



ZBSVG 系列
动态无功补偿装置
ZBSVG Series Static
Var Generator System

用户手册

(V2.1)

Users' manual

前言 Foreword

感谢您使用由中宝电气有限公司自主研发的 ZBSVG 系列产品。本手册为 V2.1 版本，适用于 6kV、10kV、27.5kV、35kV 电压等级级联式高压动态无功补偿装置。作为应用性了解，本手册提供了充足的信息。若欲安全可靠地使用本高压动态无功补偿装置，从而充分体验先进的设计理念给予您的高级享受，强烈建议您深入阅读本手册的各项内容，特别是有关安全规程和警告的部分。

Thanks for using the ZBSVG series products made by ourselves, suitable for 6kV, 10kV, 27.5kV, 35kV voltage grade cascaded high voltage dynamic reactive power compensation device. The clients must read the manual carefully before using, especially the contents of safety rules and cautions.

我们对本手册做了多方面、全方位的审核，但难免还会存在疏漏之处，如您在使用过程中发现一些疏漏，请和我们联系；本手册并没有涵盖 ZBSVG 系列产品的全部功能，如您在体验产品过程中发现本手册未涉及的功能，请和我们联系。对于您提出的建议，我们将在后续的版本升级中积极进行改进。

Any errors that found when using or the functions that not mentioned in this paper, please contact us, we will modify and update it.

中宝电气有限公司保留对后续产品做进一步升级改进的权利，用户手册相应的内容可能会有变动，我们不再另行通知。如您需要最新版本用户手册，请致电中宝电气有限公司。

The product will be updated, there will be no future notice. Please contact us for the new one.

您也可以从以下渠道获得完善有效的信息：

You can get the information from the follows:

当地办事处 Local office

请联系您所有地区的办事处，咨询有关服务、价格和调试事宜。

Please contact local office for the information, such as the service, price and commissioning and so on.

技术支持中心 The technology support center

就我们的产品和系统，为客户提供全方位的技术服务。

We will provide good service for the clients.

联系电话: +86 373 5763010

邮箱: info@zgxbdq.com

Phone number: +86 373 5763010

Email: info@zgxbdq.com

在线服务和支持 Service online

一般性的技术问题和技术资料，也可以从如下网址获得 <http://www.zgxbdq.com>

Get the technology materials or answer to the general question from <http://www.zgxbdq.com>

联系地址: 河南省新乡市高新区午阳东路 999 号中宝电气智能电网产业园

Address: Zhongbao Electric Smart Grid Industrial Park, No.999 Wuyang East Road

更多联系方式，请参见本手册封底。

More contacts are shown at the bottom of the manual.

如果您在阅读本手册时有任何困惑之处，请按上面的联系方式垂询，我们将热情为您服务。

Any questions when using, please contact us, we will provide good service for you.

定义和警告 The definitions



危险本手册以及高压动态无功补偿装置上带有“警示标志”的“危险”

是指如果不遵守有关要求不采取相应措施，就会造成死亡或严重的人身伤害。

Pay attention to the sign “danger” with “caution” , it will lead to death or serious damage.



警告本手册以及高压动态无功补偿装置上带有“警示标志”的“警告”是指如果不遵守有关要求不采取相应措施,就存在可能造成死亡或严重人身伤害的潜在危险。

Pay attention to the sign “caution” , it may lead to death or serious damage.



注意本手册以及高压动态无功补偿装置上带有“警示标志”的“注意”是指如果不遵守有关要求不采取相应措施,就存在可能导致轻度或中等程度人身伤害的潜在危险。

Pay attention to the sign “attention” with “caution” , it may lead to the damage.

注意本手册以及高压动态无功补偿装置上不带“警示标志”的“注意”是指如果不遵守有关要求不采取相应措施,就存在导致财产损失的潜在危险。

Pay attention to the sign “attention” without “caution” , it may lead to damage to the property.

提示本手册中的“提示”是指如果使用者对提示的问题不加注意就可能出现不希望有的结果或状态。

Pay attention to the sign “note” , it may lead to the unexpected result.

说明本手册中的“说明”是指出有关产品的重要信息,手册中的黑体字部分是要特别加以注意的问题。

Pay attention to the sign “instruction” ,it is the important information of the product, especially the black words.

经过认证的人员本手册中所谓“经过认证的人员”是指,在本设备上进行工作的人员必须熟悉设备的安装、调试以及投运的步骤和要求,并能避免生产中出现的各种紧急情况。

The sign “allowed people”is that the operator must know all the requirements of installation, commissioning and running of device to avoid the emergency.

他（她）们还必须具备下列条件:

The professional must be in demand of the follows:

1. 受过专门培训并考试合格,能够按照常规和本手册的规定的安全操作步骤的

要求对电路和设备进行上电、断电、清扫、接地和线路连接等各种操作。

They are trained and qualified, can do the operation of power on, power off, cleaning, grounding, connection and so on.

2. 受过培训，能够按照常规和本手册规定的安全操作步骤的要求，正确进行设备的维护和使用。

They are trained, can do the maintenance and operation to the device.

3. 受过急救方面的培训。

They are trained the content of emergency.

PE 通过接地导体的保护性接地，接地导体的截面大小应能保证在 PE 接地点与接地母线短接的情况下接地点的电压不超过 50V。通常，该点用于高压动态无功补偿装置的保护接地。

PE is connected to the earth by ground wire. The cross-sectional area of ground conductor must be large enough to ensure the voltage of PE is less than 50V when it is connected to the ground wire.

只能用于指定的应用领域本设备只能用于手册中指定的应用领域，而且只能与中宝电气有限公司推荐和认可的器件和部件配套使用。

The device is used for specified applications listed in the manual with the components and parts allowed by our company.

以下的“警告”、“注意”和“提示”是为了您的安全而提出的，是防止设备及与其相关的部件受到损伤而采取的一些措施。在处理高压动态无功补偿装置相关事项时，通常都要涉及本节中列出的“警告”、“注意”和“提示”，它们分为以下几类：常规、运输和存放、调试、操作、维修以及拆卸和废品处理相关。

The signs of “caution”, “attention” and “note” as follows is to ensure the safety of operator and avoid the damage to device. It will provide the information for the general, transportation and storage, commissioning, operation, maintenance, disassembling, dealing with the waste and so on.

特殊的“警告”、“注意”和“提示”：适用于特殊的操作，放在有关章节的开头，并在该章节需要的地方再加以重复和补充。

The special signs of “caution”, “attention” and “note” are for special operation, they are shown at the beginning of chapter, repeated and added when needed.

请仔细阅读这些“警告”、“注意”和“提示”，因为它们为您提供了人身安全的保障，并且有助于延长高压动态无功补偿装置的使用寿命。

The signs of “caution”, “attention” and “note” is for the safety of operator and is to increase the age of device.

常规相关 About the general



警告 The caution

本设备带有危险高电压，如果不遵守“警告”的规定，或不按本手册的要求进行操作，就可能造成死亡，严重的人身伤害或重大的财产损失。

Do the operation as the rules of “caution”, or serious damage will occur.

只有经过认证合格的专业人员才允许操作本设备，并且在使用设备之前要熟悉本手册中所有的安全说明和有关安装、操作和维护的规定。正确地进行搬运、装卸、就位、安装和操作维护，是实现本设备安全和成功地投运的可靠保证。

Only the trained professionals can do the transportation, disassembling, installation, operation and maintenance as the paper introduced to guarantee the safe and stable running of device.

本设备为高压设备，高压操作必须按正确的流程进行，现场由用户指定专门的高压操作人员、安全负责人员，否则可能造成死亡，严重的人身伤害或重大的财产损失。

The system is with high voltage, only the trained professionals can do operation as right procedures to avoid the serious damage to device or people.

注意触电的危险。即使高压供电已经切断，高压动态无功补偿装置功率单元的直流母排及直流电容器上仍然残留有危险的直流电压，因此在高压断电 10 分钟后直到功率单元内直流侧电容残余电能放完，才允许打开高压动态无功补偿装置的柜门，且禁止触碰功率单元的直流侧电容及相关链接铜排。

Don't touch the capacitor or the copper row in cells, wait for 10 minutes until the cell is discharging, even the input switch of high voltage is open.

注意触电的危险。控制系统控制电源由交流电变为直流电，当控制系统断电，直流电容器上仍然残留有危险的直流电压，因此在控制系统断电 15 分钟后，才允许检查和维护控制系统。

Any operation and examination to the control system is forbidden, even the input switch of control power is open, wait for 15 minutes until the capacitor is discharging.

注意触电的危险。如果接地失效，与之相连的部分或系统故障可能导致机壳与接地之间存在全部相电压大小的电压差。此时如果同时接触机壳和接地可能导致严重伤害，甚至死亡。

Pay attention to the ground wires, if it is not connected, the shell is of high voltage to the ground, it will be dangerous.



注意 The attention

防止儿童和公众接触或接近本设备！本设备只能按照制造商规定的用途来使用。未经授权的改造或使用非本设备制造商所出售或推荐的零配件，可能导致火灾、触电或其它伤害。

Non-professionals are not allowed to touch the device.

The application fields that the paper not mentioned are forbidden, do the replacing of spare components recommend by our company, otherwise fire, electricity shock or serious damage may occur.

提示 The note

请将本手册放在设备附近容易找到的地方，保证所有的使用人员都使用方便。如果要对正在处于运行状态的带电设备上进行测量或测试时，必须遵守相关安全规程，实际操作时，应该使用适当的电子器具。

Lay the manual nearby for using.

Do the test as the safety rules shown with instruments when it is running.

在安装和调试高压动态无功补偿装置之前，请您务必仔细阅读这些安全规则和警告，以及设备上粘贴的所有警示标志。确保警示标志置于醒目的地方，并更换已脱落或损坏的标志。

Read the content of safety rules and caution, pay attention to the signs on the device. Replace the broken signs, make sure all the signs are pasted well.

运输和存放相关 about transportation and storage



警告 The caution

正确的运输、存放、就位和安装，以及细心地操作和维护，对于高压动态无功补偿装置的正常和安全运行是至关重要的。

Do the right transportation, storage, laying, installation, operation and maintenance is good for stable running of device.



注意 The attention

在运输和存放期间，要保证高压动态无功补偿装置不致遭受物理性的冲击和振动，也必须保证它不受雨淋和不存放在环境温度过高的地方。

No vibration, raining, overheating are allowed when doing the transportation and storage.

调试相关 The commissioning



警告 The caution

未经培训合格的人员在本设备上的器件/系统上工作或不遵守“警告”中的有关规定，就可能造成严重的人身伤害或重大的财产损失。只有在设备的设计、安装、调试和运行方面受过培训的经过认证合格的专业人员才允许在本设备的器件/系统上进行工作。

Only the trained professionals can do the operation to device as the paper introduced, or serious damage may occur.

输入电源线只允许永久性紧固连接。设备必须接地（按照 IEC 536 Class 1, NEC 和其它适用的标准）。

The input power must be tight well, and the device must be grounded according to the standard of IEC 536 Class 1, NEC or other suitable standards.

即使高压动态无功补偿装置处于不工作状态，以下端子仍然可能带有危险电压：
——高压电源输入端子
——柜体内部直流母排及相连的直流电容

Pay attention to the input ports, the capacitors and copper bars in the cell, they may be of high voltage even the device stops.



注意 The attention

与本设备连接的电源电缆、控制电缆，都必须按照用户图纸里面的要求进行连

接，以避免由于高压动态无功补偿装置工作所造成的干扰。

Do the connection of power wires, control wires as the user drawings introduced to avoid the electromagnetic interference caused by running of device.

运行相关 About the running



警告 The caution

高压动态无功补偿装置在高压下运行；

The device is running

高压动态无功补偿装置在运行时，其某些部件上不可避免地存在危险电压；

The components are of high voltage, no touch is allowed.

为保证高压动态无功补偿装置能取得良好补偿效果，需通过操作工控机显示界面输入运行现场的参数，如用户自行配置的电压互感器、电流互感器变比等，必须与实际情况完全相符。

Enter the parameters of applications, for example the ratios of voltage transformer and current transformer must be same with the real components to achieve good performance.

现场通风良好，高压动态无功补偿装置风机启动正常，使高压动态无功补偿装置达到好的散热效果，防止系统出现过热甚至着火。

The cooling condition is good to avoid the fire caused of overheating.

维修相关 About the maintenance



警告 The caution

设备的维修，只能由中宝电气有限公司的服务部门、维修中心或者经过认证合格并得到授权的人员进行。这些人员应当十分熟悉本手册中提出的所有警告，以及正确的操作步骤；任何有缺陷的部件和器件都必须用相同的元件更换；

Replace broken components with same type by qualified professionals of our company or maintenance center as the paper introduced.

在打开中宝电气有限公司产品柜门进行维修之前，一定要先断开高压、断开高压 10 分钟后再断开控制电；应至少要等控制电断电 15 分钟后直到功率

单元内直流侧电容残余电能放完，才能打开柜门进行维修。

Wait for 10 minutes to open the control power switch after high voltage is off, and wait for no less than 15 minutes after control power is off until the capacitors in cells are discharging to do the maintenance.

拆卸和废品处理相关 About the disassembling and dealing with waste



注意 The attention

请保管好包装箱以备将来使用或把它返还给制造商。

Make sure the package is good for future using or give it back to the manufacturer.

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第二章 ZBSVG 概述 Chapter II Summary of ZBSVG

2.1 概述/Summary

ZBSVG 无功补偿装置是我公司自主研发，融合了国内外先进技术和开发理念，在国内处于技术领先地位的电力电子产品。公司秉承“创新、品质、服务”的理念，并将其融入企业经营的血脉之中，不断追求成长与突破，努力实现“节约能源，服务社会，打造中国节能产品制造基地”的长远目标，力争为国家节能减排，建设低碳和谐社会做出更大的贡献。

ZBSVG(Static Var Generator) is developed independently by our company. Development concept of domestic and foreign advanced technology is fused, which is in leading position of power electronics in domestic. Companies adheres to the concept of "innovation, quality, service", which is integrated into the company blood. We strive to achieve long-term goal of "energy conservation, social services, and building China's energy-saving products manufacturing base," which greatly contribute to national energy-saving and emission reduction, low-carbon building harmonious society.

随着现代电网的大规模发展，新能源的大量并网、大容量的电力电子设备等非线性负荷和冲击性负荷的广泛应用，带来了严重的电能质量问题：

With the large-scale development of modern power grid, a large number of new energy devices and large capacity electronic devices which bring serious quality problems have been used. The detail of power quality problems are as follows.

◆功率因数低，电网损耗增加，生产成本加大，生产效率降低。

◆Decreasing power factor, the loss of power network, increasing grid loss, increasing production costs, reducing production efficiency.

◆产生的无功冲击引起电网电压波动及闪变，严重时导致传动装置及保护装置无法正常工作甚至停产。

◆Causing power grid fluctuations and flicker generated by reactive power impact, affecting the normal use of the transmission and protection equipment.

◆电网三相不平衡，产生负序电流使电机转子发生振动。

◆Three phase unbalance of power grid, the negative sequence current caused the vibration of the motor rotor.Causing three-phase imbalance and vibration of the motor rotor

◆产生高次谐波电流，导致电网电压畸变。

◆Generating high harmonic currents, resulting in the grid voltage distortion.

◆电容器组谐振及谐波电流放大，使电容器过负荷或过电压，甚至烧毁。

◆Making the capacitor group resonance and enlarging the harmonic currents, making the capacitor overload or over-voltage, and even burned.

◆增加变压器损耗，引起变压器发热。

◆Increasing transformer loss, causing transformer fever.

◆导致电力设备发热，电机力矩不稳甚至损坏。

◆Causing power equipment fever, motor torque instability and even damaged.

◆加速电力设备绝缘老化，易击穿。

◆Accelerating the insulation aging of power equipment, easy to breakdown.

◆降低电弧炉生产效率，增加损耗。

◆Reducing electric arc furnace production efficiency, increasing the loss.

◆干扰通讯信号。

◆Interfering the communication.

随着电网的不断发展，对无功功率进行控制与补偿的必要性与日俱增。

With the continuous development of the grid, the need of control and compensate reactive power is increasing.

■输电网络对运行效率的要求日益提高，为了有效利用输变电容量，应对无功进行就地补偿。

■The requirements of network transmission efficiency are increasing day by day. In order to use the power transmission capacity effectively, it needs local reactive power compensation.

■ 电源（尤其水电，光伏等新能源）远离负荷中心，远距离的输电需要灵活控制无功以支撑解决稳定性及电压控制问题。

■ Power supply (especially hydro power, photovoltaic and other new energy) is away from the load center, the remote transmission needs to be flexible to control reactive power to support the stability and voltage control problem.

■ 配电网中存在大量电感性负载，在运行中需要大量无功，使得配电系统损耗大大增加。

■ There are a lot of inductive loads in the distribution network, which need a lot of reactive power, as a result, the loss of power distribution system are greatly increased.

■ 直流输电系统要求在换流器的交流侧进行无功控制。

■ In the DC transmission system, reactive power of AC side of the converter is controlled.

■ 用户对于供电电能质量的要求日益提高，获得经济效益的目的日益明确，对电网的无功进行补偿，尤其是就地无功补偿，在输配电系统中便显得十分必要。

■ User's requirements for power quality is increasing. So, reactive power compensation on the grid, especially, local reactive power compensation in transmission and distribution systems will become necessary.

目前最理想的解决方案就是采用 SVG(Static Var Generator—静止无功发生器)也称 STATCOM (Static Synchronous Compensator 的简称)，其主要作用是：提高电网稳定性、增加输电能力、消除无功冲击、抑制谐波、平衡三相电网，降低损耗、节能减排。其基本原理是将桥式变流电路通过电抗器并联在电网，适当调节桥式变流电路输出电压的相位和幅值或者直接调节其输出电流，使该电路吸收或者发出满足要求的无功功率，从而实现动态无功补偿的目的。

Currently, it is best solution that SVG (Static Var Generator) is used, and it is also known as STATCOM (Static Synchronous Compensator for short). Its main role is improving grid stability, increasing transmission capacity, eliminating the impact of reactive power, suppressing harmonic, balancing three-phase grid voltage, reducing losses and energy conservation. The device connects to grid with reactor through adjusting the bridge converter circuit output voltage of the phase and amplitude or

output currents to meet the requirements of absorbing or emitting reactive power, so that it can achieve dynamic reactive power compensation purposes.

SVG 型动态无功补偿与谐波治理装置的运用是目前最先进的动态无功补偿技术，最成熟的电压源型变流器技术，使得无功补偿装置实现了质的飞跃。无功补偿不再采用大容量的电容、电感器件，而是通过大功率电力电子器件的高频开关实现无功能量的变换。

It is the most advanced dynamic reactive compensation technology that SVG is used. Because of SVG using the most mature of the voltage source converter technology, reactive power compensation device achieves a qualitative leap. Reactive power compensation don't use large capacity capacitor or inductance device, but use the high frequency switch of power electronic devices to achieve reactive energy conversion.

本公司 ZBSVG 动态无功补偿装置是以 IGBT 为核心的无功补偿系统，能够快速连续地提供容性或感性无功功率，实现考核点恒定无功、恒定电压和恒定功率因数的控制等，保障电力系统稳定、高效、优质地运行。在配电网中，将中小容量的 ZBSVG 产品安装在某些特殊负荷（如电弧炉）附近，可以显著地改善负荷与公共电网连接点处的电能质量，例如提高功率因数、克服三相不平衡、消除电压闪变和电压波动、抑制谐波污染等。

The company's device of ZBSVG takes IGBT as the core of reactive power compensation system. It can provide rapid succession capacitive or inductive reactive power to achieve the assessment point of constant reactive power compensation, constant voltage and constant power factor controlling etc. which make ensure that power system is stability, high efficiency, high-quality operation. In the distribution network, the small capacity of ZBSVG products are installed in some special loads (such as electric arc furnace), which can significantly improve the power quality of PCC, such as, improving power factor, overcoming phase imbalance, eliminating voltage flicker and voltage fluctuations, suppressing harmonic pollution and so on.

2.2 ZBSVG 系列产品特点/ Features of ZBSVG series Products

本公司 ZBSVG 系列产品采用现代电力电子、自动化、微电子及网络通讯等技术，采用先进的瞬时无功功率理论和基于同步坐标变换的功率解耦算法，以设定的无功性质及大小、功率因数、电网电压为控制目标运行，动态的跟踪电网电能质量变化调节无功输出，并能实现曲线设定运行，提升电网质量。

ZBSVG series products adopt advanced instantaneous reactive power theory and power decoupling algorithm as the theory foundation, and adopt many technologies such as modern power electronics, automation, microelectronics and network communication. It can set reactive power nature and size, power factor and grid voltage as the control target. Through tracking power quality dynamically, reactive power output are adjusted. It can run at setting curve.

易操作、高性能、高可靠性的 ZBSVG 系列产品为满足用户对提高输配电网的功率因数、治理谐波、补偿负序电流的迫切需求做出相应设计，具有以下特点：

ZBSVG series product with easy operation, high performance, high reliability is designed to meet users' demands of improving power factor of power transmission, compensating harmonic and the negative sequence current. Its features are as follows,

- 模块化设计，安装、调试、设定简便。
- Modular design, easy to install, debug and set
- 动态响应速度快，响应时间 $\leq 5\text{ms}$ 。
- Fast dynamic response, response time $\leq 5\text{ms}$
- 在补偿容量足够的前提下，输出电流谐波（THD） $\leq 3\%$ 。
- Under the sufficient compensation capacity, output current harmonics(THD) $\leq 3\%$
- 多种运行模式极大的满足用户需求，运行模式有：恒装置无功功率模式、恒考核点无功功率模式、恒考核点功率因数模式、恒考核点电压模式、恒考核点无功功率模式 2，目标值可实时更改。
- A variety of operating modes, such as constant device reactive power, constant assessment point of reactive power modes, constant assessment

point of power factor modes, constant assessment point of voltage modes, constant assessment point of reactive power mode 2 (designed for users).

The target value can be set real-time.

- 实时跟踪负荷变化，动态连续平滑补偿无功功率，提高系统功率因数，实时治理谐波，补偿负序电流，提高电网供电质量。
- Tracking load changes actually, compensating reactive power dynamically and smoothly, improving power factor, actually compensating harmonics, compensate the negative sequence of current, improving power quality.
- 抑制电压闪变，改善电压质量，稳定系统电压。
- Suppressing voltage flicker, improving voltage quality, stabling the system voltage
- ZBSVG 电路参数精心设计，发热量小，效率高，运行成本低
- Elaborate design of circuit parameters, small heat value, high efficiency, low operating cost
- 设备结构紧凑，占地面积小。
- Compact structure, small floor area
- 主电路采用 IGBT 组成的 H 桥功率单元链式串联结构,每相由多个相同功率单元组成,整机输出由 PWM 波形叠加而成的阶梯波,逼近正弦,经输出电抗滤波后正弦度良好。
- Main circuit is composed of power cell, and the power cell is composed of H-bridge IGBT.Each phase is composed of multiple identical power cell, which is in series each other. The output PWM waveform is formed by step wave which is approximate to sine.
- ZBSVG 采用冗余性设计和模块化设计，满足系统高可靠性的需求。
- Redundant design to meet the needs of high reliability system
- 功率电路模块化设计，维护简单，互换性好。
- Modular design of power circuit, easy maintenance and good interchangeability
- 保护功能齐全，具有过压、欠压、过流、单元过热、不均压等保护，并

能实现故障瞬间的波形录制，便于确定故障点，易维护，运行可靠性高。

- Lots of protections, such as over-voltage, under-voltage, over-current, overheating of power cell and voltage sharing. It can record fault waveform instantly so it is easy to determine the fault point and maintain, and high reliability

- 人机界面友好显示，对外通讯提供了 RS485、以太网等接口，采用标准 Modbus 通讯协议。除具有实时数字量及模拟量的显示、运行历史事件记录、历史曲线记录查询、单元状态监控、系统信息查询、历史故障查询等功能外，还具有送电后系统自检、一键开停机、分时控制、示波器（AD 通道强制录波）、故障瞬间电压/电流波形记录等特色功能。

- Friendly human-computer interface, RS485 communication interface, Modbus communication standard protocol, real-time digital and analog display, operation record, historical curve records query, power cell state monitoring, system information query, historical fault query, system self-checking after power on, one key to start and stop, time-sharing control, oscilloscope (AD channel mandatory record), instant voltage/current fault recording

- ZBSVG 设计包含与 FC 配合使用的接口，实现定补和动补的有效结合，为用户提供更经济，更灵活的补偿方案。

- Providing FC interface, it can combine with FC effectively which is more economical and flexible for the users.

- 投切时无暂态冲击，无合闸涌流，无电弧重燃，无需放电即可再投。

- No transient impact, no inrush phenomenon, no arc reignition , switch directly without discharge

- 与系统连接时，不需要考虑交流系统相序，连接方便。

- Easy connection, without regard to the phase sequence when connecting to the system

- 可并联安装，极易扩展容量。并机运行使用光纤通讯，通讯速度快，能

够完好的满足实时补偿的要求。

- It can be installed in parallel, and easy to expand capacity. Communication speed is very fast by using the fiber optic,which can well meet the requirement of real-time compensation.

第三章 ZBSVG 系列产品介绍

3.1 ZBSVG 无功补偿基本原理/ZBSVG reactive power compensation Fundamentals

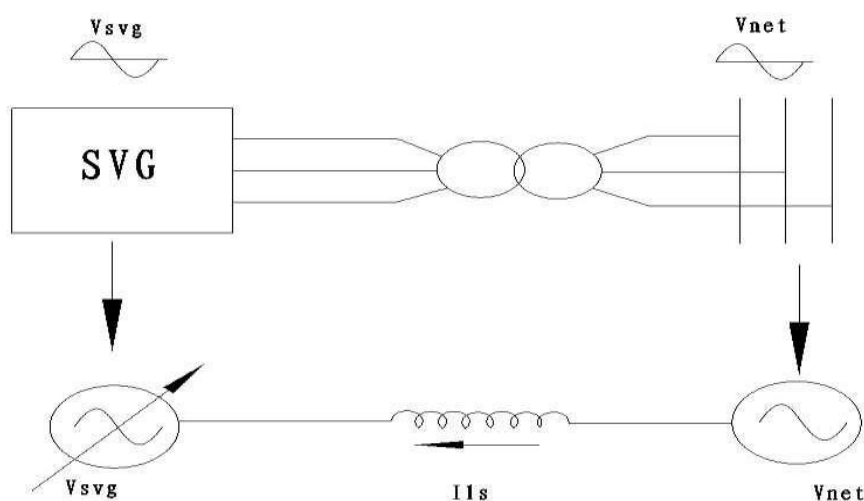


图 3.1 原理示意图/ Figure 3.1 Schematic

ZBSVG 系列产品的原理示意图如图 3.1 所示。在交流电路中，电压和电流的相位有三种情况，当负载呈现纯电阻特性时，电压和电流相位相同；当负载呈现电感特性时，电压相位超前电流相位；当负载呈现电容特性时，电压相位滞后电流相位。

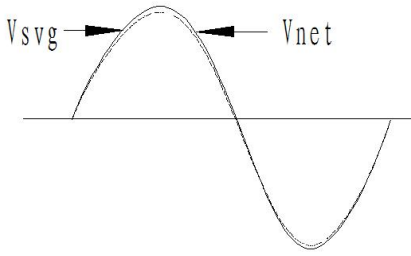
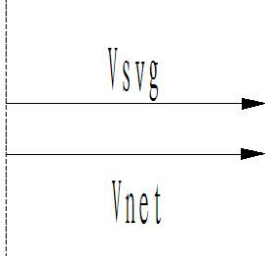
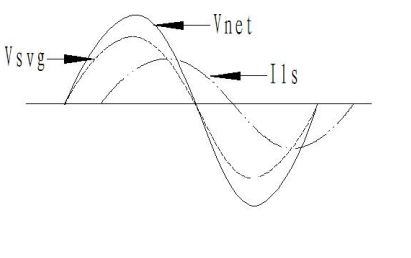
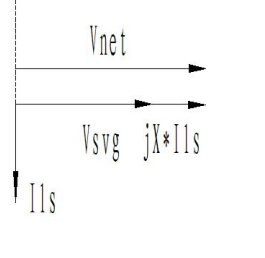
Series of ZBSVG products principle schematic is shown in Figure 3.1. There are three cases between voltage and current in the AC circuit. When the load presents purely resistive, voltage and current is in the same phase; when the load presents

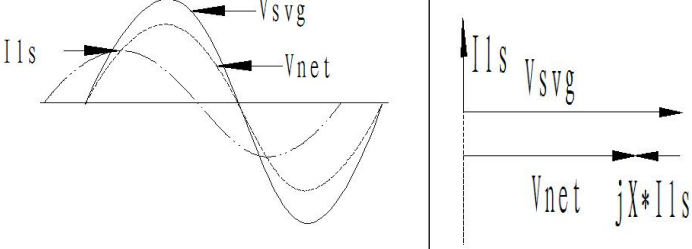
inductance, voltage phase advances current phase; when the load presents capacitance characteristics, voltage phase lags current phase.

ZBSVG 系列产品基本原理就是将自换相桥式电路通过变压器或者电抗器并联到电网上,适当地调节桥式电路交流侧输出电压的幅值和相位,或者直接控制其交流侧电流使该电路吸收或者发出满足要求的无功电流,实现动态无功补偿的目的,如表 3.1 所示。

Basic principle of series of ZBSVG products is the self-commutated bridge circuit via a transformer or reactor connected to the power line. By appropriately adjusting the AC side of the bridge circuit output voltage amplitude and phase, or directly controlling the AC side current to absorb or issue meeting requirements reactive current, thereby, dynamic reactive power compensation is achieved. The principle schematic is shown in Table 3.1.

表 3.1 运行模式原理表/Table 3.1 Principle of operation mode

运行模式 / Operation mode	波形/Waveform	相位/Phase	说明 /Instruction;
空载运行模式 /No-load operating mode			<p>若 $V_{svg}=V_{net}$，则 $I_s=0$，等效为阻值可调的电阻。If $V_{svg} = V_{net}$，then $I_s = 0$，It is equivalent to adjustable resistor.</p>
感性运行模式 Inductive operation mode			<p>若 $V_{svg}<V_{net}$，则 I_s 为滞后电流。等效为连续可调的电感 If $V_{svg}<V_{net}$，then I_s lag voltage. It is equivalent to a continuously adjustable inductor</p>

<p>容性 运行 模式</p> <p>Capacitive mode operation</p>		<p>若 $V_{svg} > V_{net}$， 则 I_{Is} 为超前 电流。等效 为连续可调 的电容</p> <p>If $V_{svg} > V_{net}$， then I_{Is} is leading current. It is equivalent to a continuously adjustable capacitor</p>
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3.2 ZBSVG 系列产品介绍/ Series of ZBSVG introduction

3.2.1 ZBSVG 主要技术参数/Main technical parameters of ZBSVG

- 额定工作电压：6kV、10kV、27.5kV、35kV；
- Rated work voltage, 6kV, 10kV, 27.5kV, 35kV；
- 额定容量：±1~±100Mvar；
- Rated capacity, ±1~±100Mvar；
- 输出无功范围：感性额定无功到容性额定无功范围内连续变化；
- Output reactive power range, which continuously change from rated inductive reactive power to rated capacitive reactive power.
- 响应时间：≤5ms；
- Response time≤5ms；
- 过载能力：1.2 倍过载 1 分钟；

- Overload capacity, 1.2 times load can run 1 min.
- 输出电压总谐波畸变率（并网前）：≤5%；
- Output voltage total harmonic distortion THD≤5%；
- 输出电流总谐波畸变率 THD：≤3%；
- Output current total harmonic distortion THD≤3%；
- 系统电压不平衡保护，整定范围：4%~10%；
- Protection of system voltage unbalance range from 4%-10%
- 效率：额定运行工况≥99.2%；
- Efficiency, rated operating conditions≥99.2%
- 运行温度：-10℃~+40℃；
- Operating temperature, -10℃~+40℃；
- 贮存温度：-30℃~+70℃；
- Storage temperature, -30℃~+70℃；
- 人机界面：采用中文彩色触摸屏显示；
- Human-computer interface, color displaying
- 相对湿度：月平均值不大于 90% (25℃)，无凝露；
- Relative humidity, month average value no more than 90% , no frost
- 海拔高度：< 1000m(高于 1000m 需定制)；
- Altitude, <1000m (more than 1000m need to customize)
- 地震烈度：≤8 度。
- Seismic intensity, ≤8 degree

3.2.2 ZBSVG 引用的部分规范/Parts of the specification referenced in ZBSVG

ZBSVG 系列产品满足以下主要标准或与这些标准规定有关的条文。凡是注日期的引用文件其随后所有的修改单（不包括勘误的内容）或修订版均不适用于本文件。凡是不注日期的引用文件其最新版本适用于本文件。

Series of ZBSVG meet the following standards or provisions with respect to these standards. For dated references, its subsequent amendments (excluding

corrections) or revisions do not apply to this document. For undated reference documents the latest version is apply to this document.

- GB 311.1-2012 绝缘配合第一部分：定义、原则和法规/ Insulation coordination -Part I, Definitions, principles and rules
- GB/T 3797-2005 电气控制设备/ Electrical control assemblies
- GB/T 4208-2008 外壳防护等级（IP 代码）/Degrees of protection by enclosure (IP code)
- GB/T 11022-2011 高压开关设备和控制设备标准的共用技术要求/ Common specifications for high-voltage switchgear and controlgear standards
- GB/T 14048.1-2012 低压开关设备和控制设备第 1 部分：总则/ Low-voltage switchgear and controlgear- Part 1, General rules
- GB/T 12325-2008 电能质量供电电压偏差/Power quality-Deviation of supply voltage
- GB/T 12326-2008 电能质量电压波动和闪变/Power quality-Voltage fluctuation and flicker
- GB/T 14549-1993 电能质量公用电网谐波/Power quality, Public grid harmonic
- GB/T 15543-1995 电能质量三相电压允许不平衡/Power quality, Three-phase voltage unbalance
- GB/T 15945-2008 电能质量电力系统频率偏差/Power quality, Power system frequency deviation
- GB/T 18481-2001 电能质量暂时过电压和瞬态过电压 /Power quality-Temporary and transient over-voltage
- GB/T 3859.3-2013 半导体变流器通用要求和电网换相变流器第 1-3 部分：变压器 / Semiconductor convertors-General requirements and line-commutated converters- Part 1-3, Transformers and reactors
- GB/T 3859.1-2013 半导体变流器通用要求和电网换相变流器第 1-1 部分：基本要求 / Semiconductor convertors-General requirements and line-commutated converters-Part 1-1:Specification of basic requirements

GB/T 3859.2-2013 半导体变流器通用要求和电网换相变流器第 1-2 部分：应用
导 则 / Semiconductor convertors-General requirements and
line-commutated converters-Part 1-2: Application Guide

GB 3906-2006 3.6kV~40.5kV 交流金属封闭式开关设备和控制设备
/Alternating-current metal-enclosed switchgear and controlgear for rated voltages
above 3.6 kV and up to and including 40.5 kV

GB 1985-2014 高压交流隔离开关和接地开关 /High-voltage
alternating-current disconnectors and earthing switches

GB/T 7261-2008 继电保护和安全自动装置基本试验方法/ Basic testing
method of relaying protection and security automatic equipment

GBT 17626.5-2008 电磁兼容试验和测量技术浪涌抗扰度试验/Electromagnetic
Compatibility-Testing and measurement techniques-Surge immunity test

GBT 17626.11-2008 电磁兼容试验和测量技术电压暂降、短时中断和电压变化的
抗 扰 度 试 验 Electromagnetic Compatibility-Testing and
measurement techniques, Voltage dips, short interruptions and
voltage variations immunity tests

GBT 17626.3-2006 电磁兼容试验和测量技术射频电磁场辐射抗扰度试验
Electromagnetic Compatibility, Testing and measurement techniques-Radiated ,
radio-frequency, electromagnetic field immunity test

GBT 17626.2-2006 电磁兼容试验和测量技术静电放电抗扰度试验
Electromagnetic Compatibility-Testing and measurement techniques-Electrostatic
discharge immunity test

GBT 17626.4-2008 电磁兼容试验和测量技术电快速瞬变脉冲群抗扰度试验
Electromagnetic Compatibility-Testing and measurement techniques-Electrical fast
transient/burst immunity test

GB/T 11032-2010 交流无间隙金属氧化物避雷器（附标准修改单 1）/
Metal-oxide surge arresters without gaps for a.c. systems (with standard amendments
1)

Q/GDW 480-2010 分布式电源接入电网技术规定/Technical rule for distributed
resources connected to power grid

Q/GDW 617-2011 光伏电站接入电网技术规定/ Technical rule for Photovoltaic power station connected to power grid

NB/T 31003-2011 大型风电场并网设计技术规范（附条文规范）/ Design regulations for large-scale wind power connecting to the system (with the provisions of specification)

DL/T 620-1997 交流电气装置的过电压保护和绝缘配合/ Overvoltage protection and insulation coordination for AC electrical installations

DL/T 672-1999 变电所电压无功控制调节装置订货技术条件/ Ordering specification for controlling Device of adjusting voltage and reactive in substation

DL/T 1215.1-2013 链式静止同步补偿器第 1 部分：功能规范导则/Chain-circuit static synchronous compensator Part 1:Guide for the functional specification

DL/T 1215.2-2013 链式静止同步补偿器第 2 部分：换流链的试验/Chain-circuit static synchronous compensator Part 2: Testing of converter chain

DL/T 1215.3-2013 链式静止同步补偿器第 3 部分：控制保护监测系统 /Chain-circuit static synchronous compensator Part 3: Control and monitoring system

DL/T 1215.4-2013 链式静止同步补偿器第 4 部分：现场试验/Chain-circuit static synchronous compensator Part 4:Field Test

DL/T 1215.5-2013 链式静止同步补偿器第 5 部分：运行检修导则/Chain-circuit static synchronous compensator Part 5: Guideline of operation and maintenance

DL/T 1216-2013 配电网静止同步补偿装置技术规范/ Technical regulation for distribution static synchronous compensator (DSTATCOM)

3.2.3 ZBSVG 型号与规格/ZBSVG types and specifications

ZBSVG 系列产品的型号命名规则如图 3.2 所示:

Series of ZBSVG types are shown in figure 3.2,

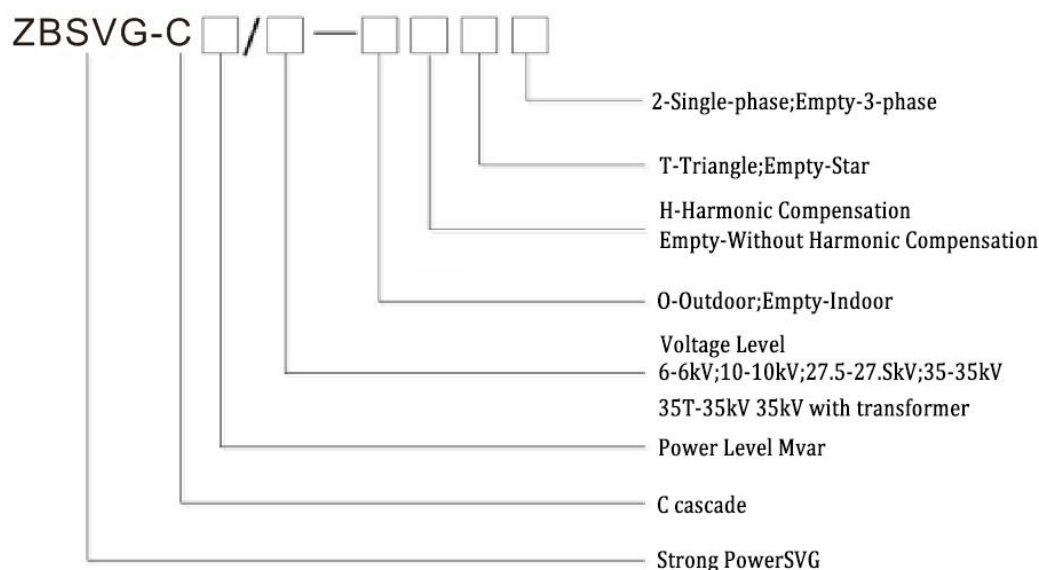


图 3.2 产品命名规则/Figure 3.2 Product Naming

注：容量（Mvar）表示从感性无功到容性无功动态调节范围内的额定最大调节容量。例如 C2.0/10，表示：直挂式 10kV、容量为±2Mvar 的装置。能够在 +2000kvar（感性）到-2000kvar（容性）范围内对无功进行连续平滑调节。

Note, Capacity (Mvar) means the rated maximum adjustment capacity range from inductive reactive power to capacitive reactive power. For example C2.0/10 means the device is connected to the 10kV power grid directly and its capacity is ±2Mvar. It can change from +2000kvar (inductive) to -2000kvar (capacitive) continuously and smoothly.

ZBSVG 系列均采用风机强制冷却，其产品规格如表 3.2 和表 3.3 所示。

Series of ZBSVG adopt forced cooling fan, its product specifications are shown in Table 3.2 and Table 3.3.

表 3.2 ZBSVG 户内式机型规格与尺寸/Table 3.2 Series of indoor ZBSVG Specifications and size

产品型号/ Product type	电 压 等 级 Voltage level (kV)	额定容 量 Rated capacity	外形尺寸 Dimensions			电抗 类型 Reactance type	重量 Weight (kg)	
			总宽度 Width (mm)	高 度 Height (mm)	深 度 Depth (mm)			
ZBSVG-C1.0/6	6	1.0	3100	2400	1400	铁 芯 电 抗	2450	
ZBSVG-C1.5/6		1.5						
ZBSVG-C2.0/6		2.0						
ZBSVG-C3.0/6		3.0						
ZBSVG-C4.0/6		4.0	3800			Iron core reactance	3450	
ZBSVG-C5.0/6		5.0						
ZBSVG-C6.0/6		6.0	3600				空 心 电 抗	2750
ZBSVG-C7.0/6		7.0						3450
ZBSVG-C8.0/6		8.0	5600			4600		
ZBSVG-C9.0/6		9.0	5600			4700		
ZBSVG-C10.0/6		10.0				4800		
ZBSVG-C11.0/6		11.0				4900		
ZBSVG-C12.0/6	12.0	Hollow core reactance		5000				
ZBSVG-C1.0/10		1.0	3800	铁 芯	2650			
ZBSVG-C1.5/10		1.5			2750			
ZBSVG-C2.0/10		2.0			3050			

ZBSVG-C3.0/10	10	3.0	3000	2400	1400	电	3200
ZBSVG-C4.0/10		4.0				抗	3400
ZBSVG-C5.0/10		5.0				Iron core reactance	3700
ZBSVG-C6.0/10		6.0				空心电抗 Hollow core reactance	2500
ZBSVG-C7.0/10		7.0				铁芯电 抗 Iron core reactance	5050
ZBSVG-C8.0/10		8.0				5100	5250
ZBSVG-C9.0/10	10	9.0	4900	2400	1400	空心电 抗	3750
ZBSVG-C10.0/10		10.0				3900	
ZBSVG-C11.0/10		11.0	5000			Hollow reactance	3700
ZBSVG-C12.0/10		12.0				3800	
ZBSVG-C13.0/10		13.0				7000	
ZBSVG-C14.0/10		14.0	8200			空心 电抗	7200
ZBSVG-C15.0/10		15.0					7400
ZBSVG-C16.0/10		16.0					7500
ZBSVG-C17.0/10		17.0					7700
ZBSVG-C18.0/10		18.0					
ZBSVG-C19.0/10		19.0					
ZBSVG-C20.0/10	20.0						
ZBSVG-C21.0/10	21.0						
ZBSVG-C8.0/35		8.0	14500				8200
ZBSVG-C9.0/35		9.0					
ZBSVG-C10.0/35		10.0					
ZBSVG-C11.0/35		11.0					8950

ZBSVG-C12.0/35	35	12.0	26200	2100	1800	空心电抗	9400	
ZBSVG-C13.0/35		13.0						9850
ZBSVG-C14.0/35		14.0						
ZBSVG-C15.0/35		15.0						
ZBSVG-C16.0/35		16.0						
ZBSVG-C17.0/35		17.0						
ZBSVG-C18.0/35		18.0						
ZBSVG-C19.0/35		19.0						
ZBSVG-C20.0/35		20.0						
ZBSVG-C21.0/35		21.0						
ZBSVG-C22.0/35		22.0					15580	
ZBSVG-C23.0/35		23.0						
ZBSVG-C24.0/35		24.0						
ZBSVG-C25.0/35		25.0						
ZBSVG-C26.0/35		26.0						
ZBSVG-C27.0/35		27.0						
ZBSVG-C28.0/35		28.0						
ZBSVG-C29.0/35		29.0						
ZBSVG-C30.0/35		30.0						
ZBSVG-C31.0/35		31.0						
ZBSVG-C32.0/35		32.0					16300	
ZBSVG-C33.0/35	33.0							
ZBSVG-C34.0/35	34.0							
ZBSVG-C35.0/35	35.0							
ZBSVG-C36.0/35	36.0							
ZBSVG-C37.0/35	37.0							
ZBSVG-C38.0/35	38.0							
ZBSVG-C39.0/35	39.0							
ZBSVG-C40.0/35	40.0	26200	2100	1800	空心电抗	17140		
	35						17560	
							17980	

ZBSVG-C41.0/35	35	41.0	52400	2100	1800	Hollow core reactance	40100			
ZBSVG-C42.0/35		42.0								
ZBSVG-C43.0/35		43.0								
ZBSVG-C44.0/35		44.0								
ZBSVG-C45.0/35		45.0								
ZBSVG-C46.0/35		46.0								
ZBSVG-C47.0/35		47.0								
ZBSVG-C48.0/35		48.0								
ZBSVG-C49.0/35		49.0								
ZBSVG-C50.0/35		50.0								
ZBSVG-C55.0/35		55.0	52400			Hollow core reactance	40100			
ZBSVG-C60.0/35		60.0								
ZBSVG-C65.0/35		65.0								
ZBSVG-C70.0/35		70.0								
ZBSVG-C80.0/35		80.0								
ZBSVG-C90.0/35		90.0								
ZBSVG-C100.0/35		100.0								
									空心电抗	

表 3.3 ZBSVG 户外机型规格与尺寸 Table 3.3 Series of outdoor ZBSVG specifications and size

产品型号	电压等级 (kV)	额定容量 (Mvar)	外形尺寸 Dimensions			电抗类型	重量 (kg)
			宽度 (mm)	高度 (mm)	深度 (mm)		
ZBSVG-C1.0/6-O	6	1.0	5200	2560	2438	Iron core reactance 铁 芯 电 抗	4450
ZBSVG-C1.5/6-O		1.5					4850
ZBSVG-C2.0/6-O		2.0					5450
ZBSVG-C3.0/6-O		3.0					5750
ZBSVG-C4.0/6-O		4.0					
ZBSVG-C5.0/6-O		5.0					
ZBSVG-C6.0/6-O		6.0					

ZBSVG-C7.0/6-O	7.0	6700	空 心 电 抗 Hollow core reactance			6450	
ZBSVG-C8.0/6-O	8.0					6600	
ZBSVG-C9.0/6-O	9.0					6700	
ZBSVG-C10.0/6-O	10.0					6800	
ZBSVG-C11.0/6-O	11.0					6900	
ZBSVG-C12.0/6-O	12.0					7000	
ZBSVG-C1.0/10-O	10	1.0	5200	2560	2438	铁 芯 电 抗	4650
ZBSVG-C1.5/10-O		1.5					4750
ZBSVG-C.20/10-O		2.0					5050
ZBSVG-C3.0/10-O		3.0					5200
ZBSVG-C4.0/10-O		4.0					5400
ZBSVG-C5.0/10-O		5.0					5700
ZBSVG-C6.0/10-O	6.0	6000					
ZBSVG-C7.0/10-O	10	7.0	6700	2560	2438	空 心 电 抗	5050
ZBSVG-C8.0/10-O		8.0					5250
ZBSVG-C9.0/10-O		9.0					5750
ZBSVG-C10.0/10-O		10.0					5900
ZBSVG-C11.0/10-O		11.0					5700
ZBSVG-C12.0/10-O		12.0					5800
ZBSVG-C13.0/10-O	10	13.0	9700	2560	2438	空 心 电 抗	9000
ZBSVG-C14.0/10-O		14.0					9200
ZBSVG-C15.0/10-O		15.0					9200
ZBSVG-C16.0/10-O		16.0					9200
ZBSVG-C17.0/10-O		17.0					9400
ZBSVG-C18.0/10-O		18.0					9400
ZBSVG-C19.0/10-O		19.0					9500

ZBSVG-C34.0/35-O	35	34.0	52000	2560	2438	抗	26000
ZBSVG-C35.0/35-O		35.0					
ZBSVG-C36.0/35-O		36.0					
ZBSVG-C37.0/35-O		37.0					
ZBSVG-C38.0/35-O		38.0					
ZBSVG-C39.0/35-O		39.0					
ZBSVG-C40.0/35-O		40.0					
ZBSVG-C41.0/35-O		41.0					
ZBSVG-C42.0/35-O		42.0					
ZBSVG-C43.0/35-O		43.0					
ZBSVG-C44.0/35-O		44.0					
ZBSVG-C45.0/35-O		45.0					
ZBSVG-C46.0/35-O		46.0					
ZBSVG-C47.0/35-O		47.0					
ZBSVG-C48.0/35-O		48.0					
ZBSVG-C49.0/35-O		49.0					
ZBSVG-C50.0/35-O		50.0					
ZBSVG-C55.0/35-O		55.0					
ZBSVG-C60.0/35-O		60.0					
ZBSVG-C65.0/35-O		65.0					
ZBSVG-C70.0/35-O	70.0						
ZBSVG-C80.0/35-O	80.0	52000					
ZBSVG-C90.0/35-O	90.0						
ZBSVG-C100.0/35-O	100.0						

说明：

Notes,

1) 户内式装置高度不含风机高度（约 500mm）。

The fan height which is about 500mm is not included in the height of indoor devices.

2) 容量（Mvar）表示从感性无功到容性无功动态调节范围内的额定最大调节容量。例如 C10.0/10，表示为 10kV、容量为±10Mvar 装置，即+10Mvar（感性）

到-10Mvar（容性）范围内对无功进行连续平滑调节。

Capacity (Mvar) means the rated maximum adjustment capacity range from inductive reactive power to capacitive reactive power. For example “C5.0/6” means the device is connect to the 6kV power grid directly and its capacity is ± 5 Mvar. It can change from +5Mvar (inductive) to -5Mvar (capacitive) continuously and smoothly.

- 4) 以上尺寸仅供参考，公司保留对产品的升级和改进权利，产品尺寸更改后不再另行通知。

The above sizes are for reference only, the company reserves the right to update and improve product. There is no future notice if the product size is changed.

- 5) 对于 35kV 系列产品，三相可分为三排前后就近布置。

For series of 35kV, three-phase can be divided into three rows so that it are arranged around nearby.

3.2.4 ZBSVG 应用领域/ZBSVG Application fields

ZBSVG 系列产品可以增强电力传输能力、减小电能损耗、补偿无功功率、治理谐波、抑制闪变、稳定电网电压、平衡三相系统、改变系统的阻尼特性、提高系统的稳定性，具有较广的应用范围。

It has a lot of benefits by using ZBSVG, such as, enhancing power transmission capacity, reducing power consumption, compensating reactive power, controlling harmonic, suppressing flicker, stabilizing the grid voltage, balancing three-phase system, altering the damping characteristics of the system, improving system stability, so its applications is very wide.

ZBSVG 系列产品可广泛应用于石油化工、电力系统、冶金、电气化铁路、城市建设等行业中，为各种异步电动机、变压器、晶闸管变流器、变频器、感应炉、电弧炉、照明设备、电力机车、提升机、起重机、冲压机、风力发电机、电焊机、轧钢机、电阻炉、石英熔炼炉等设备提供高质量、高可靠性的无功补偿的解决方案。

ZBSVG products can be widely used in many industries, for example,

petrochemical, power systems, metallurgy, electric railway, urban construction, etc. It can provide high quality and high reliability reactive power compensation solutions for many devices, such as, various asynchronous motors, transformers, thyristor converters, frequency converters, induction furnace, electric arc furnaces, lighting, electric locomotive, hoists, cranes, stamping machines, wind generators, welding machines, rolling machines, resistance furnace, quartz melting furnace, etc.

(1) 石油、化工、矿山、码头、重型工业: Petroleum, chemical, mining, docks, heavy industry,

a 稳定供电电压; Stabling power supply voltage;

b 给较多中低压电机供电的变电站集中补偿; Providing centralized compensation for substation which supply power to many middle and low voltage motors;

c 大型电机的无功就地动态补偿; Local dynamic compensation of large motor

d 对各类粉碎机、破碎机、球磨机进行无功集中补偿; Providing centralized compensation for all kinds of grinder, crusher, ball mill;

e 减少牵引传动装置的无功波动与谐波; Reducing reactive power fluctuation and harmonic of traction and drives device;

f 大型起重机设备、船闸控制系统、锻造设备等的集中补偿; Providing centralized compensation for large crane equipment, shiplock control system, forging equipment, etc.

(2) 钢铁、冶金: Iron and steel, metallurgy,

a 提高功率因数降低无功损耗; Improving power factor to reduce the reactive power loss;

b 降低电压波动,抑制闪变,提高生产效率; Increasing productivity by reducing voltage fluctuations, suppressing flicker;

c 滤除谐波,保障设备安全; Filtering harmonic, safeguarding equipment;

d 平衡负序; Balancing negative sequence

(3) 城市配网及农网供电: Urban distribution network and rural power supply,

a 提高功率因数降低无功损耗; Improving power factor to reduce the reactive power loss;

b 解决波动性负荷产生的电压波动与闪变; Solving voltage fluctuations and flicker caused by wavy load;

c 稳定受电末端电压; Stabilizing voltage of end power receiving;

d 适合对多个用户的无功与谐波集中补偿, 尤其冲击型负荷较多的场合; It is suitable to provide centralized compensation for reactive power and harmonic of many users, especially impact type loads ;

(4)新能源接入: New energy access,

a 控制风电、光伏发电设备电源接入点无功, 防止无功倒送; Controlling access point reactive power generated by wind power, photovoltaic power generation equipment;

b 稳定电网电压, 减少发电功率波动造成的电压波动; Stabilizing the grid voltage, reducing voltage fluctuations generated by power fluctuations;

c 维持接入点电压, 提高低电压穿越能力; Maintaining the access point voltage value does not change, to Improve low voltage ride through capability;

(5)电气化铁道及城市轨道交通行业; Electrified railway and urban rail transit industry,

a 牵引供电系统的无功与谐波综合治理, 改善电能质量, 提高牵引能力, 节能降耗; Compensating the reactive power and harmonic of traction power supply system comprehensively, improving power quality, increasing towing capacity and saving energy

b 平衡机车负荷产生的负序电流。Balancing negative sequence current produced by locomotive load

第四章 ZBSVG 系统结构及参数说明/System structures and parameter descriptions of ZBSVG

4.1 ZBSVG 系统结构/Structures of ZBSVG

ZBSVG 系列产品的主电路采用链式拓扑结构，模块化的结构设计，星型及三角形的连接方式实现不同容量下的最大性价比，既保证用户投资的有效性，又保障了电力系统稳定、高效、优质的运行。星型接法的结构示意图如图 4.1 所示。

Chain topology structure and modular structure design are used in series of ZBSVG products. Because star and triangle connection is adopted, cost performance is achieved in different capacity. As a result, not only the investment validity of user, but also power system stability, high efficiency and high quality is ensured. The star connection diagram is shown in figure 4.1.

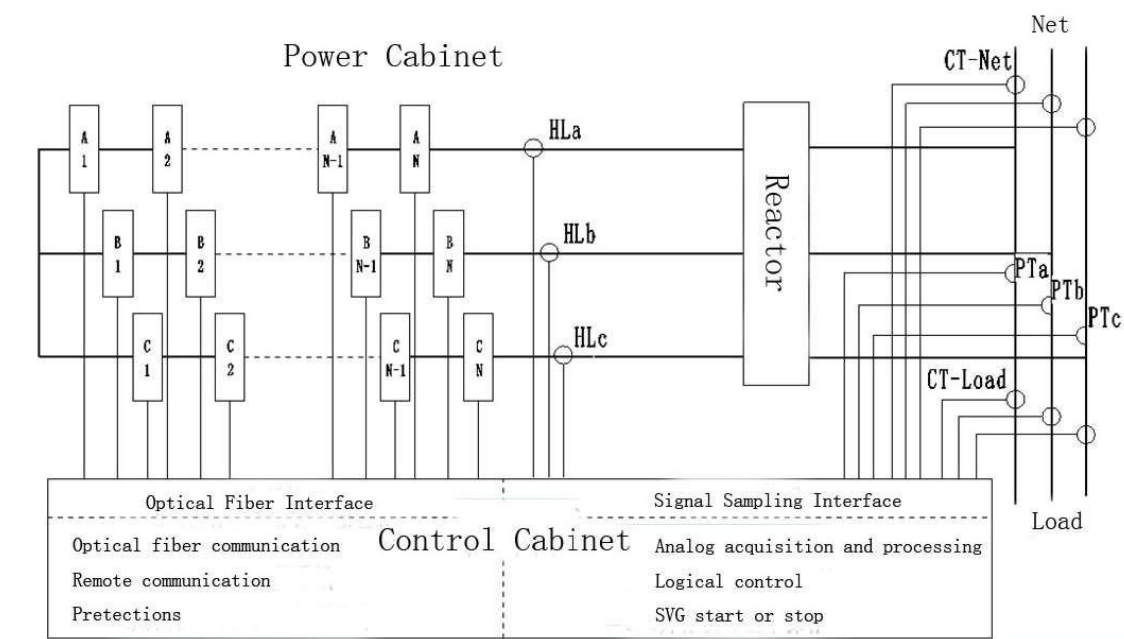


图 4.1 ZBSVG 电气结构示意图/Figure 4.1 Electrical and structure Schematic of ZBSVG

控制柜与功率柜信号通过光纤进行隔离控制，实现了高低压的可靠隔离。ZBSVG 系列产品系统对结构上做出了极大的改进处理，使维护更方便。控制柜进行了严格的抗干扰处理，保障控制系统不受高压主回路的影响。功率模块（单元）的改善使得功率柜占地面积更小，极大节省了用户设备空间，减少了投资。

户内式机型 ZBSVG-C5.0/6 如图 4.2 所示。户外集装箱式机型 ZBSVG-C20.0/35-O 如图 4.3 所示。

Optical fiber is used to transmit signal between control cabinet and power cabinet, which realize the reliable isolation between high and low voltage. Series of ZBSVG products have made a great improvement on the structure, which make the maintenance convenient. Control cabinet was strictly anti-interference processing to ensure the control system not affected by the main circuit of high voltage. Because of improvement of power module (cell), floor space of the power cabinet is smaller, which greatly saves space and reduces the investment. Indoor type models ZBSVG-C5.0 / 6 is shown in Figure 4.2. Outdoor containerized model ZBSVG-C20.0 / 35-O is shown in Figure 4.3.



图 4.2 ZBSVG-C5.0/6 正面图（仅供参考） / Front view of ZBSVG-C5.0 / 6



图 4.3 ZBSVG-C20.0/35-O 正面图（仅供参考）/ Front view of ZBSVG-C20.0/35-O

ZBSVG 系列产品主要分为三部分：控制柜、功率柜、电抗器柜。其中功率柜实现了极大的统一性，方便了产品容量的扩展及稳定性。各电压等级的装置由控制柜、功率柜及电抗器柜（或空心电抗）组成。其中 35kV 装置采用了柜体及模块的独特设计，不必使用安全围栏即可保证操作者的安全；采用最新设计使得冷却风机能够直接安装于柜顶，降低了安装难度，使安装与维护更加方便。各柜体中主要器件及作用如表 4.1 所示。

Series of ZBSVG contains three parts, control cabinet, power cabinet and reactors cabinet. The power cabinet achieved great unity, which is convenient to expand the capacity. The 35kV device adopts a unique design of cabinet and module without using the security fence to ensure the safety of operator. The new design makes the cooling fan can be installed directly on the roof, which reduces installation difficulty, and makes installation and maintain easily. The main components and the role of the cabinet are as shown in table 4.1.

表 4.1 ZBSVG 主要器件及作用/Main components and functions of ZBSVG

系统结构 System structure	主要器件分类 Main device classification	作用 Functions
控制柜 Control cabinet	开关器件 Switching device	主回路的投切与断开 Main circuit switching on and switching off
	缓冲器件 Buffer components	模块充电时的母线缓冲 Bus buffer when module charging
	数据采集器件 Data acquisition device	开关量、模拟量采集 Switch and analog acquisition
	控制箱 Control box	数据处理 Data processing
	逻辑控制器 Logic controller	逻辑控制 Logic control
	人机界面 HMI	对参数进行设置与显示以及波形记录 Setting parameters, waveform recording and display
	二次电源系统 Secondary power	对电源进行处理，实现控制系统的稳定 Controlling the power supply to achieve stability of control system
功率柜 Power cabinet	功率单元 Power cell	根据信号级联成特定幅值及相位的电压 Producing voltage with particular amplitude and phase according to the signal cascade
	强制风冷系统 Forced air cooling system	对模块单元强制冷却 Forcing cooling module cell
电抗器柜 Reactor	电抗器 Reactor	实现无功电压源的并网并对电流滤波 Realization of reactive voltage source

cabinet		paralleling in grid and current filtering
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4.1.1 控制柜/ Control Cabinet

主回路部分由隔离开关 QS1，接触器 KM1(或断路器 QF)，缓冲电阻 R 及状态检测器件等多个部分组成，如图 4.4 所示。

The main circuit is composed of switch QS1, contactor KM1 (or circuit breaker QF), snubber resistor R and state detector, etc. It is shown as figure 4.4.

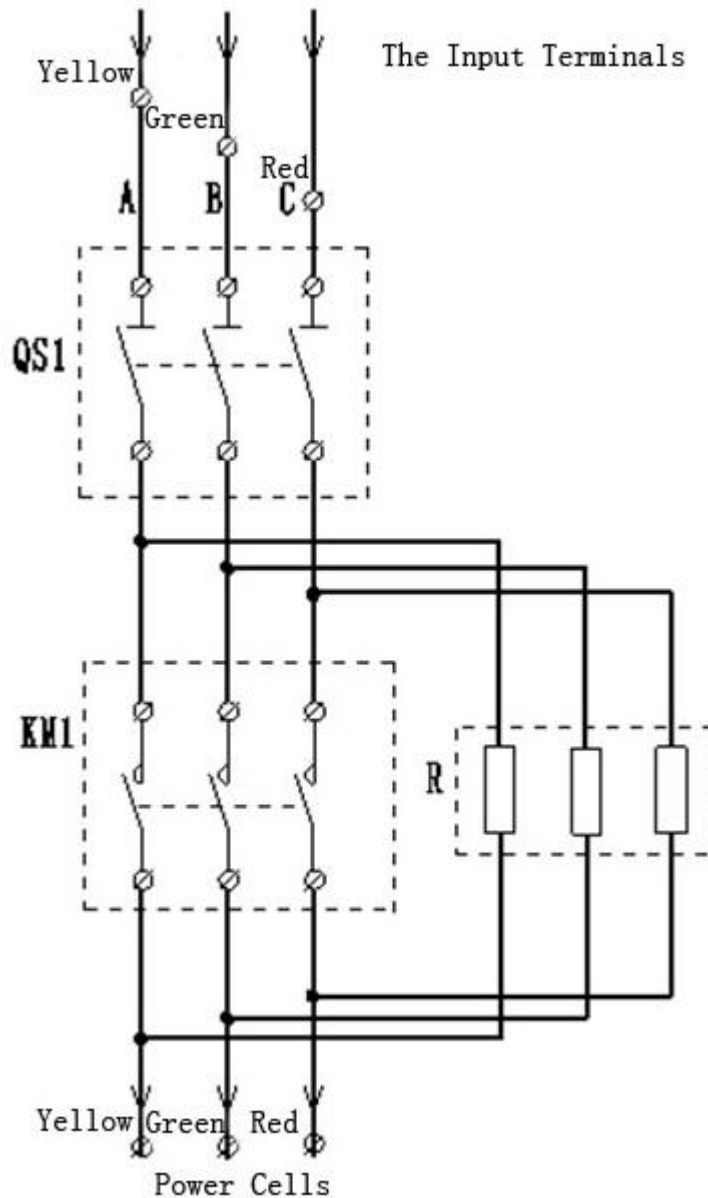


图 4.4 控制柜中主回路图/Main circuit diagram of the control cabinet

隔离开关 QS1 是在系统维护时，为保证人身安全而隔离现场电网高压的安

全防护器件，隔离开关 QS1 的操作必须在确认上一级开关柜断开情况下进行，不允许在高压送达时操作。

Isolation switch QS1 is a protection component which ensures the personal safety and isolates high voltage when the system is maintaining. QS1 must be operated under the condition of no power supply.

ZBSVG 系列产品的启动方式设计为自判断启动，隔离开关 QS1 合上，系统电网通过缓冲电阻对功率模块的电容进行充电。单元母线电压达到稳定后，闭合接触器 KM1（或断路器 QF），旁路缓冲电阻，完成整机上主电过程。

ZBSVG series product is designed to self-start, if QS1 is closed, it will charge capacitor of power module through buffer resistance. When the bus voltage is stable, we close the contactor KM1 (or circuit breaker QF) bypass the buffer resistance, and then the process of the main power is completed.

控制部分由主控箱、PLC、HMI、开关电源、继电器、滤波器、空气开关、自主开发的不断二次电源系统等部分组成。

The control part is composed of main control box, PLC, HMI, switching power supplies, relays, filters, air switch, and self-developed secondary uninterrupted power supply system.

主控箱与 PLC、主控箱和人机界面之间使用串行通信，主控箱板路之间通讯连接实现系统的分层控制，实现期望控制目标、监控 ZBSVG 运行状态、与上位机的通讯等功能。

To achieve expect control target, monitor ZBSVG running state and communicate with PC, the serial communication is used among main box, PLC, and HMI(Human Machine Interface), and the hierarchical control of the system is achieved by communications between main control boards.

1) 主控箱/ Main control box

本公司自主研发的主控箱系标准机箱，通过了 GB/T 17626 系列国标要求的严格 EMC（电磁兼容性）认证，又通过温度冲击及振动试验的处理，具有极高的可靠性。其内含有电源板、主控板、分相板、分信号板等线路板，实现插卡式互连，统一性高、稳定性好，更易维护。电源板为主控箱内各板路提供多种类型

的电源及接口，实现各板路间的数据传输；主控板实现核心控制，协调各板路进行工作，并对外进行通讯；分相板及分信号板实现对各单元模块的实时监控。主控箱正视图如图 4.5 所示。

The main control box is developed by our company. It is certificated by EMC of GB/T 17626 (electromagnetic compatibility), and has passed the processing of temperature cycling and vibration test, so it has high reliability. It contains power supply board, main control board, phase plate, sub-signal board and other circuit board, which achieves plug-in interconnection, high uniformity, good stability and easy maintain. The power supply board provides various types of power supply and interface, which data can be transmitted among every board. Main control board is the core of control, which coordinate with each board and communicate with external. Phase board and sub-signal board actually monitor each cell module. The front view of main control box is shown in figure 4.5.

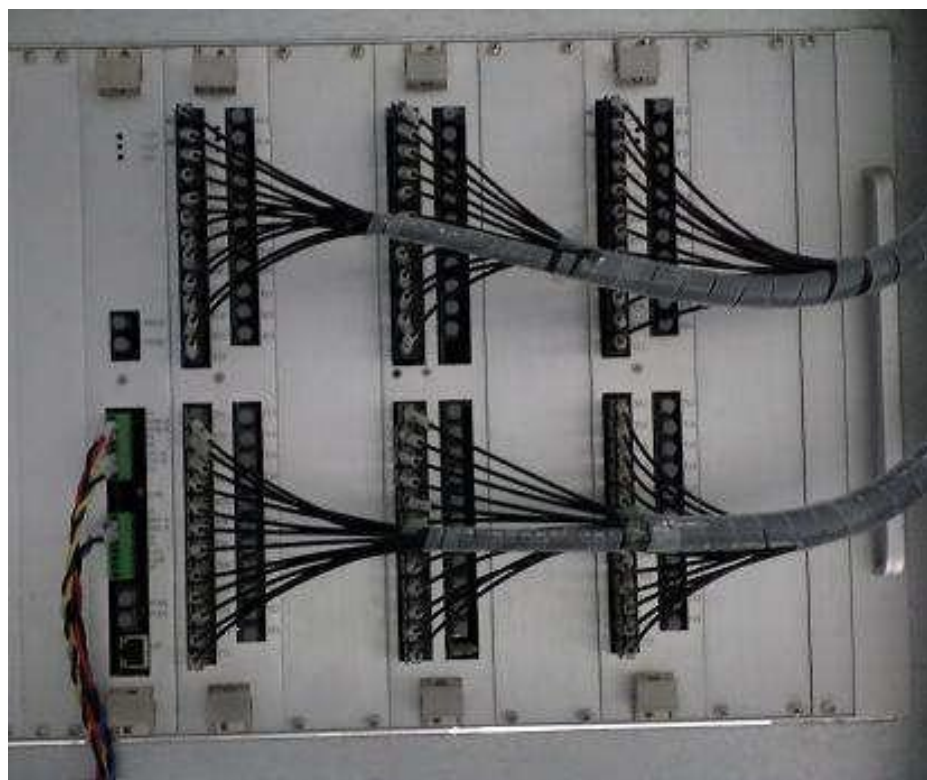


图 4.5 ZBSVG 装置控制箱/ Main control box of ZBSVG

主控箱中控制核心由 32 位高速数字信号处理器 DSP、大规模可编程逻辑器件 CPLD/FPGA 协同运算来实现。精心设计的算法可以保证 ZBSVG 达到最优的运行性能。控制器采用大规模集成电路和表面焊接技术，利用自动化焊接设备进行焊接、针床测试进行检验，极大消除了人工参与造成不稳定的影响，系统具有极高的可靠性。

The core of main control box is 32-bit DSP (Digital Signal Processor) and large-scale programmable logic device CPLD/FPGA. The well-designed algorithm can ensure ZBSVG to achieve optimal performance. Due to adopted large scale integration, surface welding technology, automatic welding device and needle bed test system, so the destabilizing effects of human intervention is greatly eliminated, and the controller is very reliable.

2) 可编程逻辑控制器 PLC/ Programmable Logic Controller (PLC)

采用国际知名品牌西门子 PLC (图 4.6), 实现柜体内开关信号的可靠逻辑处理, 以及与现场各种操作信号和状态信号的协调, 增强了系统的灵活性。

By using the Siemens PLC, the signal logic processing among the cabinet is reliable. It can be coordinated with local operation signal and state signal, which makes the system more flexible.

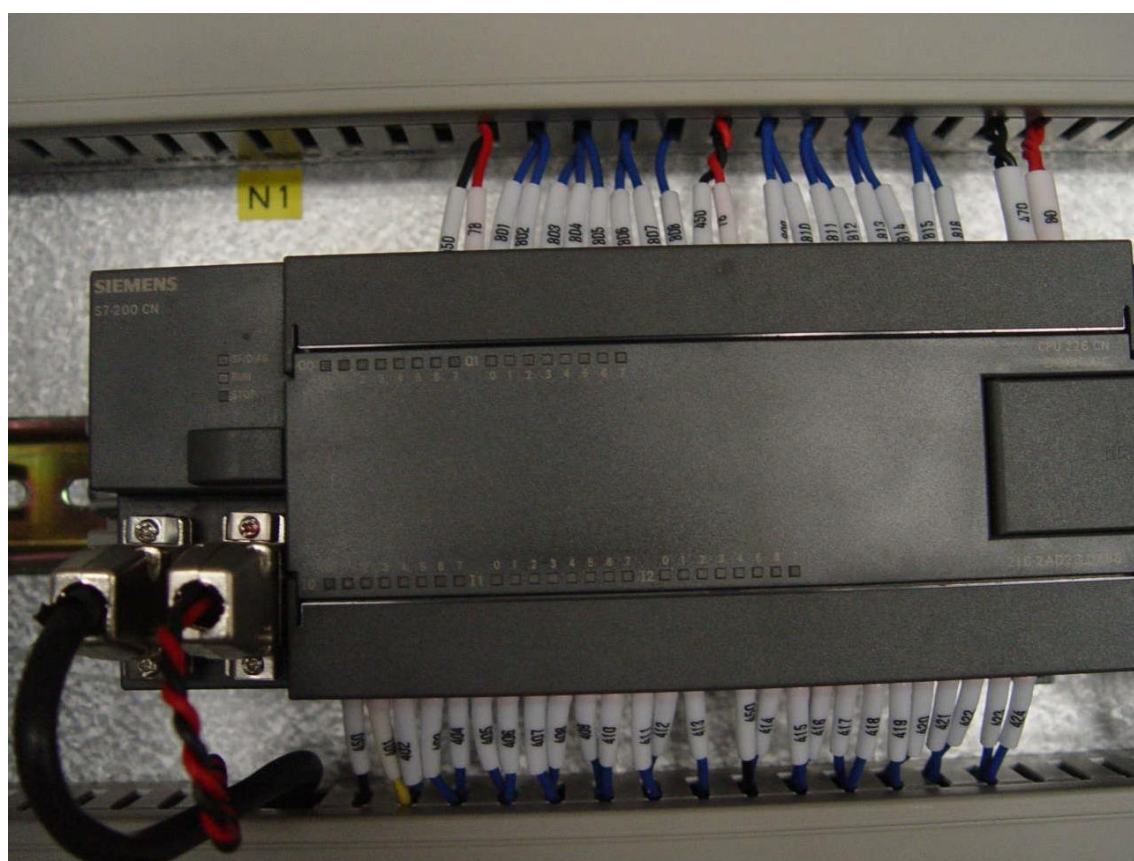


图 4.6 Figure4.6 PLC

实时与主控部分、HMI 通讯, 把装置的运行状态实时的传给 HMI 显示, 并能准确而迅速的实现 HMI、柜门按钮对装置的控制。

Through real-time communicating with the control box and HMI, PLC can transfer the

operating state to HMI to display and control the device accurately and quickly.

3) 人性化操作界面/ Human operation interface

如图 4.7 所示，柜门上安放紧急停止按钮，方便用户在紧急情况下操作。选用国内知名品牌 HMI，供货商采用世界先进的仪器设备，运用标准化作业程序执行管制，与国际标准同步，通过国际知名认证公司 SGS 的 9001-2000 验证，2005 年获得 CE、UL、RoHS 认证；率先采用符合先进环保标准的无铅零件和制造工艺，保证了其金牌品质。

The HMI was used, which is produced by advanced equipment and standardized operating procedures. The standard is synchronized with international and the company is certificated by SGS-9001-200, CE, UL, and RoHS. To ensure the quality, the advanced environmental standards lead-free parts and manufacturing process was adopted.

ZBSVG 即采用该种 HMI，提供友好的全中文监控和操作界面，采用先进的人机沟通技巧，实现设备启停等操作的自由控制。

So, the HMI is chosen by ZBSVG, which provides friendly Chinese monitoring

and operation interface. Using advanced man-machine communication skills, it is easy to achieve free operations of device control.

HMI 主要提供以下功能：

The main functions of HMI is as follows,

- 送电时对系统自检过程的检测；
- Detecting the self-test process when power on
- 对设备装置的基本操作；
- Basic operation on device
- 一键开停机功能；
- A key to startup and shutdown
- 分时控制功能；
- Time-sharing control
- 示波器功能（不同通道、不同放大倍数的 AD 强制录波）
- Oscilloscope function (AD mandatory record with different channels and different magnifications)
- 故障录波，故障瞬间电压、电流波形记录；
- Fault recording, fault instantaneous voltage and current waveforms recording
- 实时状态和模拟量显示（电压、电流、温度、功率、功率因数等）；
- Displaying running state and analog actually(voltage, current, temperature, power, power factor etc.)
- 运行历史事件记录和历史曲线记录查询；
- Running historical events recording and historical curve recording query
- 链式装置单元状态监控；
- Monitoring the cell state of chain device
- 系统信息查询、参数查询和参数设置等；
- Querying system information, parameters, and parameter settings
- 故障查询和历史故障查询。
- Querying fault and historical fault

4.1.2 功率柜/ Power Cabinet

功率柜主要由功率单元组成，构成了 ZBSVG 无功补偿的主体。功率单元分三相安装，每相单元个数相等，单元输出波形叠加成整机输出波形。每个功率单元都承受全部的输出电流、 $1/N$ 的相电压、 $1/(3N)$ 的输出功率。单元模块工作时会产生部分热量，由柜顶或后柜门设计的风机强制散热。功率柜单元排布如图 4.8 所示。

Power cabinet is mainly composed of power cells, which constitute the main body of ZBSVG. Power cell is divided into three phase to install, and the numbers of each phase cell is same. The output waveform is superimposed by each cell. Each power cell has to bear the full output current, $1/N$ of phase voltage, $1/3N$ of output power. Because of the cell module will produce heat during operation, It is necessary that using fan on the top cabinet or cabinet door to force cooling. Power cell arrangement is shown in figure 4.8.



图 4.8 功率柜中单元的排布图/Figure 4.8 Arrangement of power cabinet cell

功率单元（见图 4.9）内置多种电路板，单元控制部分除了采样回路、保护回路和输出驱动回路外，所有的逻辑和通讯处理均采用大规模 CPLD 芯片完成，智能化的设计使得硬件更简单，软件更灵活，抗干扰能力更强，可靠性更高，便于以后的功能改进和升级。

There are a variety of circuit boards built-in the power cell (It is as shown in figure 4.9). Except sampling circuit, protection circuit, output drive circuit, all logic and communication processings are completed by large-scale chip CPLD. Intelligent design makes the hardware simpler, software more flexible, anti-interference stronger, reliability higher, meanwhile it is convenient for future improvements and updates.

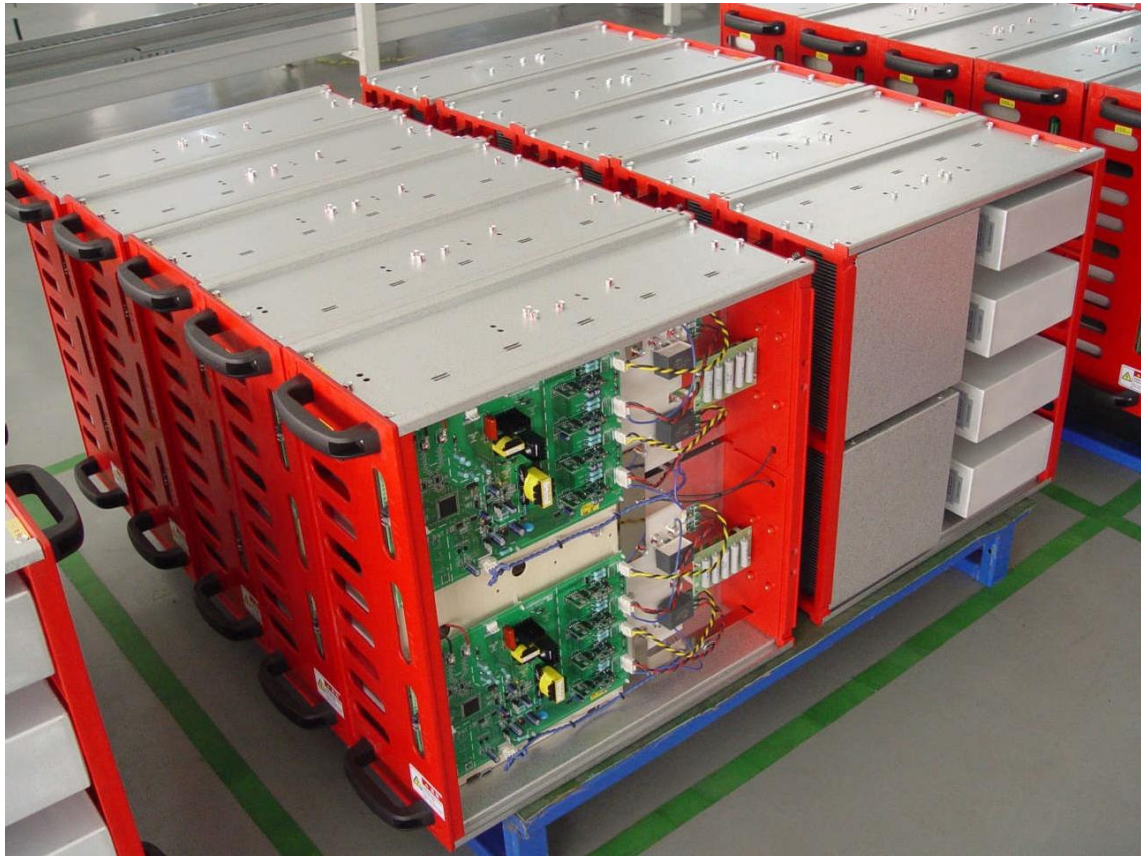


图 4.9 功率单元（模块）/Power cell (module)

直流电容精心选用知名品牌的薄膜电容，采用德国创始普 PHD 型耐高温聚丙烯基膜，特殊的蒸镀材料，既满足高电压、大电流冲击又具有良好的自愈性，为产品可靠性提供了有力保障；增加了留边的宽度，更好的保证了边缘电气绝缘距离，克服了局部放电现象；引出端子的设计具备防转动和抗拉伸功能内部填充

中温导热环氧树脂 (UL 94V-0), 无泄漏, 不开裂。

Film capacitor is selected as DC capacitor, which adopt metallized polypropylene film (Germany Treofan PHD type high temperature polypropylene film). The special evaporation material makes it not only satisfy high voltage, large current impact, but also has good self-healing. In order to ensure the electric insulation distance and overcome the partial discharge phenomenon, the width of left side is increased. The educe terminal is designed to anti-rotation and anti-stretch through filing with thermal conductivity epoxy resin (UL 94V-0), which there are many advantages such as no leak, no cracking.

每个功率单元均具有完善的保护功能 (过流、过压、过温、驱动触发异常、通讯异常等), 各单元状态均反馈到主控系统, 控制器与功率单元之间采用光纤通讯技术, 低压部分和高压部分完全可靠隔离, 系统具有极高的安全性, 同时具有很好的抗电磁干扰性能。

Each power cell has perfect protections (over-circuit, over-voltage, over-temperature, drive trigger failure, abnormal communication etc.). All the state of power cell will feedback to the main control system. Because of using optical fiber to do with communication between controller and power cell, the isolation between the high voltage and low voltage is completely reliable, which the system is not only high security, but also good resistance to electromagnetic interference.

功率单元结构上完全一致, 模块化的结构设计, 使得功率单元可以任意互换, 单元的外部接口只有两个或四个输出端子及两个光纤插口, 这使得维护和检修更简单。在单元已有冗余的情况下其它功率单元发生故障, 用户可以简单更换备用功率单元, 为恢复生产赢得宝贵时间。

Identical structure of power cell and modular design make the power cell exchange arbitrarily. The limited external interface makes it easier to maintain. If others power cell fails in the case of existing redundant cell, users can replace the fail cell on time.

每个单元通过 IGBT 逆变桥实现正弦 PWM 控制, 可得到如图 4.10 所示的单元输出波形。

By using sine PWM technology to control the IGBT inverter bridge of power cell, the output waveform can be obtained, which is shown in figure 4.10.

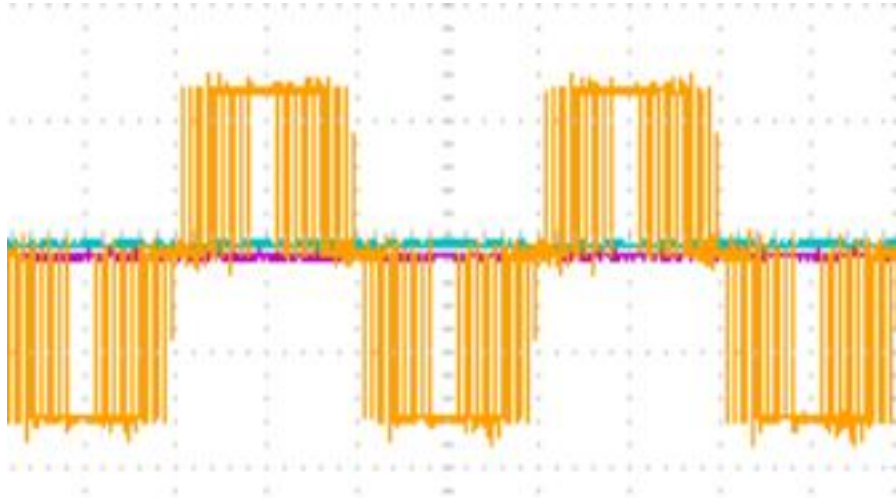


图 4.10 单元输出波形/Figure 4.10 Output waveform of cell

单元链接后三相之间进行星型或角型连接并通过电抗接入电网, 通过对每个单元的 PWM 波形的叠加, 可得到逼近正弦的阶梯 PWM 波形, 如图 4.11 所示为 10kV 星型连接的单相波形。

All cells of each phase are in series, then each phase connect by star or triangle each other. The PWM waveform of each cells are superimposed, the approximate sinusoidal PWM waveform is obtained. The 10kV star connection of single phase waveform is shown in figure 4.11.

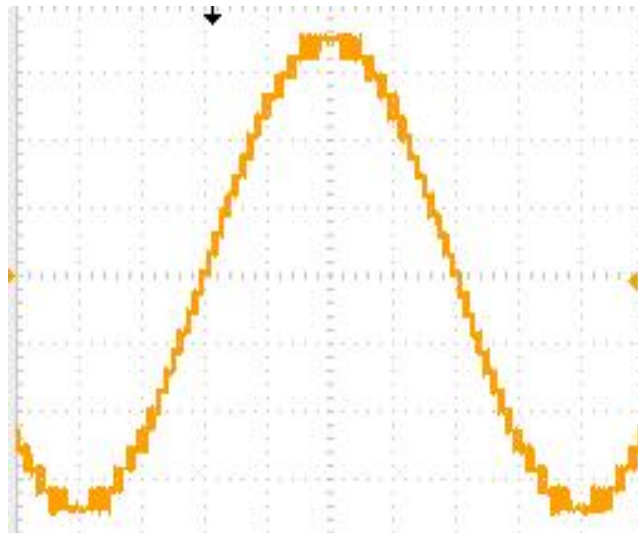


图 4.11 单元输出叠加后的波形图/Figure 4.11 Output superimposed waveforms of cell

ZBSVG 系列产品采用了先进的数字化标准载波移相技术, 它的特点是单元输出的基波相叠加、谐波彼此相抵消, 串联后又经过输出电抗器滤波, 总输出波

形正弦度好， dv/dt 小，谐波成分含量小，可减少对电缆的绝缘损坏，在输出侧无需再增加输出滤波器。

The advanced digital technology of carrier phase-shifting is used in series of ZBSVG, which fundamental waves of cell output is superimposed, and harmonics offset each other. The output waveform is close to sine through output reactor filtering. There are little of dv/dt and harmonic contents, so, the damage to insulation of the cable is reduced. There is no need to increase the output filter in the output side.

4.1.3 电抗器柜/ Reactor cabinet

ZBSVG 系列产品通过电抗器接入电网，电流波形正弦度更好。电抗器平波的同时，也抑制了 SVG 的谐波使其输出的电流谐波符合国家标准。电抗器柜的单独设计利于用户对空间的更高使用率，极大程度的缓解了空间对该设备的使用限制，一定程度上减少了用户对设备间的投资，节省了开支。

Series of ZBSVG product is connected to the power grid by the reactor, and current waveform is close to sine. The reactor not only makes the current waveform smoothly, but also inhibits the SVG harmonics. The individually design of reactor cabinet or hollow reactor is helpful to improve space utilization rate. It greatly eases the use of space limitations to the device. The equipment investment and cost are reduced for users.

4.2 ZBSVG 运行方式/The way of run for ZBSVG

4.2.1 运行方式/The way of run

运行方式包含了五种：恒装置无功功率模式、恒考核点无功功率模式、恒考核点功率因数模式、恒考核点电压模式、恒考核点无功功率模式 2。由下拉框选定，并于右侧设定目标值，目标值可随时更改，更改后可根据检测值检查补偿效果。如下表 4.2 所示，对“运行方式”进行了详细说明。

There are five running modes, such as, constant reactive power device mode, constant assessment point of reactive power mode, constant assessment point of power factor mode, constant assessment point of voltage mode, constant assessment

point of reactive power mode 2. The details of “Running mode” are as shown in table 4.2.

表 4.2 ZBSVG 系统运行方式/The way of ZBSVG running

运行方式/Running mode	说明/Description
恒装置无功功率模式 Constant reactive power device mode	ZBSVG 固定发送或吸收所设定大小的无功功率 Transmitting or absorbing fixed reactive power to set
恒考核点功率因数模式 Constant assessment point of power factor	在 ZBSVG 补偿容量范围内对考核点以设定的功率因数（-100%~+100%）为目标进行补偿。 In the capacity of ZBSVG, it take the assessment point of power factor(-100%~+100%) as the target
恒考核点电压模式 Constant assessment point of voltage mode	以用户设定电压值为目标,通过调节无功输出从而使电网电压稳定在设定值附近。 The device takes user-set voltage value as the target by adjusting the reactive power output, so the grid voltage is stabled near the set value.
恒考核点无功功率模式 Constant assessment point of reactive power mode	通过调节 ZBSVG 的无功输出从而使考核点无功功率稳定在设定值附近。 By adjusting the reactive power output, the assessment point of reactive power is stabled around setting value
恒考核点无功功率模式 2 Constant assessment point of reactive power mode 2	该模式检测负载侧无功功率,调节 ZBSVG 的无功功率,以使系统侧无功功率为零或稳定在设定值。 The reactive power of load side is detected in this mode, thus, system side reactive power will be zero or stabilized at the set value by adjusting output reactive power of ZBSVG.

4.2.2 通讯设置/Communication settings

为与上位机建立通讯,本装置采用标准的 MODBUS_RTU 通信协议及

CDT-91 循环规约。

In order to communicate with PC, the devices adopt MODBUS_RTU standard communication protocol and CDT-91 cycle protocol.

ZBSVG 并联运行，依托本公司成熟的通讯模式使用光纤通讯，保证并联运行装置的安全、可靠运行，提升从机的跟踪速度，实现大容量 ZBSVG 的并网要求。

ZBSVG can be run in parallel mode. The sophisticated fiber-optic communication mode is used, so, the device in parallel runs safely and reliably, and the tracking speed of slave machine is enhanced. Then, large capacity of ZBSVG connected to grid is achieved.

柜门人机界面还提供了装置未上高压时，通讯信息的遥信遥测验证功能，方便现场调试人员对通信数据通道及数据进行测试（见图 4.12）。

When the device don't power on the high voltage, HMI of door provides validating function of communication, which is remote measurement and remote communication. It is very convenient that commissioning personnel test on data access and data of communications (It is as shown figure 4.12).

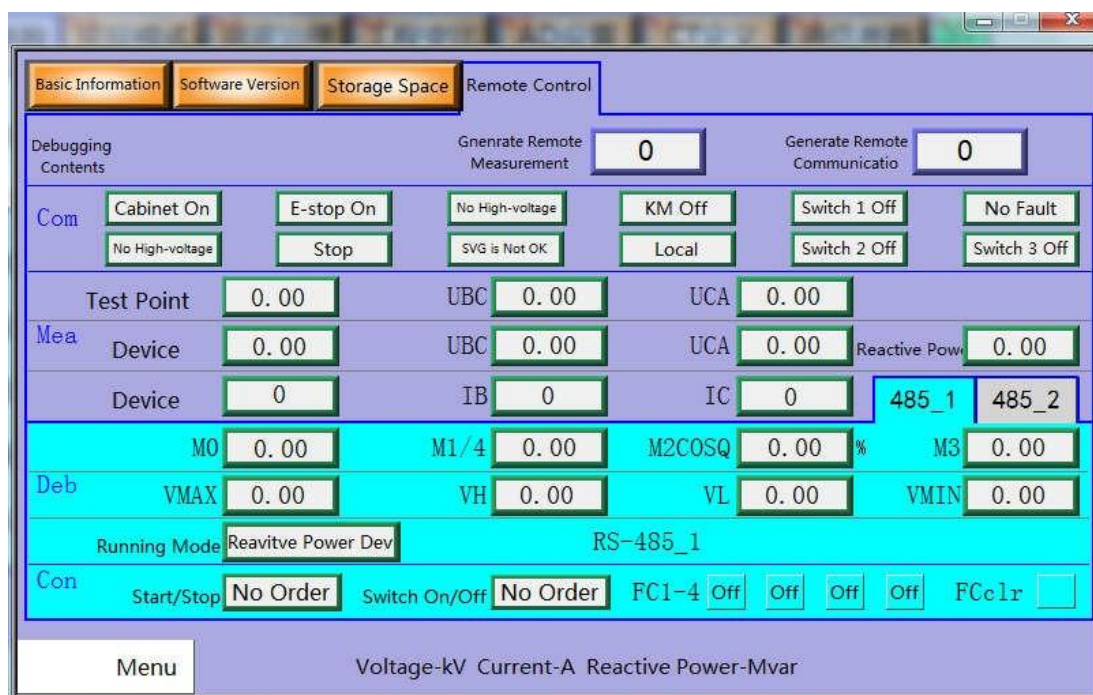
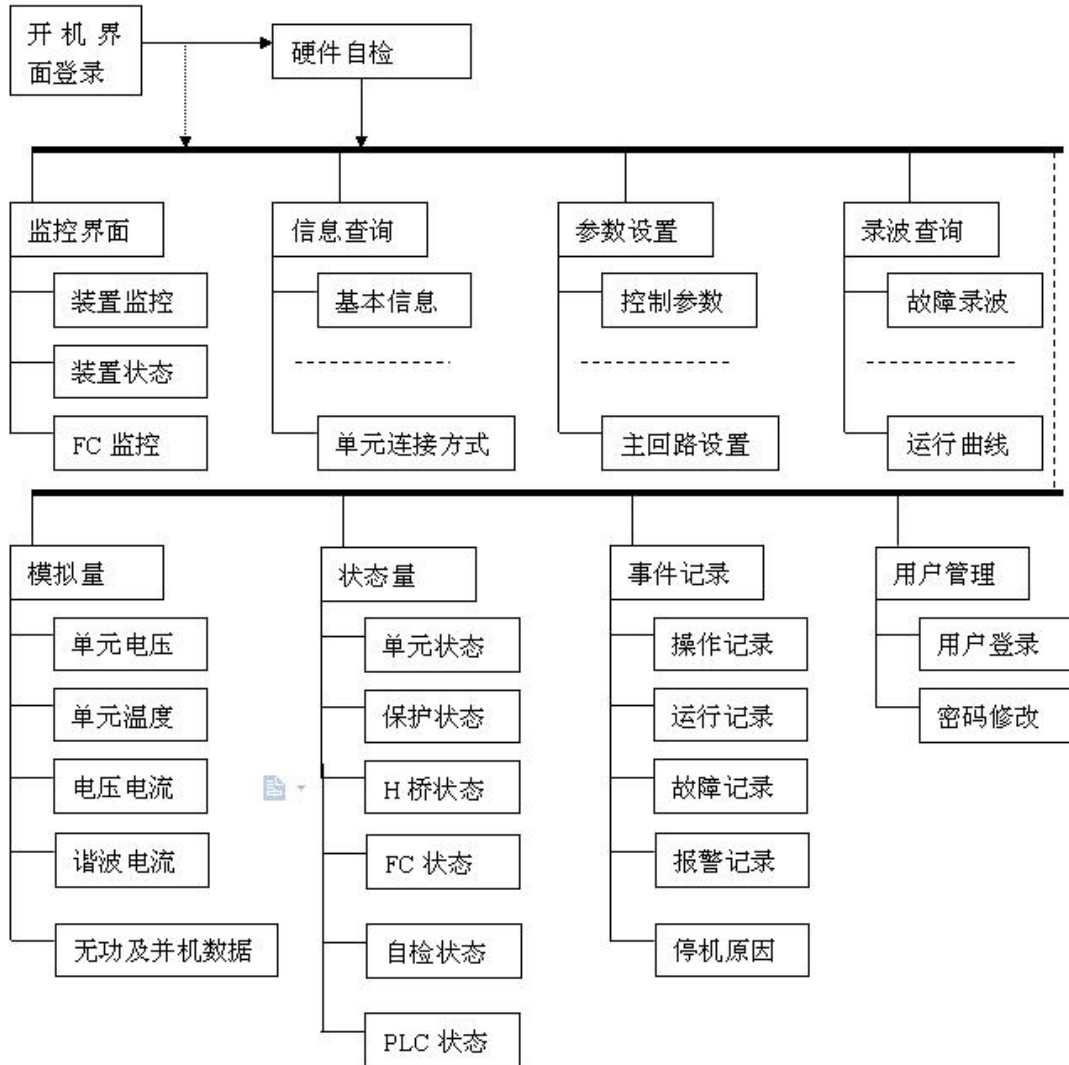


图 4.12 “四遥”测试界面 Figure 4.12 Test interface of four remote controls

第五章人机界面简介/Chapter 5 HMI

5.1 HMI 系统框架/HMI Framework



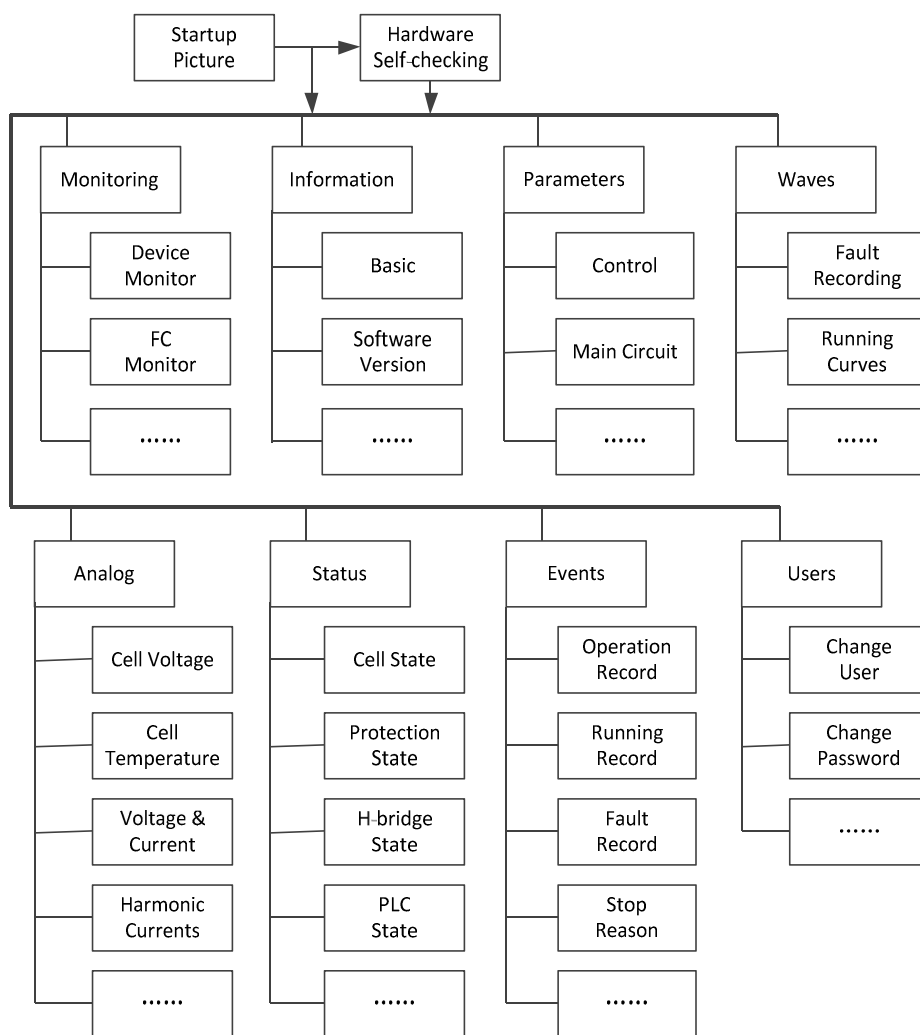


图 5.1 HMI 架构

Figure5.1 HMI Framework

5.2 HMI 页面功能介绍/HMI Introductions

1) 装置监控页面：显示系统和装置电量参数及对整机的分合闸、开停机等操作。

Device Monitor: display the electrical parameters of system and device, control the system on or off

2) 单元电压页面：显示各单元母线电压。

Cell Voltage: display the voltages of cell bus

3) 单元温度页面：实时显示各单元温度（需定制）。

Cell Temperature: display the cell temperatures in real-time (to be customized)

4) 系统数据页面：显示系统、装置、负载电压、电流、功率等信息。

System Data: display the currents of system, power factor, voltages of device, etc.

5) 谐波电流页面: 显示每相各次谐波电流大小。

Harmonic Current: display the currents of harmonic

6) 并机数据页面: 显示双机并联设置的相关信息。

Parallel SVG Data: display the settings of parallel SVG

7) 单元状态页面: 显示各单元的状态。

Cell state: display the states of cell

8) 保护状态 1 页面: 显示高速通信故障、整机故障等信息。

Protection State 1: display the states of High-speed communication and device fault and other information

9) 保护状态 2 页面: 显示载波配置故障及 H 桥配置故障等信息。

Protection State 2: display the carrier configuration fault and H-bridge configuration fault and other information

10) 保护状态 3 页面: 显示通信故障及电源故障等信息。

Protection State 3: display the faults of the communication and power and other information

11) 自检状态页面: 显示自检故障信息。

Self-checking: display the faults of self-checking

12) 操作记录页面: 显示开停机操作记录。

Operation Record: display the operating record of start or stop

13) 运行记录页面: 显示运行过程中的电量信息。

Running Record: display the electrical parameters of running

14) 故障记录页面: 显示故障类型及报警原因。

Fault Record: display the type of fault and alarm reasons

15) 停机原因页面: 显示停机原因。

Stop Reason: display stop reasons

16) 故障录波页面: 显示故障瞬间的电压、电流波形。

Fault Recording: display the voltage and current waveforms of fault instantaneous

17) 用户更改页面: 更改登录用户的身份。

Change User: change the user who logged in

5.3 HMI 使用介绍/HMI Instructions for Use

控制电送入，装置进行自检，图 5.2 所示。自检不通过必须通过提示查明原因，自检通过后进入监控界面（图 5.3 所示）。

The system will go into self-checking interface, after the user logs in, as shown figure 5.2. If the self-checking is passed, HMI will go into device motoring interface, as shown in figure 5.3, if not, the fault reason must be identified.

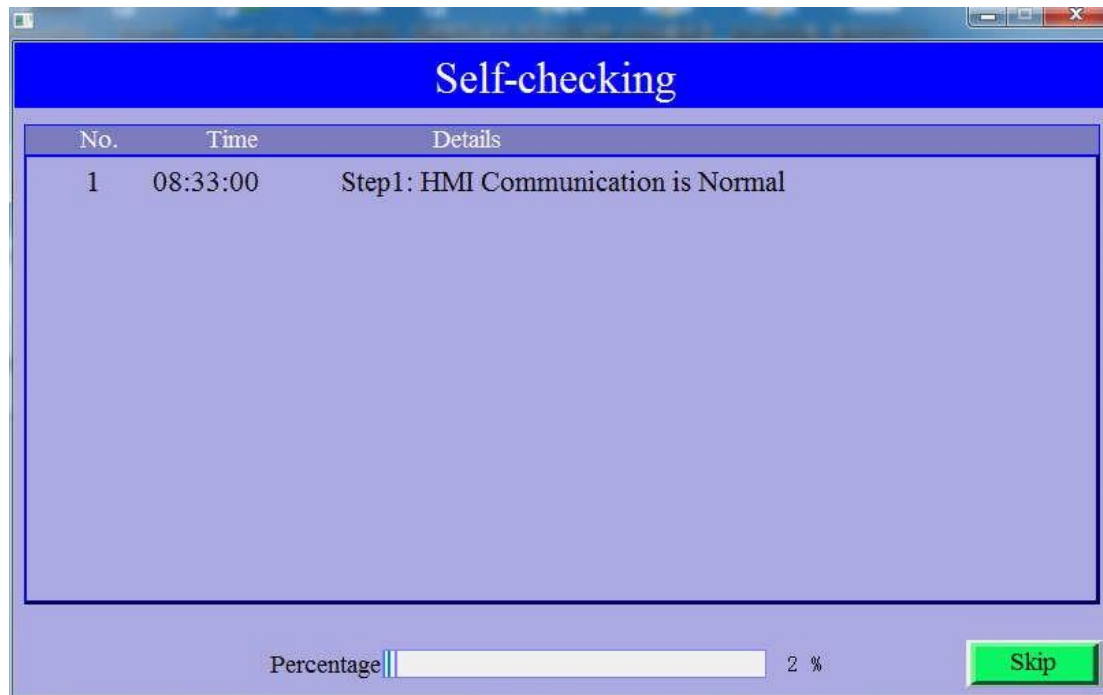


图 5.2 系统自检界面/Figure5.2 Self-checking Interface

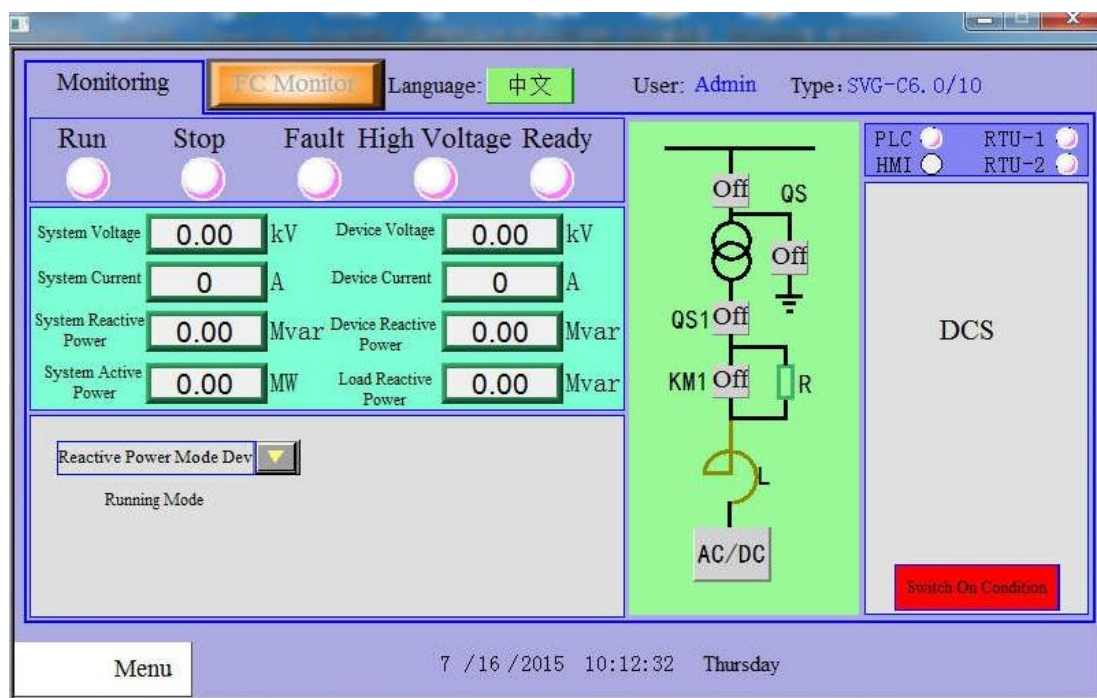


图 5.3 装置监控界面/Figure5.3 Device Monitor Interface

1) 模拟量查询：查询单元电压、温度（需定制）、谐波电流、装置无功、并机数据等模拟量。图 5.4 为单元电压显示界面，图 5.5 为单元温度显示界面。

Analog: The information of cell voltages, cell temperatures (to be customized), harmonic currents, device reactive power and other information can be seen in analog interface. Figure 5.4 is the interface of cell voltages. Figure 5.5 is the interface of cell temperatures.

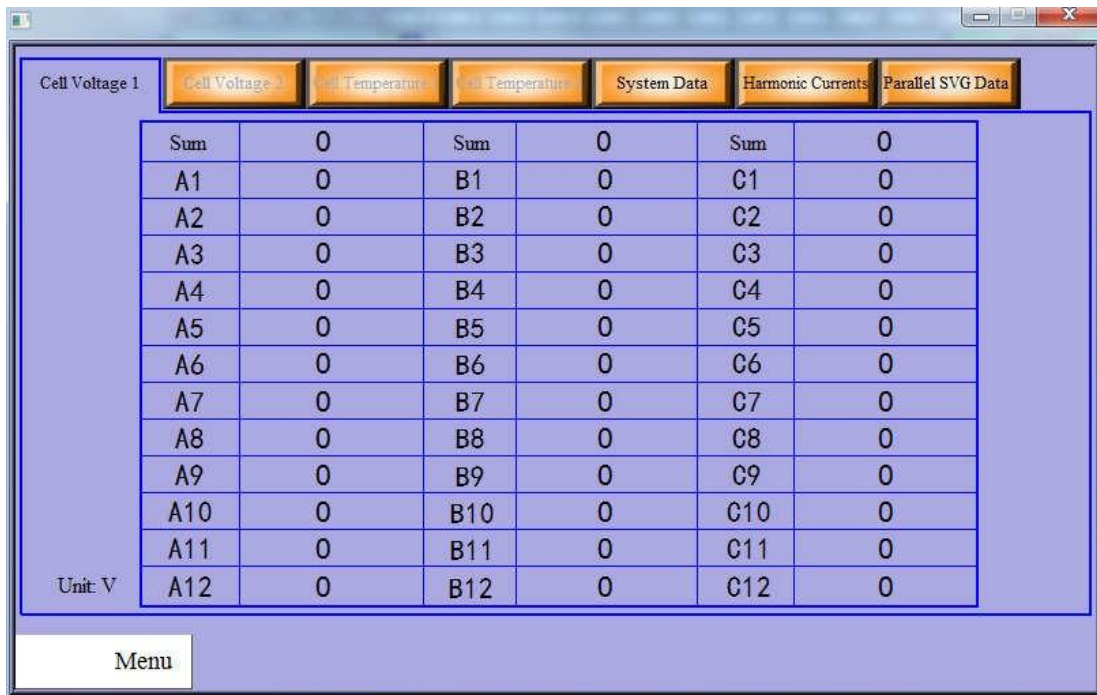


图 5.4 单元电压显示界面/figure 5.4 Cell voltages Interface

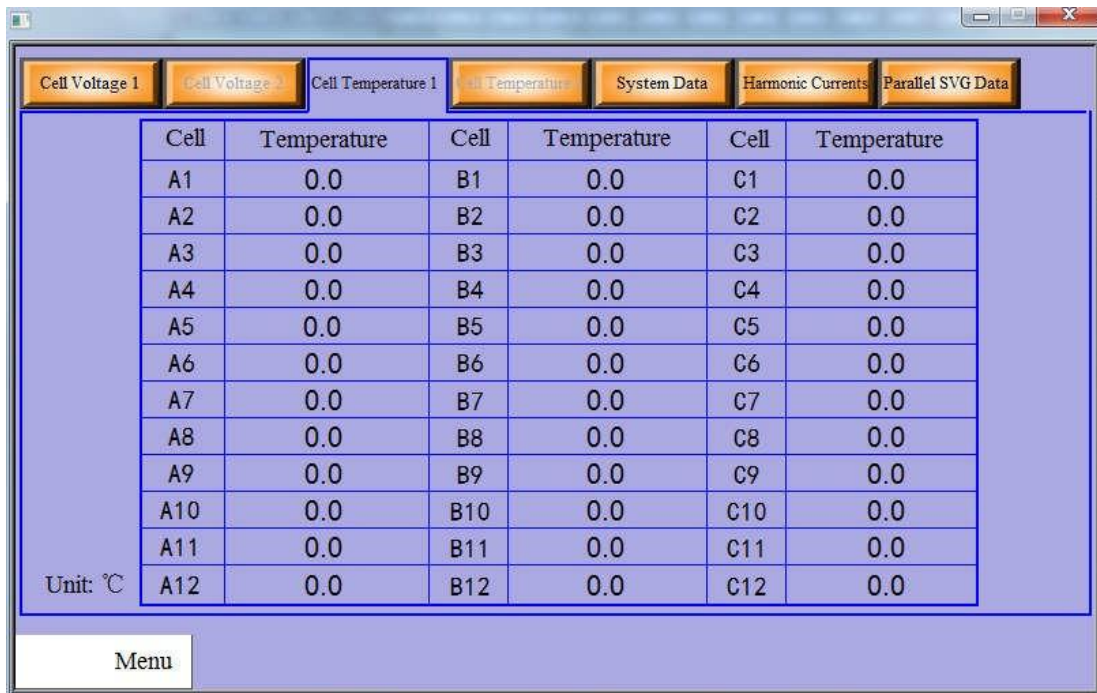


图 5.5 单元温度显示界面（温度显示需定制）

Figure5.5 Cell temperatures Interface (to be customized)

2) 状态量查询：查询单元的基本状态、PLC 输入输出点状态等。图 5.6 为单元状态界面（星型接法）。

Status: The state of cell and PLC can be seen in this part. Figure 5.6 is the interface of

cell states (star connection)



图 5.6 单元状态界面/Figure 5.6 Cell States Interface 注：单元

状态中若显示红色或者蓝色则表示该单元异常。 **Note: It**

means abnormal, if the state of cell is red or blue.

3) 故障录波：图 5.7 为故障录波界面，可以记录故障瞬间电压及电流波形；

Fault Recording: Fault recording interface is shown in Figure 5.7, it can record the voltage and current waveforms of fault instantaneous.

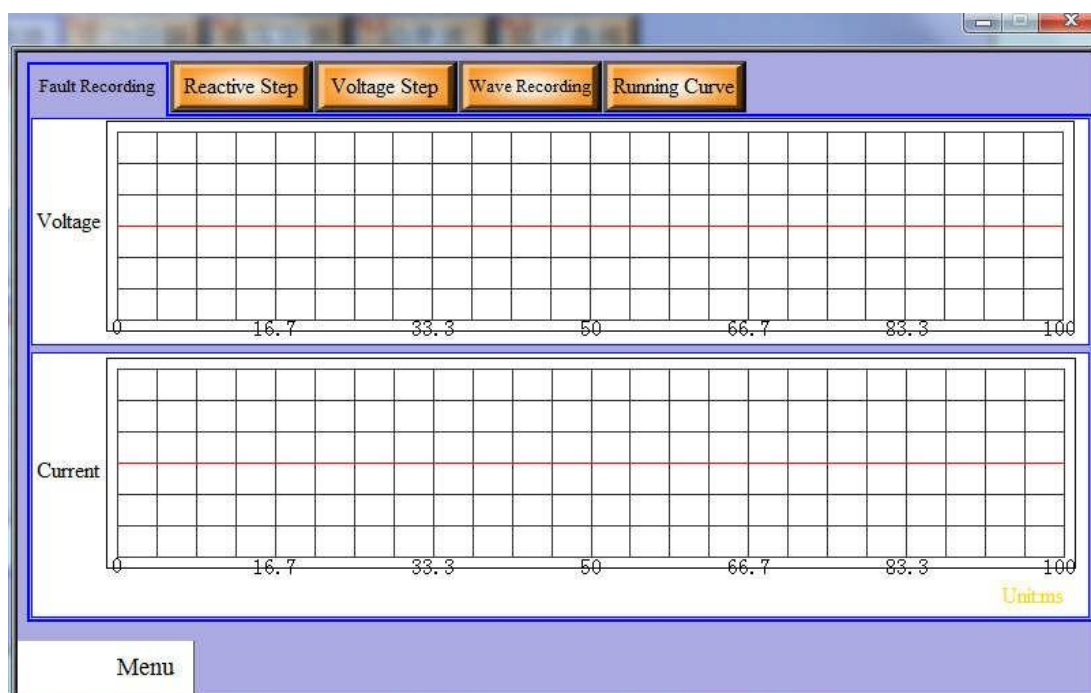


图 5.7 故障录波界面/Figure 5.7 Fault Recording Interface

第六章 ZBSVG 使用和维护/Chapter 6 The Use and Maintenance of ZBSVG

6.1 ZBSVG 使用注意事项 /Cautions

本产品属于微电子技术、光电通信技术、高压应用技术、电子计算机技术等现代电力电子变换技术的高科技产品，使用时务必注意且满足如下规定。

This product is a high-tech product, which contains many modern power transformation technologies such as microelectronics, optical communications technology, high voltage application technology, computer technology etc. And the following rules should be obeyed.

- 使用环境应符合产品的技术条件要求。

The environment should meet the technical requirements of products.

- 安装应该由符合电气设备安装条件的有资质的正规安装公司或由生产厂家进行安装。

The installation of the product should be completed by the manufacturer or the company which has the conditions of installation of electrical equipment.

- 产品的操作使用人员必须是经过专业训练的电气设备操作使用人员。

The operator of the product must be professionally trained.

- 产品在使用过程中必然会不断地凝集灰尘以及各种杂质，必须定期进行清理维护。

Dust may affect product performance, and therefore regularly cleaning and maintenance is needed.

- 产品经过一段时间的运行后，由于风机的振动和其它机械震动可能引起电气接触部件的松动，以至于引起接触不良甚至损坏元件、部件及整机，造成用户的不便和损失。因此，在使用一段时间后需要进行维护和清理检查避免造成损失。

After a period of running, the fan vibration and other mechanical vibration may cause loose contacts, and even cause damage to the device. Therefore,

regularly checking and maintenance is needed.

- 应该经常检查电气设备的绝缘有无损坏（如主回路大线）、缓冲电阻是否损坏、柜门是否完好，保护接零或保护接地是否正确，接地阻抗是否符合要求。

The electrical insulation (such as the main circuit cable), the snubber resistor, the cabinet, the protective ground and the grounding resistance should be checked regularly.

- 应该形成记录设备运行状况的制度和应用维护制度。

Running records and maintenance records should be made.

6.2 ZBSVG 开停机操作步骤/ZBSVG Operation Steps

为使 ZBSVG 装置在现场能够以最优的状态运行，装置在公司和现场调试时已对参数进行了最优配置，若无必要请勿改动，系统有所变动时请咨询本公司。对于需要改动的参数，请被授权人员（高级用户或调试人员）根据咨询结果进行相应改动。

ZBSVG parameters have been configured optimally, there is no need to change. If necessary, please contact the company when the system is subject to change. For change of parameters, please consult authorized person.

- 1)进行 ZBSVG 操作前请先确认上级开关柜小车已摇出，开关柜处于冷备用状态。

Before ZBSVG operation, to make sure the higher level switch is open and cold standby.

- 2)客户现场配电室将 AC220V 电源或者 DC220V 电源送至 ZBSVG，闭合图 6.1 所示 ZBSVG 控制柜内 AC220V 电源空气开关 QF1 或者 DC220V 电源空气开关 QF2，为 ZBSVG 二次系统供电。

In order to make ZBSVG control loop working, the site needs to provide AC220V or DC220V power supply. After that, close the air switch QF1 or QF2. The AC220V air switch and the DC220V air switch are shown in Figure 6.1.

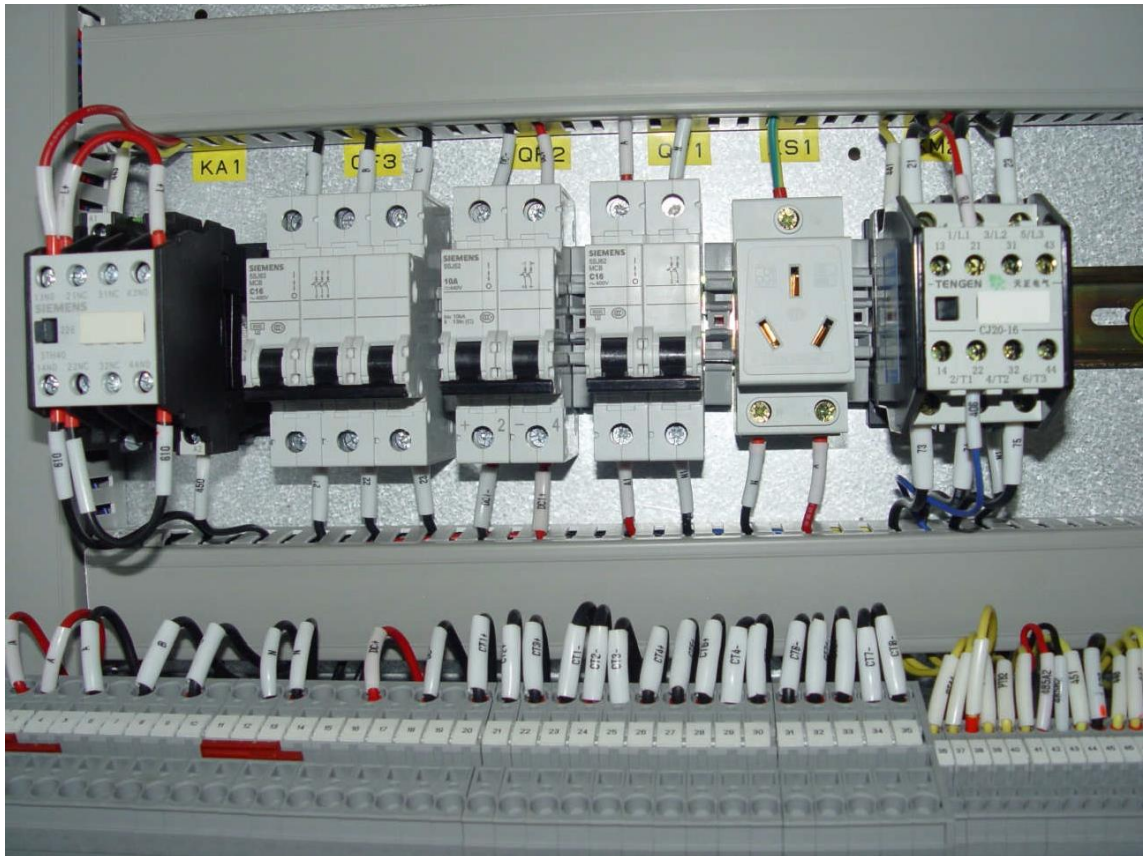


图 6.1 控制柜布局/Figure 6.1 Control Cabinet Wiring

3)ZBSVG 通过自检后 HMI 进入装置监控界面，通过此界面中状态框状态和 相关提示进行相应操作，如图 5.3 所示。

HMI will go into the device monitor interface after the completion of self-checking. This interface enables start-stop operation, as shown in Figure 5.3.

4)客户现场配电室将 380V 电源送至 ZBSVG，闭合 ZBSVG 控制柜风机电源空气开关 QF3。电源送达后按住控制风机的中间继电器 KM2 凸起（如图 6.1 所示）或相应接触器的动铁芯大约 2 秒，松开，观察风机转向是否与图标一致。如不一致，调整任意两相相序。

In order to make ZBSVG fan working, the site needs to provide AC380V power supply. After that, close the air switch QF3. In order to make sure that the fan works normally, press the button located in the middle of KM2 for 2seconds. If the direction of the fan turning is not inconsistent with the icon, please change any two phase sequence.

5)关闭所有柜门，检查主回路隔离开关状态，在上级开关柜冷备用状态下闭

合 ZBSVG 隔离开关，如图 6.2 所示。

Close all of the cabinet doors, and check the state of the main circuit disconnecter. Close the ZBSVG disconnecter when the higher level switch is open. The disconnecter is shown in Figure 6.2.



图 6.2 隔离开关闭合时操作杆位置/ Figure 6.2 The position of disconnecter lever closed

6)按照规程将上级开关柜小车摇进，开关柜转为热备用状态。

Make the higher level switch in the state of hot standby.

7)按照规程使用“远方”工作模式将上级开关柜断路器闭合，将主电送至 ZBSVG。送电过程中后台控制室和 ZBSVG 安装室分别有工作人员在场，观察装置并相互通报状态，送电过程中发生异常现象在确保安全前提下通过急停分断上级开关柜。

The staffs must in the control room and the ZBSVG device room respectively,

while switching on the higher level breaker. The staff can inform each other the state of the device. When the abnormal phenomenon occurs, please press the emergency button under the conditions of safety.

8)各功率单元开始工作，单元进行自检。HMI 装置监控页面“高压”灯亮起，表明主电已送达，可进行下一步操作。HMI 装置监控页面“合闸条件”背景颜色为绿色允许合闸；若显示红色则不允许合闸，点击“合闸条件”在弹出的窗口对显示红色的项目进行检查和处理。

If the high voltage light on the HMI device monitor interface turns red, it means that the main power has been delivered and the next step can be done. Click “switch on” button if the background of “switching on conditions” is green, otherwise click “switch on conditions” button to see the conditions that not satisfied.

9)若 HMI“故障记录”页面显示冗余异常，应在 HMI“母线电压”页面显示的电压降为 0V 后再等待 10 分钟，检查冗余设置和短接输出端子的单元是否对应。若装置有故障指示，请根据指示将故障清除，然后按下装置监控页面“复位”按钮对装置予以复位。

If there is any fault displaying on the “fault record” interface or the fault light on the device monitor interface turns red, please clear the fault according to the prompts. At last, click “reset” button to reset the device.

10)查看 HMI“母线电压”页面显示的单元母线电压是否均压（差值 $<50V$ ）。旋开柜门急停（如图 6.3 所示），按下装置监控页面“合闸”按钮，装置将从充电状态进入就绪状态，此时装置监控页面“就绪”灯亮起。

Before clicking “switch on” button, please unscrew the emergency button and make sure the difference of cell voltage is less than 50V. If the device is ready to start, the “ready” light on the device monitor interface will turns green.

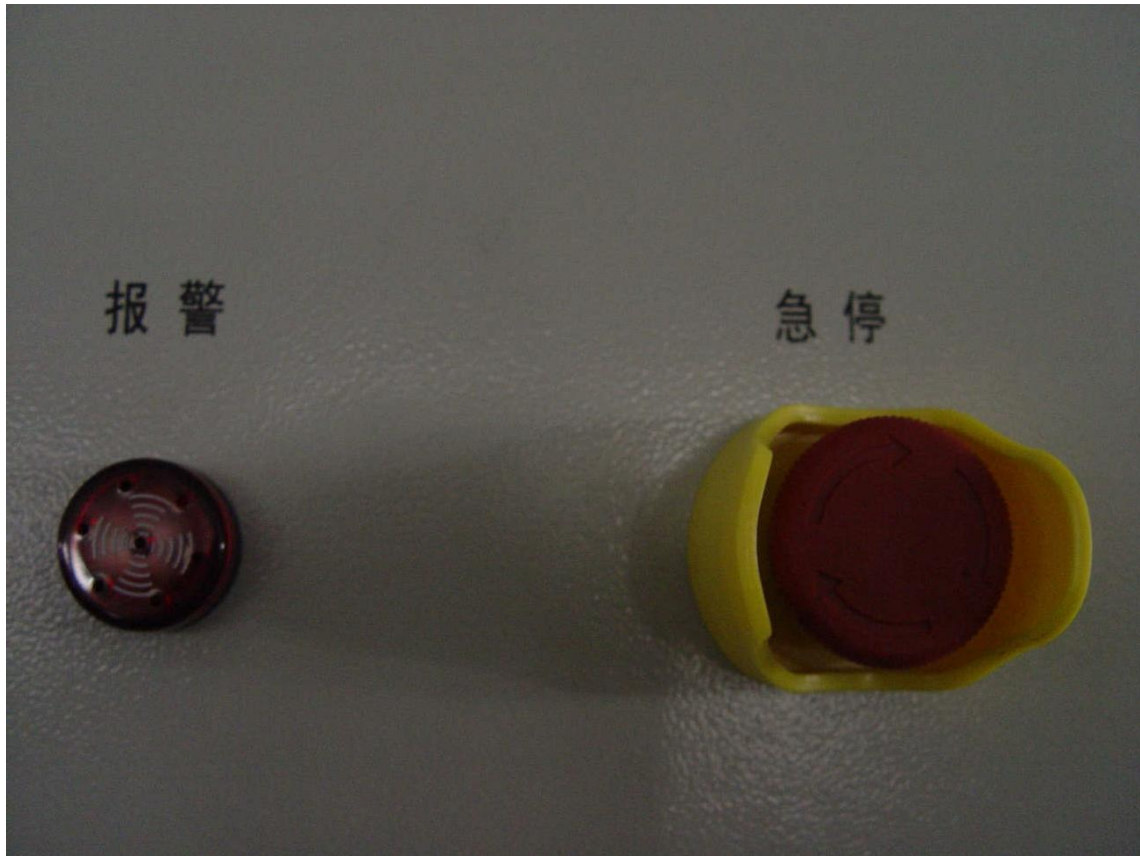


图 6.3 柜门急停/ Figure 6.3 Emergency Stop Button 11)由下拉框选择运行模式，输入框中设定控制目标。

如图 5.3 所示，选定恒考核点无功功率_2 模式，系统无功设定为 0Mvar，即在装置容量足够的情况下，将系统侧的无功功率补偿至 0Mvar。点击装置监控页面“开机”按钮，ZBSVG 将从就绪状态进入运行状态，此时“运行”灯亮起，“就绪”灯灭，功率柜柜顶冷却风机开始工作。

Click the “start” button. ZBSVG will go into running state. And then, the “running” light will turns green and the “ready” light will off. The fan at the top of the power cabinet began to work.

12)若单元或系统发生故障，则 HMI 装置监控页面“故障”灯亮起，同时控制柜柜门警报灯周期性报警，ZBSVG 自动关机并断开主开关，若该故障设定联跳功能则联跳上级开关柜断路器。排除故障后，点击装置监控页面“复位”按钮对 ZBSVG 进行复位，而后可对 ZBSVG 重新开机。

12) If the unit or system fails, the "Fault" light on the HMI device monitoring page will light up, and the control cabinet door alarm light will periodically give an alarm. ZBSVG will automatically shut down and disconnect the main switch. Jump on the upper switchgear circuit breaker. After troubleshooting, click the "Reset" button on the device monitoring page to reset the ZBSVG, and then restart the ZBSVG.

13)点击 HMI 装置监控页面“停机”按钮，ZBSVG 正常停机，ZBSVG 将从运行状态转到停机状态，“停止”灯亮起。

Click the “stop” button. ZBSVG will stop and the “stop” light will turn red.

14)点击 HMI“分闸”按钮断开 ZBSVG 主开关。注意：此时主回路依然有高压。

Click “switch off” button. Note: at this point, the main circuit still has high voltage.

15)远方操作断开上级开关柜断路器，开关柜转热备用

Switch off the higher level breaker,making the higher level switch in the state of cold standby.

16)手动摇出上级开关柜小车，转冷备用，并接地。

16) Manually shake out the upper switchgear trolley, turn it cold for standby, and ground it.

17)断开 ZBSVG 隔离开关。

Open the ZBSVG disconnecter.

18)观察 HMI 各单元直流母线电压显示，等待直流母线电压降为 0V，再等待 10 分钟。然后断开 ZBSVG 控制柜电源空气开关 QF1、QF2、QF3

Watching the cell voltages on the HMI until the voltages are turn to 0. After that, switch off the air switch of QF1, QF2 and QF3 10 minutes later.

19)在配电室依次断开 ZBSVG AC380V、AC220V 或 DC220V 电源开关。

Turn off the AC380, AC220V or DC220V power supply switch in the distribution room.

6.3 ZBSVG 开停机注意事项 ZBSVG Notes

1) ZBSVG 系列产品操作使用时必须严格遵守相关的操作规程，任何错误的操作都可能导致人员伤害和设备损坏。

Operation rules of ZBSVG product must be abided, any wrong operation may lead to personal injury and equipment damage.

2) ZBSVG 为高压设备，操作时必须要有高压危险意识，严格遵守操作手册。

ZBSVG is high voltage equipment. The operators must have the conscious of danger.

3) ZBSVG 中的有关参数出厂时已经设置完毕，如果对 ZBSVG 和负荷系统没有

足够的了解，请不要随意更改参数，否则可能会造成系统异常，甚至发生重大事故。

The parameters of ZBSVG have been set at the factory. Please do not change any of them. Otherwise, it may cause system failure and even major accident.

4) 正常运行时，不可随意按动 HMI 或柜门操作按钮，否则可能引起系统误动作。
If the equipment is running well, do not arbitrarily touch HMI or operation button. Otherwise, it may cause system malfunction.

4) ZBSVG 的操作维护人员必须经过专门培训，同时应仔细阅读本用户操作手册。

The operators of ZBSVG must be professionally trained, and should read the user's manual carefully.

5) 本产品的控制柜后半部分、功率柜、电抗器柜等均属高压危险区域，在高压通电情况下严禁打开柜门进行作业。

The power cabinet, reactor cabinet and the second half of control cabinet are high voltage danger area. In the case of high voltage, opening cabinet door is forbidden.

7) 重要注意事项 Important note

- 系统电压应在额定标称的 $\pm 10\%$ 之间。

System voltage should be ranged from 90% to 110% of rated voltage

- 送电、断电顺序应遵循：送电时先送控制电，再送高压电；断电时先断高压电，待高压电放电完毕后再断开控制电。

The power on sequence is that first connect control power then the high voltage.

The power off sequence is that first disconnect the high voltage then the control power supply.

- 运行当中用户应随时监视运行情况，出现问题时能及时停机。

Users should monitor the running state of the equipment at any time, and stop the equipment when it is abnormal.

- 应保证室内良好通风，维持环境温度在 $-10\sim +40^{\circ}\text{C}$ 范围。

Guarantee the system with good ventilation, keep the temperature is within

the range of $-10 \sim +40^{\circ}\text{C}$.

6.4 ZBSVG 的维护 Maintenance

- 投运 1 周左右，停机，断主电，对导电连接部位、接地线等处的螺钉、螺栓等做紧固处理，满足接触可靠的要求。

Please stop to tight the screws when the equipment is running for a week.

- 投运后，每一季度应重复进行一次测量接触点温度的工作。

Check all the connections quarterly.

- 运行后应每年安排一次计划停机，并打开一个功率单元抽检电容，对于薄膜电容壳体应无异常，密封面应平滑、颜色黑亮。若其中任何一个电容出现异常应立即通知厂家进行处理。

Arrange a planned stop annually, and check the film capacitor of power cell. The sealing surface of the film capacitor should be smooth. If any of them is abnormal, please contact the manufacturer immediately.

- 运行中每天巡视 ZBSVG 状态，如果装置内发出异常声响，排风口处没有出风或风量比平时偏小，则应立即停机断主电检查装置进风口是否有异物遮挡、冷却风机是否良好、排风管道是否堵塞。根据实际情况进行更换风机、清理风道的处理。当装置内出现异味（特别是臭氧味）时，应立即通知厂家处理。

Please check the state of ZBSVG daily. If there is any abnormal vibration or noise, stop equipment and disconnect main circuit to check. If the wind speed of the air inlet or outlet is abnormal, clean the air duct or replace fan according to the actual condition.

- 室内应保持清洁，避免灰尘积累。

Keep the room clean.

- 室内需做防鼠害处理，避免小型动物进入 ZBSVG 柜体。

Avoid small animals such as mouse entering the ZBSVG cabinet.

- 注意保持室内温度，当室内温度高于 38°C 应尽量做降温处理，如加强室内外通风，开启空调等。

If the room temperature is higher than 38°C, decreasing temperature treatment should be done, such as strengthening ventilation or opening air conditioning.

6.5 ZBSVG 的定期检查 ZBSVG Regular Check

用户根据本用户操作手册相关内容并根据现场环境条件，每 3 个月对 ZBSVG 产品进行一次定期检查。检查内容如下：

Regular check must be done for every 3 months, according to the environmental conditions of the site and the related instructions of this manual. The check contents are as follows.

- 接线端子螺丝是否松动；

Terminal screws are loose or not.

- 回路端子是否有接触不良的情况，铜排连线处是否有过热痕迹；

The circuit connector is contact well or not.

- 电缆、控制电缆有无损伤，尤其是与金属表面接触的表皮是否有割伤的痕迹；

The cable is damage or not.

- 电缆接线鼻的绝缘包扎带是否已脱落；

The insulation of cable lugs is damage or not.

- 风道滤网和风道内全面清扫，最好使用吸尘器；

Clean the air duct and the filter net.

- 各风机是否运行正常。

The fans are running normal or not.

6.6 ZBSVG 维护注意事项 ZBSVG Maintenance Notes

ZBSVG 系列产品在设计时已充分考虑到操作人员的安全，然而犹如其他任何功率装置一样，许多内部端子上存在足以致命的高电压。另外，散热器和其它一些内部元件温度较高，所以在接触和操作 ZBSVG 时要遵循以下原则。

As other power devices, series of ZBSVG products have been designed with

safety of the operator. But there is still high voltage inside. Therefore, the following rules must be abided when operating ZBSVG.

- 使用人员必须接受培训，熟悉 ZBSVG 的结构，并掌握实际运行知识及注意事项。

The operator must be professionally trained and familiar with the structure of ZBSVG.

- 只有经过上述培训的人员才允许操作、维护、维修 ZBSVG。

Only the person who has been trained is allowed to do the installation, operation and maintenance of ZBSVG.

- 检修时，严格遵守操作票制度，要确保 ZBSVG 控制柜上的隔离开关断开，并且有其他监护人员在场。

During maintaining, strict compliance with operation sheets, to ensure that the disconnecter of the ZBSVG is off. And all the operations must be done under the supervision of another person.

- 只有在装置不带电（高压电和控制电），并且不存在高温时才能接触柜内部件。

Only the device is not electrified (high voltage and control power) and without high temperature, the inside of the device can be touched.

- 维护时必须遵守高压操作规程，如戴绝缘手套、穿绝缘鞋、戴安全眼镜等。

High voltage operating procedures must be abided, such as wear insulated gloves, insulated shoes, safety glasses and so on.

- 安装安全防护栏(标有高压危险)，使用中不要将其挪为他用。

Lay the fences with the danger signs, and it can't be moved when it is using.

- 禁止把易燃材料(包括设备图纸和用户手册)放在 ZBSVG 附近。

Any flammable materials are not allowed to lay in or near the ZBSVG, such as the drawings and manual etc.

- 在处理或测量装置内部件时要谨慎操作，注意不要让仪表引线互联或接触其它端子。

Do not let the instrument lead connected or contacting other terminals when measuring the internal parts of equipment..

- 禁止在主电路有电时断开散热风机电源，否则会引起设备故障。

Do not turn off the power of fan, or it will damage the equipment.

- 在搬运 ZBSVG 时，装车必须对称、平整；在卸货时确认用于放置的地面是水平的。

When transporting ZBSVG, please make sure that it is placed horizontally and symmetrically. When unloading, please make sure the ground is horizontally.

- 用户进行故障维护仅限于记录故障现象，并在必要时更换单元，进一步的维修应移交厂家进行处理。

When a fault occurs, the user is allowed to record the fault or replace the fault cell if necessary. Further repairing requires contacting the manufacturer.

- 更换单元必须在 ZBSVG 停主电超过 10 分钟然后停掉控制电后方能进行。

Only the main power has been power off for 10 minutes and the control power is off, replacing cell is permitted.

- 任何不正确的操作都可能导致人员伤害或 ZBSVG 损坏。

Any incorrect operations may result in injury or damage ZBSVG.

- 遵守在本手册中提及的其它安全注意事项，以防止人员伤亡和设备损坏。

In order to prevent casualties and equipment damage, please abide all the safety precautions mentioned in this manual.

- 断电插拔装置的各种插件。

The connectors must be plugged when the power of the equipment is off.

- 不要触摸印制电路板上的芯片和器件。

Do not touch any chips and devices on the printed circuit board.

- 使用合格的测试仪器和设备对装置进行试验和检测。

Using qualified instrument to test the equipment.

- 在对电流互感器进行操作前，应确保其副边保持短路。请勿断开工作中电流互感器的副边。

Make sure the secondary side of the current transformer is shorted. Do not disconnect it while it is using.

第七章储存及安装 Chapter 7 Storage and Installation

7.1 概述 Summary

中宝电气有限公司贯彻质量第一、用户优先的原则，对 ZBSVG 设计原理进行优化，在器件选型、生产制造、出厂测试、安装等各个环节都严格 按质量标准执行，保证在正常使用条件下产品高可靠性稳定运行。

The principle of our company is “quality first, user priority”. All the quality standards are strictly satisfied such as device selection standard, testing standard, installation standard and so on. ZBSVG can work with high reliability in normal use.

7.2 验收 Acceptance

正确的验收程序由以下几部分组成：

The correct acceptance is consists of the following components:

- 核对发货清单，设备齐全

Checking the shipping list, making sure it is fully equipped.

- 检查运输中可能发生的损坏

Check the damage that may occur in transportation.

- 如有损伤，拍照留下证据以便向运输公司索赔

If damaged, take photos as evidence to transportation company claim for compensation.

7.3 储存 Storage

各种原因造成的 ZBSVG 较长时间停机或存放等状况可能造成 ZBSVG 故障率增加，为了避免此类情况的发生，请在较长时间的停机或存放时注意如下几点：

If ZBSVG is stop or storage for a long time, it may cause the failure rate of ZBSVG increasing. In order to avoid such situations, please note the following points when it stops or storage for a long time.

- 注意设备放置环境的状况应该与运行环境基本一致,即放置环境不得有灰尘、水滴,湿度不得超过 90%。

There is no dust, water in the placed environment, and the humidity not exceed 90%.

- 设备应该用防水薄膜覆盖,以免水滴与湿气不断侵入造成设备的故障。

The equipment should be covered with waterproof film to avoid water drop and moisture.

- 设备内部应该放入吸水材料。

The water-absorbing material should be put into the inside of the equipment.

- 定期对设备进行排除水分的作业。

Discharge water regularly.

- 有条件的时候定期进行通电检查。

Do power check regularly if it is possible.

- 储存温度: $-40\sim+65^{\circ}\text{C}$

Storage temperature: $-40\sim+65^{\circ}\text{C}$

- 相对湿度: 月平均值不大于 90% (25°C), 无凝露;

Relative humidity: month average value no more than 90% at 25°C , no condensation

- 振动(储存): 最大 0.3mm, 最大 1m/s^2 (正弦)

Vibration (storage): MAX 0.3mm, MAX 1m/s^2 (sine)

- 振动(地震): 最大 9mm, 最大 18m/s^2 (正弦)

Vibration (earthquake): MAX 9mm, MAX 18m/s^2 (sine)

- 冲击(储存和运输): 最大 100m/s^2

Shock (storage and transport): MAX 100m/s^2

- 环境条件: 无腐蚀性、易燃、易爆等危险物品

Environment: no-corrosive, no-flammable, no-explosive and other dangerous goods

- 运输过程中必须小心轻放,严禁雨淋、暴晒、撞击及倒放

Products must be handled carefully during transport, rain and strong sunlight are

forbidden.

7.4 机械安装 Machinery installation

7.4.1 环境要求 Environment

为使 ZBSVG 系列产品长期稳定可靠运行，对 ZBSVG 的安装环境和电气使用条件做如下要求：

In order to make ZBSVG series products working stably and with high reliability, the installation environment and the electrical condition requirements are as follows:

■ 安装环境：Installation environment

- 运行环境条件最低环境温度 -20°C ，最高环境温度 40°C 。工作环境的温度变化应不大于 $5^{\circ}\text{C}/\text{h}$ 。如果环境温度超过允许值，应考虑配备相应的空调设备。

The minimum environment temperature is -20°C and the maximum temperature is 40°C , and the temperature variation of the working temperature should be no more than $5^{\circ}\text{C}/\text{h}$. If the temperature is more than the allowable value, the air conditioning equipment should be added.

- ZBSVG 的标准产品安装高度要小于海拔 1000 米。若安装高度超过海拔 1000 米,必须在设备订货时说明，以便采取特殊设计。

The installation height of ZBSVG should be less than 1000m. If it is more than the 1000m, special design should be considered.

- 空间要求：装置正面距离墙壁的最小距离不得小于 1500mm，背面距离墙壁的最小距离不得小于 1000mm，侧面距离墙壁的最小距离不得小于 1000mm，顶部距离设备间顶部最小距离不得小于 1500mm。

Space requirement: The distance between the front side of the equipment and the wall should not be less than 1500mm. The distance between the behind side of the equipment and the wall should not be less than 1000mm. The distance between the side of the equipment and the wall should not be less than 1000mm. The distance between the top of the equipment and the roof

should not be less than 1500mm.

- 相对湿度的变化率每小时不超过 5%，避免凝露。

The relative humidity variation rate should not exceed 5% per hour, so as to avoid condensation.

- 不要将 ZBSVG 安装在有较大灰尘、腐蚀或爆炸性气体、导电粉尘等空气污染的环境里。

Do not install the ZBSVG in the polluted environment such as large dirt, corrosive or explosive gases and conductive dust.

- ZBSVG 安装地点所允许的振动条件：振动频率 10Hz--150Hz，当 ZBSVG 由于安装台基振动可能产生共振时，应对设备采取减振措施，以避免共振频率。

Vibration conditions of installation: vibration frequency is from 10Hz to 150Hz.

If the ZBSVG begins to resonance with the installation stylobate, vibration attenuation measures for the ZBSVG should be taken.

■ 电气使用条件：Electrical conditions

- ZBSVG 并网的输配电网电压波动限值不超过额定的输入电压的 $\pm 10\%$ 。

The voltage fluctuation should not more than $\pm 10\%$ of the rated voltage.

- ZBSVG 控制电源为 50Hz 单相 AC220V 或直流屏 DC220V 和三相 AC380V，容量请参考随机运输的配线图，交流电压持续波动偏差为 $+7\% -- -10\%$ 。

The control power supply of ZBSVG is single-phase AC220V or DC220V. It's capacity should refer to the wiring diagram. The frequency of the AC power is 50Hz. And it's voltage fluctuation deviation is $+7\% -- -10\%$.

7.4.2 设备外形及柜体装卸和安装 Equipment sizes, loading and unloading, installation

以 10kV/4Mvar ZBSVG 为例，其外型正视图如图 7.1 所示，外型左视图如图 7.2 所示，10kV/4Mvar ZBSVG 外形尺寸：3800mm(长) \times 2400mm(高不含风机) \times 1400mm(深)。其它产品规格及其外形尺寸可参考表 3.2 和表 3.3 的内容。

Taking 10kV/4Mvar ZBSVG as an example, it's front view is shown in Figure

7.1 and the left view is shown in Figure 7.2. The sizes of the 10kV/4Mvar ZBSVG is: 3800mm in length, 2400mm in height without fan height, 1400mm in depth. Other products types and sizes are shown in table 3.2 and table 3.3.

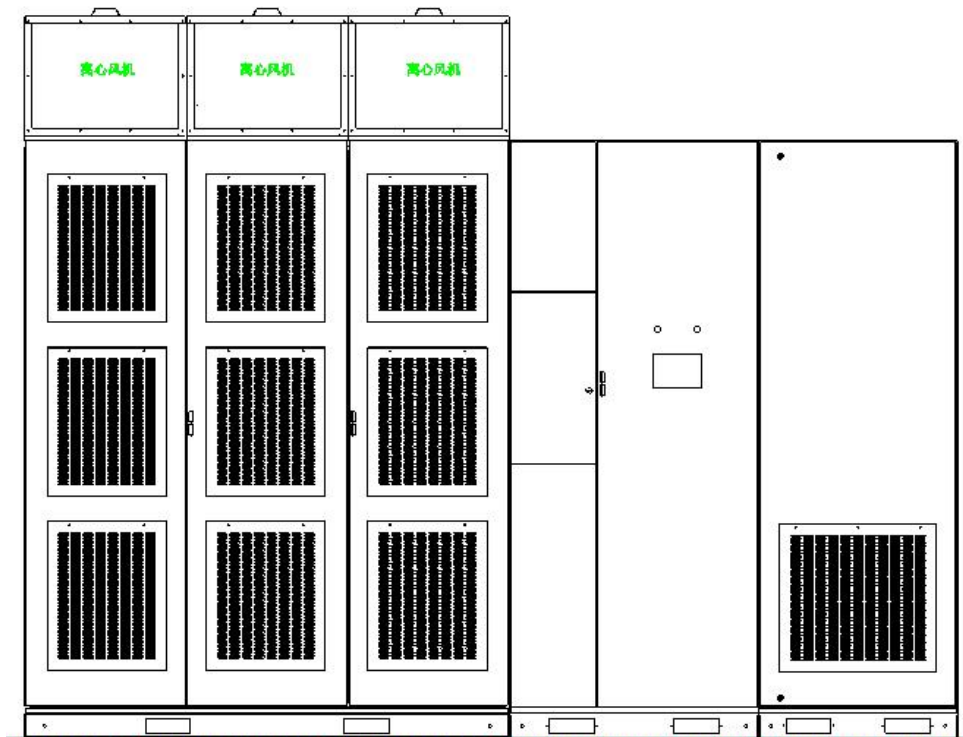


图 7.1 ZBSVG-C4.0/10 正视图 Figure 7.1 The front view of ZBSVG-C4.0/10

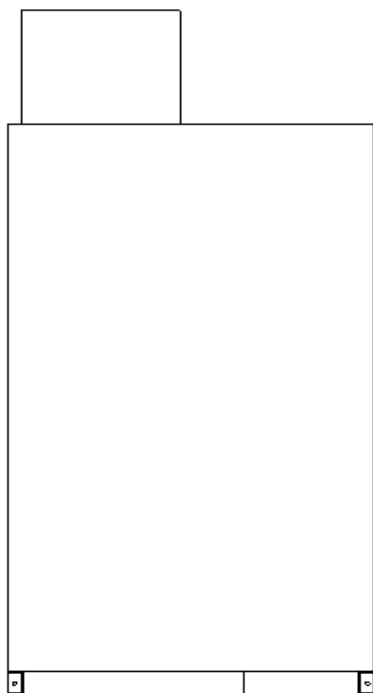


图 7.2 ZBSVG-C4.0/10 左视图 Figure 7.2 The left view of ZBSVG-C4.0/10

ZBSVG 系列产品设备安装时，应考虑通风散热及操作空间的需要，整套装置正面离墙距离不得小于 1500mm，装置背面离墙距离不得小于 1000mm，装置左右侧面离墙距离不得小于 1000mm，如图 7.3 所示。同时装置顶部与屋顶空间距离不得小于 1500mm。

When installing the ZBSVG series products, the ventilation and operation space should be considered. The distance between the front side of the equipment and the wall should not be less than 1500mm. The distance between the behind side of the equipment and the wall should not be less than 1000mm. The distance between the left-right side of the equipment and the wall should not be less than 1000mm. The distance between the top of the equipment and the roof should not be less than 1500mm. The details are as shown in figure 7.3.

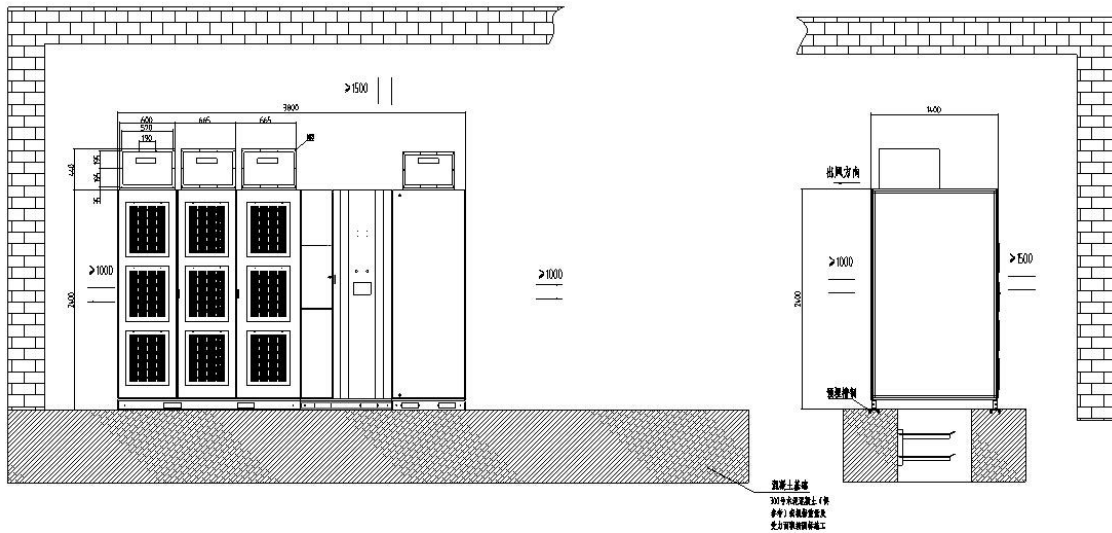


图 7.3 ZBSVG-C4.0/10 安装地基图 Figure 7.3 The installation drawing of ZBSVG-C4.0/10

所有柜体应牢固安装于基座之上，并和厂房大地可靠连接。装置屏蔽层及接地端子 PE 也应接至厂房大地。各柜体之间应相互连接成为一个整体并要有可靠接地（接地电阻 $<500\text{m}\Omega$ ）。

All the cabinet should be installed on the foundation and connected with the earth of the plant reliably. The shield and ground terminal PE should connected with the earth of the plant reliably too.

安装过程中要防止装置受到撞击和震动，所有柜体不得倒置，倾斜角度不得超过 30° 。装置安装场地应采取完善的小动物防护措施。

The hit and vibration are forbidden when installing. Tilt angle should not more than 30°.

Avoid small animals such as mouse entering the ZBSVG cabinet.

ZBSVG 系列高压动态无功补偿装置在运输时，控制柜、功率柜和功率单元单独装运。功率单元备件（若有）、各柜顶的风机单独包装运输。

The control cabinet, power cabinet, power cells and fans are shipped separately, when transporting ZBSVG. The spare power cell is shipped separately too if it has.

各柜体的底座有为使用叉车而设计的叉车孔，可用以下方式搬运：

At the bottom of the cabinet, forklift hole have been designed. It can be carried in the following ways.

1) 吊车搬运 Crane

吊车或倒链提升。最好用两根长度不小于 1.5m 的足够强度的金属梁，穿过柜体底座合适的叉车孔，前后两端用足够强度的绳索提升。在柜顶用加强梁进行支撑，以防止柜体变形，如图 7.4 所示：

Using two metal girders which is 1.5m long at least and strong enough fix the cabinet bottom through the forklift hole. Using sufficient intensity ropes fix metal girders. To prevent deformation of cabinet, strengthen girders is needed at the top of the cabinet, as shown in figure 7.4.

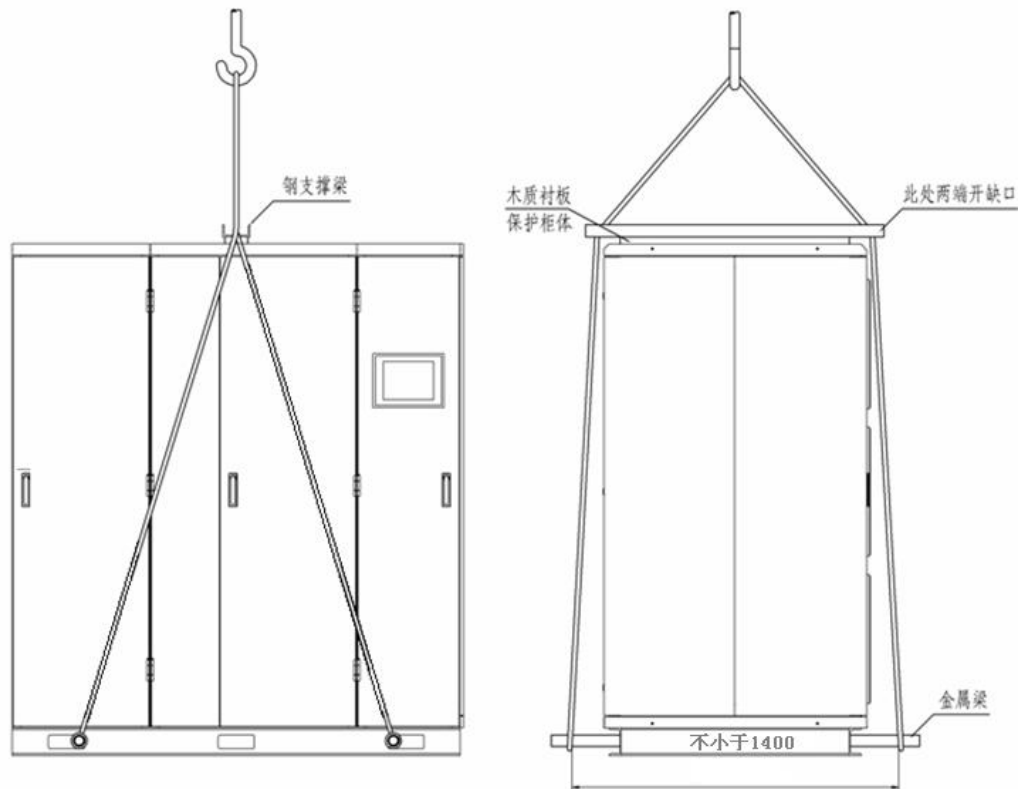


图 7.4 底部吊装搬运图 Figure 7.4 Crane Transport

注意：在吊运时一定要注意绳索或金属梁穿在合适的叉车孔中，尽可能使吊装中心与所吊柜体的重心相吻合，ZBSVG 系列高压动态无功补偿装置的控制柜和功率单元柜的重心靠近控制柜的重心，而不是柜体的几何中心；功率单元柜与控制柜整体的重心靠近整体的几何中心。

Note: When lifting, make sure that the rope or metal beam is put in the appropriate forklift hole, and the lifting center should be as close as possible to the center of gravity of the cabinet to be lifted. The center of gravity of the control cabinet of the ZBSVG series of high-voltage dynamic reactive power compensation devices and power unit cabinet is close to the center of gravity of the control cabinet, not the geometric center of the cabinet; the center of gravity of the power unit cabinet and the control cabinet is close to the geometric center of the whole.

2) 叉车搬运：使用叉车搬运时，叉车必须能承受相应重量，叉车的叉铲的长度不小于 1600mm,叉铲的宽度不大于 170mm，厚度不大于 50mm。如图 7.5 所示：

Forklift: When transporting, the weight of the cabinet could not more than the upper limit of the forklift. The length of fork shovel is more than 1600mm, and the width is less than 170mm and the thickness is less than 50mm, as shown in figure 7.5.

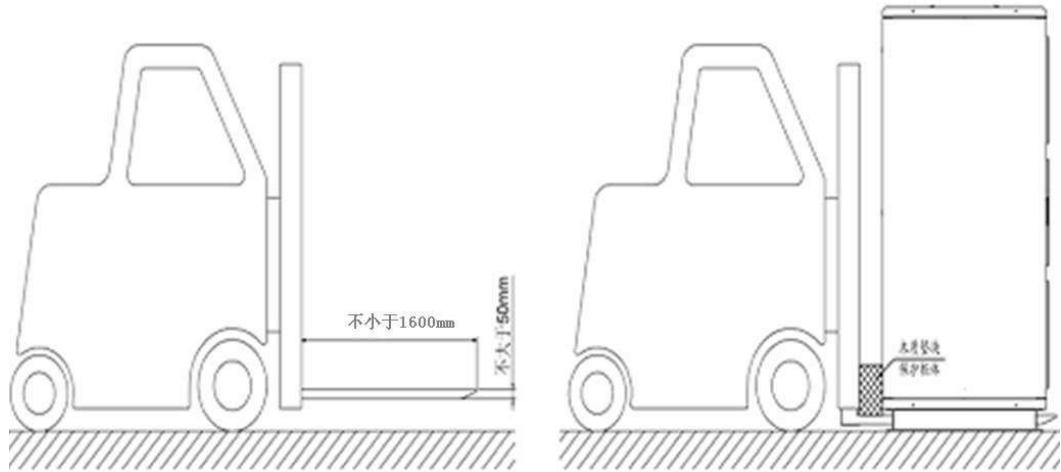


图 7.5 叉车搬运图 Figure 7.5 Forklift Transport

采用叉运方式前，需先拆下底座前后两侧的堵板，搬运就位后将堵板装回原位。

Before using the forklift method, remove the blocking plates on the front and rear sides of the base first, and then install the blocking plates back to their original positions after being transported in place.

3) 滚筒车：用滚筒车搬运时，必须将滚筒车放在底座槽钢的下面。如图 7.6 所示：

Cylinder car: The cylinder car must be placed below the channel steel, as shown in figure 7.6.

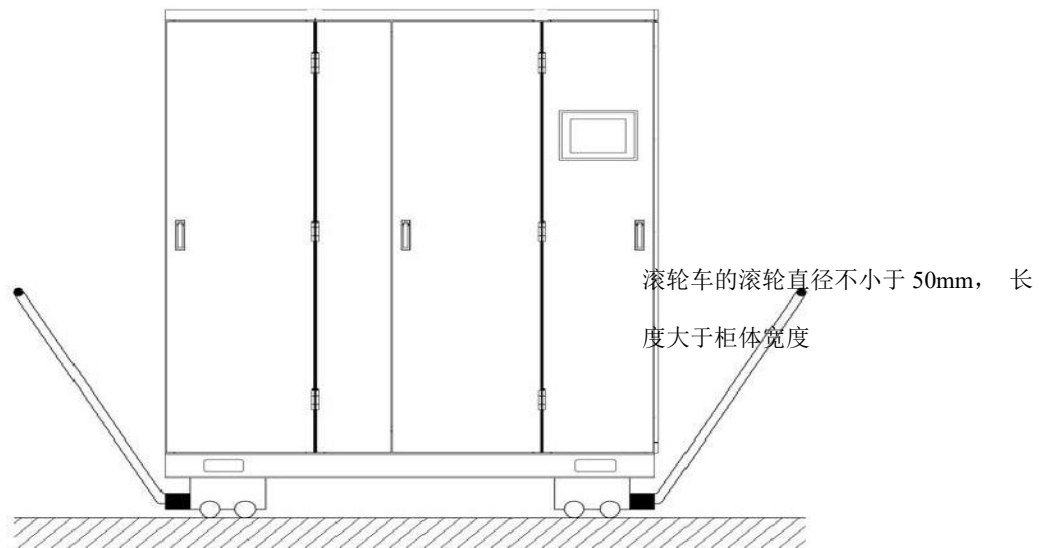


图 7.6 滚筒车搬运示意图 Figure 7.6 Schematic Diagram Of Cylinder Car Transport

4) 滚轮：在地板上并排放置许多滚轮，将机柜放在滚轮上面，循环移动滚轮进行搬运。滚轮的长度应大于柜体宽度。如图 7.7 所示

Roller: The schematic diagram of roller transport is shown in figure 7.7. The

length of roller should be greater than the width of the cabinet.

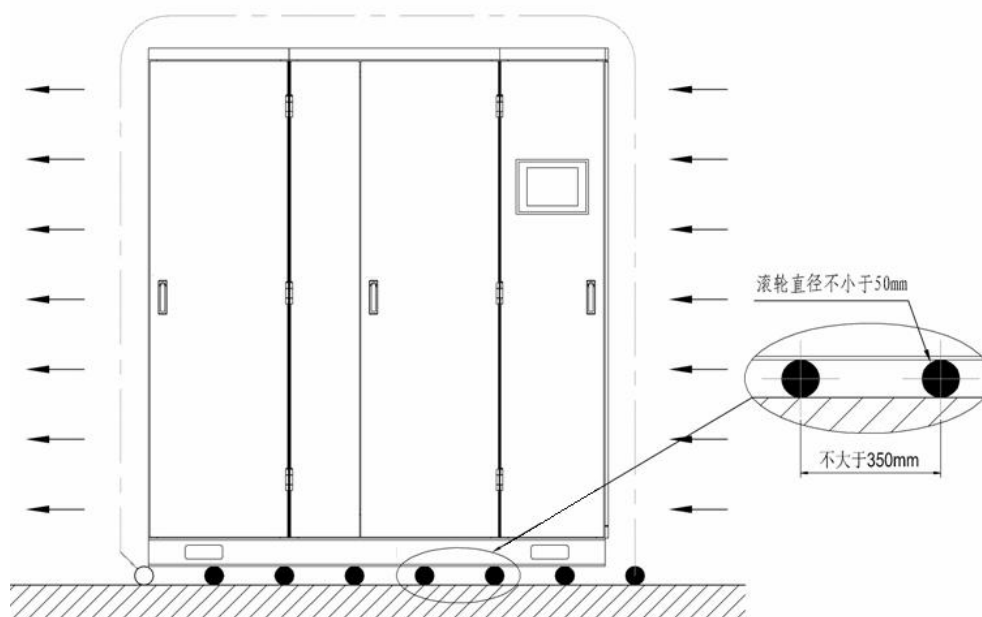


图 7.7 滚轮搬运示意图 Figure 7.7 Schematic Diagram of Roller Transport

7.5 电气安装 Electrical Installation

电气安装主要包括柜体之间的连接线、现场到柜体的并网高压电缆以及接地电缆、现场到柜体的交流或直流 220V 和交流 380V 控制电源电缆、现场与柜体之间的控制及信号线的配线。

Electrical installation includes connecting wires between the cabinet, cables between the site and cabinet such as power supply cables, signal cables, ground cables and parallel in cables.

对外配线方法与配线标准: Cable standards

1) 高压电缆连接 High-voltage cables

- 确保输入电压满足要求; Make sure the input voltage is satisfied.
- 确保电缆线的线径及耐压满足要求; Make sure the diameter and withstand voltage of the cable is satisfied.
- 输入电缆线可靠连接控制柜后部标有“三相输出”的端子上,如图 7.8 所示。

The input cables are connected on the terminals reliably. Terminals are shown as figure 7.8



图 7.8 三相主电缆连接端子 注：用户现场若有进线要求，请在技术合同中明确进线方式，不特别说明，按下进线方式处理。

Note: If the site is upper wiring pattern, please clear it in the technology contract. Otherwise, lower wiring pattern is adopted.

2) 接地电缆连接 Ground Cable

尽量选择与输入电缆线径相同的高压电缆，将设备底座上接地端子可靠连接到用户现场的就近接地点，确保接地电阻小于 $500\text{m}\Omega$ ，以保证设备和人员安全。

The diameter of ground cable is preferably consistent with the high-voltage cables.

3) 控制电源电缆连接 Control Cables

设备需要用户现场提供稳定可靠的电源（交流 380V、交流 220V 或直流 220V），电源容量及配线规格请参考随机配送的《SVG 控制柜外部接线端子图》

The equipment requires the site providing stable and reliable power supply such as AC380V, AC220V or DC220V. The capacity of power refer to “External terminal diagram of SVG control cabinet”.

建议用户采用三芯电缆提供散热离心风机的 380V 交流电源。

Three-core cable is recommended to provide AC380V.

4) 网侧电流信号采样 Grid-sides current sample

- ZBSVG 需要实时采样接入点对应的两相或三相网侧电流信息，用户应提供 0--5A 的电流信号，精度 0.2%--0.5%，建议为 0.2 级。

Users need to provide 2-phase or 3-phase current signal of grid, and the current size is 0--5A. Accuracy of the signal is 0.2%--0.5%, and the recommended level is 0.2.

- 配线方式：根据采样点的距离，建议采用 2.5 mm² 以上的双芯屏蔽电缆。

Wiring: Dual-core shielded cable is recommended, and the section area of the cable is 2.5mm²at least.

- 具体接入点：参照随机用户图纸。

Access point: Refer to user drawings.

5) 负载侧电流信号采样 Load current sample

- ZBSVG 需要实时采样接入点对应的两相或三相负载侧电流信息，用户应提供 0--5A 或部分现场 0-1A 的标准电流信号，精度 0.2%--0.5%。

Users need to provide 2-phase or 3-phase current signal of load, and the current size is 0--5A. Accuracy of the signal is 0.2%--0.5%, and the recommended level is 0.2.

- 配线方式：根据采样点的距离，建议采用 2.5 mm² 以上的双芯屏蔽电缆。

Wiring: Dual-core shielded cable is recommended, and the area of the cable is 2.5mm²at least.

- 具体接入点，参照随机用户图纸。

Access point: Refer to user drawings.

6) 通讯接口连接 Communication interface

- ZBSVG 支持与上位机的通讯功能，通讯采用 RS485 接口或以太网接口，RS485 接口采用标准 Modbus 通讯协议，以太网根据 IEC-104 通讯规约进行通讯。

ZBSVG can communicate with host computer. The communication interface is RS485 or Ethernet. RS485 interface using standard of Modbus as

communication. Ethernet interface use IEC-104 standard as communication.

- 配线方式：建议采用多芯屏蔽通讯电缆。

Wiring: Recommending for multi-core shielded communication cables..

- 具体接入点：参照随机用户图纸。

Access point: Refer to user drawings.

7) FC 投切控制接口接线 FC Control

- 为满足更多工业现场，为用户提供更经济，更灵活的补偿方案，ZBSVG 设计与 FC 配合使用接口，实现定补和动补的有效配合。ZBSVG 标准配置输出 4 个无源节点，可用于控制现场的 4 级 FC 投切，若需要增加投切级数需另行说明。

To control the FC switching, there are 4 passive nodes on the ZBSVG. If you need to increase the number of switching, please explain in advance.

- 配线方式，建议采用 1.5 mm² 以上安装电缆或屏蔽电缆连接。

Wiring: Shielded or installation cable is recommended, and the section area of the cable is 1.5 mm² at least.

- 具体接入点，参照随机用户图纸。

Access point: Refer to user drawings.

8) 高压就绪和连跳高压 High-voltage ready signal and inter-tripping signal

- 为确保系统可靠、安全运行，上级开关柜应提供一个无源节点，在开关柜给出高压电后，ZBSVG 装置通过该节点检测高压电后，进入高压就绪状态。

In order to make ZBSVG more reliable, a passive node which gives a state of high-voltage ready signal to the ZBSVG should be provided by the higher level switching cabinet.

- ZBSVG 装置提供一个无源节点串联到开关柜的吸合回路中，在 ZBSVG 主动退出或故障退出运行时，给出连跳高压状态量，使上级开关柜断开。

ZBSVG provides a passive node which series connected with closing circuit of high level cabinet. When the equipment is in fault, the high level cabinet switch will be opening.

- 配线方式，建议采用 1.5 mm² 安装电缆或屏蔽电缆连接。

Wiring: Shielded or installation cable is recommended, and the area of the cable is 1.5 mm² at least.

- 具体接入点，参照随机用户图纸。

Access point: Refer to user drawings.

9) 电气安装注意事项 Electrical Installation Notes

- 高压电缆必须经过严格的耐压测试。

The high-voltage cables must be tested strictly.

- 非专业人员不可开柜门使用或检测。

The cabinet door can not be opened or detected by the non-professionals person.

- ZBSVG 出厂前已作过耐压试验，不建议用户再对 ZBSVG 进行耐压试验。

The withstand voltage of ZBSVG has been tested. There is no need to do it again.

- 不可将三相输入改成两相输入。

Do not change the input from three-phase to two-phase.

- 现场连接到 ZBSVG 的信号线，布线时应该与强电电线分开布线，信号线最好采用屏蔽线，屏蔽线的一端可靠接地。

The signal lines in site should be separated from the strong electricity and shielded cable should be considered. One end of the shielded cable should be grounded.

- 要一直保证 ZBSVG 柜体和厂房大地的可靠连接，保证人员安全。

In order to ensure personal safety, ZBSVG need reliable grounding.

- 设备进行电气安装时，应为控制系统埋设专用接地极，要求接地电阻 不大于 500mΩ。

During electrical installation, ground electrode for control system is needed and the grounding resistance is less than 500mΩ.

- 线路接好后，要仔细检查，确保接线可靠无误。

Check the connected lines carefully and make sure it is correct.

- 仔细检查 ZBSVG 容量、连线规格是否匹配，导线是否完好无损。

Checking the capacity of ZBSVG and wires specification, make sure they are

right.

第八章水冷 SVG 安装、调试、发货注意事项 Attention of installation, debugging, delivery of water-cooling SVG

对于户内 10kV 直挂、户内 35kV 降压式和户外集装箱 SVG 设备使用整体运输，现场主要是增加管道连接和部分电源、信号线连接。户内 35kV 直挂设备需要现场安装内容较多，需要特别注意。

For indoor 10kV hanging, 35kV buck and outdoor container SVG devices, the pipeline, and part of the power supply and signal line connection is increased in its site. There are more content for on-site installation of 35kV indoor hanging equipment, we need to pay special attention to.

特别注意：

Particular attention:

1、水冷装置运行正常后方能给 SVG 送高压电，水冷装置给出跳闸信息时必须断开高压电，水冷装置给出报警信号时需要查看触摸屏中故障信息显示内容进行处理；

Water-cooling device must normally operate before high-voltage is sent to SVG. When water-cooling device is given trip information, high-voltage must be disconnected, and if water-cooling device gives the alarm signal, you need to view the HMI display fault information to solve.

2、水冷装置触摸屏上设定参数不能随意修改；

Water-cooling device settings parameters of HMI can not be modified at will.

3、安装使用前，清除管道中明显的异物例如，沙粒、纸屑、塑料物件等；

Before the installation and use, pipe foreign body was cleared, for example, sand, paper, plastic articles etc.

4、检查测试水冷装置就地手动模式运行正常后，方能换成自动模式运行；

Water-cooling device is operated in an automatic mode after it is operated in a manual mode

5、循环泵不能空转、反转；

The pump for circulating is not idling and reverse.

6、乙二醇防冻液有毒，需要注意避免皮肤接触和误食；

Glycol antifreeze is toxic, pay attention to avoid skin contact and ingestion.

7、水冷系统除现场运行设备维修时，连接管道或排气阀处可使用密封带外，其余调试中不允许使用，特别是主管道排气阀位置。

Connection pipe or exhaust valve can be used with the seal in addition to on-site operation of equipment maintenance, and other debugging is not allowed to use, especially the main pipe exhaust valve position.

水冷装置使用过程：安装——储水罐储水——系统补水和排气——主要器件控制测试——降电导率——送高压电运行。

The using process of water-cooling device: installation - storage up water - system replenishment and exhaust air - test main device - down conductivity- send operation electric conductivity.

其它操作：排空、更换单元、更换树脂、更换器件。

Other operation: exhaust air, Replace cell, resin, and component.

8.1 安装 Installation

1. 器件检查 Checking component.

参照水冷装置文件材料，对于器件种类和数量进行检查，是否存在器件受损、丢失问题，特别注意管道中是否有杂质颗粒，若有请及时清理。

Refer to the document of water-cooling device, please check the type and quantity of the device, whether there is damage or loss of the device, pay special attention to whether there are impurities in the pipeline.

特别注意去离子罐和过滤器的固定，有支撑物保证正常运输过程中无损坏。

Pay special attention to the fixing of the deionization tank and filter, and it is ensure that the normal transport process without damage.

安装前拆除管道密封口，确定功率柜内水管道中无大的明显异物，保留好管道密封件，并柜后进行出换热器管、进换热器管和换热器端 2 个法兰连接。

Before the installation, the pipe sealing mouth is removed, there is not the apparent eyewinker in power cabinet internal water pipe. The pipe sealing element should be keep good, and after the cabinet is combination, the heat exchanger tube, the heat exchanger tube and the heat exchanger end are connected with 2 flanges.

信号线连接包括：风机电源线。

Signal line connection includes: fan power cord

使用万用表测试电源相间短路问题，若有短路则查找原因。

Using multimeter to test the power of the interphase short-circuit problem, if there is a short circuit, please check.

2.设备安装 Device installation

需要安装管道、穿墙套管、风机电源线、装置电源线、信号线

Need to install pipes, wall bushing, fan power line, power line and signal line

8.2 调试 Debugging

1 水冷装置通电测试 Test water-cooling device on power 完成连线，初次上电时，如图 8.1 所示，从右向左依次闭合所有断路器。 When completing the connection, please turn off all breakers from right to left in the first power up, it is as shown in Figure 8.1.



图 8.1 控制盘 Figure 8.1 Control panel

2 储水罐储水 Water storage tank

水冷系统中循环水都需要经过储水罐，先将水存入储水罐，然后由储水罐连接的补水泵给循环管道中注入水。现场调试完成后，技术支持人员请确定储水罐内水位加到 30 以上，以供设备运行中补水之用。

Circulating water of water-cooling system is through the water storage tank. The water is stored in the water storage tank and a water pump connected by a water storage tank injected water to the circulation pipe. After the completion of debugging, technical support staff make sure water level of water storage tank more than 30 for the operation of equipment for water.

储水过程如下： The water storage process is as follows:

将水注入储水罐 C3 中，观察内部刻度防止水位过高溢出储水罐。

The water will be injected into the storage tank C3, and to prevent high water overflow tank by observing the internal scale.

3 系统补水和排气 System replenishment and exhaust air

主要说明手动模式下，系统补水和排气操作。

It is illustration that water supplying and exhaust operating.

补水泵不可长期空转，否则会烧坏水泵，使用前请检查风机转向是否正确，防止出现反转问题。

A water pump can not be prolonged idling, otherwise it will burn out the water pump, please check the fan is turned to the right before use, to prevent the emergence of inversion problem.

补水过程：

Replenishment process:

确保水路连接好、所有断路器闭合；

Make sure that the water connections are good and all the circuit breakers are closed.

关闭排水阀 BV03、BV4、BV6 及功率柜内底部管路上的排水阀，并将管路系统中的其它蝶阀及球阀全部打开，使水路畅通；

Close the drain valve BV03, BV4, BV6 and power cabinet in the bottom of the drainage valve on the pipeline, and the pipeline system in other butterfly valves and ball valves are all open, so that water flow.

用皮管一端放在储水罐（图 8.2）入口中，可通过自来水水龙头向容器中注水，或通过盛水容器倒入储水罐中；

Hose is placed in a water storage tank (Figure 8.2) entrance, water can be filled into the container through the tap water faucet, or pour water into the storage tank through the water container.

控制面板上的旋钮打到“就地”、“手动”，主副泵旋钮处于“停”位置，储补水旋钮处于“停”位置，风机旋钮处于“停”位置，切除投入旋钮处于“切除”位置；

The control panel on the knob to "local" and "manual", the main and auxiliary pump knob is in the "stop" position, reservoir water knob is in the "stop" position, the fan knob is in the "stop" position, and removal of input knob is in the "removed" position.

将水注入到储水罐中，观察液位显示不要超过 50；

The water is injected into the water storage tank, but the liquid level is not more

than 50.

选择控制柜门上开关打到“P3”位置，可以听到 KM3“啪”吸合的声音，补水泵 P3 运转；

By selecting the control cabinet door switch to "P3" position, you can hear "bang" pull voice from KM3, and P3 of water pump start running.

储水罐液位下降，罐内的存水进入水冷系统内部，观察补水流量计是否上浮，如图 8.3 所示，并时刻观察触摸屏上的储水罐（如图 8.4 所示）处于红色缺水状态时，停止补水，再次给储水罐储水；

When liquid level of water storage tank drops, The water of storage tank flow into the internal water cooling system. Please observe whether the water supply meter is floating, as shown in figure 8.3. When storage tank is in a state of lack of water which is in the red water(as shown in figure 8.4), please stop water supply, and again to put water into storage tank.

储水、补水循环若干次，将整个水路系统中灌满水，这个过程中时刻注意观察触摸屏上的压力不要超过 0.12MPa，如果超过了则进行手工排气，，分别如图 8.5 所示，在排气孔处喷出水证明放完气，压力降到 0.1MPa 以下时才可再次补水；

The whole water system filled with water by cycle of water replenishing and storing several times. In this process, water pressure of HMI display should not exceed 0.12MPa. If it is more than 0.12MP, it is air-out manually, as shown in Figure 8.5. When water spouts out of the Vent hole, there is no air. When the water pressure drop to 0.1MPa or less, water replenishing can be done.

储水、补水一段时间后系统压力上升，并且水路中气体较少（肉眼观察单元水道循环水中无明显气泡），手动运行循环泵 2min，停止后触摸屏压力在 0.12MPa 不降低时，停止补水。

The water storing and replenishing for a period of time, and the system pressure is rising. Operating of circulating pump on 2min after no air bubbles in water. If hydraulic pressure maintained at 0.12Mpa, please stop water replenishing.



图 8.2 Figure 8.2



图 8.3 Figure 8.3



图 8.4 触摸屏界面 Figure 8.4 HMI



图 8.5 手动排气点 Figure 8.5 Manual exhaust point



图 8.6 管道中的气泡 Figure 8.6 Air bubbles in ducts

说明：选择厂内和现场能够找到的最纯净水源，例如：自来水、天然泉水、地下井水、可饮用水等，尽量减小过滤器负担，减少系统降电导率所需时间。

Description: Finding the most pure water to use, such as tap water, natural water, underground water, drinking water, to reduce the burden of the filter and the time required for reduced conductivity.

若补水过程中出现如图 8.6 所示大气泡，手动开启循环泵，将循环系统中部分角落的气体和风机换热器中气体排出，补水完成后少量死角处积存的气体或树脂内夹带的气体，通过汽水分离器和自动排气阀连续不断的排除。

As shown in Figure 8.6, there is a large bubble replenishment process, please manually open circulating pump, so that gas in the circulatory system and fan for gas heat exchanger is out. Gas accumulated in the small amount of dead or entrained within the resin replenishment s constantly being excluded, by steam separator and automatic exhaust valve

主泵及副泵不可长期空转，否则会烧坏水泵；使用前请检查风机转向是否正确，防止出现反转问题。

The main pump and the auxiliary pump can not be long idling, otherwise it will burn out. Please check the fan that is turned to the right before use, to prevent the emergence of inversion problem

4 降电导率 Reduced conductivity

电导率过高会导致电气间隙不够，引起相间短路等重大问题，需特别关注此模拟量变化。

Electrical conductivity is too high will lead to the gap not enough, causing inter phase short circuit and other major issues, which pay attention to changes of electrical conductivity specially.

1) 在“就地”、“手动”方式下开主泵运行，通过调整蝶阀 V01、V04 开启比例，控制运行压力和介质流量在设计值正常范围内，例如 15M 水冷设备运行压力设定值为 0.25~0.35MPa，介质流量为 15 m³/h；

The pump operates in the "local" and "manual" mode, which the operation pressure and medium flow in the normal range value by adjusting the butterfly valve

V01, V04 opening ratio, such as the operating pressure of 15M water cooling equipment set value is 0.25~0.35MPa, the medium flow is 15 m³/h.

2) 通过旋钮开关控制水冷装置在“就地”、“自动”方式下运行，水冷装置自动进行降电导率工作；

The water cooling device is operated under the "in place" and "automatic" mode by the knob switch.

3) 由于设备中储水的水质不同降电导率所需时间不同，等电导率将至电导率报警界限值以下，此时水冷装置触摸屏显示状态为正常。

Due to the water quality of water storage equipment of different, reduction conductivity of required time is different. When conductivity alarm threshold value is approaching, the water-cooling device of HMI display state is normal

4) 将水冷装置旋钮开关调整为“远程”、“自动”模式，循环泵体、风机和补水泵控制为“停”，蜂鸣器为“投入”，通过 SVG 触摸屏水冷监控页面控制按钮将水冷装置开启至运行状态。

Adjusting the water cooling device knob switch to "remote" and "automatic", circulating pump, air blower and water pump is "stopping", and the buzzer is "inputting". Water cooling device is opening by SVG HMI of water monitoring page.

水冷装置触摸屏显示正常，SVG 触摸屏水冷监控页面就绪灯为绿色时，水冷装置满足 SVG 送高压电的条件，可按照风冷 SVG 调试过程进行设备调试。

Water cooling device HMI display is normal, "Ready light" of SVG HMI display turn green. water cooling device to meet the conditions of the SVG to send high voltage, which can be adjusted according to debugging process of the air cooling SVG equipment.

8.3 使用说明 Instructions

1 排空 Drainage

1) 控制水冷装置处在停止状态，关闭蝶阀 V01~V04、所有断路器，断开电源；

Water cooling device is in the stop state, closing the butterfly valve V01~V04, all

circuit breakers, and disconnect the power supply.

2) 功率柜管道中水可通过功率柜内底部管道上的排水阀排空，打开排水阀放出部分水后，将排气点排气塞打开，让管道中进入空气便于管道尽快排空；

Power cabinet pipe water can be discharged through the drain valve on the bottom of the power cabinet, open the drain valve to release part of the water and the exhaust valve exhaust plug, so that the air is putted into the pipe to facilitate the evacuation of the pipeline as soon as possible.

3) 拆下风机换热器上其中一个法兰，排空风机换热器内和管道内水，打开 BV03 和 BV04 排水阀将水冷装置柜体内管道中水排空。

Removing one of flange the heat exchanger fan, emptying the heat exchanger fan, water pipes, and water-cooling device cabinet pipe by opening BV03 and BV04 drainage valve.

2 维修或更换单元 Repair or replacement cell

1) 控制水冷装置处在停止状态，关闭蝶阀 V01、V04、所有断路器，断开电源；

The water cooling device is in the stop state, closing the butterfly valve V01, V04, all circuit breakers, and disconnect the power supply;

2) 功率柜管道中水可通过功率柜内底部管道上的排水阀排空，打开排水阀放出部分水后，将排气点排气塞打开，让管道中进入空气便于管道尽快排空；

Power cabinet pipe water can be discharged through the drain valve on the bottom of the power cabinet, open the drain valve to release part of the water and the exhaust valve exhaust plug, so that the air is putted into the pipe to facilitate the evacuation of the pipeline as soon as possible.

3) 首先将需维修的单元后外接电容拆下，其次单元输出铜排、固定螺丝拆下，然后将前面散热器上连接的管道和单元控制板上的通信光纤拆下，最后保持单元前高后低抬下（防止散热片内残留的水流出溅到其它单元中）；

Firstly, removing the external capacitor connect to the power cell, then removing the output copper of cell, screws, the front radiator and fiber connecting pipes, finally keep the cell from high to low lift (to prevent the residual heat sink in the water splashed on the other unit in).

4) 进行单元维修或更换;

Maintenance or replacement of cell

5) 首先将单元放好安装固定螺丝, 其次连接单元输出铜排和外接电容固定, 然后将前面散热器上连接的管道和单元控制板上的通信光纤安装好, 最后将固定单元和电容的螺丝紧固。

Firstly, cell placed and mounting screws, then the output connecting copper cell bar and external capacitor is fixed, and then in front of the radiator pipe and the cell control board of the optical fiber communication is installed, the screw fastening cell and fixed capacitor

6) 打开蝶阀 V01、V04、所有断路器, 按照储水罐储水、系统补水和排空说明内容操作, 开启水冷装置。

Opening the valve V01, V04, all circuit breakers, according to that content of the operating system, the water storage ,water and emptying, opening water cooling device.

注意: 拆散热器上连接的管道时, 先拧下单元上水嘴, 再拧下单元下水嘴; 安装时先安装下水嘴, 再安装上水嘴。

Note: removing the radiator pipe, first unscrew the cell to unscrew the faucet, the water nozzle unit; the installation to install the water nozzle, then install the faucet.

3 更换树脂 Resin replacement

水冷系统配备高纯去离子树脂, 可以控制系统电导率在预警值以下, 随着系统的运行, 电导率会逐渐上升。电导率超过预警值时, 应择机更换, 不需要立刻停机更换, 但当未上高压电水冷装置单独运行, 电导率无法降至预警值以下时, 必须立刻更换树脂后方能送高压电。

The water cooling system is equipped with high purity deionized resin, which can control the conductivity of the system under the early warning value. With the operation of the system, the conductivity will increase gradually. The conductivity exceeds the warning value, should choose to change, do not need to immediately stop to replace, but when there is no high-voltage, water-cooling device run separately, the conductivity can not be reduced to below the warning value, which immediately replace the rear.

1) 控制水冷装置处在停止状态，关闭球阀 BV02、BV05、所有断路器，断开电源；

The water cooling device is in the stop state, close the ball valve BV02, BV05, all circuit breakers, and disconnect the power supply.

2) 拆下去离子罐上端卡箍，打开去离子罐顶盖，在排水阀 V05 处放置容器（例如水桶）接住流出的树脂和水，在去离子罐剩余 1/4 时，使用 PVC 管（或干净物体）放入罐体内搅动，排水阀无水流出时，关闭 V05，加入 3L 水搅动打开阀门 V05 尽量将罐体中树脂排出，最后关闭 V05；

Removing the ion tank top clamp, opening the cover of deionized tank, drain valve V05 (e.g. bucket) leaking resin and water tank in deionized residual 1/4, stirring in a tank by using a PVC tube (or clean object), draining valve outflow, close the V05, add 3L of water V05 will try to open the valve to stir the resin discharge, finally closing V05.

3) 打开控制电源和补水泵断路器，通过补水泵运行，向罐体内注入 15L 纯净水，然后加入 15~20L 树脂，加入树脂过程中使用 PVC 管不断搅拌，避免沉积接底；

Open the control power supply and circuit breaker of water supply pump through the water pump operation, putting 15L pure water into the tank and then join the 15~20L resin, stirring constantly in the process of using PVC pipe, to avoid the deposition of the bottom.

4) 将罐顶盖放好，重新箍紧卡箍后打开球阀 BV02 和 BV05，适当补水；

Put the top cover of the tank, and then tighten the clamps to open the ball valve BV02 and BV05, and replenish water appropriately.

5) 开启水冷装置。

Start-up water-cooling device

注意：罐顶盖下有密封胶圈，拆卸和安装过程中请注意防止遗漏。

Note: the sealing ring under tank top, please pay attention to prevent the omission in the process of disassembly and installation.

4 更换器件 Replacement component

某器件损坏需要更换时，首先停止水冷装置的运行，断开电源，然后关闭器件前后的阀门，进行器件更换操作，此处以更换滤芯(滤芯发黑时证明需要更换)为例进行讲解：

Replacing damaged component, firstly, stop the water-cooling device running, disconnect the power supply, and then close the device before and after valve to replace operation component, here to replace the filter (filter that need to replace black) as an example to explain:

1) 控制水冷装置处在停止状态，断开电源；

The water cooling device is in a stopping state.

2) 在滤芯正下方柜底铺抹布（或其它可吸水的物品），关闭滤芯上下阀门，例如图 8.7 所示滤芯 Z2 上下阀门 BV02 和 BV03；

Cloth (or other absorbent items)is placed at the bottom of the cabinet, close the filter valve, as shown in Figure 8.7 filter Z2 upper and lower valve BV02 and BV03.

3) 使用备品备件中的工具，将过滤器拧下，更换为新滤芯，并清洗过滤器；

The filter is unscrewed by using tool of spare parts, and replaced with a new filter, cleaning filter.

4) 安装好过滤器，打开上下阀门，提供电源，开启水冷装置。

The filter is installed, the upper and lower valve is opened, the power supply is provided, and the water cooling device is opened.



图 8.7 滤芯 Z2 示意图 Figure 8.7 Schematic diagram of filter element Z2

5 故障查询 Fault query

水冷装置故障分为预警和跳闸两种，预警时水冷装置和 SVG 蜂鸣器响，设备可继续运行，给出报警提醒人员及时处理，跳闸时会引起 SVG 停机跳闸，并联跳上级开关柜。

Water cooling device fault is divided into two kinds of warning and tripping, warning buzzer and SVG water-cooling device, equipment can continue to run, give the alarm to remind staff timely, which will cause the SVG stop tripping, and jump higher parallel switch cabinet.

水冷装置预警信息和跳闸信息可在 SVG 触摸屏的故障查询页面读取，在水冷装置触摸屏上有部分信息显示，显示内容如下：

Water-cooling device early warning information and trip information can be read in the SVG HMI fault inquiry page, touch screen display there are some of the information in the water cooling device HMI display, which is as follows:

1) 部件故障时，界面中将使用“+”符号覆盖故障部件，表示需要检修；

When a component fails, the "+" symbol will be used to cover the part of the fault, which maintenance is required.

2) 泵工作水循环流动时，界面有箭头标识水流方向；

When the pump works water circulation, there is an arrow to indicate the direction of water flow in the interface.

3) 所有传感器指示实时数值，超标将黄底显示并闪烁，正常为白底；

All sensors indicate real-time values, which is over, the yellow will be displayed and flashing.

4) 补水罐缺水图示蓝色柱消失，出现缺水指示的红色柱；

When water tank is shortage of water, there is indicating red column instead of blue column.

5) 缓冲欠压，囊罐将变成红底，正常为黑底；

Buffer under pressure, the capsule will become a red bottom, normally black. 6)

过滤器堵塞，过滤器将变成红底，正常为黑底。

The filter is clogged, the filter will turn red, which is normally black.

6 日常维护 Daily maintenance

(1) 日常巡视项目 Daily inspection items

1) 在设备附近，有无异常的振动、声响、气味、冒烟；

Near the equipment, there is no abnormal vibration, sound, smell, smoke.

2) 通过摄像头观察室内 SVG 或 SVG 集装箱内情况，照明应正常，地面无积水和异物，设备无放电、冒烟、过热变色；

Through the camera to observe the situation inside the SVG or SVG container, lighting should be normal, no water and foreign bodies on the ground, the device without discharge, smoke, overheating discoloration.

3) 通过后台系统，查看 SVG 运行/停止状态正常，无报警和故障；

Through the background system, SVG running / stopping state is normal, which are no alarm and fault.

4) 通过 SVG 上触摸屏观察单元的状态应正常，母线电压正常，水冷系统进阀温度、出阀温度、水压、储水罐水位、电导率和流量应正常；

Cell status should be normal by the SVG HMI, normal bus voltage, cooling system temperature, inlet valve temperature, water pressure, water storage tank, conductivity and flow should be normal.

5) 系统侧高压合指示灯正常, SVG 状态和数据信息读取应正常。

The system side indicator light of high voltage is normal. SVG status and data information should be read normally

6) 发生单元故障, 更换单元后, 24h 内应注意更换单元的状态, 检查水冷系统压力是否正常;

When failure cell occurs, the cell is be stead of. please pay attention to the state of the replacement cell, and water system pressure is normal.

7) 额定容量运行时, 水冷系统水温是否异常, 外部引线接头有无过热、变色;

When it operates at rated capacity, whether the water temperature of the system is abnormal, the external lead joint overheating, discoloration.

8) 经检修、改造、试验或停用半年以上的设备需重新投入时, 需检查冷却水电导率有无异常, 是否渗漏, 对单元进行两次充电, 检查单元充电电压是否正常。

After repair, alteration, test, or stop using equipment for more than half a year to return to, need to check whether there is any abnormal on cooling water conductivity, whether the leakage, to charge twice unit, check whether the unit charging voltage is normal.

(2) 日常巡检项目 Daily inspection items

1) 检查水冷系统人机界面的报警信息;

Checking the alarm information of man-machine interface of water cooling system

2) 检查去离子水流量是否正常;

Whether the deionized water flow is normal

3) 检查各压力表读数, 与上次数据进行比较;

Checking readings of the pressure gauge and comparing them with the last data

4) 检查主循环泵电机、风机电机的运行噪声、温度等;

Checking the main circulating pump motor, fan motor operating noise, temperature, etc.

5) 对显示仪表数据进行记录;

Recording the display instrument data

6) 经检修、改造、试验或停用半年以上的设备重新投入后一段时间, 应检查水冷系统发生泄漏的地方是否有渗水/漏水现象, 压力和流量是否正常;

After repair, renovation, testing or maintenance of equipment, which operate more than half a year, it should be checked whether there is leakage of water cooling system leakage / leakage phenomenon, pressure and flow is normal

7) 大风天气过后, 观察风机上方是否有覆盖物。

It is observed whether there is a cover above the fan after windy

(3) 定期维护项目 Periodic maintenance project

1) 每年进行一次集装箱内空调系统的检查;

Checking the container air conditioning system once a year

2) 每年进行一次功率单元的维护检查, 包括电气连接螺丝是否紧固, 检查单元外观, 检查连接端子是否紧固;

Checking the maintenance of power cell once a year, including the electrical connection of the screw whether is tightened, the appearance of cell, whether the connection terminal is tight.

3) 每年进行一次补水泵补水, 检查补水泵是否有异常振动、噪声, 压力、流量是否正常;

It is checked whether there is abnormal replenishment pump vibration, noise, pressure, flow once a year.

4) 每年一次对循环泵、风机电机轴承进行润滑;

Making circulation pump, fan motor bearing lubrication once a year.

5) 每年进行一次清洗板翅, 用高压水枪对换热器板翅污垢进行清洗, 水压在 3~4bar 之间, 不可抬高;

Plate fin is cleaned every year. The heat exchanger fin dirt is washed with water cannons, which water pressure is between 3~4bar, but not exceeding this.

6) 去离子罐长期使用导致树脂正常耗尽后, 为满足水冷系统维持极低的电导率, 需要对树脂进行更换, 建议 3 年更换树脂一次;

After long term use of deionized tank, it is necessary to replace the resin for 3

years after the resin is exhausted. In order to maintain the low conductivity of the water cooling system, it is necessary to replace the resin.

7) 每年进行一次清洗或更换主循环管道滤芯;

Cleaning or replacing the main circulating pipe filter every year. 8)

建议 5 年更换密封胶圈一次。

Replacing a sealing ring after five years.

8.4 附件 Accessory

1、带垫圈的螺丝位置请将垫圈放平整后再紧固，例如去离子罐上端

The position of the screw with washer should be flat and then tighten, such as the top of the tank.



图 8.8 去离子罐上端封口位置示意图

Figure 8.8 Schematic diagram of the upper sealing position of deionization tank

2、法兰四个螺丝紧固前请调整中间孔，对准后采用循环紧固的方式进行;

Please adjust the middle hole before tightening the four screws of the flange, the cycle of fastening is adopted.

3、涂抹液态生料带的管口需要保持干燥，涂抹后需要等 24h 后再通水;

Apply pipe liquid raw materials need to keep dry, the need to wait 24h after

water after smearing.

4、电动比例阀在断控制电情况下手动调节开度，避免里面电机损坏；

Adjusting electric proportional valve opening with breaking control power supply, which is to avoid damage to the motor.

5、设计中需要在去换热器的管道上增加阀门，软管使用物品密封口，尽量保证管口不受到破坏。

It is need to add the valve in designing. The hose mouth is sealed by using goods so that hose mouth is not damaged.



图 8.9 单元软管损坏示例

Figure 8.9 Damage example of cell hose

第九章常见问题的处理 Chapter 9 Common Problems

9.1 概述 Summary

ZBSVG 系列产品发生单元故障、系统故障后，系统做记忆处理。故障一旦发生，系统报警并自动跳闸停机。只有故障彻底排除后才能重新开机。

When the cell fault and system fault occurs, ZBSVG will remember it and stop. The equipment can be started only the fault has been solved.

故障发生时，ZBSVG 主开关将自动分断。如果因为其他特殊原因主开关没有分断，用户可以用柜门的“急停”按钮将主开关强行手动分断。

When a fault occurs, the main switch will be automatically separated. If not, please press “emergency stop” button.

9.2 常见问题与处理对策 Common Problems and Solving

Method

ZBSVG 具有高度的智能化水平和完善的故障检测电路，并能对所有故障提供精确的定位，在 HMI 页面上作出明确的指示。用户可以根据 HMI 显示的故障信息，分别采取相应的处理措施。

ZBSVG has many fault detection circuit. When a fault occurs, the fault message will be displayed on the HMI. Users can take actions according to the message.

主控软件和硬件检测故障和报警并将它们保存在控制系统存储器中，故障可以是直接检测到的硬件故障，也可能是由软件产生的。单元故障由每个功率单元内的单元控制板上的单元控制系统逻辑检测。每个功率单元有自己的检测电路。主控系统根据发生故障的单元及故障的内容对单元故障进行解释、显示和记录。

The faults can be detected either hardware or software. Each cell has its own fault detection circuit. When the cell fails, the fault information will be transmitted to the main control. The main control will display it on the HMI according to the fault type.

通常，所有故障将使 ZBSVG 立即停机脱网。一些用户定义的故障可通过系统

程序控制 ZBSVG 的停机。报警将被显示和记录，但通常不禁止 ZBSVG 运行。

Normally, all failures will cause ZBSVG to shut down immediately. Some user-defined faults can be controlled by the system program to stop ZBSVG. The alarm will be displayed and recorded, but ZBSVG is usually not prohibited from running.

一般故障的保护原因、保护类型及处理对策请参考如表 8.1 所示。

The common faults and solving method are shown in figure 8.1.

表 9.1 故障的处理对策 Table 9.1 Common faults and solving method

故障/异常 Fault/Abnormal	可能的原因 The Possible Reason	相应对策 Solving Method
PLC 通讯故障 PLC communication fault	主控与 PLC 的连接线接触不良。 The connecting lines between master control and PLC are poor contact.	检查连接线情况并检查插针是否锈蚀 Check the connecting lines and pins.
HMI 通讯故障 HMI communication fault	主控与 HMI 的连接线接触不良。 The connecting lines between master control and HMI are poor contact.	检查 485 通讯线连接情况 Check the connecting lines of 485.
柜门状态故障 Cabinet door state fault	柜门打开 The cabinet is open.	检查柜门的关闭情况，调整行程开关位置 Check the cabinet and travel switch.
单元过温 Cell over-heat	1) 风机不转或反转 The fan does not turn or reverse. 2) 柜门滤网灰尘过多通风不好 The ventilated is poor because the dust is excessive. 3) 风道封闭不严 The duct is not strictly closed.	1) 检查风机 Check the fan 2) 打扫柜门滤网 Check the cabinet door filter。 3) 检查风道，做好封闭措施。Check the air duct.
单元过压 Cell over-voltage	1) 单元母线电压取样后通讯部分发生故障 Communication section after bus voltage sampling is failure. 2) 现场电磁干扰过大造成误动作 Eletromagnetic interference.	1) 检查 ZBSVG 内部排线连接情况。Check the internal cable connections. 2) 做好屏蔽措施。Take good shielding measures.

系统过压 System over-voltage	可能为电网发生故障 Power failure	等待恢复，复位。 Waiting for recover and reset.
单元过流 Cell over-current	1) 单元过流误保护 False protection 2) 系统电压故障，导致突变 System power failure, resulting in current mutation.	1) 重新送电，复位后开机 Power on again and reset to start 2) 等待自动恢复 Waiting for recovery.
系统过流 System over-current	1) 系统负荷冲击过大； The impact of system load is too large. 2) 系统电压发生故障，导致突变； System voltage failure, resulting in current mutation. 3) ZBSVG 运行容量过高过载 ZBSVG running in the state of overload.	1) 观察系统电压和负荷冲击是否有异常； Check the system voltage and load. 2) 等待 ZBSVG 自动复归； Waiting for ZBSVG recovery. 3) 检查 ZBSVG 输出电流互感器的接线是否正确，电流方向的定义是否正确 Check the output of current transformer connections are correct or not.

9.3 如何更换故障单元 How to replace the fault cell

如果某一单元由于故障而不能正常工作，可以联系中宝电气有限公司购买同型号功率单元。在 ZBSVG 停机断主电的情况下用该单元将故障单元替换。更换故障单元应遵照以下步骤进行：

If there is any cell, it can be replaced by the spare cell. If there is no spare cell,

please contact with our company. The fault cell replace steps are as follows.

第一步 将 ZBSVG 停机，并将控制柜柜门急停按钮按下；

Step1: Stop ZBSVG and press the “emergency stop” button on the control cabinet.

第二步 上级开关柜操作至冷备用状态，并接地；

Step2: Open the higher level switch and make it cold standby.

第三步观测 HMI 单元母线显示，确定单元母线电压变为 0V 后等待 10 分钟，将 QF1、QF2、QF3 断开；

Step3: Watching the cell voltages on the HMI, until the voltages are turn to 0. After that, switch off the air switch of QF1, QF2 and QF3 10 minutes after.

第四步 打开功率柜柜门，拔掉故障单元光纤头，并做好防尘处理；

Step4: Open the power cabinet. Pull off the fibers in the fault cell and deal with dust prevention.

第五步 将故障单元沿轨道拔出（勿触碰光纤），注意轻拿轻放；对于小容量 SVG，需将单元后面的紧固螺栓松开。

Step5: Pull out the fault cell lightly. For the small capacity SVG, the fixed bolt behind the power cell needed to be taken off.

第六步 将同种型号的单元沿轨道推入，按原来的连接方式连接好电缆/铜排及光纤；

Step6: Install the spare cell in reverse process as before

第七步 按照操作手册，检查无问题后，系统重新送电投入运行；

Step7: Restart the ZBSVG according to the user’s manual.

第八步 与厂家联系维修故障单元。

Step8: Telephone the company to repair the fault cell.

第十章服务及保修 Chapter 10 Service and Warranty

□售前服务 Pre-sale services

- 为用户筹划，提出建议性的系统设计思路，提供技术咨询服务。

Provide technical advice and system design ideas.

- 提出安装方案、环境要求。

Propose installation and environment requirements

- 预估运行效果。

Estimate running results.

□售后服务 After-sale services

- 免费培训操作人员，永远的免费咨询。

Free training and free consultation.

- 12 个月内免费保修（人为或错误操作造成的损坏除外）。

Free warranty within 12 months (except man-made caused damage)

- 无论何时、何地使用本公司产品，终身保修。

All the products are lifetime warranty.

□保修规则 Warranty rules

- 保修范围 Warranty coverage

◇ 保修范围指 ZBSVG 装置及本公司提供的附件；

The warranty coverage include ZBSVG equipment and the accessories which provided by our company.

◇ 在正常使用情况下，发生故障或损坏，本公司负责设备运行正常后的 12 个月以内的免费维修。

If the equipment is in normal use and it has fault in 12 months after it running, our company provides free repair.

- 有限维修 Warranty limited

本公司保修服务承诺不适用于下列情况：

The following situations are not included in warranty.

◇ 超出保修期的产品或部件；

The products or components are beyond warranty period.

◇外部设备、非在本公司工厂装入、附加的第三方产品、零部件及用户提供的产品或零部件；

External device, third-party products, users' products or components

◇未按产品使用要求，未经本公司同意在非产品所规定的工作环境或其他错误下安装、保管及使用（例如温度过高、过低、湿度过高，电压或电流不稳定，输入不合适电压，操作失误等）造成的故障或损坏；

The fault or damage is caused by incorrect installation environment, such as hot, cold, high humidity, unstable voltage and unstable current.

◇非本公司授权的安装、修理、更改或拆卸所造成的故障或损坏；

The fault or damage is caused by installation, repair, alteration, demolition that are not authorized by our company.

◇非本公司供应的零部件导致的故障或损坏；

The fault or damage is caused by the parts not belong to our company.

◇因意外事故或其他外部因素（包括自然灾害、火灾、水灾、战争、暴力行为或其他类似事件）导致的故障或损坏。

The fault or damage is caused by accident or other external factors, such as natural disasters, fires, floods, war, violence or other similar events

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