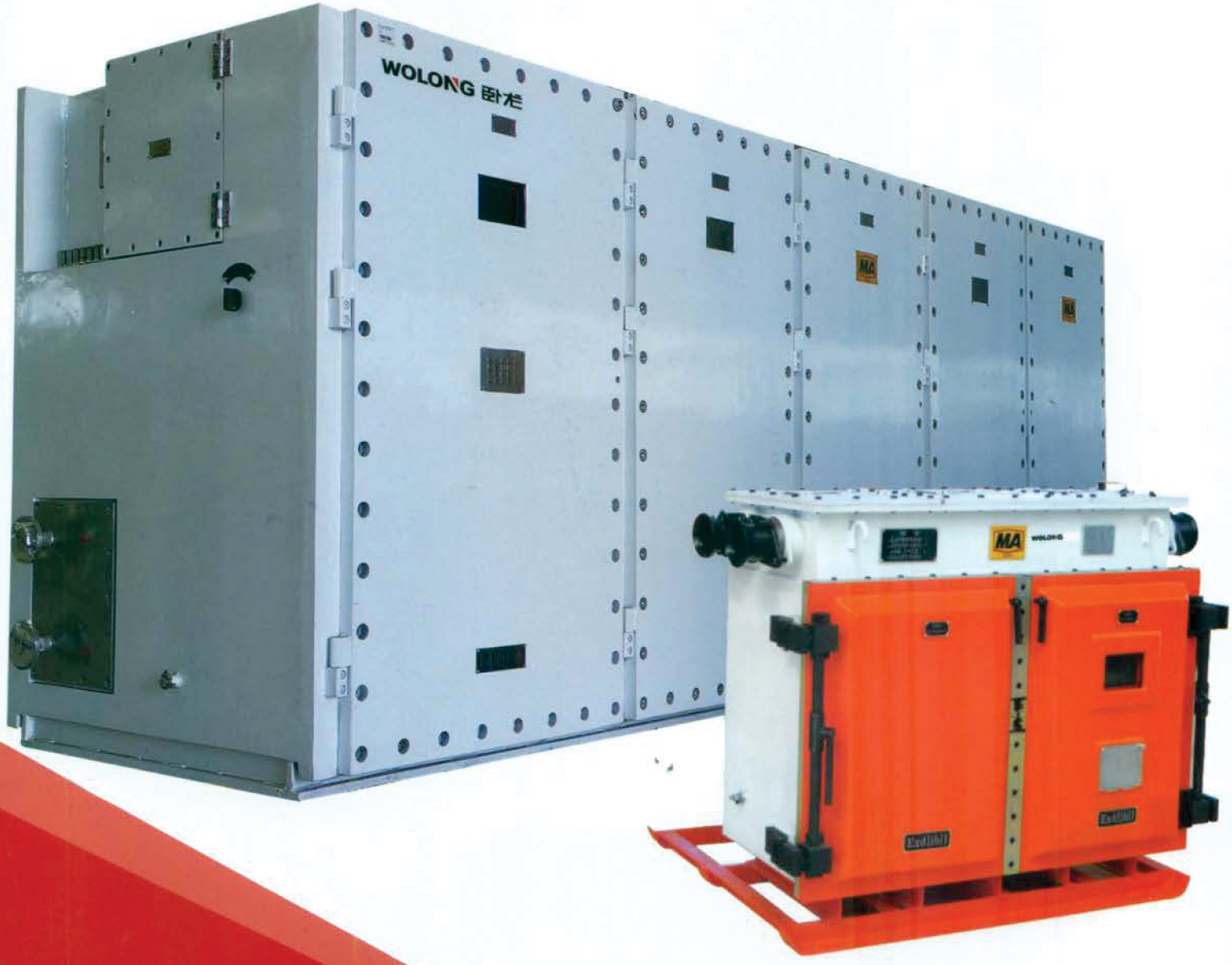

Mine Flame-proof and Intrinsically-safe (chain-circuit) Static Var Generator

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WOLONG
Power your future

WOLONG ELECTRIC GROUP CO., LTD.

As a global well-known manufacturer of motor & drive solutions, Wolong Electric Group co., Ltd. was founded in 1984, after more than 30 years of innovation and development in China, Vietnam, England, Germany, Austria, Italy, Poland, Mexico, India and Serbia it has 39 manufacturing factories and three technology centers with more than 18000 staff. In 2018, total assets reaches CNY 30 billion, and annual sales revenue reaches CNY 36.5 billion. Wolong mainly manufacturers all types of motors, generators, control drive products, industrial automation products and so on to provide our customers optimal solution and service in oil & gas, petrochemicals, power, mine, rail transportation, building, water & waste water, automation, new energy vehicles and so on.

Wolong Electric Large Drive Business Group Drive Division

Wolong Electric Large Drive Business Group Drive Division (referred to as the Drive Division) is dedicated to power electronics field, and with many years of experience in design of MV electrical products Drive Division Electric Drive has developed competitive MV inverter--RMVC5000 series & RMVC5100 series, MV SCR type soft starter VFS series, and explosion-proof series electrical products with high reliability as the design principle and easy-to-maintain as the design objective, which have reached to international leading level in technology.

In the field of ex-proof electrical products, Drive Biz Unit is specialized in R&D, manufacturing, sales and service of large drive and automation control equipment with their system application software. Drive Biz Unit has first-class production, detection and test equipment, builds up a set of scientific product quality assurance system strictly following ISO9001 quality management system from components input detection, production & assembly, product parts debugging & testing to finished product FAT. So far, ex-proof electrical products have been applied to more than 40 mine bureaus and more than 200 coal mines, which received users' unanimous praise.

Ex-proof products mainly include:

- Mine Flame-proof and Intrinsically-safe Type Inverter
- Mine Flame-proof and Intrinsically-safe Type Combined Inverter
- Mine Flame-proof and Intrinsically-safe Type Power Transformation Inverter
- Mine Flame-proof and Intrinsically-safe Type MV Combined Inverter
- Mine Flame-proof and Intrinsically-safe Type Inverter for Ventilator Application
- Mine Flame-proof and Intrinsically-safe Type Dual-power Dual-inverter for Ventilator Application
- Mine Flame-proof and Intrinsically-safe Type (chain type) Static Var Generator
- Mine Flame-proof and Intrinsically-safe Type Programmable Control Box
- Mine Intrinsically-safe Type Consoles
- Mine Flame-proof and Intrinsically-safe Type MV AC Soft Starter

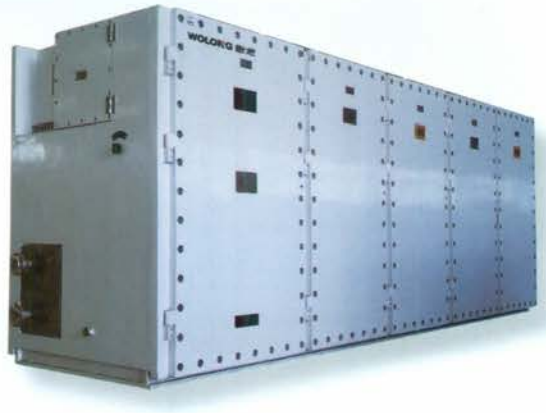
4 Mine Flame-proof and Intrinsically-safe (chain-circuit) Static Var Generator

Product Overview

Drive Division has successfully developed a Mine Flame-proof and Intrinsically Safe Static Var Generator, referred to as Ex-proof SVG, by integrating the advanced SVG technology and advanced APF technology into our mature ex-proof technology. Ex-proof SVG is a self-commutated rectifying circuit composed of gate turn-off IGBT. SVG is connected in parallel to the grid through reactors, which properly adjusts AC side voltage amplitude & phase of the bridge circuit or control AC side current to generate the inductive or capacitive reactive power. SVG as an active compensation device, not only tracks the impact current of impact load, but also tracks and controls the 5^{th}, 7^{th}, 11^{th} and 13^{th} harmonic currents.

In order to meet the needs of underground equipment in the coal mines in future, Drive Division initially developed 660V, 1140V, 3.3kV, 6kV, 10kV mine flame-proof and intrinsically-safe (chain-circuit) static var generators. This series of SVG products adopt advanced technology, and their single compensation capacity can reach 300kVar, 500kVar, 1.8MVar, 2.5MVar, 3.2MVar and 5MVar respectively, which perfectly solve the problem of underground power quality under the new trend.

Products have superior characteristics such as improve stability of the line circuit due to fast response time, maintain voltage at the power receiving end, compensate system's reactive power to improved power factor, compensate harmonic dynamically to improve power quality, suppress voltage fluctuation and flicker, compact size and so on.

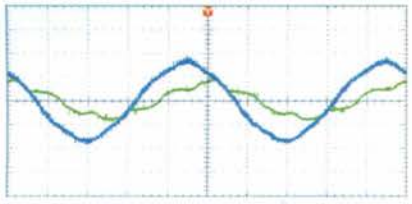


Main Uses of the Products

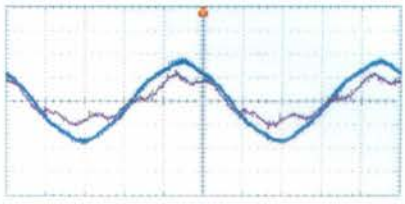
- **Improve power factor of the power grid, greatly reduce the line current, save energy and reduce the consumption**
  SVG may automatically compensate the reactive power based on reactive power contained in the grid, keeping the power factor above 0.95.
- **Increase the power supply voltage of grid terminal equipment to maintain voltage stability**
  Due to the long transmission distance of the underground power supply in the coal mines, the voltage of the terminal equipment is often insufficient. SVG may quickly support the voltage, maintain the voltage of each load at the power supply terminal within a stable range, and greatly reduce the harm of voltage fluctuation to grid equipment.
- **Elimination of Harmonics Pollution to Power Grid**
  SVG can effectively control the 5th, 7th, 11th and 13th characteristic harmonics generated by nonlinear loads, and reduce the influence of harmonics on power supply system and electric equipment.

Perfect Compensation Effect

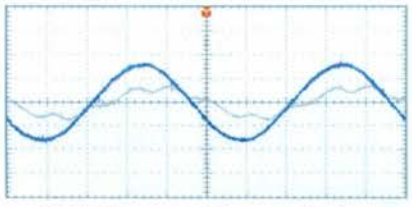
Ex-proof SVG can dynamically compensate the reactive power of the power grid in real time, keeping the power factor infinitely close to 1. Meanwhile, it can control the characteristic harmonics, protect other electric equipment from the harmonic interference to greatly improve the power quality of the grid.



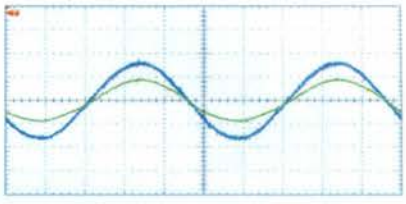
Grid Voltage and Current before Compensating the Reactive Power



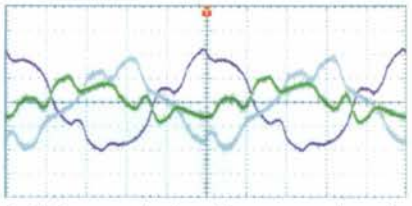
Grid Voltage and Current after Compensating the Reactive Power



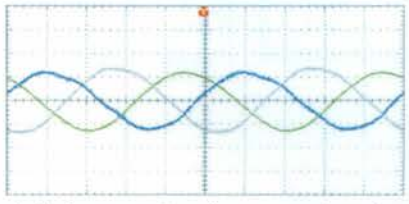
Grid Voltage and Current before Compensating the Reactive Power and Harmonics



Voltage and Current of Grid after Compensating the Reactive Power and Harmonics



Grid Current before Compensating the Reactive Power, Harmonic and Negative Sequence



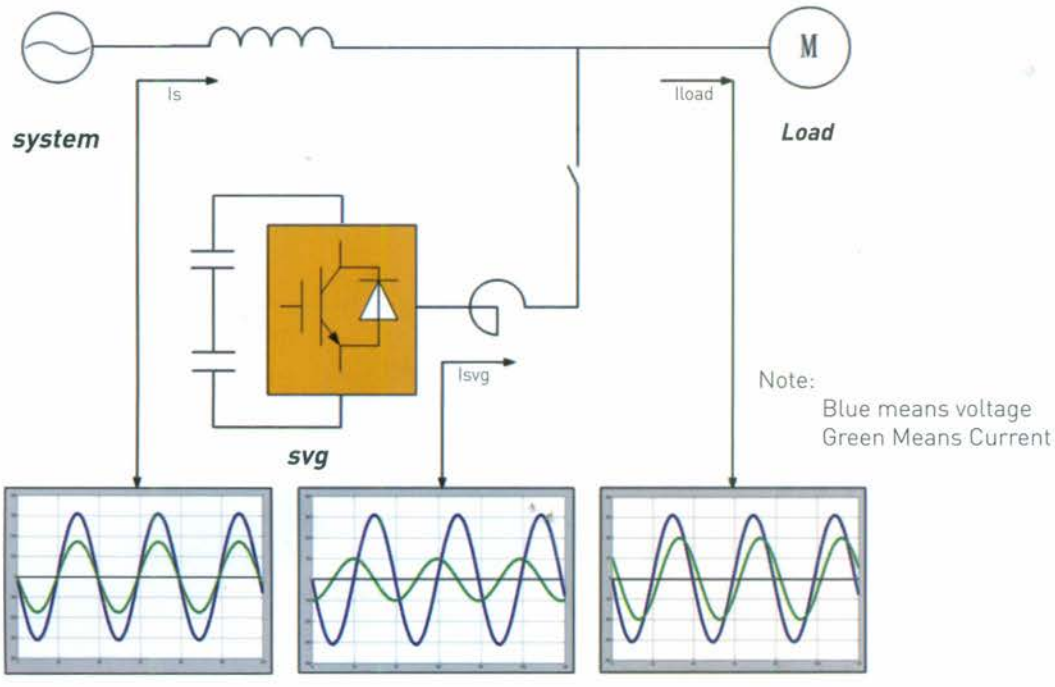
Grid Current after Compensating the Reactive Power, Harmonic and Negative Sequence

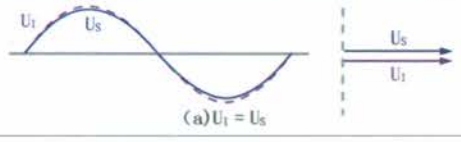
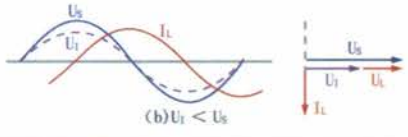
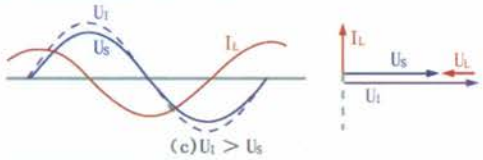
Product Qualification

6 Mine Flame-proof and Intrinsically-safe (chain-circuit) Static Var Generator

Working Principle

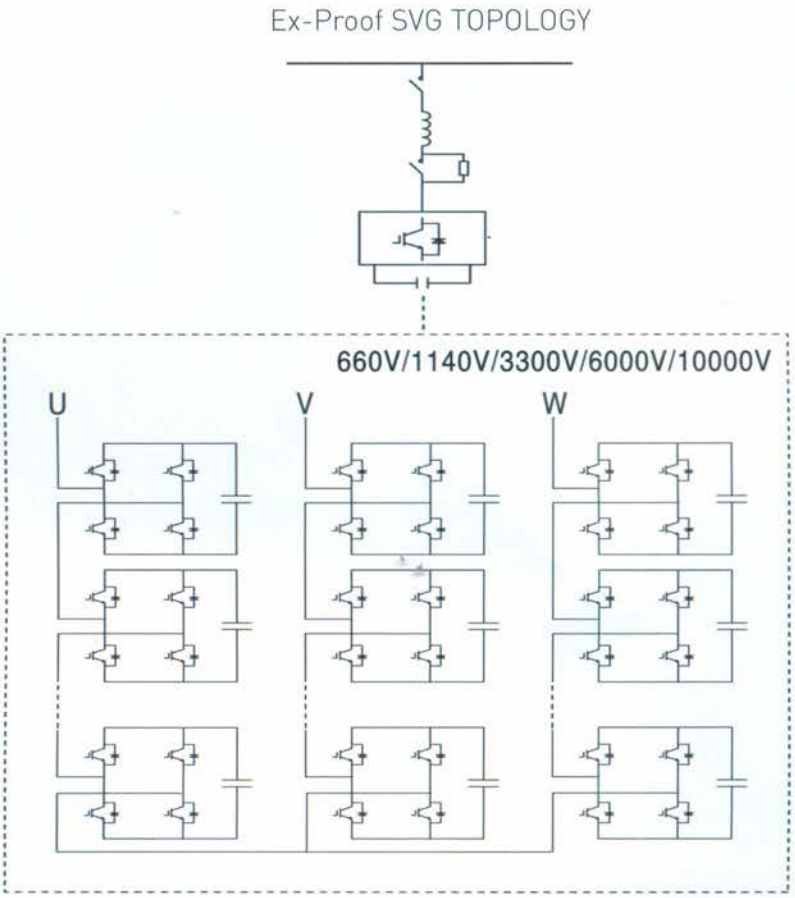
Ex-proof SVG uses IGBT to form a self-commutated bridge circuit, which is connected in parallel to the grid through reactors. By properly adjusting AC side output voltage amplitude & phase of the bridge circuit or directly controlling its AC side current, the circuit can absorb or generate reactive current that meets the requirements to realize the purpose of dynamic reactive compensation.



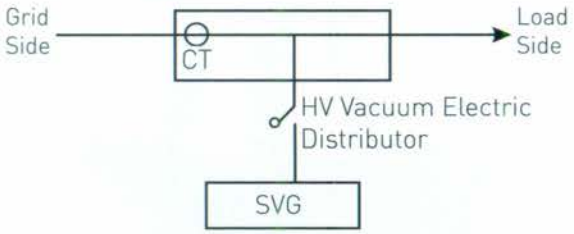
Operating Mode	Waveform and Phase Diagram	Description
No-Load Operating Mode		When $U_l = U_S$, SVG will not Compensate
Inductive Operating Mode		When $U_l < U_S$, SVG is equivalent to a continuously adjustable inductance.
Capacitive Operating Mode		When $U_l > U_S$, SVG is equivalent to a continuously adjustable capacitor.

Topological Structure

Structure and performance of each power unit of Ex-proof SVG are completely identical and the technology is reliable. This modular topology greatly improves the reliability, flexibility and maintainability of the static var generator.

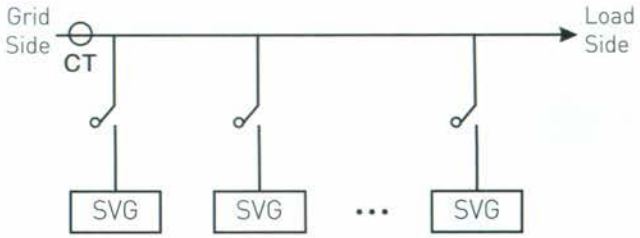


Schematic Diagram



660V/1140V equipment does not require HV vacuum electric distributor.

Single SVG Connected in Parallel to the Grid for Operation



660V/1140V/3300V/6000V/10000V

Multiple SVG Connected in Parallel to the Grid for Operation

Mine Flame-proof and Intrinsically-safe Static Var Generator

Equipment Capacity: 300kVar/660V, 300kVar/1140V, 500kVar/1140V

Product Features

SVG can track and compensate the reactive power of the compensated equipment and has good dynamic response performance.

LV SVG uses efficient heat pipe air-cooled radiator to provide a good heat dissipation environment for its internal IGBT and other high-power heating devices to extend the service life of the power devices and ensure a safe and reliable operating.

Diversified Compensation Functions

It can compensate the reactive power & terminal voltage and suppress harmonic automatically.

Using the Advanced Control Technology

LV SVG adopts the high-speed DSP TMS320F28335 processor made by TI Company in the United States, which has fast operation speed. The 16-bit high-precision AD sampling chip has high sampling precision, which makes the calculation of the reactive power more accurate and the dynamic tracking compensation performance more superior.

Diversified Compensation Methods

SVG can adopt various schemes such as the centralized compensation, regional compensation and local compensation according to the actual situation on sites. In addition to single compensation, it may also be used in parallel with multiple units. At the same time, it may form multi-stage compensation with the reactive power compensation equipment of the upstream power supply system to form a reactive power compensation network covering the whole underground power supply system.

Extremely Low Harmonic Content

SVG adopts SPWM technology, 3-level technology and multiplex technology, which not only can produce extremely-low harmonic content, but also compensate the harmonic and reactive power of the load and control a certain amount of harmonics of the compensated grid (25% respectively for the 5^{th} and the 7^{th}, 15% respectively for the 11^{th} and the 13^{th}).

Perfect Software and Hardware Protection

It has hardware and software protection such as over-current, short circuit, over-voltage, under-voltage, phase loss, 3-phase imbalance, communication interruption, optical fiber interruption, air cooling fan fault and IGBT over-temperature and so on.

Mine Flame-proof and Intrinsically-safe Chain-circuit Static Var Generator

Equipment Capacity: 1.8MVar/3.3kV, 2.5MVar/6kV, 3.2MVar/6kV, 5MVar/10kV

Product Features

Modular Structure Design

- A new multilevel inverter structure is adopted to realize a series connection of inverters, reducing the equipment size as much as possible and improving the power density;
- The mechanical structure and electrical performance of each power unit are completely identical, the units can be interchanged, and the installation and maintenance are simple with little workload;
- This SVG equipment has small occupied area, which is particularly suitable for occasions with higher request on occupied area. What's more, it can be transformed to a mobile device.

High Power Water Cooling Technology

HV SVG uses isolated internal / external water for heat dissipation, meeting the heat dissipation requirements in narrow space under the ground. Water-cooling system can stably output the fixed quantity of deionized water with constant temperature and constant pressure during operating to effectively cool the heating semiconductors and enable the equipment to work within the appropriate temperature range. Our water-cooling system has the following advantages:

- High heat dissipation efficiency and low long-term operating cost;
- Significantly reduce operating noise;
- Key instruments and meters are the products from international top brands to ensure the reliable operating of the system;
- The main and the standby water pumps work in turn to extend the service life.

Internal Water Circulation Cooling System

Water-cooling Double H-Bridge Power Unit

Water Cooling Power Unit

- The power unit uses a double H-bridge cascade structure which effectively reduces the space needed for unit layout. Drawer type vertical stacking arrangement is adopted between units, and the units of each phase are connected in series;
- Unit cooling water pipes are connected in parallel to ensure the uniform flow distribution;
- The main heat source components are arranged on the surface of the radiator whose flow of cooling water is adjusted to respond to different heat dissipation requirements;
- The laminated busbar design with small parasitic inductance is adopted to make the unit structure compact;
- The water inlet and outlet of the power unit are the double cut-off quick connectors, which facilitates the replacement of the power unit;
- Key components are all imported from Germany, Japan and other countries.

10 Mine Flame-proof and Intrinsically-safe (chain-circuit) Static Var Generator

Technical Advantages

Drive Division SVG is a compensation device based on voltage source converter, which has achieved a qualitative leap in the reactive power compensation. It no longer uses the large-capacity capacitors ord inductors, but uses the high-frequency switches of high-power power electronic devices to convert reactive energy. Drive Division SVG has the following advantages over the traditional reactive power compensation devices:

- Faster Response Time
- Wider Operating Range
- Dynamic Control of Characteristic Harmonics in Grid
- User-friendly Interface Design, Automatic Control, Intelligent Operating
- Low power loss, and Economical Operating
- Real-time Self-Inspection, Real-time Recording, and Real-time Detection and Compensation
- Stronger Voltage Fluctuation Suppression Capability
- Diversified Compensation Functions
- Modular Structural Design with less floor space
- High Efficiency Heat Dissipation System, water-water heat exchange or heat pipe heat exchange
- Configurable Remote Monitoring to realize nobody-on-duty operating.
- Standard Water-saving Electric Valve with automatic control to save the external cooling Water

Technical Parameters

Input	
Grid Voltage	3-Phase, 50Hz/660V/1140V/3300V/6000V/10000V
Allowable Operating Voltage	<120%
Compensation Performance	
Power Factor	>0.95 (within the compensation capacity range)
Harmonics	Effectively Filter Out the 5^{th}, 7^{th}, 11^{th} and 13^{th} Harmonics to make the power quality meet the GB/T 14549-93 Standard
System Response	Up to 5ms
Reliability and Life	Design Life is 20 Years MTBF>750000 Hours MTTR < 5 Minutes
Miscellaneous	
Protection Functions	Over-Voltage, Under-Voltage, Over - Current, Over-Temperature, IGBT Failure, Control Power Failure, Communication Failure, etc.
System structure	Integrated design, modular design, integral transport, Ready-to-use.
HV Isolation	Optical Fiber Signal Transmission
Power Semiconductor	IGBT
Cooling Method	Heat Pipe Air Cooling/Internal and External Isolation Water Cooling
Ex-proof Type	Exd[ib]I

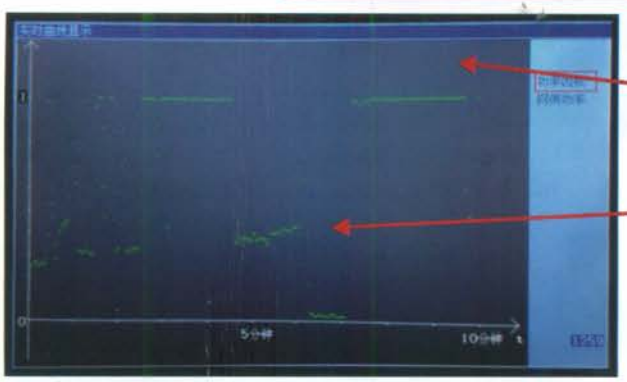
Control	
Control Mode	Instantaneous Current Detection Technology SPWM Current Tracking Control Technology Direct Current Closed Loop Control Technology Voltage Balance Control Technology on DC Side
Control Chip	Using the Most Advanced DSP FPGA Programmable Gate Array
Accessory Functions	All digital microcomputer control,real-time communication network, self-diagnosis function.
Control Functions	Reactive Power Compensation, Harmonic Current Compensation, Improving Grid Voltage
Control Source	Internal Transformer Supply
Telecommunications	Rs485 Interface, Modbus Protocol
Industrial Controller Display	Grid current, grid voltage, load current, compensation current, active power, the reactive power, power factor, etc.
Environment	
Place of Use	Underground in coal mine
Working Temperature	0°C+40°C (Ambient Temperature+40°C+50°C)
Ambient Humidity	< 90%, No Frost
Altitude	Below 1000m
Storage Temperature	-25°C~55°C

Human - Machine Interface

The HMI uses a colored LCD with a size of 7 inches and a resolution of 800×480TFT. Using Chinese/English display, there is no complicated parameter code, and parameters can be set. It has the function of recording equipment historical faults, and the number of records can reach 100 pcs. Meanwhile, it can display real-time operating data such as power factor, grid side power and harmonics content change trend.

Main Interface

Real-Time Operating Curve



Equipment Operating Record

With fault records, and operation records for up to 10 years, support automatic and manual USB export function.

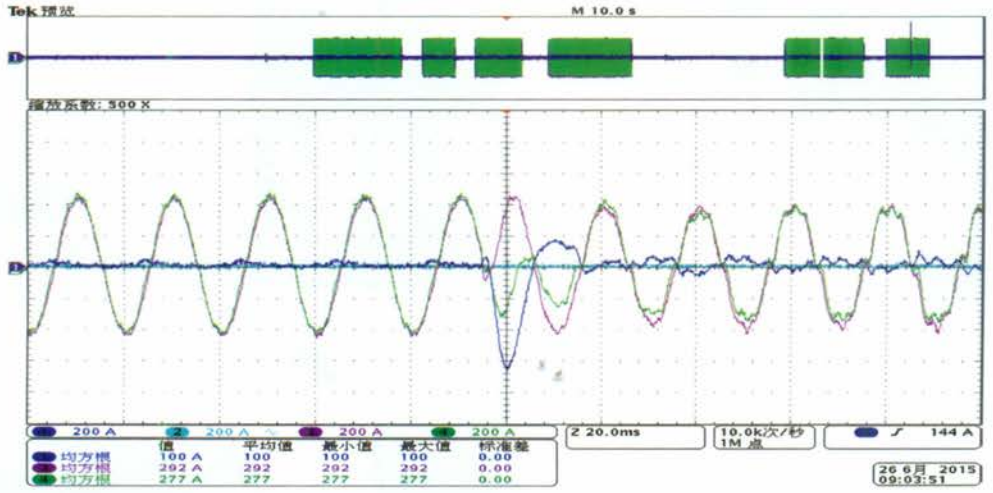
Main Functions

Ex-proof SVG is a representative of the latest technology in the field of the reactive power compensation. SVG is connected in parallel to the grid, which is equivalent to a variable reactive current source. Its reactive current may quickly change with the change of load reactive current to automatically compensate the reactive power required by the system. SVG's main functions are as follows:

- **The Reactive power compensation to improve power factor. Greatly reduce line current, save energy and reduce the consumption.**

SVG equipment can automatically detect the reactive power of the power grid, and automatically adjust output to compensate the reactive power according to the reactive power content without under-compensation or over-compensation in order to maintain the power factor above 0.95. Figure below shows reactive power waveform under automatic compensation mode of SVG.

Reactive Power Waveform of Dynamic Compensation System

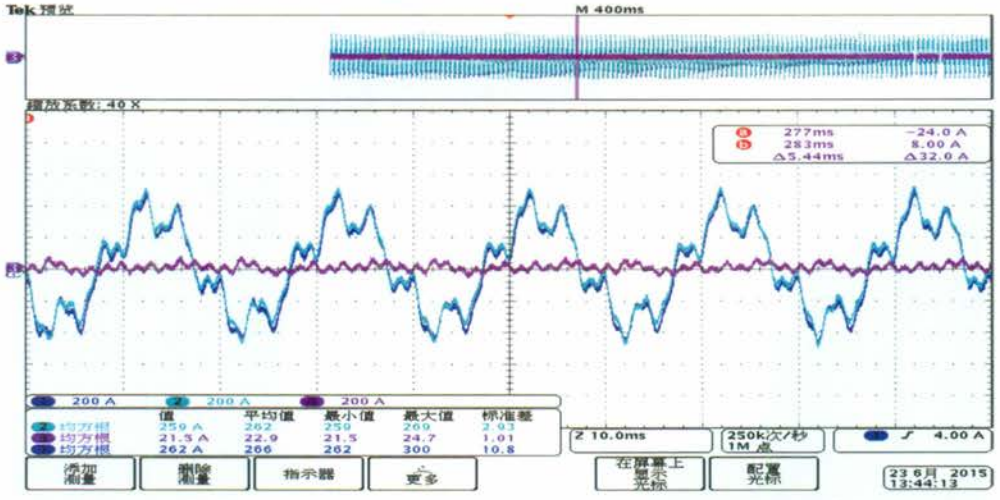


(CH1: Power Grid Side Current, CH3: Load Reactive Current Waveform, CH4: Reactive Current Waveform under Automatic Compensation mode.)

- **Dynamic real-time harmonics regulation to improve the quality of power supply, reduce power equipment failure, and improve the quality of power supply.**

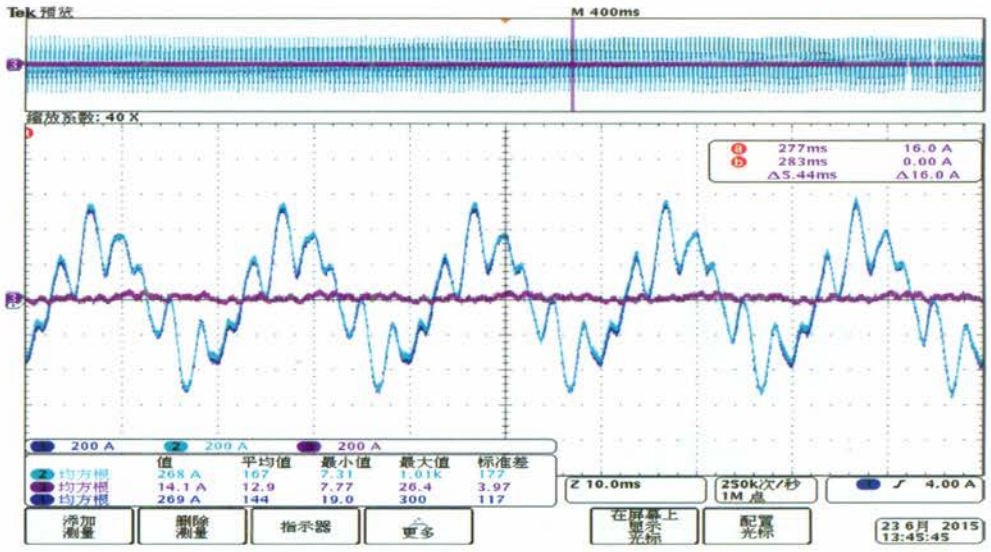
SVG equipment can effectively compensate the 5th, 7th, 11th and 13th harmonics, with compensation capability for the 5th and the 7th harmonics respectively being 25% of the rated capacity, and the 11th and the 13th harmonics respectively being 15% of the rated capacity.

5th Harmonics Waveform of SVG Compensation System



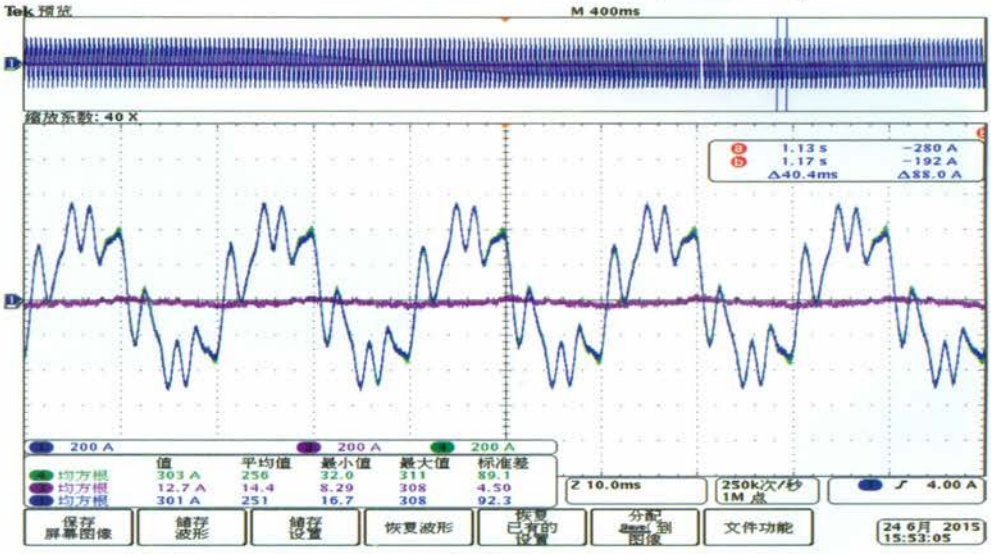
(CH1: Harmonic Current Waveform under automatically compensating mode, CH4: Load Harmonic Current Waveform, CH3: Power Grid Side Current Waveform).

5th, 7th Harmonics Waveform of SVG Compensation System



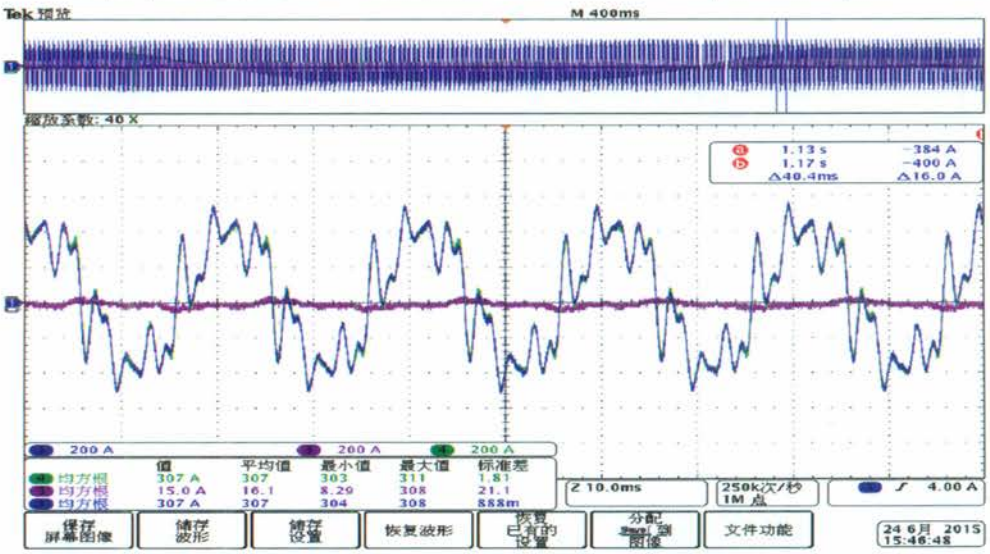
(CH1: Harmonic Current Waveform under automatically compensating mode, CH2: Harmonic Current Waveform Generated under Manual mode, CH3: Power Grid Side Current Waveform).

5th, 7th, 11th Harmonics Waveform of SVG Compensation System



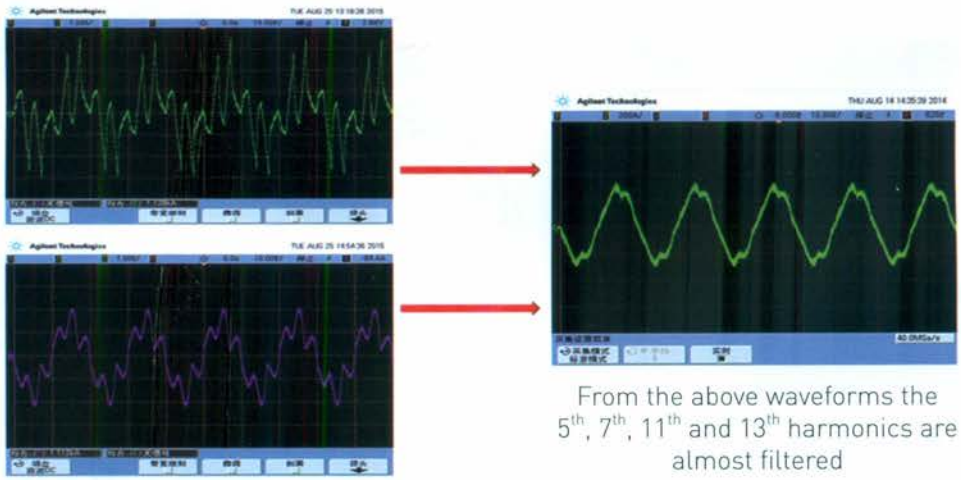
(CH1: Harmonic Current Waveform under automatically compensating mode, CH4: Load Harmonic Current Waveform, CH3: Power Grid Side Current Waveform).

5th, 7th, 11th and 13th Harmonics Waveform of SVG Compensation System



(CH1: Harmonic Current Waveform under automatically compensating mode, CH4: Load Harmonic Current Waveform, CH3: Power Grid Side Current Waveform).

Below Figure shows the comparison before and after SVG harmonic compensation.



From the above waveforms the 5th, 7th, 11th and 13th harmonics are almost filtered

• Voltage compensation function to improve grid voltage stability and terminal supply voltage.

Underground power supply is usually transmitted from the ground substation. Generally, the transmission distance is relatively long, reaching the several kilometers or even tens of kilometers. Solution for most coal mines is to raise the voltage at power supply end to ensure the voltage stability of the electrical equipment. SVG may quickly support the voltage and maintain the voltage of each load at the end of power transmission within the required voltage range, greatly improving the stability of grid voltage and reducing the harm of voltage fluctuation to equipment connected to the grid.

Typical Cases

• Typical Case of LV SVG: Yankuang Group Guizhou Qinglong Mine

Basic Working Condition: 660V power supply is used for 21604 gas bottom drainage tunnel under the Mine, with 3×50 cables of approximately 1700m. When no load is applied, the voltage at the end of the line is 710V, and when the load device works, the voltage fluctuates violently at 540V~660V. Due to long-distance power supply and thin cables, the voltage fluctuates violently and the starting of the downstream load is difficult.

Solution: Install a LV Ex-proof SVG at the front end of the equipment, utilize the fast response speed of SVG and adopt the voltage support function to quickly generate the capacitive reactive power for voltage support when the grid is at low voltage. When there is no load, it emits inductive reactive power to suppress voltage.

Regulation Effect: After SVG is used for voltage compensation, the 660V grid voltage drops from 710V to around the target value 660V when no load is applied. When the load is working, the voltage at the terminal is increased by more than 10%, and the voltage is stable at 630V~660V.


防爆 SVG 设备在长距离供电系统中的应用

• Typical Case of HV SVG: Heilonggou Coal Mine in Yulin, Shaanxi Province

Basic Working Conditions: At fully mechanized coal mine face, due to the increase of the coal mine output, the rear-stage load continues to increase, the power factor of the grid is low (approximately 0.5), the line current continues to increase, the loading on transformers and cables continues to increase, and the heating is serious; among them, the rear-stage loads of one mobile substation are mainly scraper and crusher, totaling approximately 2800 kW; the rear-stage loads of the other mobile substation are mainly shearer and reversed loader, totaling approximately 2600kW.

Solution: Install high-voltage explosion-proof SVG device WJL-1800/3.3 on 3.3kV side of each transformer.

Regulation Effect: The power factor of the grid is increased to 0.99, the line current is reduced by 58%, and the utilization rate of 3.3kV power supply and transformer is greatly improved. Cable loading is greatly reduced and the temperature is obviously reduced.

• Typical Case of HV SVG: Xinglongzhuang Coal Mine of Shandong Yankuang Group

Basic Working Conditions: In Shimen substation, the transmission distance of 6kV HV power supply is over 11km, and the capacity of 6kV power supply capacitor is not enough due to the continuous increase of the load at the rear-stage, so this substation has to add one power supply and totally uses two power supplies in parallel. The working line current reaches 300~400A, the power factor is approximately 0.6, the total load of the rear stage is approximately 10000 kW, and the actual operating power is approximately 5000 kW.

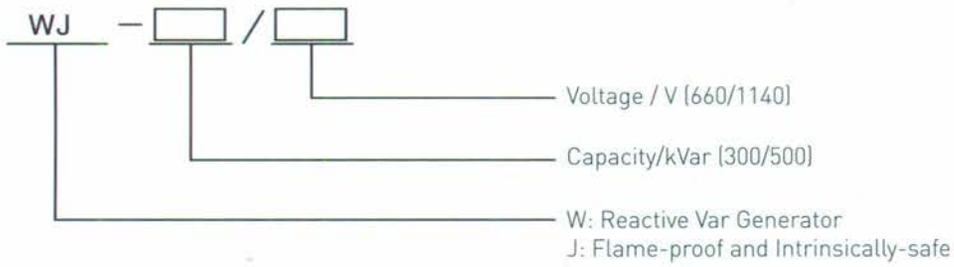
Solution: Install HV Ex-proof SVG WJL-2500/6 equipment in Shimen Substation of No. 1 Coal Mine.

Regulation Effect: The power supply line of the substation is changed from two parallel power supplies to one power supply, the starting voltage is adjusted from 6300V to 6000V, and the terminal voltage is stable above 5900V. Power factor is increased to 0.99, harmonics are completely filtered, and the line current is reduced by approximately 32%. Energy saving and consumption reduction are obvious, with direct annual savings of approximately 804,000 yuan.

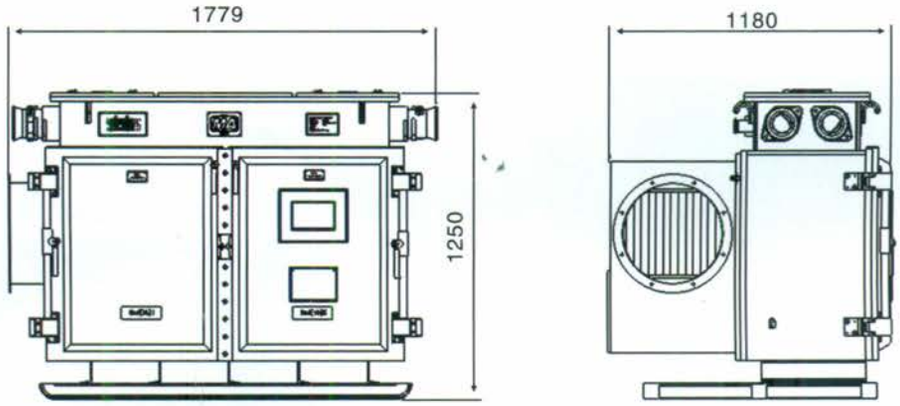
We are the creator of the first underground Ex-proof SVG in China. It is the only one Ex-proof SVG product with good application reference in China. Hundreds of SVGs at installation sites are running and have been recognized and recommended by the majority of users. As proven by practices, Ex-proof SVG can guarantee the electrical safety of underground production equipment, improve their service life in coal mines, extend routine maintenance period, and effectively save energy while ensuring production efficiency, which provides users considerable economic benefits.

Mine Flame-proof and Intrinsically-safe Static Var Generator

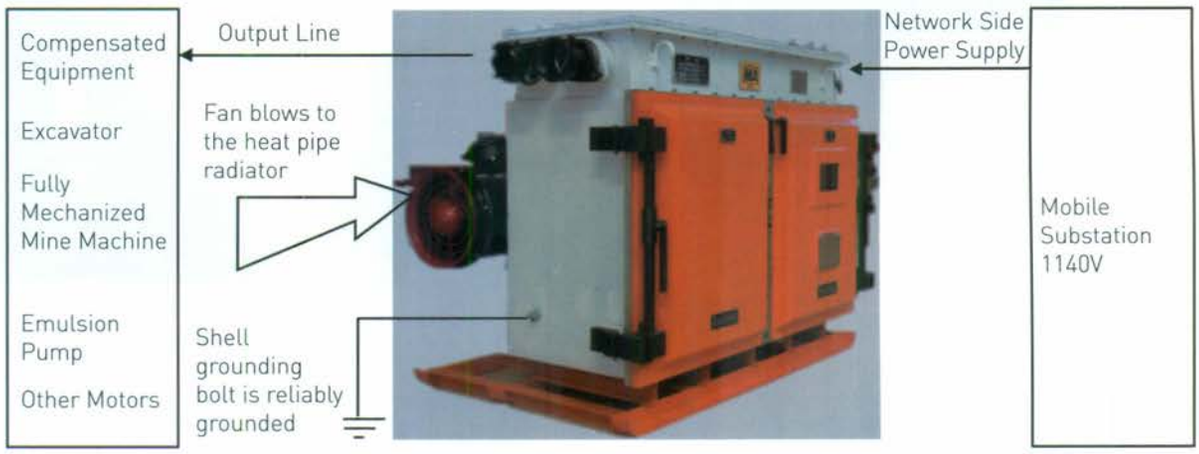
Equipment Model



Equipment Dimension



Equipment Installation



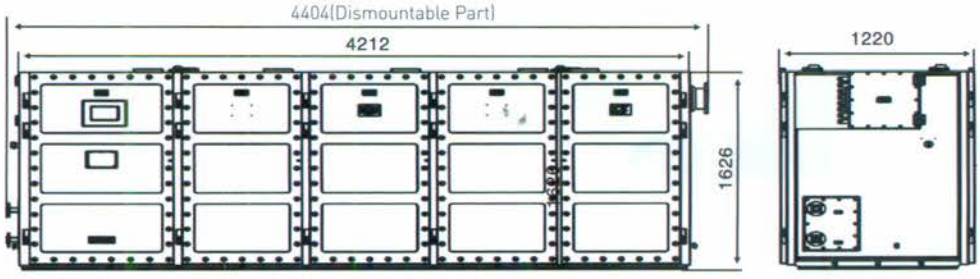
Mine Flame-proof and Intrinsically-safe Chain-circuit Static Var Generator

Equipment Model

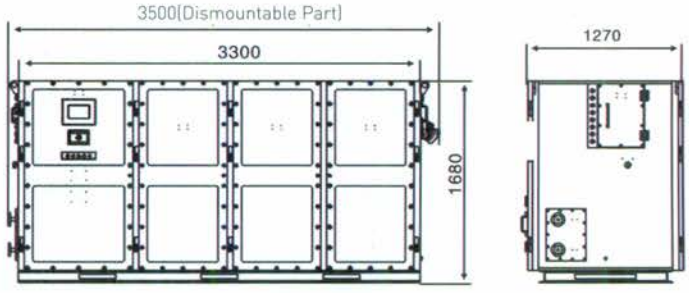
WJL2 — □ / □

- Voltage / V (3300/6000/10000)
- Capacity/kVar(1800/2500/3200/5000)
- Design S.N.
- W: Reactive Var Generator
  J: Flame-proof and Intrinsically-safe
  L: Chain-circuit

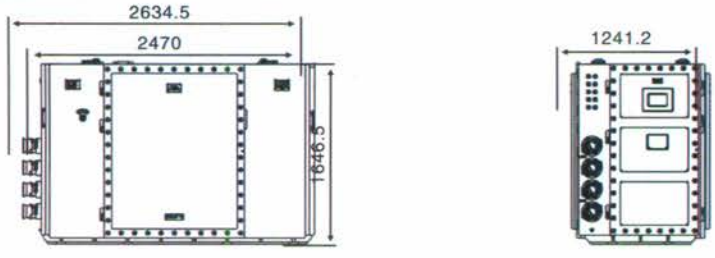
Equipment Dimensions



5000kVar/10kV

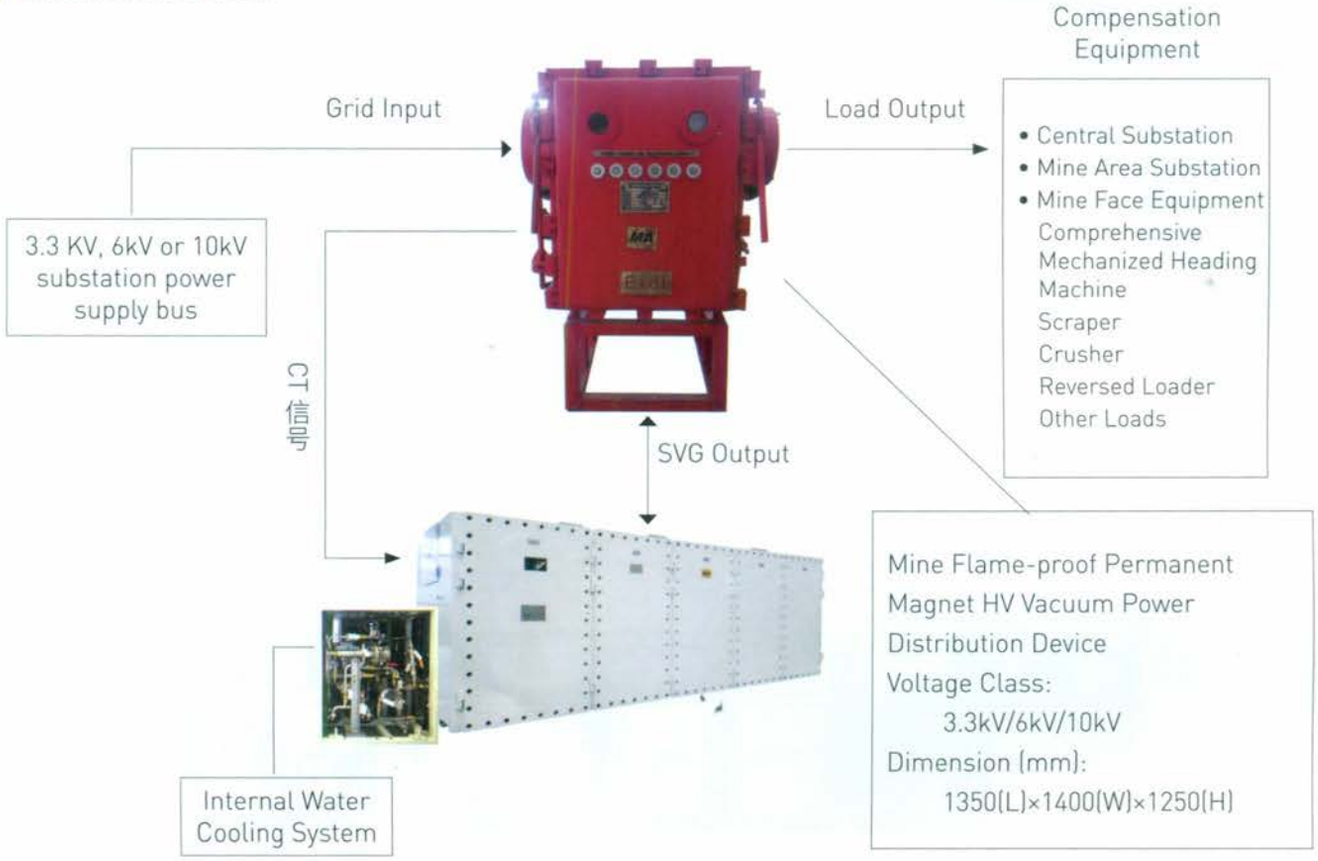


2500kVar/6kV



1800kVar/3.3kV

Equipment Installation



Mine Flame-proof and Intrinsically-safe (chain-circuit) Static Var Generator Selection Table

Equipment Type	Voltage Class	Compensation Capacity	Overall Dimension (Length × Width × Height) mm	Weight (Kg)
WJ-300/660	660V	300kVar	1779×1180×1250	2000
WJ-300/1140	1140V	300kVar	1779×1180×1250	2000
WJ-500/1140	1140V	500kVar	1779×1180×1250	2000
WJL2-1800/3.3	3300V	1800kVar	2635×1241×1646	5500
WJL2-2500/6	6000V	2500kVar	3500×1270×1680	6000
WJL2-3200/6	6000V	3200kVar	3500×1270×1680	6000
WJL-5000/10	10000V	5000kVar	4404×1220×1626	10500

Note:
According to the principle of the selection of compensation capacity, the reactive power content of the grid is approximately 1/3 of the capacity of the upstream power supply transformer. If harmonic compensation is needed, capacity may be increased.

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