW							
FGSVG-C50.0/35-OW							

Table 3.3 Models and Dimensions of 10kV-G40 Outdoor Air Cooling SVGs

Model	Voltage Level (kV)	Rated Capacity (Mvar)	Dimensions			Remarks	Weight (kg)
			Total Width (mm)	Height (mm)	Depth (mm)		
FGSVG-C0.5/10-O	10	0.5	3200	2591	2350	iron core reactor	3000
FGSVG-C0.6/10-O		0.6					
FGSVG-C0.7/10-O		0.7					
FGSVG-C0.8/10-O		0.8					
FGSVG-C0.9/10-O		0.9					
FGSVG-C1.0/10-O		1.0					
FGSVG-C1.5/10-O		1.5					
FGSVG-C2.0/10-O		2.0					
FGSVG-C3.0/10-O		3.0					
FGSVG-C4.0/10-O		4.0					

Table 3.4 Models and Dimensions of 35kv-G40 Outdoor Air Cooling SVGs

Model	Cooling Method	Voltage Level (kV)	Rated Capacity (Mvar)	Dimensions			Remarks	Weight (kg)
				Total Width (mm)	Height (mm)	Depth (mm)		
FGSVG-C5.0/35-O	air cooling	35	5.0	10600	2591	2350	air core reactor	15000
FGSVG-C6.0/35-O			6.0					
FGSVG-C7.0/35-O			7.0					
FGSVG-C8.0/35-O			8.0					
FGSVG-C9.0/35-O			9.0					
FGSVG-C10.0/35-O			10.0					
FGSVG-C11.0/35-O			11.0					
FGSVG-C12.0/35-O			12.0					
FGSVG-C12.5/35-O			12.5					

Notes about outdoor models:

- 1) The above dimensions are only for reference; We reserves the right to upgrade and improve its products without further notice;
- 2) For a 35 kV device, the three phases can be arranged in three rows as convenient.

SVG products cover power capacities from 1Mvar to 100Mvar, water cooling and air cooling, and indoor and outdoor models. Products of the different models are slightly difference in appearance. The following drawings are only for reference.

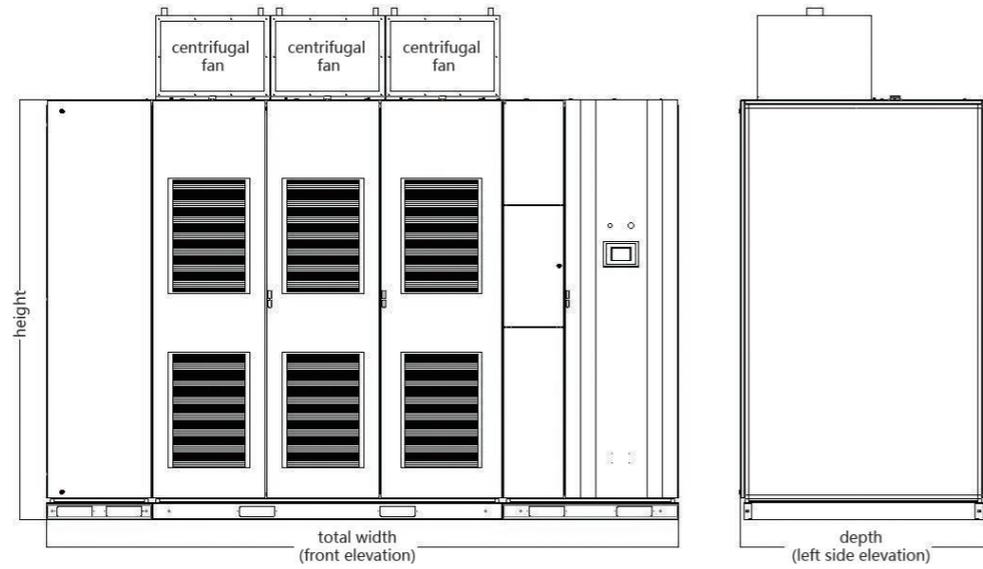


Figure 2.3 Dimensional Drawing of G31-6kV-Indoor-Air Cooling FGSVG-C6.0/6

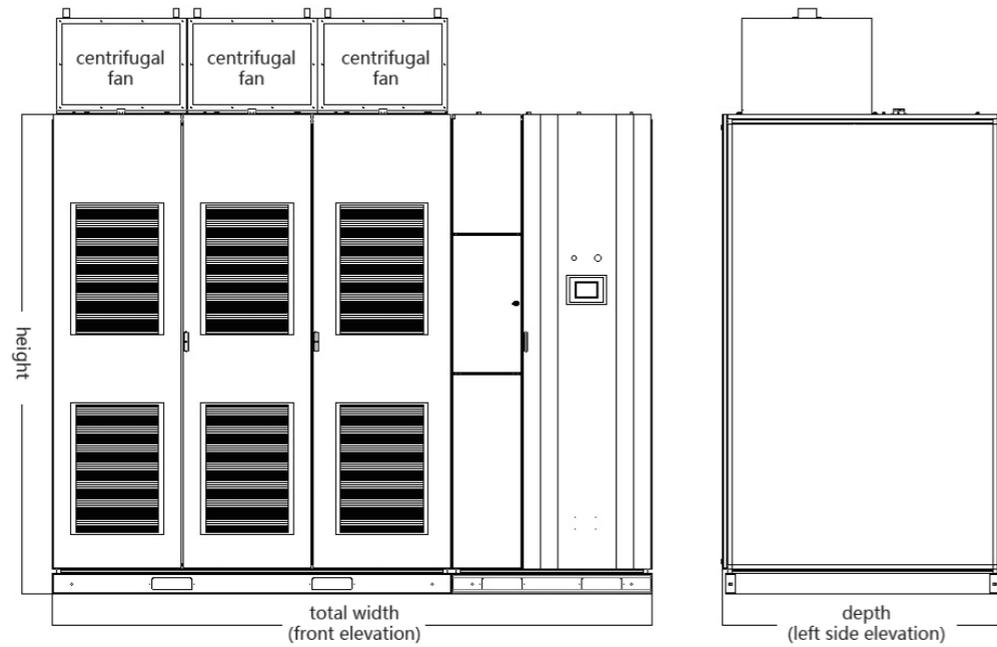


Figure 2.4 Dimensional Drawing of G31-10kV-Indoor-Air Cooling FGSVG-C6.0/10

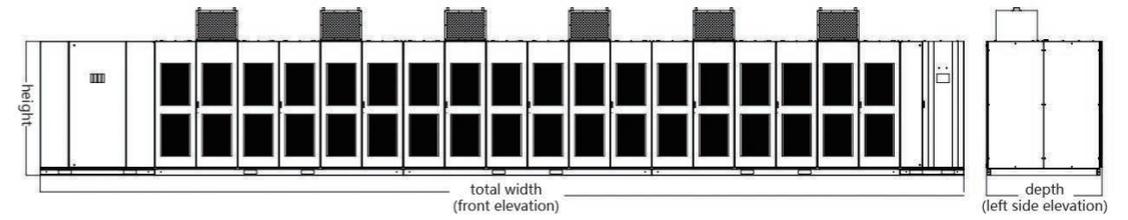


Figure 2.5 Dimensional Drawing of G31-35kV-Indoor-Air Cooling FGSVG-C12.0/35

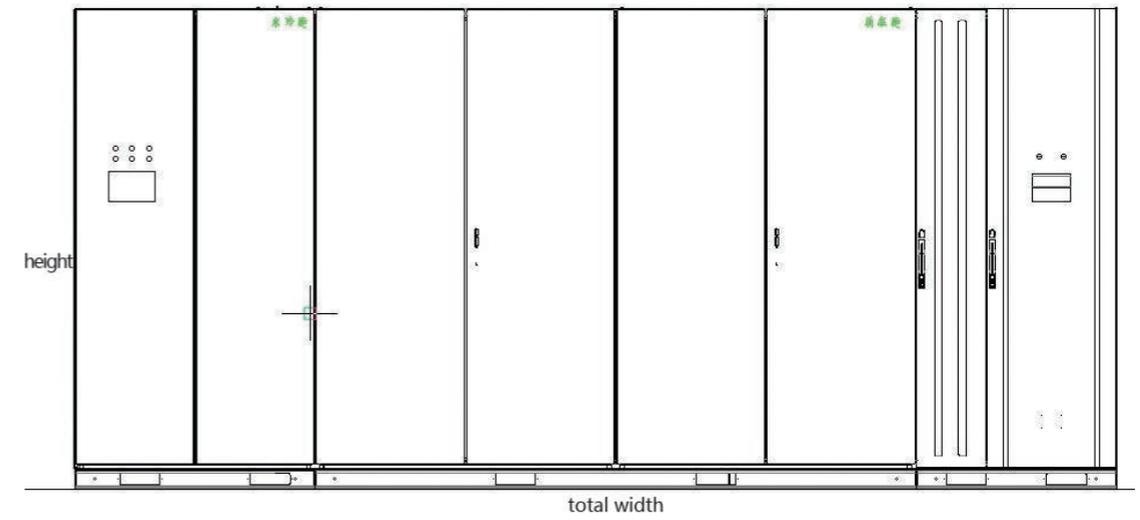


Figure 2.6 Dimensional Drawing of G31-10kV-Indoor-Water Cooling FGSVG-C1.0/10-W

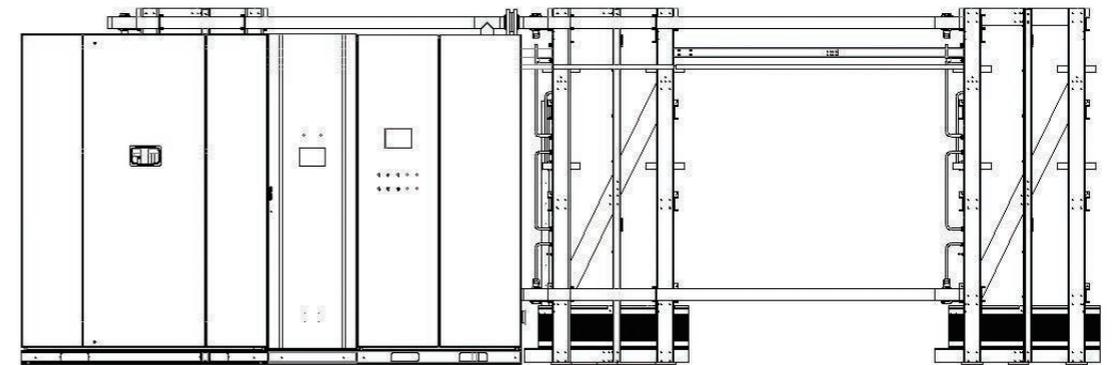


Figure 2.7 Dimensional Drawing of G31-35kV-Indoor-Water Cooling FGSVG-C5.0/35-W

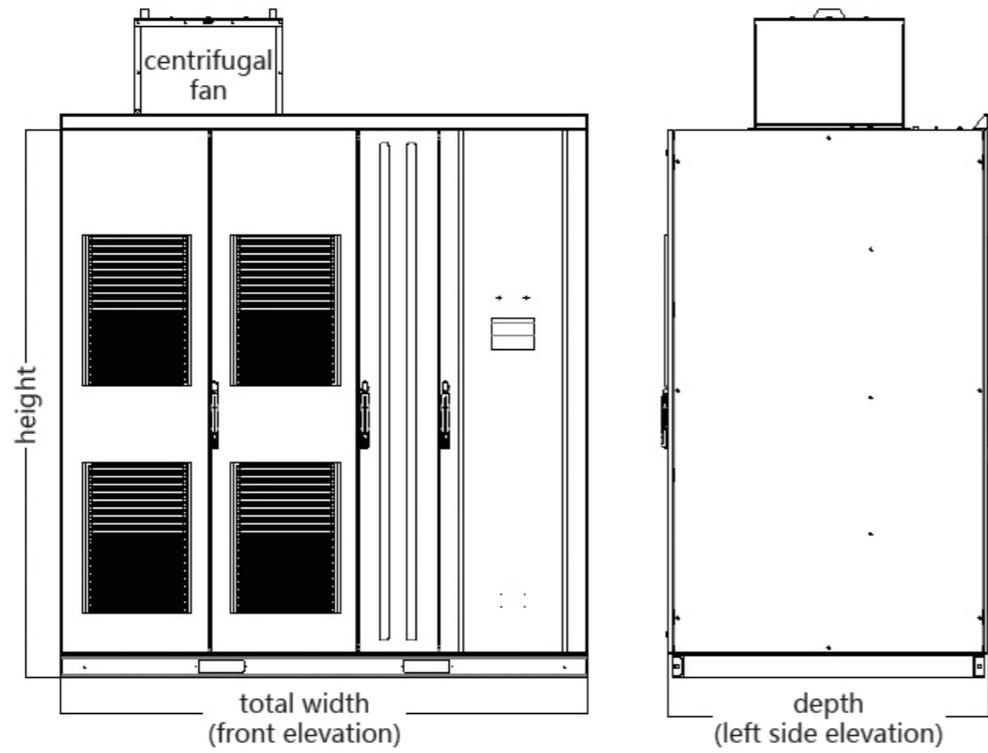


Figure 2.8 Dimensional Drawing of G40-10kV-Indoor-Air Cooling FGSVG-C2.0/10

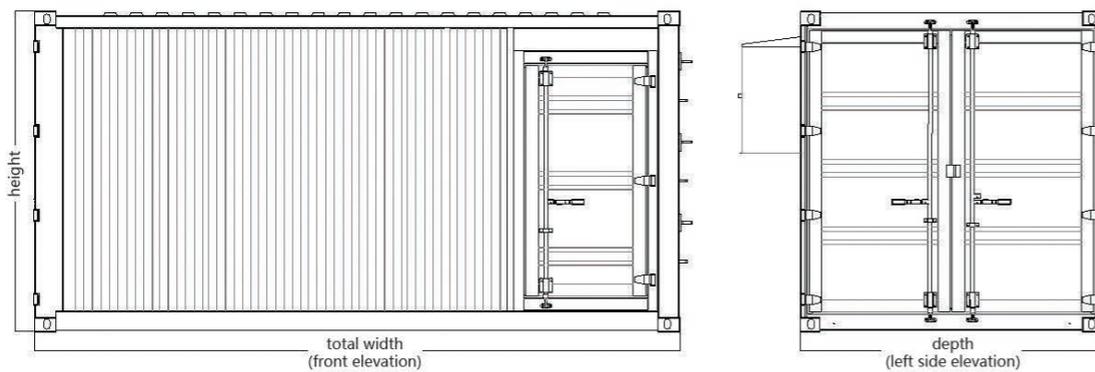


Figure 2.9 Dimensional Drawing of G31-6kV-Outdoor-Air Cooling FGSVG-C6.0/6-O

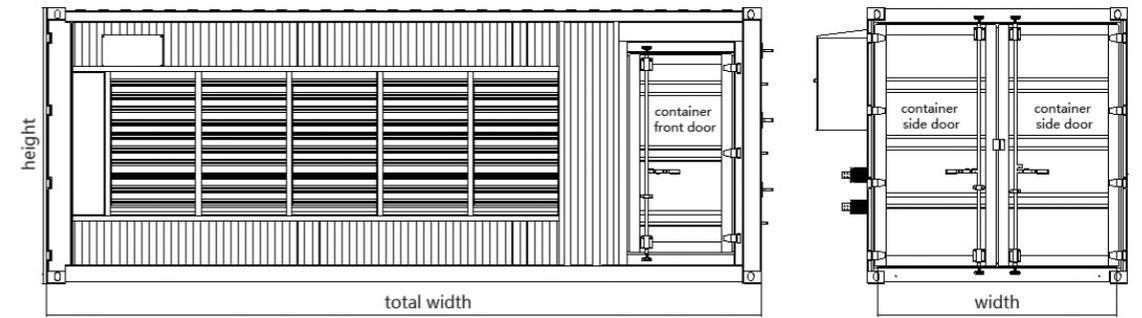


Figure 3.0 Dimensional Drawing of G31-10kV-Outdoor-Air Cooling FGSVG-C10.0/10-O

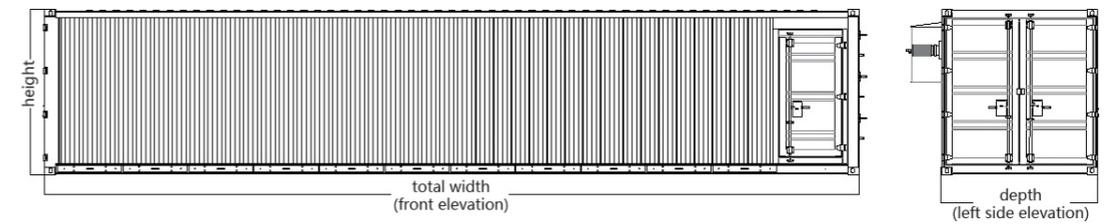


Figure 3.1 Dimensional Drawing of G31-35kV-Outdoor-Air Cooling FGSVG-C12.0/35-O

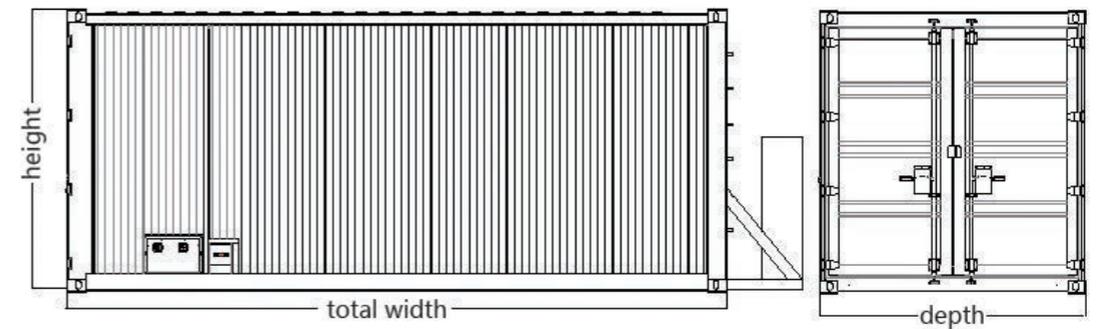


Figure 3.2 Dimensional Drawing of G31-10kV-Outdoor-Water Cooling FGSVG-C2.0/10-OW

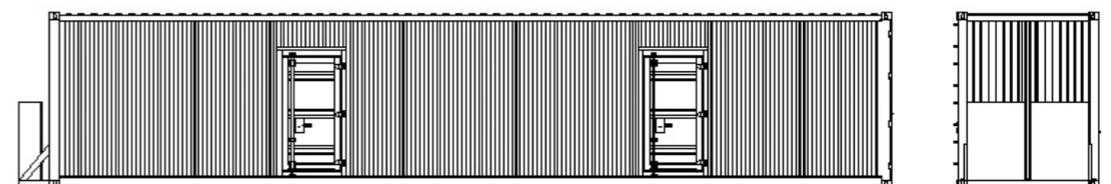


Figure 3.3 Dimensional Drawing of G31-35kV-Outdoor-Water Cooling FGSVG-C6.0/35-OW

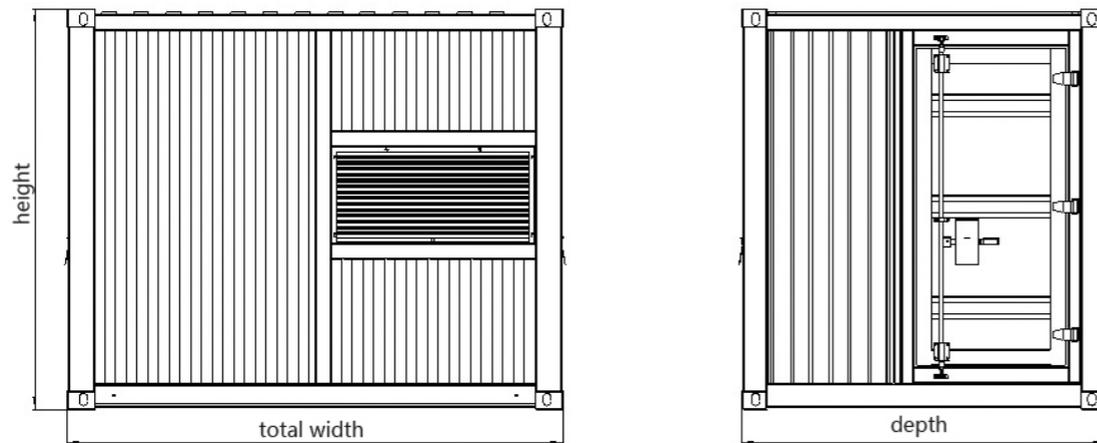


Figure 3.4 Dimensional Drawing of G40-10kV-Outdoor-Air Cooling FGSVG-C0.5/10-O

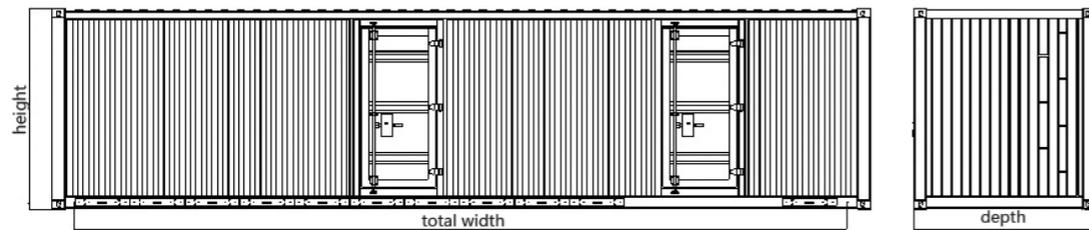


Figure 3.5 Dimensional Drawing of G40-35kV-Outdoor-Air Cooling FGSVG-C10/35-O

2.2.4 SVG applications

SVG series is widely used to increase power transmission capacity, decrease power loss, compensate reactive power, control harmonics, inhibit flickering, stabilize grid voltage, balance the three-phase system, change the damping property and enhance system stability.

SVG is applied to new energy, petroleum and chemical engineering, electrical system, metallurgy, electricity-powered railway, urban construction and other fields. It can provide highly qualified and reliable reactive power compensation solutions that are useful for various asynchronous motors, transformers, thyristor converters, variable frequency drives, inductive furnaces, arc furnaces, lighting fixtures, electric locomotives, hoists, cranes, punching machines, wind power generators, electric welding machines, plate rolling machines, resistance furnaces, quartz melting furnace and so on.

(1) petroleum, chemical engineering, mining, dock and heavy industry:

- a. stable power supply;
- b. centralized compensation for a substation that provides power for many low and middle voltage motors;
- c. local dynamic reactive power compensation for large motors;
- d. centralized reactive power compensation for various crushers, crackers and ball millers;
- e. decreased reactive power fluctuation and harmonics of traction and transmission devices;
- f. centralized compensation for large hoisting equipment, ship lock control systems and forging equipment;

(2) steel and iron, metallurgy:

- a. increase power factor and lower reactive power consumption;
- b. lower voltage fluctuation and inhibit flickering to improve productivity;
- c. filter harmonics to ensure equipment safety;
- d. balance negative sequence;

(3) urban distribution grid and rural power supply:

- a. increase power factor and lower reactive power consumption;
- b. solve voltage fluctuation and flickering caused by fluctuating load;
- c. stabilize the voltage at receiving end;
- d. provide centralized compensation of reactive power and harmonics for multiple users, in particular in the case of many impulse loads;

(4) grid-connected renewable energy:

- a. control the reactive power at the points where wind power and photovoltaic power generators are connected to the grid to prevent reactive power from going back to the grid;
- b. stabilize the grid voltage and mitigate the voltage fluctuation caused by changes in generator power;
- c. maintain the voltage at connection point and increase low voltage ride through capability;

(5) electricity-powered railways and urban transits:

- a. comprehensively control the reactive power and harmonics of traction power supply system, improve electricity quality, increase traction capability and decrease energy consumption;
- b. balance the negative sequence current generated by locomotive loads.

Chapter 3 System Structure and Parameters of SVG

3.1 SVG System Structure

A main circuit with chain topology, modular-based structure, star and delta connections ensure the maximum cost effectiveness at different capacities, which guarantees effective user investments and a stable and efficient operation of power System. Star connection is shown in Figure 3.10.

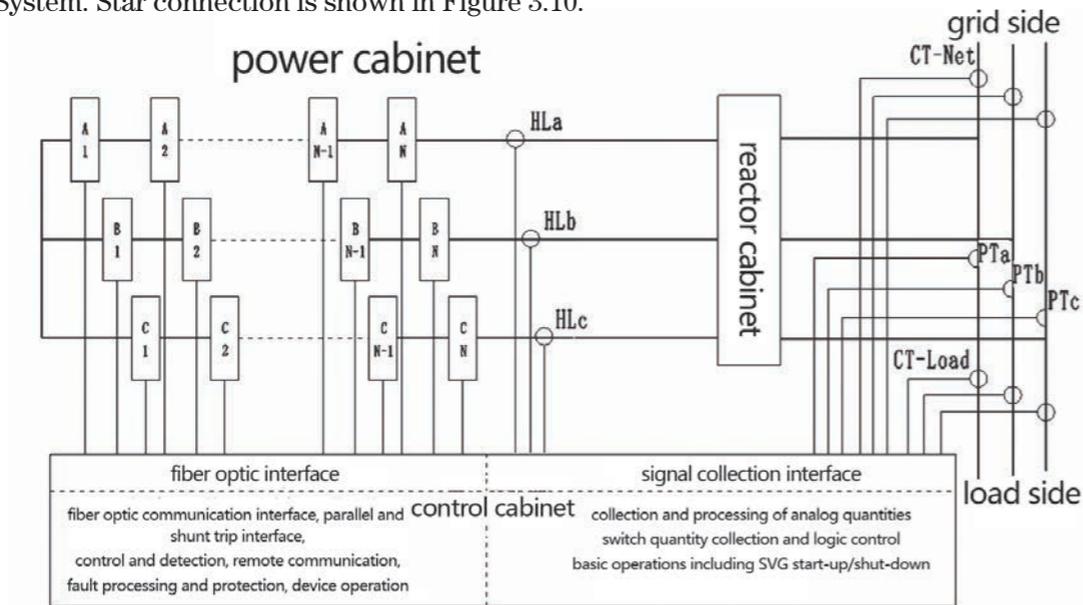


Figure 3.10 SVG's Electrical Connection Diagram

Signals of control cabinet and power cabinets are separated by fibers, a reliable way to separate high voltage from low voltage. Significant improvement in the structure of SVG series ensures the easier maintenance. Strict anti-interference protection is taken for the control cabinet to prevent the control system against the high voltage main circuit. Power module (unit) is improved so that it requires a smaller space, a way to reduce user's investment requirement. The photo of G31 FGSVG-C6.0/10, an indoor air-cooling model, is shown in Figure 3.11. The photo of FGSVG-C20.0/35-0, an outdoor container air-cooling model, is shown in Figure 3.12. The photos of G31 FGSVG C15.0/10-W and G31 FGSVG-C20.0/35-W, two outdoor water cooling models, are shown in Figure 3.13 and Figure 3.14, respectively.

Figure 3.11 FGSVG-C6.0/10 Front Side (only for reference)

Figure 3.12 FGSVG-C20.0/35-0 Front Side (only for reference)



Figure 3.13 FGSVG-C15.0/10-W Front Side (only for reference)



Figure 3.14 FGSVG-C20.0/35-W Front Side (only for reference)

An SVG product is chiefly comprised of three parts: control cabinet, power cabinet and reactor cabinet (this cabinet is not available for air core reactor). The power cabinet is greatly standardized, which provides convenience for capacity extension and stability. SVG devices of different voltage levels consist of control cabinet, power cabinets and reactor cabinets (or air core reactors). Specifically, the 35 kV device is designed in a cabinet-shape and with module concept, which saves the safety fence; the newly designed cooling fan can be directly mounted on the cabinet top, which reduces the installation difficulty and provides easy installation and maintenance. Main components in each cabinet and their roles are listed in Table 3.10.

Table 3.10 Main Components and their Roles

Structure	Component	Role
Control Cabinet	Switch	Switch on or off the main circuit
	Snubber	Suppress the voltage spikes on bus when the module is being charged.
	Data Collector	Collect switching quantities and analog quantities
	Control Box	Process data
	Logic Controller	Logic control
	Human-Machine Interface	Parameter setting and display as well as waveform recording
	Secondary Power Source System	Power source processing for a stable control system
Power Cabinet	Power Unit	Voltage of certain amplitude and phase cascaded as indicated in signals
	Mandatory Air Cooling System	Mandatory cooling of the modular unit
Reactor Cabinet	Reactor	Connection of reactive power source to the grid and current filtering

3.1.1 Control cabinet

The main circuit includes an isolator switch QS1, a contact KM1 (or breaker QF), a snubber resistor R, a status detector, etc., as depicted in Figure 3.1.5.

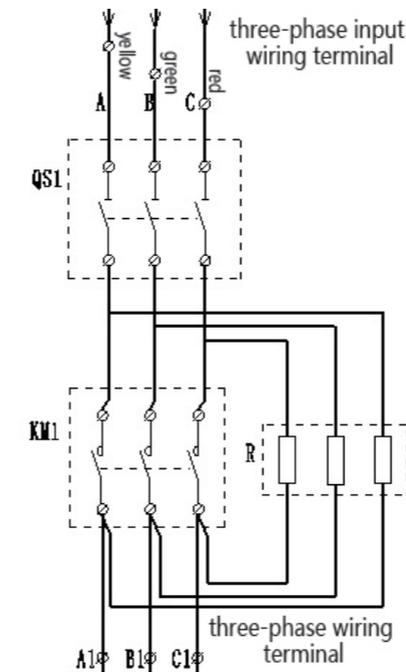


Figure 3.15 The Diagram of the Main Circuit in the Control Cabinet

Isolator switch QS1 is a protection component that isolates the high voltage from the grid for human safety in the event of system maintenance. QS1 cannot be operated unless the higher level switchgear is disconnected and cannot be operated when high voltage is delivered to the device.

SVG series is started up in a judgment manner. When the isolator switch QS1 is switched on, the system grid charges the capacitors in the power module through the snubber resistor. When the voltage of the unit bus is stabilized, the contactor KM1 (or breaker QF) is closed to bypass the snubber resistor, thereby having the main power source connected to the entire device.

The control cabinet of G31 model consists of the main control box, a PLC, an HMI, a switch mode power supply, a relay, a filter, an air switch, the UPS developed by us on its own, and other parts.

The control cabinet of G40 model consists of the main control box, a PLC, an HMI, a switch mode power supply, a relay, a filter, an air switch, the UPS developed by us on its own, and other parts.

Series communication is used between the main control box and the PLC, or among the I/O box, main control box and HMI. The communication connections between circuits in the main control box provide multiple-level control of the system, thereby controlling the target, monitoring the SVG's operating status and providing communication for the host.

1) Main control box

The standard main control box independently developed by us has passed the EMC certification under GB/T17626 and temperature shock and vibration tests, indicating its extremely high reliability. In the main control box are power supply board, main control board, phase separation board, signal separation board and other boards, which are interconnected in the card-inserting manner, providing high standardization, stability and easy maintenance. The power source board provides various power sources and interfaces for boards within the main control box to achieve the data transmission between boards. Main control box provides the core control function by coordinating all boards and ensuring outward communication. Phase separation board and signal separation board monitors all unit modules in a real time manner. The front side photo of the main control box is indicated in Figure 3.16.

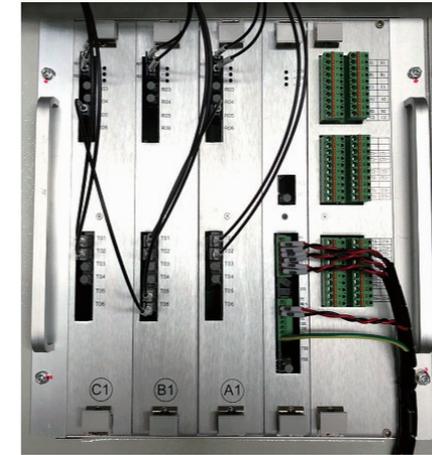


Figure 3.16 SVG Control Box

The control core of the main control box is provided by the synergy computation between a 32-bit high speed digital signal processor (DSP) and a complex programmable logic device (CPLD)/FPGA. Carefully designed algorithm ensures the optimum operating performance of the SVG. Large scale integration based controller is manufactured with surface welding technology. Automated welding equipment is used for welding process and CT test is performed to detect the welding defects, which eliminates the instability caused by manual operation and provides high system stability.

2) Programmable logic control module

Programmable logic control module sends the real-time operating status of the device to HMI and quickly and accurately help HMI and the cabinet door control the device.

3) HMI

As indicated in Figure 3.17, an emergency stop button is placed on the door to facilitate the user to operate in the case of emergency. We inview HMI from a leading Chinese supplier who adopts world-class equipment and standardized operating procedures that are parallel in international standards and have obtained the ISO9001: 2000 certificate issued by SGS for manufacturing products which have passed the CE, UL and RoHS certifications in 2005. It takes the lead in using lead-free parts and manufacturing processes that ensures its premium quality.



Figure 3.17 HMI Used for SVG

This HMI used for SVG provides friendly monitoring and operating interfaces in Chinese, automatically controls the device starting up and shutting down by using advanced human-machine communication skills.

The HMI is mainly able to:

- test the self-test of the system during the powering on process;
- offer basic operations on the device;
- start up and shut down the device with a one-key function;
- achieve time-shared control;
- provide oscilloscope displays (mandatory AD wave recording at different channels and different amplifications) ;
- record the waveforms, including transient voltage and current waveforms, in the case of fault;
- display the real time status and analog quantities (voltage, current, temperature, power and power factor);
- record the operating history events and inquire history curves;
- monitor the status of chain unit;
- inquire system information and parameters, and set parameters;
- help fault inquiry and history fault inquiry.

3.1.2 Power cabinet

The power cabinet contains many power units, forming the main part for SVG reactive power compensation. All power units are installed in three phases and each phase is connected to the same number of power units. The waveforms outputted by all units are superimposed to form the output waveform of the device. Each power unit bears the entire output current, $1/N$ of the phase voltage and $1/(3N)$ of the output power. The heat generated by each unit when it is working is dissipated by the fan designed on the top or back door of the cabinet. Units within an air-cooling power cabinet and a water-cooling power cabinet are shown in Figure 3.18 and Figure 3.19, respectively.



Figure 3.18. Units Arranged in an Air-Cooling Power Cabinet



Figure 3.19. Units Arranged in a Water-Cooling Power Cabinet

Many kinds of circuit boards are built in each power unit (Figure 3.20). For the control component of a unit, except for the sampling circuit, protection circuit and output drive circuit, all logic and communication functions are provided by large scale CPLD, an intelligent design that provides easier hardware, more flexible software, stronger interference resistance and higher reliability and helps further improvement and upgrading.

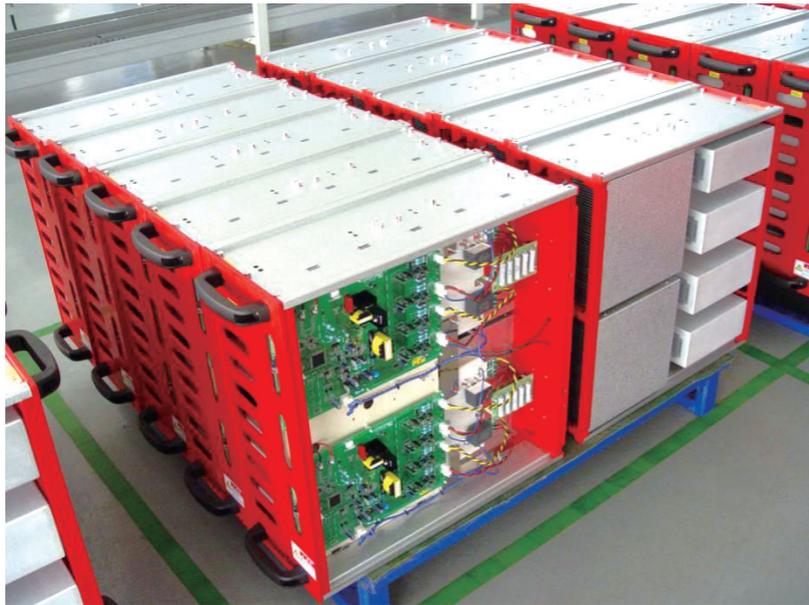


Figure 3.20 Power Unit (Module)

Deliberately selected film DC capacitors made from the PHD high temperature resistant PP film manufactured by Treofan Germany GmbH using special vapor evaporation process. Not only can they withstand high voltage and current impulse, but they also provide good self-healing property, thereby ensuring the product reliability. Increased free margin better ensures the electric instance distance at the edge and overcomes local discharge problem. The lead-out terminal is designed to be rotation-resistant and tensile-resistant. It is filled with medium temperature heat conductive epoxy (UL94V-0) without leak and crack.

Each power unit provides complete protections (over-current, over-voltage, over-heat, drive trigger exception and communication exception). The status of each power unit is sent back to the main control system. Optical fiber communication is used between the controller and power units with completely and reliably separation of low voltage from high voltage. In this way, the system excels in

safety and EMI immunity.

Modular-based design makes all power units share the same structure and ensures high interchangeability. Only two or four lead-out terminals and two optical fiber connectors are designed as external interfaces, a design that ensures easier maintenance and service. With redundancy design, the user can simply use backup units when other units fails to save the valuable time for production recovery.

Each power unit provides sine PWM control through IGBT-based inverter bridge so that the unit output waveform shown in Figure 3.21 can be obtained.

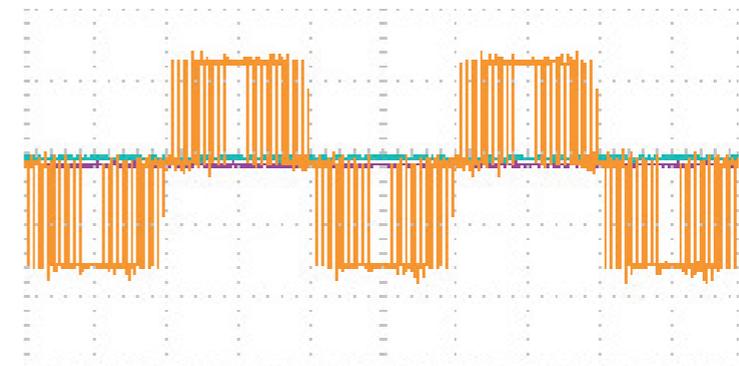


Figure 3.21 Waveform Outputted by Each Unit

After each power unit is chained, three phases that are star or delta connected are then connected to the grid through reactors. Superimposition of all PWM waveforms from all units result in the square PWM waveform that is similar to a sine waveform. Figure 3.22 gives the waveform of a single phase from a 10kv star-connected device.

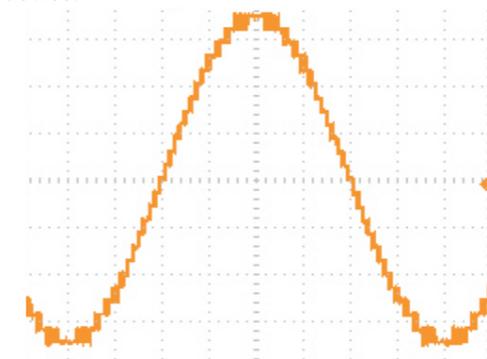


Figure 3.22 Waveform Superimposed by all Unit Outputs

SVG series is designed with the state-of-art Carrier Phase Shifting (CPS) technology with which, fundamental waves outputted by all units are superimposed harmonic waves outputted by all units are offset, and waves from units in series are filtered by output reactors so that the total output has a good sine wave form with a small dv/dt and a small harmonic component, which can reduce the damage to cable insulation and save the necessity to add output filters at the output side.

3.1.3 Reactor cabinet

An SVG device is connected to the grid through reactors for better sine waveform current. While smoothing waves, these reactors also inhibit SVG harmonics so that the current harmonics outputted by the SVG complies with national standard. Split-designed reactors increases space utilization and mitigates the space limitation to the device, a way that also reduces investment.

3.2 Operating Modes

3.2.1 Operating modes

Five operating modes are available: device reactive power mode, targeted point reactive power mode, targeted point power factor mode, targeted point voltage mode, targeted point reactive power mode 2, each of which can be selected in a pull-down list on the right of which the targeted value is set and may be modified at any time. The compensation effect after each change of the setting value can be examined based on the test value. "Operating modes" are detailed in the following Table 3.2.

Table 3.2 SVG Operating Modes

Operating Mode	Description
device reactive power mode	The SVG sends or absorbs the reactive power of the set value.
targeted point power factor mode	The SVG compensates the targeted point at the set power factor (-100%~+100%) within its compensation capacity.
targeted point voltage mode	The SVG stabilizes the grid voltage around the value set by the user by adjusting its reactive output.
targeted point reactive power mode	The SVG stabilizes the reactive power of the targeted point around the value set by the user by adjusting its reactive output.
targeted point reactive power mode 2	In this mode, the SVG adjusts its reactive power by detecting the reactive power of the load side so that the reactive power of the system side is kept at zero or around the set value.

3.2.2 Communication settings

To achieve the communication between the SVG device and its host, MODBUS_RTU protocol and CDT-91 protocol are adopted.

Matured communication mode developed by us guarantees the safety and reliability of SVGs that operate in parallel, increases the tracking speed of slave devices and meets the demand for large scale SVG's connection to the grid.

The HMI installed on the cabinet door provides tele-signaling and tele-metering verification regarding communication information when the device is not powered at high voltage in order to help the commissioning professionals test communication channels and data (Figure 3.23).

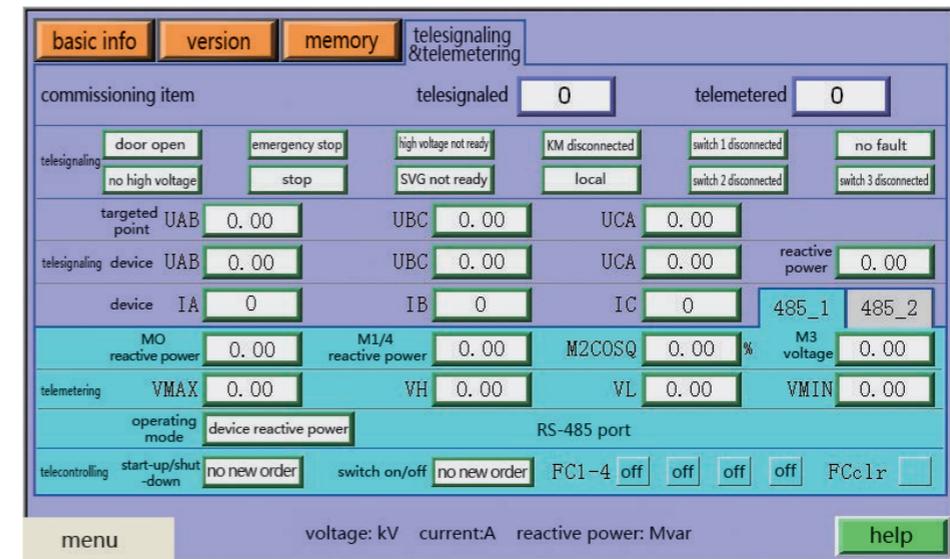


Figure 3.23 "Tele-signaling, Tele-metering, Tele-controlling and Tele-adjusting" Test Interface

Chapter 4 Human–Machine Interface Introduction

4.1 System Framework

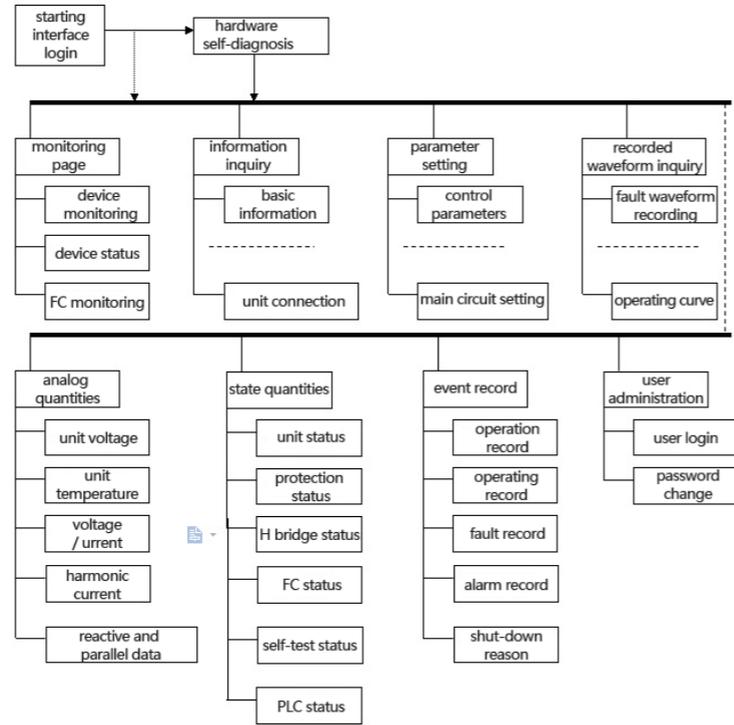


Figure 4.1 HMI Architecture

4.2 Description of Page Functions

- 1) Device monitoring page: Electrical parameters of the device and the system as well as operations like switching on/off and starting up/shutting down are displayed.
- 2) Unit voltage page: Bus voltages of all units are displayed.
- 3) Unit temperature page: Real-time temperatures of all units are displayed.
- 4) System data page: Information about the system, device, load voltage, current, power and other necessary information are displayed.
- 5) Harmonic current page: Harmonic currents of all orders from each phase are displayed.
- 6) Parallel data page: Information relating two devices in parallel are displayed.
- 7) Unit status page: Status of each unit is displayed.

- 8) Protection status 1 page: Information about faults of high speed communication and entire device are displayed.
- 9) Protection status 1 page: Information about faults in carrier configuration and H bridge configuration are displayed.
- 10) Protection status 3 page: Communication failures and power source failures are displayed.
- 11) self-test status page: Faults found in self-test displayed.
- 12) Operation record page: Records of starting up and shutting down operations are displayed.
- 13) Operating record page: Electrical parameters during the operating process are displayed.
- 14) Fault record page: Fault types and alarm reasons are displayed.
- 15) Shut-down reason page: Reasons for shut-downs are displayed.
- 16) Fault waveform recording page: Transient voltage and current waveforms in the event of fault are displayed.
- 17) User change page: The identity of the log-in user is changed on this page.

4.3 HMI Usage Introduction

After the control power supply is delivered to the device, the device performs self-test as shown in Figure 4.2. The reason for self-test failure must be indicated; and the monitoring page (Figure 4.3, the monitoring page when touch panel is used to control the start-up and shut-down operations) will be displayed after successful self-diagnosis.

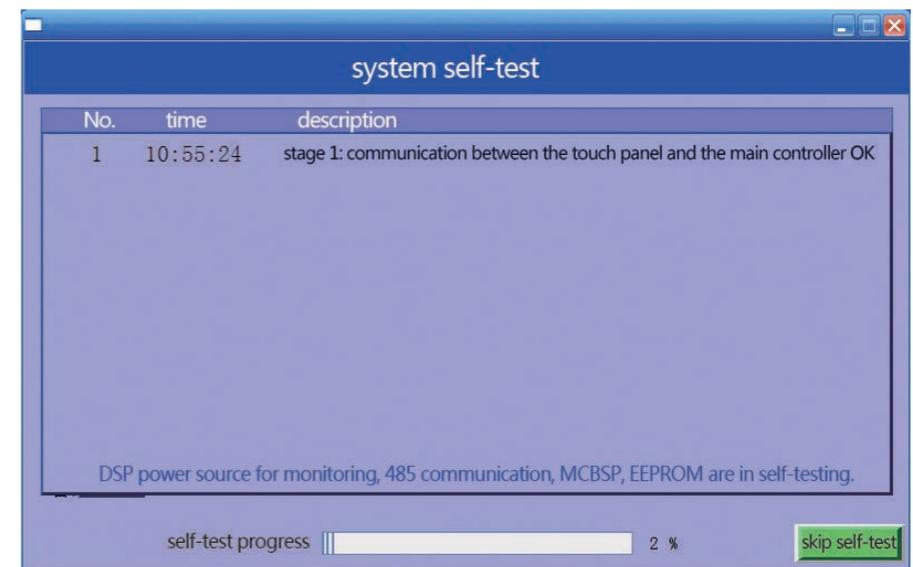


Figure 4.2 System Self-test Page

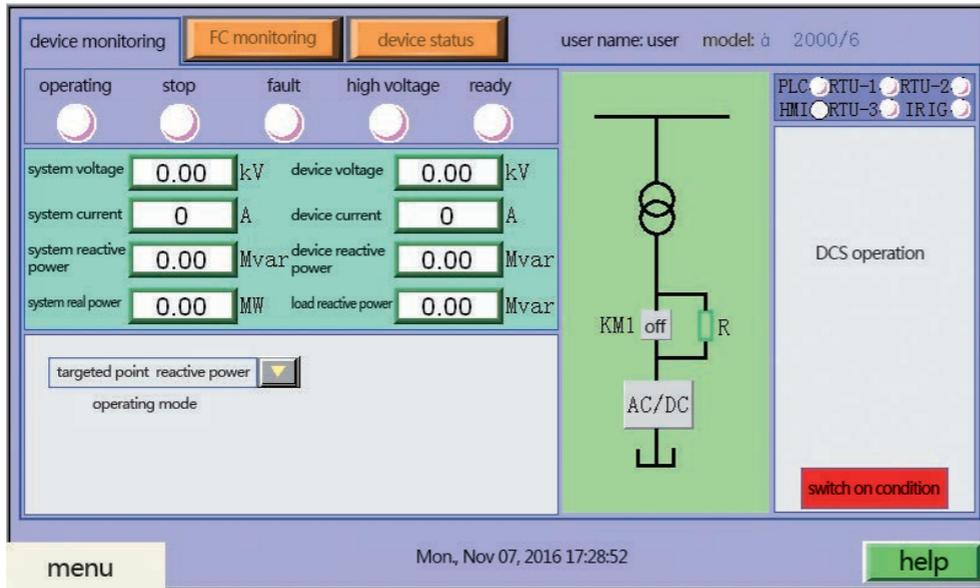


Figure 4.3 Device Monitoring Page

1) Analog quantity inquiry: Analog quantities such as unit voltage, temperature (customized function), harmonic current, device’s reactive power and parallel data can be searched. Figure 4.4 gives the page on which unit voltage is displayed and Figure 4.5 the page on which unit temperature is displayed.

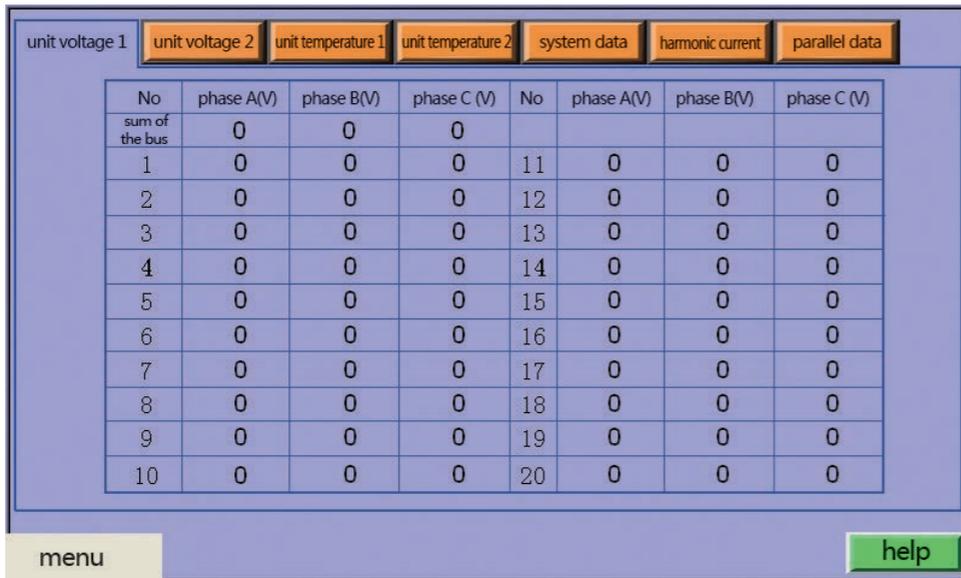


Figure 4.4 Unit Voltage Display Page

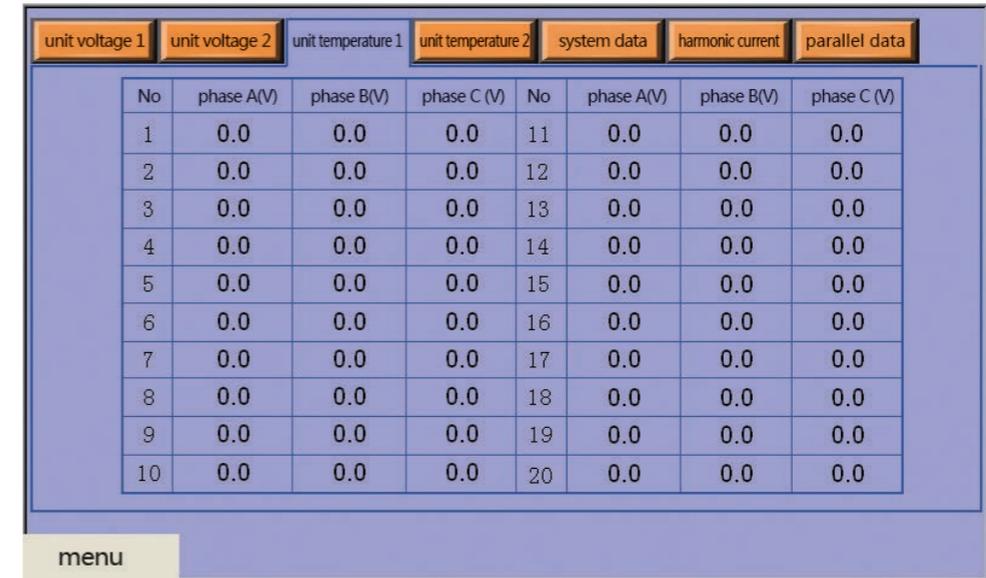


Figure 4.5 Unit Temperature Display Page

2) Status quantity inquiry: The basic status of each unit and the status of PLC’s I/O point can be searched. Figure 4.6 shows the unit status page (star-connection).



Figure 4.6 Unit Status Page

Note: Red or blue status means an exception for the unit.

3) Fault waveform recording: Figure 4.7 shows the page on which transient voltage and current waveforms in the event of fault are recorded.

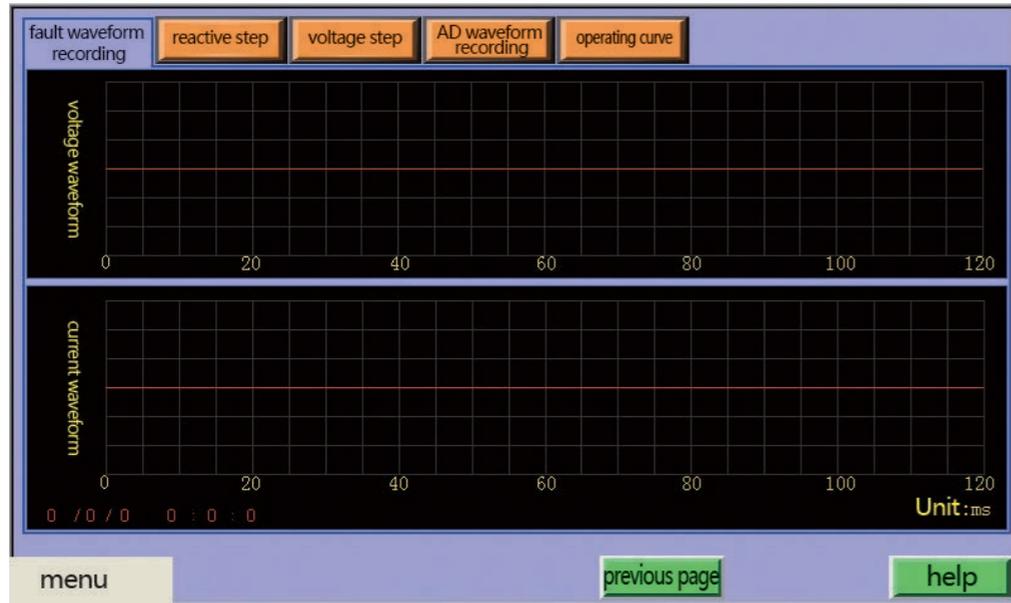


Figure 4.7 Fault Waveform Recording Page

Chapter 5 Use and Maintenance of SVG

5.1 Use Precautions

As a high-tech product that integrates microelectronic technology, photoelectric communication, high-voltage application technology, computer technology and other modern technologies relating to electricity and electronics, this product requires the following conditions for its use.

- The environment where it is used must satisfy the specified technical requirements.
- It must be installed by a qualified installer who is subject to electric equipment installation approval or the manufacturer.
- It must be operated by specially trained electric operators.
- It requires periodic cleaning and maintenance for removing the dust and dirt formed due to long-term use; in particular, the filter in the air inlet window of the power cabinet must be cleaned on a regular basis, once per month as recommended.
- Fan vibration and other mechanical vibrations due to long-term use may cause electric contacts to loosen, which may further cause poor contact or even damage components, parts or the device, which results in inconvenience and loss of the user. The device must be maintained and cleaned regularly to prevent such inconvenience and loss.
- Electric insulation, snubber resistors, cabinet doors, neutral connection and earthing connection and the earthing impedance must be often checked to ensure their proper performance and compliance.
- The systems for recording device operating and for device maintenance must be established.

5.2 Start-up and Shut-down Steps

To provide the optimum operating performance, the SVG device has been configured with the optimized parameters in factory and during on-site commissioning. These parameters may not be changed unless necessity arises. We must be consulted before any change is made to the system. Only authorized persons (senior users or commissioning persons) are allowed to change parameters as necessary in accordance with the suggestions from us. Starting up and shutting down are done on the monitoring page shown in Figure 4.3 (the page for HMI control of the start-up/shut-down operations; the pages for tele-controlled or background controlled cases are identical to this page).

Start-up steps: set the required operating mode (in the left bottom corner of Figure 4.3) → click Switch On button → click Start button

Shut-down steps: click Shut button → click Switch Off button

The detailed steps for powering on the device:

1) Before operating the SVG, the operator must confirm trolleys of the higher-level switchgear have been moved out and the earthing switch of SVG's high voltage switchgear is closed, namely, the switchgear is in cold backup.

2) Carefully complete and check the secondary circuit against the wiring and installation instructions before moving to the next step for delivering the control power supply.

3) The user's on-site power distribution room sends the AC380V (three-phase four-wire distribution system) power source or DC220 power source to the SVG to power its secondary control system. Power supply switches in SVG control cabinet are shown in Figure 5.1 where QF1 is the air switch for AC220V power source, QF2 is the air switch for DC220 power source and QF3 is the air switch for the power source of heat dissipation fan in the power cabinet.

4) Switch QF1 and QF2 on to power the SVG's secondary control system; after

which, HMI is starting. After the password that corresponds to the authorized user's level (user or senior user) is entered, the self-test page is displayed. After successful self-diagnosis, device monitoring page is displayed and on which operations can be performed according to the status box information and relevant hints, as described in Figure 4.3.

5) Close QF3. After the power source is delivered, press the protruding part of middle relay KM2 for the control fan (for models without such contact, please contract our after-sale service staffs who will provide guidance for fan direction test) or the moving iron core of the corresponding contact for about 2 seconds and then release it to observe if the fan rotates in a direction identical to the arrow mark. If not, adjust the sequence of any two phases.

6) Close all cabinet doors of the device, check the isolator switch of the main circuit to ensure it is closed when the higher-level switchgear is in cold backup, as shown in Figure 5.1.



Figure 5.1 Operating Rod Position when the Isolator Switch is closed

7) Moves in the trolleys of the higher-level switchgear by following operating procedures to change the switchgear in hot backup and prepare for sending the master power source to SVG device.

8) During the power delivery process, operators in background control room and SVG installation room observe the device and report the observed status to each other; if any exception occurs during this process, the SVG's higher level high voltage switchgear must be switched off immediately.

9) After the master power source is delivered to SVG, all power units start to work for self-diagnosis. On device monitoring page, the "High Voltage" light that turns on means the master power source has been delivered successfully, indicating that the next step can be performed. The fact that "Switch on Condition" background color on the device monitoring page turns green means switching on is permitted; red color means switching on is not permitted, and it is required to click the "Switch on Condition" and check and process the red items in the pop-out window.

10) Check "bus voltage page" to ensure unit bus voltages are balanced (voltage difference <50V). Turn on the Emergency Stop button on the cabinet door (Figure 5.2) and press the Switch On button on button monitoring page to turn the device from charging status to readiness status. At that time, the "Ready" light on device monitoring page turns on.

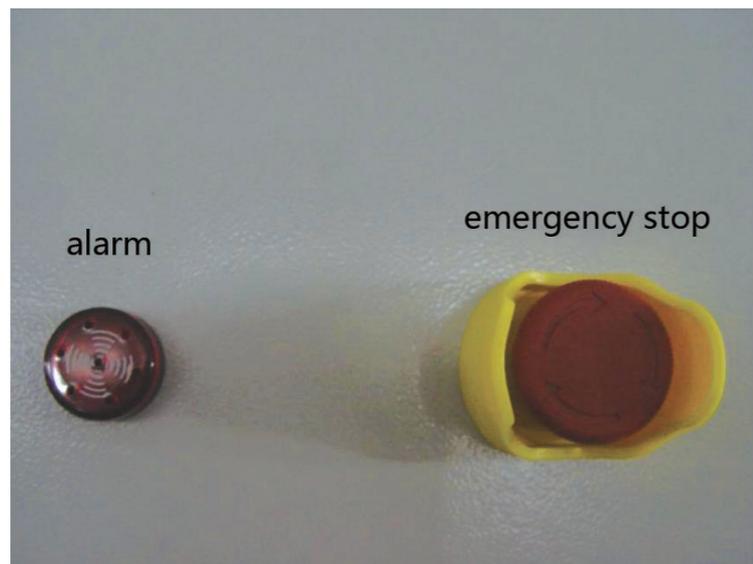


Figure 5.2 Emergency Stop on Cabinet Door

11) Select the required operating mode in the pull-down list, set the control target in the input box and start the device.

12) In the event of a unit fault or system fault, the "Fault" light on device monitoring page will turn on, the alarm light on the control cabinet door will send alarms periodically, SVG will be automatically shut-down and the switch through which SVG itself is connected to the grid is disconnected; if the shunt trip function is available to the fault, the higher-level switchgear's breaker will trip too. After the fault is solved, click the "Reset" button on device monitoring page to reset SVG and then restart it.

The detailed steps for powering off the device:

1) Click the "Shut Down" button on device monitoring page to stop SVG normally; then SVG will transfer from operating status to stop status and the "Stop" light turns on.

2) Click "Switch Off" button on HMI to disconnect master switch of the SVG. Caution: The main circuit is still at high voltage at this time.

3) Disconnect the breaker of higher-level switchgear remotely to transfer the switchgear to hot backup.

4) Manually move out trolleys of higher-level switchgear to transfer the switchgear to cold backup and earth it.

5) Disconnect SVG isolator switch.

6) Observe DC bus voltages of all units on HMI until they decrease to 0V and wait for 10 minutes.

Then disconnect QF1, QF2 and QF3, three air switches of power source for SVG control cabinet.

7) In distribution room, disconnect SVG AC380V, AC220V or DC220V power source switches one by one.

5.3 Precautions Start-up/Shut-down

1) Relevant operation procedures must be strictly observed for proper use of SVG series since any wrong operation may cause human injury and device damage.

2) As a high voltage device that presents high voltage danger, SVG must be operated in strict accordance with the operation manual.

3) Relevant parameters of SVG are set before it is shipped, and may not be changed if you are not adequately familiar with SVG and its load because improper change may result in system exception or even major accident.

4) During SVG is operating normally, do not press either HMI or buttons on cabinet doors to avoid wrong action of the system.

5) People who operate and maintain SVG device must be specially trained and carefully care this user manual.

6) Back part of the control cabinet, power cabinet and reactor cabinet are dangerous due to high voltage; when high voltage is delivered, any work that requires opening a cabinet door is prohibited.

7) Attention:

- System voltage should be within rated voltage $\pm 10\%$.
- Powering on and powering off must be performed in the following order: First send control power supply and then send high voltage power supply after the control power supply is delivered normally; first disconnect the high-voltage power supply and then the control power supply after high voltage is fully discharged.
- When SVG device is operating, the user must closely monitor the operating condition so that the device can be shut-down immediately in the event of any problem.
- Good indoor ventilation and an ambient temperature between $-10\sim 40^{\circ}\text{C}$ must be kept.

5.4 Maintenance

After one week since the device is put into service, the following maintenance is required: shut down the device, disconnect the master power source, tighten the screws and bolts used for conductor connections and earthing wires to satisfy the reliable contact requirement.

- After the device is put into service, contact temperatures must be measured once per quarter.
- After the device is put into service, a planned shut-down is required each year and it is required to open a power unit to inspect capacitors by sampling. Enclosures of film capacitors should show no exception, with smooth and black sealing surfaces. If any of these sampled capacitors is defective, the manufacturer must be notified.
- During operating process, daily patrol is required; if abnormal noise is generated inside or no or less air flows out of the air outlet, the device must be shut-down and master power source disconnected at once, then the following checks are performed: if the air inlet is blocked, if the cooling fan performs well and if air exhaust pipe is blocked. As necessary, the damaged fan should be changed and the air inlet or air exhaust pipe cleaned. The manufacturer must be immediately notified if the device gives off odor (especially, ozone odor).
- The room where the device is positioned must be kept clean without dust accumulation.
- Rat control must be provided to avoid small animals from entering the SVG cabinet.
- Indoor temperature should be properly kept and cooling actions (e.g., improved ventilation and air-conditioning) taken when indoor temperature exceeds 38°C .

5.5 Periodical Checks

An entire check in accordance with this manual and subject to actual environment must be performed on the SVG per three months. The check covers the following works:

- Comprehensively clean filter of the air inlet window and the air channel of power cabinet;
- Check if screws of wiring terminals are loosened;
- Check if poor contact of circuit terminals and over-heat indications exist;
- Check if cables (either control or not) are damaged, in particular if the surface sleeves that contact with metallic surfaces are damaged by cut;
- Check if the insulating tapes that wrap the cable lugs are detached;
- Check if all fans perform properly.

5.6 Maintenance Precautions

Despite the fact that all-around consideration for operator safety has been taken accounted in SVG design, like many other power devices, many internal terminals of the SVG are at lethal high voltage. Further, radiators and some other internal elements have high temperatures. The following requirements must be met for safety reason.

- The user must have been properly trained and familiar with SVG structure, necessary knowledge about its operation and relevant precautions.
- Only trained persons are allowed to operate, maintain or repair SVG.
- Operation order system must be strictly observed when SVG is serviced. At the same time, the isolator switch of SVG control cabinet must be disconnected and other safety supervisors must be present.
- Only when the device is completely disconnected from the power supply (high voltage and control power) and no high temperature exists are components inside the cabinet allowed to be touched.

- High voltage operation procedures must be followed, such as wearing insulation gloves, insulating shoes and safety glasses, for SVG maintenance.
- Safety fence (marked with high voltage danger) must be correctly used and may not be used for other purpose when SVG is in operation.
- Combustible materials (including drawings and user manual) are not allowed to be placed near SVG.
- Caution must be taken to work with or measure components inside the device to prevent instrument lead wires from getting interconnected or contacting other terminals.
- The power supply for radiator fan may not be disconnected when the main circuit is powered on, failing which may cause device fault.
- SVG must be loaded onto the transportation vehicle in a symmetric and flat way for proper handling and the ground onto which it is unloaded must be horizontal.
- Maintenance work that users can provide are limited to recording fault phenomena and as necessary changing the defective unit; any further repair must be handed to the manufacturer.
- Unit replacement may not be performed until the master power source has been disconnected for 15 minutes and the control power source has then been disconnected.
- Any wrong operation may cause human injury or SVG damage.
- Other safety precautions mentioned in this manual must be observed to prevent death, injury and damage.
- Only when the power source is disconnected are various plugs permitted to be inserted or pulled out.
- Do not touch chips or components on PCBs.
- Use qualified instruments and devices to test SVG.
- The secondary coil of a current transformer must be short circuit before the transformer is operated. The secondary coil may not be disconnected when the current transformer is working.

Chapter 6 Storage and Installation

6.1 Overview

Carrying through the principle of quality first and customer first, We optimizes product design and strictly follows quality standards throughout the entire production process from component selection, manufacturing, test to installation to ensure the product's stable and reliable performance in normal condition.

6.2 Acceptance

The complete acceptance includes the following steps:

- check if the device is completely delivered against the shipment note.
- inspect if any damage is caused in the transportation.
- if any transportation damage is found, take a photo of the damage as evidence for making a claim against the carrier.

6.3 Storage

Long-term shut-down or storage of SVG for any reason may increase the possibility of SVG failure, to prevent which, the following points must be underscored during necessary long-term shut-down or storage:

- keep the storage environment basically consistent with the operating environment, i.e., there is neither dust and nor water drops and the relative humidity does not exceed 90%;
- cover the device with a waterproof film to prevent device failure caused by water drops and moisture that intrude into the device;
- place moisture absorbing materials into the device;
- perform water drainage for the device periodically;
- conduct an entire check when the device is powered on if possible;
- storage temperature: $-30 \sim +70^{\circ}\text{C}$;

- relative humidity: monthly average value is not higher than 90 % (25°C) without condensation;
- vibration (storage): maximum 0.3 at a maximum acceleration of 1m/s^2 (sine);
- vibration (earthquake): maximum 9mm at a maximum acceleration of 181m/s^2 (sine);
- impact (storage and transportation): maximum 100 m/s^2 ;
- environmental condition: no corrosive, combustible or explosive materials;
- during transportation, the device must be handled carefully and may not be exposed to rain, strong sunshine, collision or bottom-upside placement.

6.4 Mechanical Installation

6.4.1 Environment requirements

The following environmental requirements and electrical conditions are the prerequisites for long-term stable performance of SVG products.

■ Installation environment:

- Operating environment: ambient temperature must be within $-20^{\circ}\text{C} \sim +40^{\circ}\text{C}$. The ambient temperature change may not exceed $5^{\circ}\text{C} / \text{h}$. If the ambient temperature is out of the said scope, an appropriate air-conditioner must be provided.
- Standard installation height is below 2,000 meters in elevation. If it is to be installed on an elevation higher than 2,000 meters, the requirement must be specified in the purchase order to consider a special design.
- Space requirements: The front-to-wall distance, back-to-wall distance, side-to-wall and top-to-ceiling distances are 1,500 mm, 1,000 mm, 1,000 mm and 1,500 mm, respectively, at a minimum.
- Relative humidity change does not exceed 5% per hour and condensation should be avoided.
- Do not install the product in an environment where there is a heavy dust, or corrosive or explosive gas, or conductive dust.

- The vibration permissible in the place where SVG is installed: frequency is between 10Hz and 150 Hz; if resonance may occur due to installation base vibration, actions must be taken to avoid the resonance frequency by reducing the device vibration.
- Electrical conditions:
 - The voltage of power transmission or power distribution grid to which SVG is connected can only fluctuate within $\pm 10\%$ of the rated input voltage.
 - SVG's control power source is either single phase AC220 at 50 Hz or DC 220V or three-phase AC380, with a capacity as indicated in the wiring drawings supplied with the device and the continuous fluctuation of AC voltage within $-7\% \sim 10\%$.

6.4.2 Device dimensions and loading/unloading and installation of cabinet

With the 10 kV/4 Mar SVG as an example, its front elevation and left elevation are shown in Figure 6.1 and Figure 6.2, respectively. Dimensions of 10 kV/4 Mar SVG: 4100mm (L) \times 2400mm (H) (excluding the fan) \times 1400mm (D). For dimensions and specifications of other products, please refer to Table 3.2 and Table 3.3.

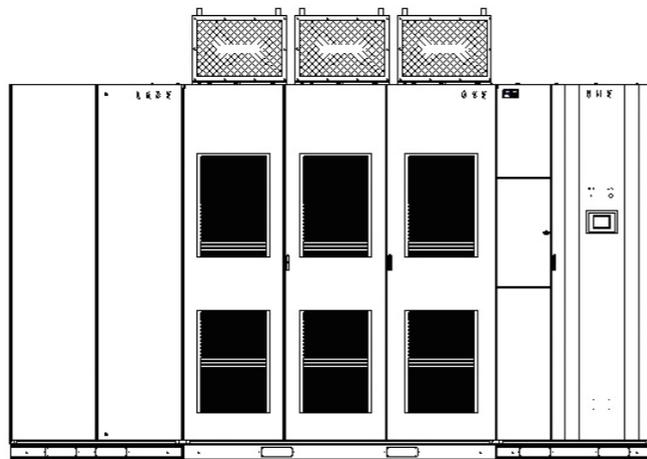


Figure 6.1 FGSVG-C4.0/10 Front Elevation

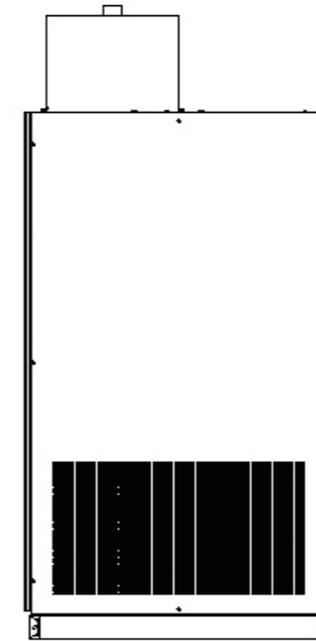


Figure 6.2 FGSVG-C4.0/10 Left Elevation

Ventilation and accessibility must be taken into account for SVG installation; for this reason, the front-to-wall distance, back-to-wall distance, side-to-wall distance and top-to-ceiling distance must be kept at least 1,500 mm, 1,000 mm, 1,000 mm and 1,500 mm, respectively, as shown in Figure 6.3.

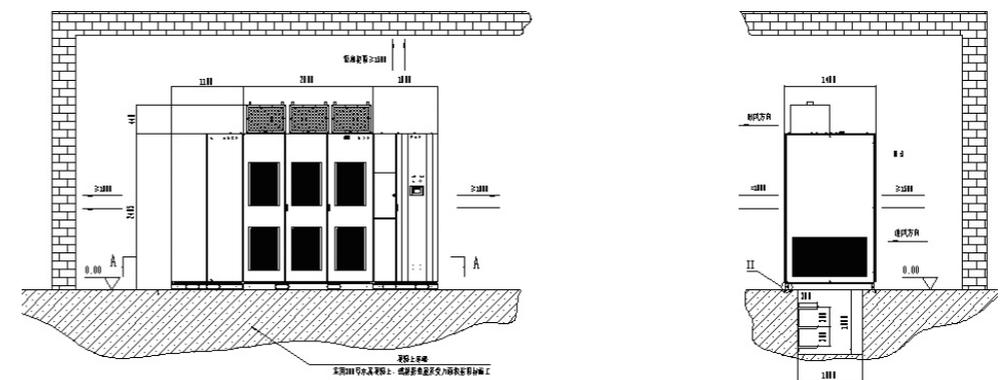


Figure 6.3 Drawing of FGSVG-C4.0/10 Installation Foundation

All cabinets must be firmly installed on the foundation and reliably attached to the plant ground. The shield layer and earthing terminals must also be connected to the plant ground. Cabinets must be connected to form an entirety that must be reliably earthed (earthing resistance <math>< 500 \text{ M}\Omega</math>).

During device installation, the device must be protected against collision and vibration, no cabinet may be placed upside down or inclined for over 30 degrees. Proper actions must be taken in the installation site to prevent damage caused by rats and other small animals.

Control cabinet, power cabinet and power units are shipped separately for transportation. Spare parts (if any) of power units and fans to be installed on tops of cabinets are packed and shipped separately.

Openings designed for forklift are available on the bases of cabinets, which can be handled in the following ways:

1) crane handling

Lifted by a crane or a chain block. It is recommended to have two strong enough metallic beams of not more than 1.5 in length penetrate the forklift openings and lift the cabinet with strong ropes at front and back ends. Use reinforced beam to support the cabinet top to prevent deformation, as shown in Figure 6.4.

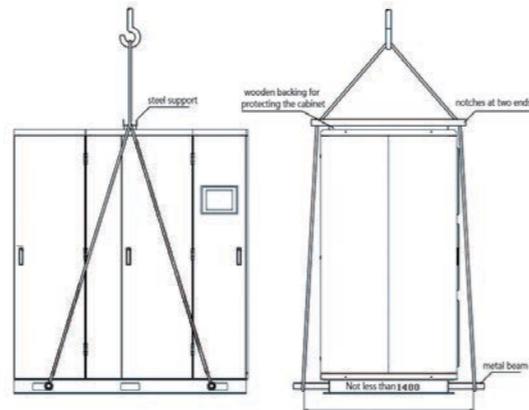


Figure 6.4 Bottom-Lifted Handling Diagram

Caution: Ensure the ropes or metallic beams penetrate into the appropriate forklift openings during handling and keep the lifting center as close to the cabinet gravity center rather than the geometric center as possible.

2) Forklift handling: The forklift used for handling must be able to bear the cabinet weight and its fork may not exceed 1600 mm in length, 170 mm in width and 50 mm in thickness, as indicated in Figure 6.5.

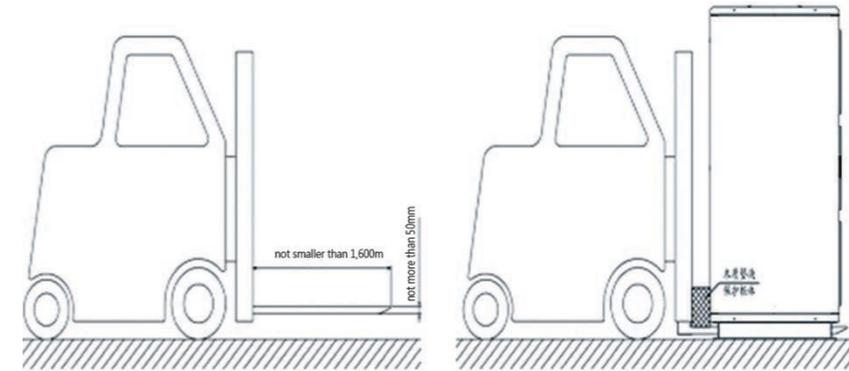


Figure 6.5 Forklift Handling Diagram

The blind plates at front and back sides of the base must be removed before forklift handling and assembled again after handling.

3) Roller trolley handling: The roller trolley must be placed below the U-channel steel of the base, as shown in Figure 6.6.

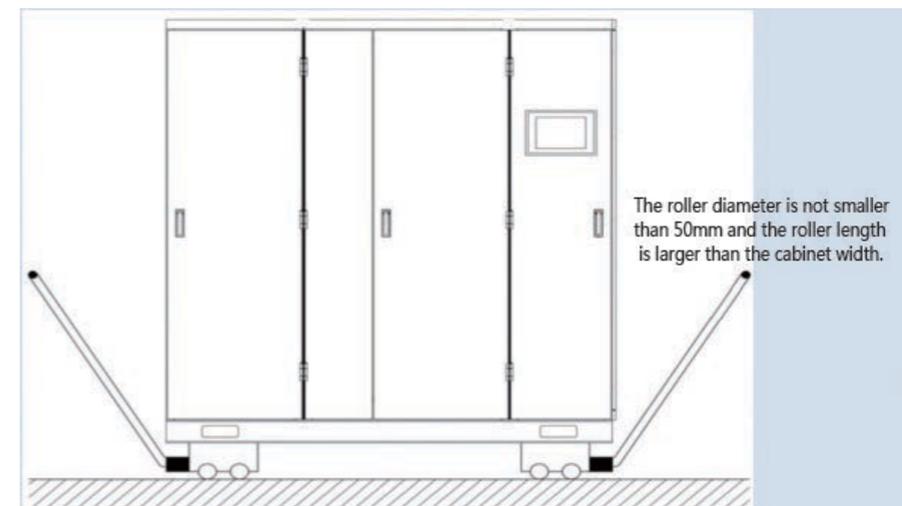


Figure 6.6 Roller Trolley Handling Diagram

4) Roller handling: Place rollers in a row on the floor, put the cabinet on these rollers and move the rollers for handling (as shown in Figure 6.7). Roller length must be larger than cabinet width.

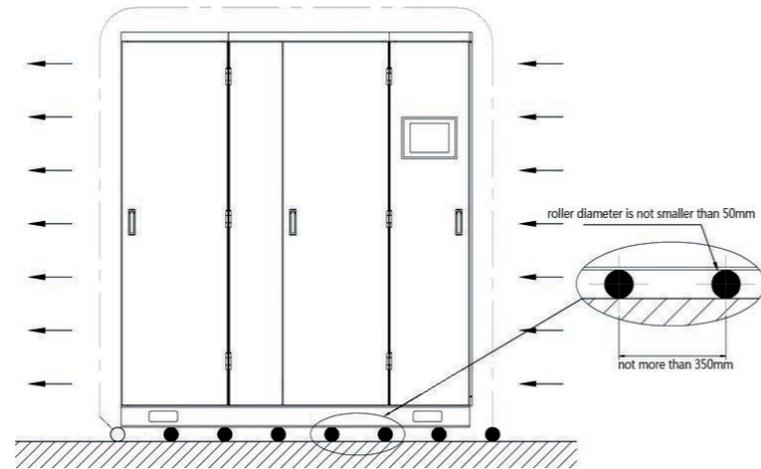


Figure 6.7 Roller Handling Diagram

6.5 Electrical Installation

Electric installation mainly refers the wiring connections between cabinets, connection of high-voltage cables and earthing cables from the field to the cabinet for grid connection, connection of AC220V or DC 220V or AC 380V control power cables from the field to the cabinet and connection of control and signal cables from the field to the cabinet.

Outbound wiring methods and standards:

1) G31 high-voltage cable connection:

- ensure the input voltage meets requirements;
- ensure the cable diameter and resistance meet requirements;
- reliably attach input cables to the positions indicated by blue box in Figure 6.8.

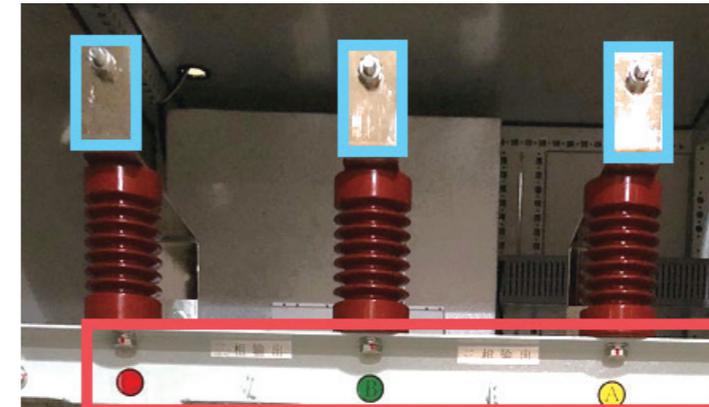


Figure 6.9 Three-Phase Master Cable Terminals for G40 Model

Note: All incoming wiring requirements from the user must be specified in the technical contract, and cables are connected into the cabinet at the bottom.

3) Earthing cable connection

It is preferred to use high voltage cable whose diameter is identical to the diameter of the input cable to connect the earthing terminal at the device

base to the nearest earthing point on site, with an earthing resistance less than 500 M Ω for both human and device safety.

4) Control power cable connection

The device needs a stable and reliable power source (AC380V, or AC220V or DC220V) whose capacity and wiring specification are indicated in the Schematics for External Wiring Terminals of SVG Control Cabinet supplied with the device.

It is recommended that the three-core cable 380VAC power source with a centrifugal fan for heat radiation.

5) Grid current signal sampling

- SVG needs the real-time data about two-phase or three-phase grid current in respect of the connecting point, for which purpose, the user should provide the standard current signal of 0-5A or 0-1A with a precision of 0.2%-0.5%.
- Wiring method: Depending on the distance to the sampling point, two-core shielded cable of more than 2.5mm² in diameter is recommended.

Note: The diameter of current sampling cable may not exceed 4mm² to prevent large-sized cable from being inserted into SVG terminal block.

- Connecting point: Refer to the user drawings supplied with the device.

6) Load current signal sampling

- SVG needs the real-time data about two-phase or three-phase load current in respect of the connecting point, for which purpose, the user should provide the standard current signal of 0-5A or-0.5%.
- Wiring method: Depending on the distance to the sampling point, two-core shielded cable of 2.5mm² in diameter is recommended.

Note: The diameter of current sampling cable may not exceed 4mm² to prevent large-sized cable from being inserted into SVG terminal block.

- Refer to the user drawings supplied with the device for the connecting point.

7) Communication port connection

- SVG supports the communication with its host, for which, RS485 under Modbus protocol or Ethernet port under IEC104 protocol is used.

- Wiring method: Multicore shielded communication cable is recommended.
- Connecting point: Refer to the user drawings supplied with the device.

8) Wiring of FC switching control port

- SVG is designed to have ports that go with FC, a way that can effectively combine static and dynamic compensation, in order to provide more economical and flexible compensation solutions for users and meet the needs of diverse industrial situations. The SVG in standard configuration outputs four reactive nodes used for controlling the 4-grade switching of FC on the site. Separate instructions are needed if the user requires more switching grades
- Wiring method: Installation cable or shielded cable of more than 1.5mm² in diameter is recommended.
- Refer to the user drawings supplied with the device for the connecting point.

9) High voltage readiness and shunt trip high voltage wiring

- To ensure the reliable and safe performance of the system, the higher-level switchgear should provide a reactive node, if, through which, SVG detects the high voltage after the switchgear sends high voltage power, the system enters high-voltage readiness status.
- SVG provides a reactive node which is in series connected to the switching circuit of the switchgear; when SVG exits from operating actively or due to failure, the reactive node gives a status quantity that indicates shunt trip high voltage to disconnect the higher level switch gear.
- Wiring method: Installation cable or shielded cable of more than 1.5mm² in diameter is recommended.
- Refer to the user drawings supplied with the device for the connecting point.

10) Precautions for electrical installation

- High voltage cable must have passed the strict voltage resistance test.
- Nonprofessionals are not allowed to use or test the device.
- The device has received resistance test before it is shipped; users are not recommended to perform another voltage test on it.
- It is not allowed to change three-phase input into two-phase input.
- Signal cables that are connected to SVG on the installation site must be isolated from the high voltage cables. Shielded cable is preferred for signaling purpose with one of its end reliably earthed.
- The reliable connection between SVG cabinet and plant ground must be kept to ensure human safety.
- For electric installation, an earth electrode whose earth resistance may not higher than $500M\Omega$ must be specially buried for the control system.
- Careful check is required after wiring is completed.
- The matching of SVG capacity and the wiring specification and wire completeness must be checked.

Chapter 7 Common Problems and Solutions

7.1 Overview

In the event of any unit fault or system fault, the fault information will be recorded automatically, an alarm will be send and the system will trip and shut down. The system cannot be restarted until the fault is completely removed.

After a fault occurs, the master switch for SVG-grid connection will be automatically disconnected. If the master switch is not disconnected for any special reason, the user can manually disconnect it by pressing the "Emergency Stop" button on the cabinet door.

7.2 Common Problems and Solutions

SVG is designed with highly intelligent and completed fault detection circuit which can precisely locate all faults, which can then be indicated on HMI. Given the fault information displayed on HMI, the user may take proper actions.

The main control software and hardware detect faults and alarms and store them into the memory of control system. Faults may be directly from hardware or generated by software. Unit faults are detected by the control system within the power unit and each power unit has its own detection circuit. The main control system interprets, displays and records a unit fault given the unit where such fault occur and the nature of the fault.

Generally, every fault results in immediate shut-down of SVG, disconnection of the master switch for grid connection and sending of a shunt-trip signal to the higher-level switchgear.

The user may define some slight faults that do not affect proper performance of SVG and in the case of any of such fault, an alarm will be displayed and recorded, but the SVG will continue operating. Refer to Table 7.1 for protection reasons, protection types and solutions for common faults.

Table 7.1 Solutions to Faults

Fault/Exception	Possible Reasons	Solutions
PLC or I/O communication fault	poor contact between main controller and PLC/ or I/O box	check if the connection performs normally and if the pins are corroded.
HMI communication fault	poor contact between main controller and HMI	check the 485 communication cable connection
Cabinet door status fault	door opened	check if the door is properly closed and adjust the position of the travel switch
unit over-temperature	1) fan does not work or rotates in the wrong direction; 2) filter is covered with dust that causes bad ventilation; 3) air channel is not properly closed.	1) check the fan; 2) clean the door filter; 3) check the air channel and close it properly.
unit over-voltage	1) communication component of the unit bus goes wrong after the bus voltage is sampled; 2) large electromagnetic interference causes wrong action.	1) check the internal bus bar connections; 2) provide proper shield.
system over-voltage	grid failure	reset the device until the grid is recovered
unit over-current	1) the unit's over-current protection works; 2) system voltage error causes current change.	1) re-deliver power, reset and start the device; 2) wait for automatic recovery.
system over-current	1) too high system load impact; 2) system voltage error causes current change; 3) too high operating capacity causes overload.	1) observe if system voltage and load impact are normal; 2) wait SVG's automatic recovery; 3) check if output current transformer of SVG is wired correctly and if the current direction is defined correctly.

7.3 How to Replace Defective Units

If the device cannot perform normally due to the defect of a certain unit, the user can purchase a power unit of the same model from us. Replace the defective unit with the new one when SVG is shut-down with the master power source disconnected. Steps for replacing the defective power unit:

Step 1: Stop SVG, click "Switch Off" and press the "Emergency Stop" button on control cabinet door;

Step 2: Disconnect the breaker of SVG higher-level switchgear and have the earthing switch connected to the ground reliably;

Step 3: Observe the bus information of the defective power unit displayed on HMI until the bus voltage changes to 0V and wait for 10 minutes, then disconnect QF1, QF2 and QF3;

Step 4: Open the power cabinet door, pull off the fiber optic connector of the defective unit, and place the fiber optic cap for proper protection;

Step 5: Remove front and back fixing bolts of the defective unit and pull them out along the guide track (do not touch the optical fiber) carefully;

Step 6: Push the new unit along the track and connect the cable/copper bus bar and optical fiber correctly;

Step 7: If no alternative power unit of the same is available and long-term shutdown of SVG is not acceptable, it is allowed to set the defective unit as a redundant unit, which does not impact the performance of device. Please contact the manufacturer for redundancy setting method;

Step 8: Check the entire system in accordance with the operation manual to ensure no problem is present and then power the system on again for operation;

Step 9: Request the manufacturer to repair the defective unit.

Chapter 8 Services and Warranty

Pre-sale services

- We proposes system design ideas and technical consulting services for behalf of the user.
- We develops the installation plan and environmental requirements.
- We estimates the operating effect.

After-sale services

- A training session for operations and permanent consulting service free of charge.
- Quality warranty free of charge for 12 months (defects or damages caused by human reasons or improper operations are not covered).
- Life time warranty for any product whenever and wherever.

Warranty rules

- Warranty coverage
- ◇ Warranty coverage means SVG device and accessories provided by us;
- ◇ We repairs all faults or damages that occur in the normal use condition within 12 months after the device is put into production.
- Limited repair

The warranty provided by us does not apply to:

- ◇ products or parts that are out of the warranty period;
- ◇ external devices, third-party products or parts that are not assembled in this or that are separately added, products or parts that are provided by the user;
- ◇ faults or damages caused due to installation, storage or use under such environment or with such methods as not specified for this product, without the consent , such as too high or too low temperature, too high

relative humidity, unstable voltage or current, improper input voltage or wrong operation;

- ◇ faults or damages caused by any installation, repair, modification or disassembly not authorized by us;
- ◇ faults or damages caused by any part not provided by us;
- ◇ faults or damages caused by accidents or other external factors (including natural disasters, fire, flood, war, violence or other similar events).