SVG

STATIC VAR GENERATOR
01 The biggest 66kV/10000kVA HV power station for SVG test in China
02 Advanced full automatic SMT production Line
03 Most self-contained all kinds of SVG test system
04 The unique high voltage SVG full load test center in China
05 The first high power SVG for traction conversion substation (27.5kV/5MVA)
06 The creator of HV converter heat pipe technology
07 The owner of many patents
08 The only one SVG passed ISO9001 professional approval in China

Rongxin Power Electronic Co., Ltd. (RXPE) is specialized in R&D, manufacture and application of HV power electronic equipment such as: HV SVC, HV SVG, Power filtering device (FC), MV motor drive (MVC). It is one of the most famous high-tech companies in China. Located at Anshan Economic Development Zone with an area of 60 ksqm and building area of 35 ksqm, RXPE possesses modern manufacturing line, 66kV/10000kVA HV test power station, the unique advanced SVG full load test center and many other test facilities. RXPE’s advanced HV SVC have reached the corresponding period international level, owns 35 national patents, 6 software property rights, the ratio of performance to price is much better than imported same kind products. Up to now 18000 MVar SVC has been applied, which makes RXPE become both the leader of SVC in China, and one of the main suppliers of SVC in the world.

As the successor of SVC, SVG owns even prevailing performance with faster response, stronger voltage stabilizing capability, wider operating area for transmission capability and transient voltage limit improvement, lower harmonics, lower system losses and small size. Rely on the solid technical ability, RXPE has embarked the research of HV big capacity of SVG since 2005. In 2006, the main controller utilizing DSP of TI TMS320F2812 and the SVG test bench has been finished smoothly. In 2007, the first SVG for traction power station was put into service.

RXPE owns a team of experienced experts and engineers. We are willing to join our efforts with all clients to promote our advanced technology and high quality products application, to devote for stabilizing power networks and upgrading green power. Serving all of our clients for saving energy, reducing lost and safety production is the responsibility of RXPE.
Grid voltage quality is evaluated according to stability, symmetry and sinusoid performance usually. Because of wide application of modern electronic non-linear loads, the grid quality is seriously affected, and the main interference source are power electronic switching devices and frequently varied load.

- The power transmission system lacks of var regulation timely. Thus surge is easily enlarged and system stability is reduced.
- The load center is lack of rapid var support, thus causing lower voltage even voltage crash easily.
- The low power factor makes higher grid losses, higher production cost and lower productivity.
- Varied var causes grid voltage dip, voltage fluctuation and voltage flicker. In severe condition, it may causes transmission and protection failure even stopping production.
- A great deal harmonic current generates grid voltage distortion. It is even the recessive killer of grid:
  - Protection and safe devices misact.
  - Enlarge harmonic current of capacitor banks, make capacitor over load or over voltage, even burn out.
  - Increase transformer losses, causes transformer over heat.
  - Induce electric equipment heat, motor torque unstable even damage.
  - Promote the aging of electric equipment, make it easily be broken.
  - Reduce arc furnace efficiency, increase consumption.
  - Interfere communication.

- Different loads Cause 3 phase unbalance, generate negative sequence current and cause motor rotor vibration.
Now the optimal solution is to use SVG, which increases stability and transmission capability of power grid, eliminate var impact, harmonic and unbalance.

**SVG Operating Principle**

SVG is the representative of newest technology in var compensation area. SVG is connected in parallel to the grid, similar to a variable var current source. Its var current can change following the vary of load var current rapidly and automatically. Since the response speed of SVG is very fast, it is also called Static Synchronous Compensator, STATCOM for short.

SVG’s fundamental configuration is 2-phase or 3-phase self commutated bridge circuits adopting full controlled power electronic semiconductor devices (like IGBT and IGCT). Through reactors the SVG is connected in parallel to the grid. By adjusting the output voltage amplitude and phase angle or direct controlling AC side current, the SVG can absorb or generate var according to the load reactive power or the grid voltage level.

<table>
<thead>
<tr>
<th>work mode</th>
<th>wave form</th>
<th>explain</th>
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<tbody>
<tr>
<td>no load</td>
<td><img src="image1.png" alt="Waveform" /></td>
<td>In case of $U_1 = U_S$, SVG has no compensation capability.</td>
</tr>
<tr>
<td>Inductive operation</td>
<td><img src="image2.png" alt="Waveform" /></td>
<td>If $U_1 &lt; U_S$, SVG can output inductive current continuously.</td>
</tr>
<tr>
<td>Capacitive operation</td>
<td><img src="image3.png" alt="Waveform" /></td>
<td>If $U_1 &gt; U_S$, SVG can output capacitive current continuously.</td>
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Integrating the strong points of ABB & Mitsubishi, RXPE SVG uses diode clamped 3-level power converters, which are parallel connected with the grid via a step-up transformer.

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**Multilevel SVG system diagram for 3-level power units with parallel transformer**

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**Features of RXPE SVG**

- **Modularization**
  As an example, 35kV/200MVA SVG system consists of 4 identical 50MVA SVG.

- **Redundancy**
  For a 35kV/200MVA SVG, each 50MVA SVG and its power units can work together or operate separately.

- **High reliability**
  RXPE SVG is the most reliable solution in the world. The Units are spared with each other.

- **Easier maintenance**
  The SVG units are interchangeable. The modularized SVG can be maintained independently.
Features of 3-level PWM power unit

- low output voltage harmonics
- smaller reactor impedance & volume
- low switching frequency
- high power density

2-level PWM converter structure

3-level PWM converter structure

Output line voltage waveform of 2-level PWM converter

Output line voltage waveform of 3-level PWM converter
Main Functions of SVG

◆ Improve the stability of power transmission

In long distance transmission system, SVG can not only compensate the power line losses caused by reactive power, increase line voltage and improve effective transmission capacity under normal operation, but also offer reactive power adjustment in time, damp system oscillation and improve system stability in case of fault.

◆ Maintain the receiving-end voltage level

Since high capacity load centers lack reactive power support, it is easy to cause grid voltage dip, even cause voltage collapse. However, SVG is capable of fast var adjustment. Therefore, the receiving-end voltage level is greatly stabilized.

◆ Reactive power compensation leading to high power factor and low line losses

Many types of loads need a mass of reactive power when operation, such as asynchronous motors, arc furnaces, rolling mills and high rating rectifiers. At the same time, the upstream transformer and line impedance also generate reactive power, which still leading to low power factor. For the power system, loads with lower power factor will increase the line losses, voltage drop and deteriorate voltage quality. Additionally, reactive power will reduce efficiency of power generation, transmission and distribution. For clients, low power factor will increase production costs.

◆ Restrain voltage fluctuation and flicker.

Voltage fluctuation and flicker are mainly caused by rapid loads variation. This rapid variation also causes the load current fluctuation dramatically. The current variation leads to system voltage losses changing very fast, which brings the receiving-end grid voltage flicker. The typical loads that cause voltage flicker are arc furnaces, rolling mills, electric locomotives, etc. SVG can offer fast reactive power regulation, which mitigate voltage fluctuation and flicker easily caused by loads variation. Now, SVG is the best solution to restrain voltage fluctuation and flicker.

◆ Mitigate 3-phase unbalance.

In distribution network, there are a lot of 3-phase unbalance loads, typically like electric locomotives and arc furnaces. At the same time, line and transformer impedance unbalances can also cause voltage unbalance problem. SVG can fast compensate negative sequence current caused by unbalance loads, which ensure balanced 3-phase grid current. Thus, it improves the power supply quality greatly.
SVG is the most advanced var compensator technologically, which realizes an evolution of reactive power compensation mode based on voltage source converter. Big volume capacitors and reactors are no longer needed. SVG uses HV IGBT or IGCT with high switching frequency to realize reactive power regulation. Therefore, SVG has the following advantages compared with traditional compensation methods:

◆ **Faster response speed**

SVG response time: \( \leq 5\text{ms} \)

Traditional static compensator response time: \( \geq 10\text{ms} \).

SVG can finish the conversion from rated capacitance var to rated inductance var in a very short time. This unexampled response speed makes SVG very suitable for impact load compensation.

◆ **Stronger voltage flicker restrain capability**

SVC can restrain voltage flicker to 2:1 in maximum, but SVG can achieve 5:1, even higher. SVC cannot improve its capability for voltage flicker mitigation even with high capacity because of low response speed. But SVG responds fast. When its capacity is increased, the capability of voltage flicker mitigation can be further improved.

◆ **Wide operation range**

SVG can work from rated inductive power to rated capacitive power. So compared with SVC, SVG operation range is much wider. Furthermore, SVG can output rated reactive current even under low system voltage.

◆ **Multiple compensation function**

RXPE SVG is not only functioned as fast reactive power compensator, but also harmonics and unbalance compensator according to different demands of different clients.

◆ **Low harmonic content**

RXPE SVG utilizes PWM, 3-level and multiple technologies. Therefore, it generates very low harmonics with compensating load harmonics at the same time. Thus, SVG becomes a true multifunctional compensator.

◆ **Small volume**

HV big capacitors and reactors are not necessary. SVG installation area is greatly smaller than that of the same capacity SVC, only 50% or even lower.
SVG STATIC VAR GENERATOR

Application fields of RXPE SVG

**Long distance power transmission**
At present, there is a worldwide trend to use big power grid and long distance power transmission. This causes high power losses, at the same time forces the power transmission and distribution system to increase its capacity. SVG can increase the performance of transmission & distribution of power system, which has been proven worldwide. Therefore, installing SVGs at one or several places of the grid can reach the following goals:
- Stabilize weak system voltage.
- Reduce the lose of power transmission.
- Increase transmission capability.
- Increase transient stabilization limit.
- Damp small interference.
- Boost up voltage control and stabilization capability.
- Attenuate power oscillation.
SVG system becomes a strong technical support for grid interconnecting operation.

**City second level substation (66/110kV)**
In regional grid, several capacitor banks is put into or out of service group by group to compensate system var and improve power factor. This way can only offer capacitance var and cannot follows the load variation. Sometimes power factor is ensured with overfed capacitive var, driving up the line voltage and harming the facilities and system stability. RXPE SVG can fast and precisely compensate both capacitive and inductive var, stabilize line voltage, increase power factor, at the same time solve var overfed problem greatly. Installation of new SVG system can still use original fixed capacitor groups and thyristor control reactors (TCRs), which is the most effective way to improve regional grid quality with minimum investment but best result.

**Arc furnace**
As a nonlinear and ruleless load, arc furnace will make a series of strong impact on the grid as follows:
- Negative sequence current causes serious 3-phase unbalance.
- Many high order harmonics, including 2, 4 even-order and 3, 5, 7 odd-order harmonics, makes the voltage distortion more complicated.
- Serious voltage flicker.
- Low power factor.
The only way to solve this problem for clients is installing fast response dynamic var compensator. RXPE SVG system responses less than 5 ms, which offers arc furnace with fast var support, significantly reduces voltage flicker, stabilizes line voltage, increases metallurgy power output, as well as productivity. SVG has the function of phase compensation and it can eliminate the 3-phase unbalance caused by arc furnace. The assistant filter is able to remove harmful high order harmonics and offer capacitive var to increase power factor.
Electric locomotive power supply
The mode of electric locomotive transportation protects the environment, but seriously pollutes the grid at the same time. Since electric locomotive uses single phase power supply, several power quality problems arise such as 3-phase unbalance, lower power factor, and negative sequence current. Now, the only solution in the world is to install SVG system along the railway substations. Through the function of SVG, the 3-phase network is balanced and the power factor is improved. RXPE SVG has remarkably high ratio of performance to price, with solving the problem not only technically but also economically.

Hoister and other heavy industry loads
When hoister and other heavy industrial load operate, the power grid will be influenced as follows:
- Cause voltage dip and fluctuation.
- Lower power factor.
- Transmission equipment will generate harmful high order harmonics.
RXPE SVG can solve these problems perfectly, with keeping line voltage stable, low harmonics and high power factor.
The Structure of RXPE SVG

A  Transformer
- Step down the voltage to a low level that is suitable for the power units operating.
- Realize electric isolation between high voltage and low voltage to increase the system reliability.

B  Power unit
- It is the core of SVG main circuit to realize power conversion.
- Modular design. All power units are the same in structure and electric performance, thus interchangeable.
- Adopt RXPE patent—advanced high efficiency heat pipe technology, improving the reliability of IGBT significantly.

C  Input reactor
- It is utilized to connect SVG and grid, realizing power buffering.
- Reduce the current ripples of SVG, simultaneously reducing the common-mode noises.
D  Control cabinet
- Cabinet structure, used for SVG and its auxiliaries real-time control.
- Realize the communications of SVG with upstream computer and control center.

E  Full digital control system
- Uses US TI TMS320F2812 type DSP.
- The system var is calculated at real time, realizing dynamic tracking and compensating.
- Control system uses modular design.
- DSP control panels are back up each other as redundancy.

F  NMI integrative workstation
- Offer with friendly WINDOWS monitoring and operating interfaces.
- Realize remote monitor and network control.
- Provide with PLC which can flexibly meet all kinds of client’s special requirements.
**A Top quality IGBT module for Traction**
- Utilize international first class switching semiconductors
  - German EUPEC top quality IGBT modules
- Super capability of bearing high current and voltage spikes.
- With more operation margin for module design to increase its reliability and safety.

**B Low inductance power capacitor**
- High rated voltage and current.
- Long service life and free maintenance.
- Low high frequency stray inductance to reduce the voltage overshoots when IGBT turn off.
- Advanced performance at high temperature condition.

**C Unique Cooling design**
- Advanced heat pipe design with high efficiency heat radiation technology.
- Eliminate heat-island effect of HV IGBT thoroughly.
Advanced components test center

Though RXPE uses components mostly purchased from ABB、TI、EUPEC、TOSHIBA、MITSUBISHI or army grade chips made in China, RXPE is still equipped with the components test center which can perfectly detect all of the incoming components, such as resistors, capacitors, SCRs & IGBTs etc.
SMT and double wave-soldering production line
The SMT and double wave-soldering production line improves the quality and technique dramatically during soldering processes.
SVG combines high complexity of technology, such as power, electronic and control electric engineering, however the control part is the heart of the system. The quality of the control system depends on the soldering quality of the circuit boards. The SMT of RXPE can ensure the circuit boards with excellent capability of anti-interference, which ensures long-term reliable operation of the products.
The SVG test platform utilizes US TI TMS320F2812 type DSP as key controller to realize the following tests:

- Manually generate adjustable capacitive or inductive reactive power.
- Automatically compensate reactive power.
- Stabilize grid voltage.
- Compensate load harmonics.
- Compensate load unbalance.
- Compensate reactive power, harmonics and load unbalance simultaneously.

Low voltage SVG test platform

The SVG test platform utilizes US TI TMS320F2812 type DSP as key controller to realize the following tests:

- Manually generate adjustable capacitive or inductive reactive power.
- Automatically compensate reactive power.
- Stabilize grid voltage.
- Compensate load harmonics.
- Compensate load unbalance.
- Compensate reactive power, harmonics and load unbalance simultaneously.
High & low temperature ageing center

All key components of RXPE SVG products are subjected to serious high & low temperature ageing test piece by piece, under the control of ISO 9001 quality control system. These tests can lay a solid foundation for the quality of the system.
Power unit ageing center

Key energy conversion parts of RXPE SVG products are power units. Their reliability will determine the reliability of the SVG system. So each power unit must be subjected to 24h high temperature ageing test under rated operation condition before delivery.
Many kinds of test loads
Utilizing RXPE SVC, FC, HV asynchronous motor and HV synchronous motor, reactive power, harmonics, unbalance, impact current and other power quality problems can be simulated easily, thus in workshop the full power compensation performance of SVG can be realized.
Professional HV Full Load Test Center—Base of the Quality Guarantee for SVG

- National high-tech industrialization demonstration project.
- The unique SVG HV full-load test center in China.
- Test voltage of 6kV, 10kV, 27.5kV, 35kV, 66kV
- Test capacity of 10000kVA
- 72h continuous full-load dynamic operation. (Ex-work test)
- Extremely shorten the time for field test, and improve reliability of the equipment.
Computer simulation center
RXPE is provided with perfect computer simulation center, where SVG main circuit, control circuit, operating principle, dynamic and steady performances can be simulated. It can also offer theoretic guidance for initial design, which plays an essential role in system design, commission and maintenance.
Global remote monitor center create an unique service brand

Utilizing RXPE global remote data monitor technology, the clients need only a tele-wire or wide band to feed back the SVG operation data and status to RXPE remote monitor center. All clients can obtain wardships and supports from RXPE full-time service engineers, which ensures the equipment operates stably and reliably.
Qualifications

National key-software Enterprise

National key-high-tech Enterprise

Apply International Standard

Patents

ISO9001 Certificate