HTSVG Low Voltage STATCOM Manual

For Installation, Commissioning, Operation and Maintenance

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energy insight

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Preface

This manual is intended for the following equipment: HTSVG LV STATCOM

Due to constant product development, specifications and design of our products are subject to change without notice.

1. Safety instructions

1.1. Safety signs

This sign indicates risks of equipment damage, property loss, severe physical injury or even death if not following instructions contained in this manual.

This sign indicates risks of equipment damage, property loss if not following instructions contained in this manual.

1.2. General safety instruction

Hazardous voltage is present in this equipment. Not following instructions or neglecting of warnings in this manual may lead to equipment damage, property loss, physical injury or death.

Due the existence of a large amount of DC capacitors, hazardous voltage and energy is still present, even if the equipment is disconnected from the mains power. Always wait for at least 5 minutes for capacitors discharging through discharging resistors before handling the live parts. Always verify by measurement to make sure that DC capacitors have been discharged.

Installation, commissioning and maintenance should be carried out by qualified personnel after reading through this manual. Local and international regulations should be observed as well.

Keeping the front door closed during operation to avoid contacting hazardous voltage.

2. Working principle and features

2.1. Working principle of HTSVG LV STATCOM

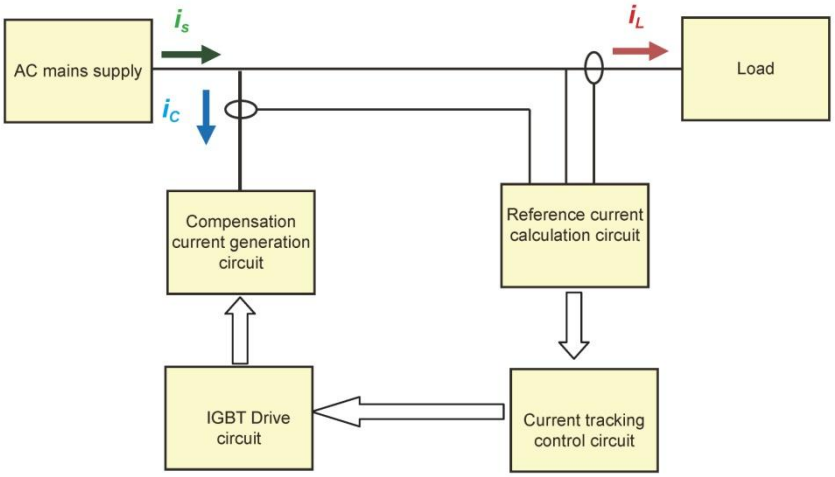

Fig.1: Working principle diagram for HTSVG LV STATCOM

As shown in Fig.1, HTSVG LV STATCOM is mainly comprised of reference current calculation circuit and compensation current generation circuit. The reference current calculation circuit monitors the load current in real time, and converts analog current signal into digital current signal, which is fed into DSP controller for processing. The DSP controller generates reference current by extracting the reactive current component and harmonic current component from the digital current signal. Based on the value of reference current, the current tracking circuit and IGBT drive circuit will send PWM signals as IGBT driving pulse, to drive the IGBTs or IPM power modules in the compensation current generation circuit. As a result, the compensation current, which is of the same value but the reversed phase of the load reactive or harmonic current, is generated and injected into grid to achieve dynamic and precise reactive power as well as harmonic compensation.

2.2. HTSVG LV STATCOM primary circuit

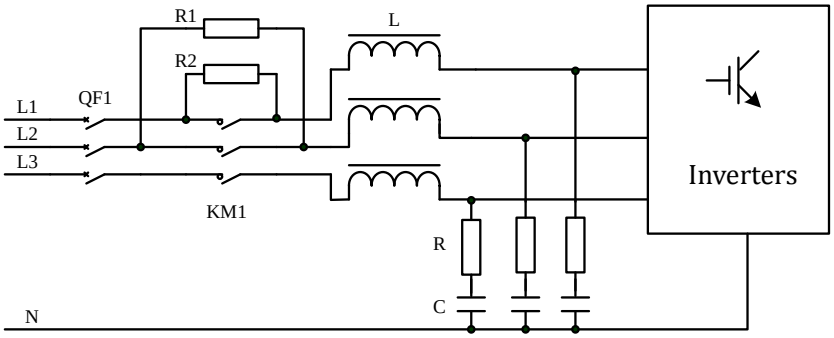

Fig.2: HTSVG LV STATCOM primary circuit diagram

As shown in Fig.2, QF1 is the incoming circuit breaker, KM1 being the pre-charge contactor and R1, R2 being the pre-charge resistors. The purpose of the pre-charge circuit is to avoid high inrush currents that could damage DC capacitors when HTSVG powered on. Output filter resistor R, output filter capacitor C and output reactor L make up output filter to reduce ripple current. For 3 phase, 3 wire STATCOM, there is no neutral connection in Fig.2.

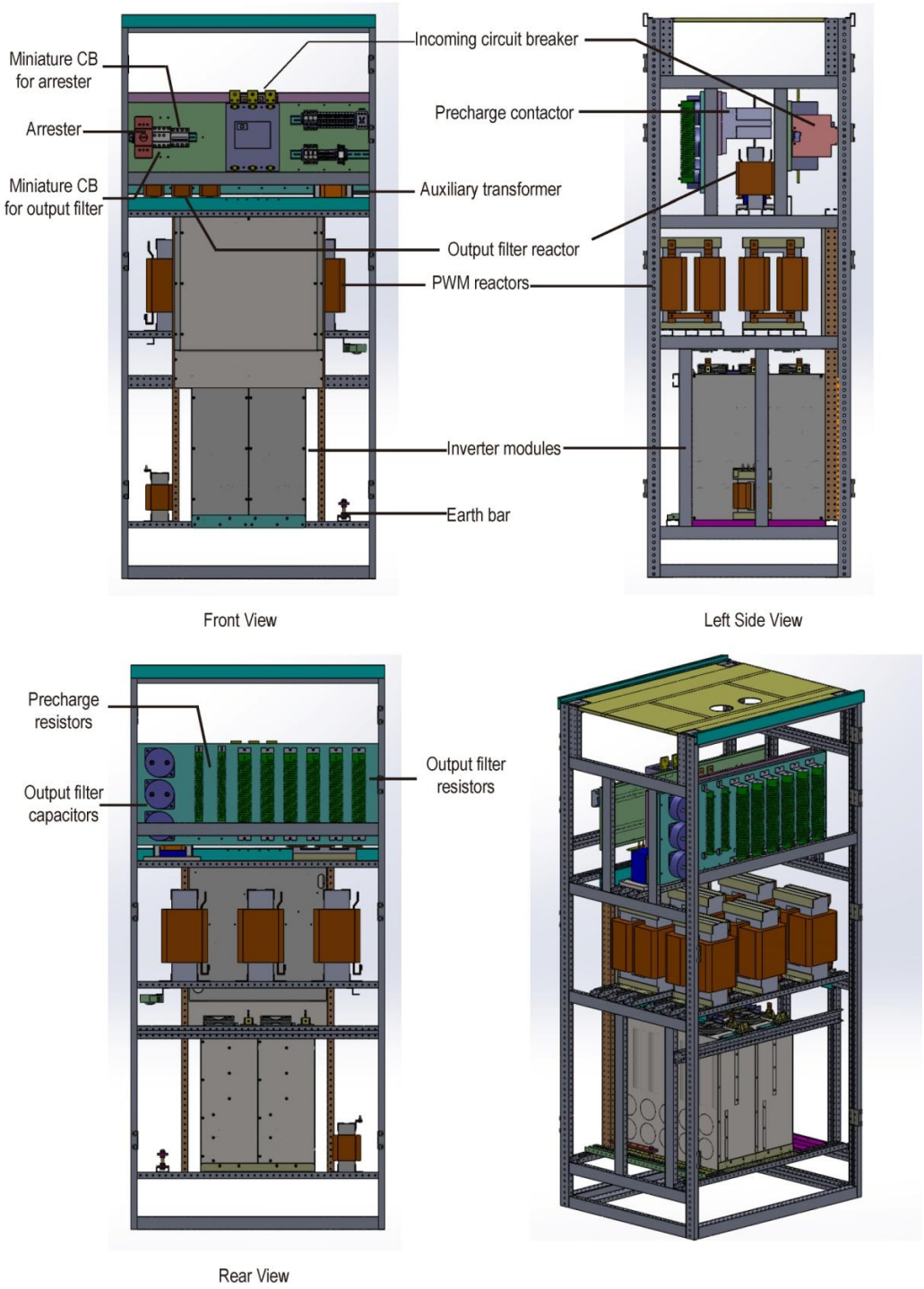

Fig.3: Major component layout of primary circuit

2.3. Patented double-interleaving inverter technology

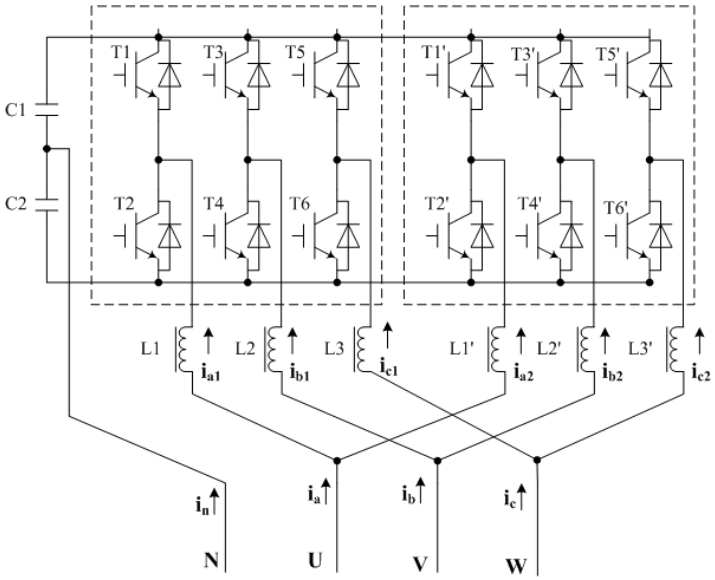

Fig.4: HTSVG LV STATCOM inverter topology

As shown in Fig.4, HTSVG LV STATCOM uses two identical three-phase full-bridge inverters in parallel to increase system capacity. More importantly, PWM double-interleaving technology is employed to drive inverters in order to reduce output ripple current effectively. As can be seen in Fig.5, where the total output current is represented in yellow as i_a and the individual output currents of two inverters are represented in green as i_{a1} and purple as i_{a2}, the ripple current in i_a is significantly reduced. The remaining ripple current can be filtered by the output filter further.

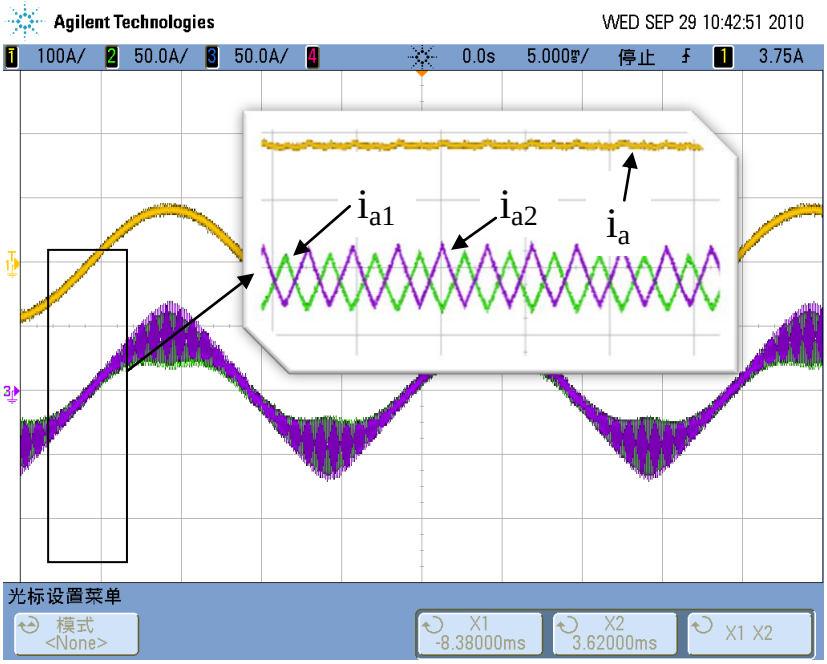

Fig.5: PWM double-interleaving ripple-current-cancellation technology

2.4. Main functions

Maintaining load side voltage and improving reliability of electrical distribution system

For load center, heavy load burden without the proper support of large capacity reactive power supply can easily lead to low grid voltage or stability accident like voltage collapse. With the STATCOM's dynamic reactive power compensation ability, the voltage at the load side and grid stability can be raised effectively.

Compensating reactive power, improving power factor, lowering line loss and enhancing energy efficiency

From the point of view of electrical distribution system, large loads like induction motors, arc furnaces, rolling mills and large capacity rectification equipment, require large amount of reactive power during operation. In the meantime, the transformers and line impendence cab also generate reactive power demand. All these factors combined lower the power factor of the system.

Mitigation of voltage fluctuation and flicker

Voltage fluctuation and flicker are mainly caused by load fluctuation. This is because load fluctuation will result in current fluctuation, which in return causes voltage flicker at the load side. Typical loads causing voltage flicker are arc furnaces, rolling mills and electric locomotives

STATCOM can provide dynamic reactive current super fast to mitigate voltage fluctuation and flicker caused by load fluctuation. To date, the most effective solution to voltage fluctuation and flicker is the STATCOM

Harmonic compensation

The non-linear loads prevailing in electrical distribution system, such as VFDs, rubber mixers, hoists and arc furnaces, generate large amounts of harmonics. Those harmonics distort voltage and current waveform distortion, increase failure rate of loads and power loss through the distribution system, or cause system resonance and tripping accident related.

The H type HTSVG LV STATCOM can cancel harmonics by injecting reversed-phase harmonic current into grid. The maximum harmonic compensation capacity of H type HTSVG STATCOM is 30% of rated power.

Load unbalance compensation

Unbalanced loads, such as electric locomotive traction systems and AC arc furnaces, are quite common in electrical distribution system. In addition, the three-phase impendence unbalance of transmission and distribution equipment, like power lines and transformers, can also result in voltage unbalance.

HTSVG LV STATCOM is capable of compensating the negative sequence current generated by unbalanced loads rapidly, to ensure the balance currents between three phases.

2.5. HTSVG LV STATCOM features

Superior efficiency and low power loss

- Patented PWM double-interleaving ripple-current-cancellation technology for lower harmonic distortion of output voltage and current, lower power loss caused by harmonics.
- Super fast and precise control powered by synchronous operation between multiple DSPs

More functions, more working modes

- Comprehensive compensation ability for both reactive power and harmonics to meet various requirements of different distribution system.
- Programmable selective harmonic compensation function (only available on H type model)
- Unbalance compensation function allowing for balancing load current between phases.
- RS232, RS-485 and TCP/IP interfaces with MODBUS RTU protocol for remote monitoring via SCADA or BAS system.

Higher stability, higher reliability

- Optical fiber for IBGT drive signals to ensure safety, reliability and anti-interference ability
- Multiple protections, rigorous thermal design to ensure reliable operation.

- Advanced control algorithm to ensure reliable operation in all kinds complex site conditions
- Fully digital, intelligent controller with bilingual HMI
- Self-diagnose of failure and event log function

Higher power density and easier maintenance

- Controller and power modules are all of modular design to provide higher power density and easy maintenance.
- Multiple units can operate in parallel to meet various demand on compensation capacity.
- No risk of overload by automatic output current limitation of 100% rated compensation current.
- Programmable load side CT position and source side CT position for easy installation on site.

3. Storage and transport

During storage and transport, HTSVG LV STATCOM must be kept in vertical position and avoid tipping, shock or severe vibration. Otherwise, mechanical structure of the equipment might be damaged.

3.1. Environment requirement for storage

Ambient temperature: -25 to 55°C (-13 to 131°F)；
Humidity：≤90%。

3.2. Precautions for long period storage

Sealed packaging and moisture-proof measure should be used for long period storage

For the first time HTSVG STATCOM is powered on after being stored for more than 3 months, please switch on the incoming circuit breaker and let the equipment in the standby mode for at least 10 hours before operation, in order to restore the withstanding voltage of DC capacitors. The purpose of this process is to reform (or reage) the DC capacitors. Without reforming, capacitors may be damaged when the STATCOM starts to operate.

4. HTSVG LV STATCOM selection information

4.1. HTSVG model description system

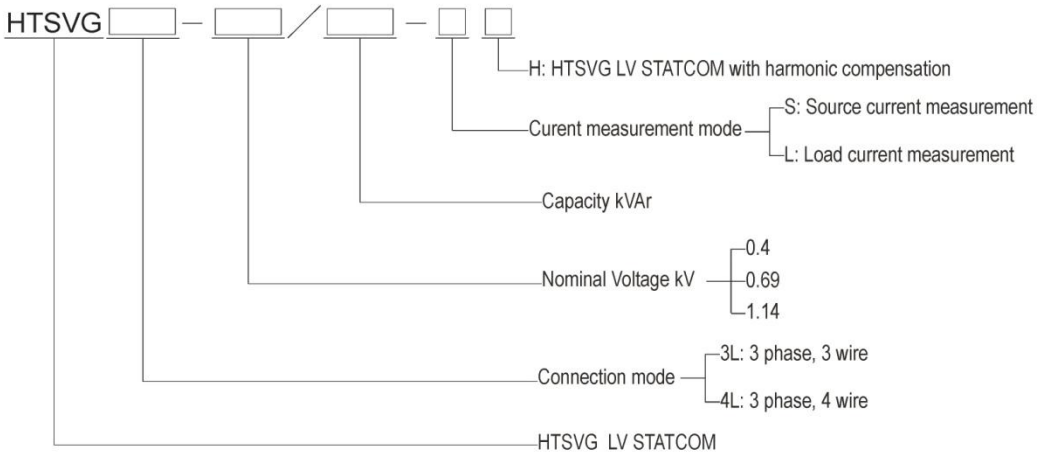

Fig.6: HTSVG Model description system

4.2. Selection table

The information below is only for general information purpose only. The model and dimensions are subject to change without notice, please contact the manufacturer to make sure.

Model	Voltage class（kV）	Capacity（kVAr）	Current（A）	Dimensions, (subject to modification according to specific order requirement）			Installation
				Width（mm）	Depth（mm）	Height（mm）	
HTSVG-0.4/20	0.4	20	30	440	630	176	Rack-mount
HTSVG-0.4/33		33	50	440	630	176	Rack-mount
HTSVG-0.4/50		50	75	440	570	264	Rack-mount
HTSVG-0.4/66		66	100	440	570	264	Rack-mount
HTSVG-0.4/100		100	150	600	800	2200	Floor-standing
HTSVG-0.4/133		133	200	800	800	2200	Floor-standing
HTSVG-0.4/165		165	250	800	800	2200	Floor-standing
HTSVG-0.4/200		200	300	800	800	2200	Floor-standing
HTSVG-0.4/266		266	400	1000	1000	2200	Floor-standing
HTSVG-0.4/330		330	500	1000	1000	2200	Floor-standing
HTSVG-0.4/400		400	600	1000	1000	2200	Floor-standing
HTSVG-0.69/120	0.69	120	100	800	1000	2200	Floor-standing
HTSVG-0.69/180		180	150	800	1000	2200	Floor-standing
HTSVG-0.69/240		240	200	1000	1000	2200	Floor-standing
HTSVG-0.69/360		360	300	1000	1000	2200	Floor-standing

Table1: HTSVG LV STATCOM selection table

5. Installation instructions

5.1. Installation environment requirements

HTSVG STATCOM should be mounted on a firm foundation reliably and kept in vertically position. Proper clearance around the STATCOM is required for easy installation, maintenance and equipment ventilation.

Avoid direct sun exposure, fire, high temperature, rain, moisture as well as inflammable or corrosive gas in the installation environment. The ambient environment should meet the requirements which are specified in Table 12.

5.2. Mechanical mounting

Make sure all the external cable connections are removed

Move the equipment with care and avoid violent turbulence or shock during transport.

5.3. Electrical connections

Basic functionality of HTSVG STATCOM can be obtained after connection of:

- Earth bar (PE).
- Three power cables
- Three current transformers

5.3.1. Earthing connection

Each HTSVG LV STATCOM has an earth bar (PE-point/Earth symbol) in the bottom part, as illustrated in Fig.3. For safety reasons and for proper operation, the earth bar must be connected to the installation's earth (PE-point). When the HTSVG LV STATCOM system consists of more than one unit, all the earth bars must be connected directly to the installation's PE-point individually and additionally, all the earth bars must be interconnected. The proper sizes of earth conductor are given in Table 2 in Section 5.3.2.2.

5.3.2. Power cable connection

5.3.2.1. Before connecting HTSVG STATCOM to mains power

Make sure the grid voltage and frequency are within the range of nominal value.

The routing of external cables should comply with international and local electrical installation regulations and standards. The cable size and cable terminals should be adequately rated in order to carry the currents of HTSVG STATCOM safely during operation.

Make sure that the HTSVG LV STATCOM is isolated upstream from the mains power of the installation area and the incoming circuit breaker in the HTSVG LV STATCOM is in OFF position during installation.

Make sure that cable terminals or lugs should be tightened adequately to provide good contact and the enclosure of the STATCOM is grounded reliably.

5.3.2.2. Power cable size selection

For power cables with cross-section above 120mm^2, multiple cables with the same cross-section in parallel is recommended to avoid skin effect

Due to the fact that the site conditions, such as ambient temperatures of cable ducts or cable trenches, quantity of cables in parallel, cable routing methods, varies greatly, there are many practical factors needed to be taken in consideration in terms of selection of proper cable size. For this reason, the information of cable size selection in Table 2 is for general guideline only.

Copper busbar connection is recommended for applications with higher currents.

Rated current (A)	Single core cable (mm^2)	PVC insulated and sheathed three or four-core cable (mm^2)	Earth conductor (mm^2)
30	6	3×10	6
50	10	3×16	10
75	16	3×25	16
100	25	3×35	16
150	50	3×70	25
200	70	3×95	35
250	95	3×150	50
300	120	3×185	70
400	185	3×300	95
500	300		150
600	400		200

Table 2: Guideline for HTSVG power cable selection

5.3.2.3. Connecting the power cables

Please follow the steps below:

1. Route the power cables to the power cable terminals or the main incoming circuit breaker within the HTSVG STATCOM

2. Make sure the phase sequence of power cables to be positive, otherwise the phase sequence alarm will go off.

3. Connect the power cables to their corresponding terminals within the HTSVG STATCOM in accordance with the cable connection diagram which is another document coming with the equipment. Tighten the connection firmly.

4. Tie up and fix the cables properly

5.3.3. External current transformer connection

5.3.3.1. Selection of CTs and signal cables

HTSVG LV STATCOM requires three external CTs to measure the source or load current. The accuracy class of the CTs should be better than 1% and the secondary rating must be 5 Amp.

The CT signal cables are required to be THREE 2.5mm^2×2 twisted-pair cables with sheath or shield.

The selection of CT power burden should depend on the length of CT signal cables due to the fact that the longer the signal cables are, the higher the power loss through the cables is. Consequently, the CTs should be rated greater than or equal to the values specified in the Table 3.

	Actual current value of CTs	2.5mm^2×2 signal cable length							
		10m	20m	30m	40m	50m	60m	80m	100m
Minimum power burden of CTs (VA)	5A	5	10	15	20	25	30	40	50
	3.5A	2.5	5	7.5	10	12.5	15	20	25
	2.8A	2.5	2.5	5	5	7.5	7.5	10	12.5

Table 3: CTs' power burden versus signal cable length

Excessively long signal cables will lower the measurement and compensation accuracy of HTSVG STATCOM. If the power rating of CTs is lower than the line loss, CT overheating or damage could occur.

5.3.3.2. Connecting CTs

Depend on specific site conditions, connect the CTs, signal cables as well as CT terminals within the STATCOM in accordance with the right connection method as shown in Fig.7 and Fig.8, and keep the contact firm. Make sure the phase sequence of signal cables correspond to that of power cables, and ensure the polarity of CTs is correct.

Please note that the secondary of any CT is not allowed to be open circuited. Otherwise, damage to CT or electrical shock may occur. The S2 terminals of CTs should be earthed reliably to avoid electrical shock!

Depending on the specific site conditions, the external CTs can be located on the load side or source side. Please connect the external CTs as shown in Fig.7 and set the "External CTs position" setting, which is mentioned in Section 6.5.6.2.1, on the touch screen, during the commissioning.

Please note that the input terminals of the CTs are usually short-circuited when out of factory. Please provide short-circuit kits according to the external CT connection method.

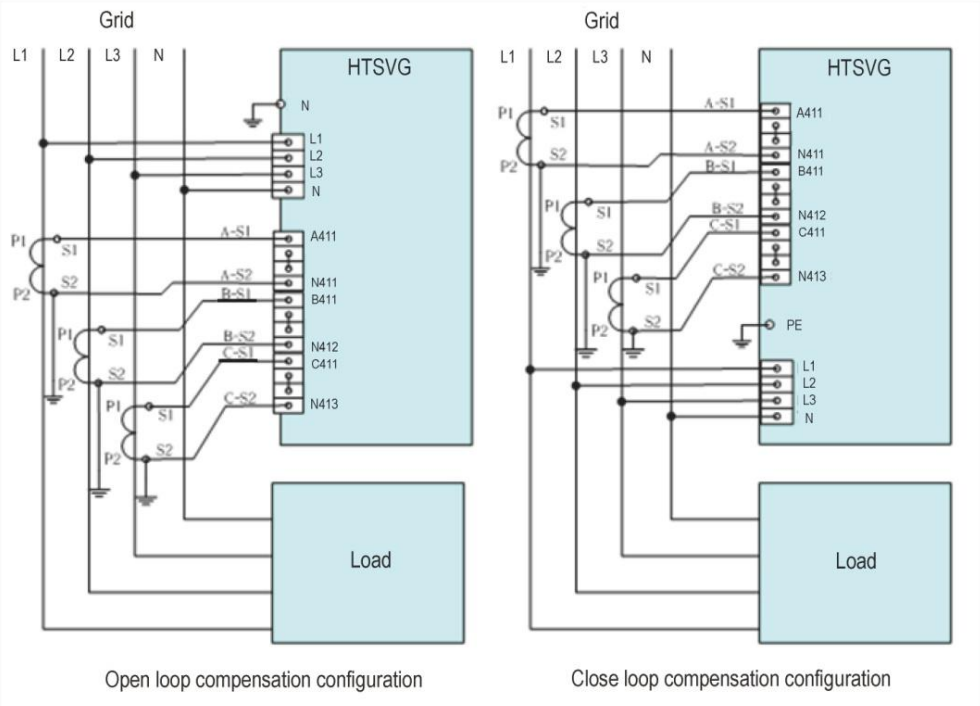

Fig.7: CT connection diagram

5.3.4. Multiple units in parallel operation

Multiple HTSVG STATCOMs can operate in parallel. Users can assign compensation current between the units. Please refer to the Section 6.5.6.3 and Section 7.2 for detailed information. Fig.8 indicates the connection method for double-unit application and the connection methods for applications with more than two HTSVG STATCOMs are similar. It's recommended using the open loop compensation, where the CTs are located at the load side, as shown in Fig.8. For application of parallel operation, users can use one set of CTs or multiple sets of CTs to measure the currents as long as the CTs are properly rated.

Theoretically there is no limit to the number of HTSVG STATCOM in parallel. However, as the number of units in parallel increases, so does the fault points of the whole system and the system reliability is lower as a result. It's recommended that no more than four HTSVG STATCOMs operate in parallel.

Please set the "Output percentage" on the "Service settings" page on every HTSVG LVSTATCOM in parallel according to Table 10. during commissioning.

Wrong "Output percentage" setting could lead to under-compensation or over-compensation

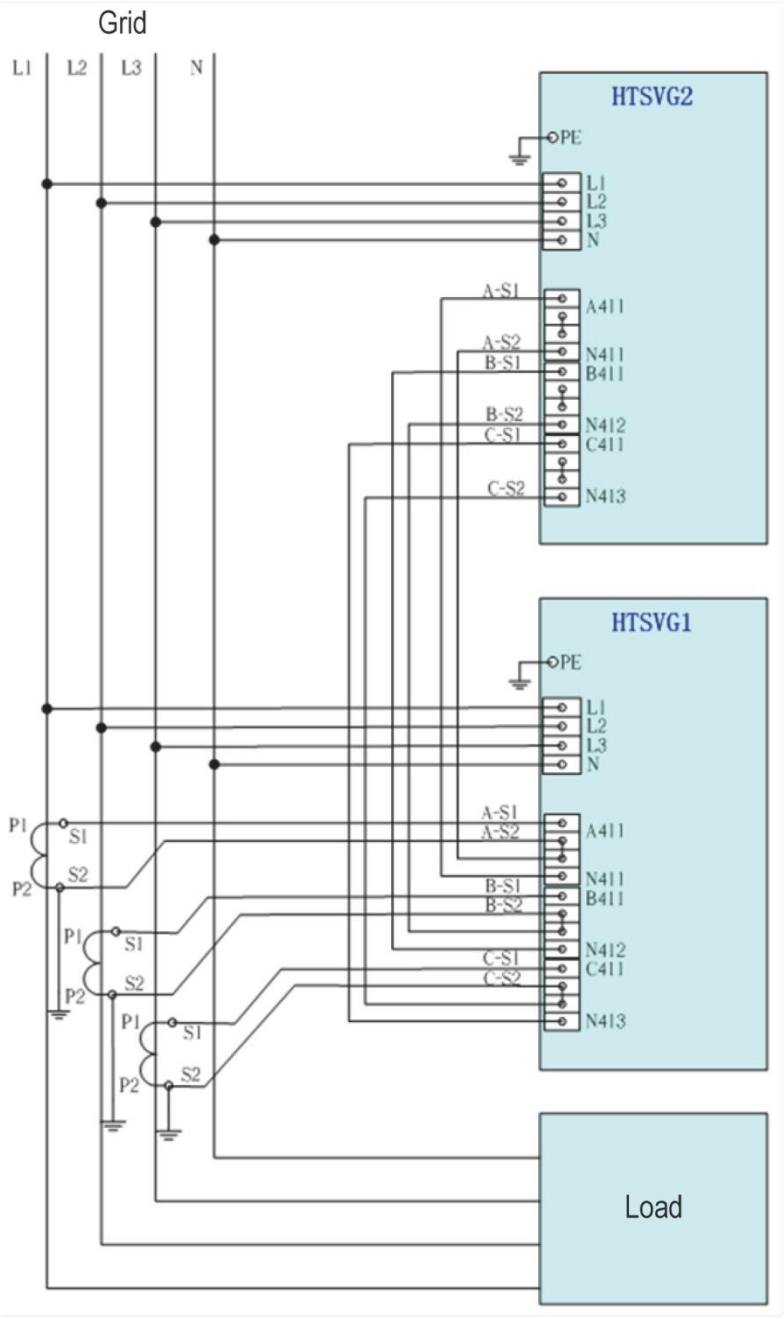

Fig.8:3 Connection diagram for double-unit parallel operation

5.3.5. Complex electrical distribution system

Complex electrical supply system with multiple power supplies or multiple transformers, please contact the manufacturer and provide detailed information, including distribution system diagram, for specific solutions.

6. User interface

6.1. Introduction

The user interface of HTSVG LV STATCOM is based on a 7-inch/10.1-inch touch screen while the wall-mount or rack-mount models with small kVAr ratings employ a 4.3-inch touch screen. The user interface will be described via the most used 7-inch touch-screen for the sake of convenience.

6.2. Hardware specification

The 7-inch touch screen used is a 4-wire resistive touch screen with resolution of 800×480. It is fitted with a RS232/RS485 interface for master PC monitoring, and a TCP/IP network interface for Ethernet monitoring as well as a USB port.

Front View Rear View

Fig.9: Exterior of HTSVG's touch screen

6.3. Remote communication

HTSVG LV STATCOM can perform remote communication through this touch screen. The default communication interface is RS232. RS485 and TCP/IP communication is viable with this touch screen.

6.4. Welcome page upon power-on

Upon HTSVG powered on, the welcome page will display as in Fig.10 and then a progress bar will display. There is no need to do any operation at this stage. After the process bar is finished, the system will enter into the main page of HMI.

Fig.10: Welcome page

6.5. Introduction of the HMI

There are 7 pages of the HMI for setup and display of all status and settings. Their functions are listed below in Table 4, users can press the navigation buttons at the right hand area of the main page to enter corresponding pages.。

Item	Description and function	
“Main” page	Display all the important electrical parameters. User can perform stop or start operation on this page	
“Waveforms” page	Voltage and current waveform display, including grid voltage waveforms, source current waveforms, load current waveforms and compensation current waveforms	
“Spectrum” page	Display the specific information of fundamental current I_S and harmonics up to 50th order, including THD bar chart, current values and percentage composition.	
“Status” page	User can check all the failure status in this page	
“History” page	Event log with time stamp of STATCOM operation history and abnormal status	
“Settings” page	“User settings” subpage	Settings for general parameters and harmonic orders to be compensated. Default password is “1”
	“Service settings” subpage	Including settings modified by on-site engineers during on-site commissioning according to site conditions. Please contact manufacturer for password.
	“Factory settings” subpage	Only for commissioning at factory, not accessible to users
“Contact Us” page	Manufacturer Contact information	

Table 4: List of pages of the HMI

6.5.1. Main page

6.5.1.1. Buttons and parameters on the Main page

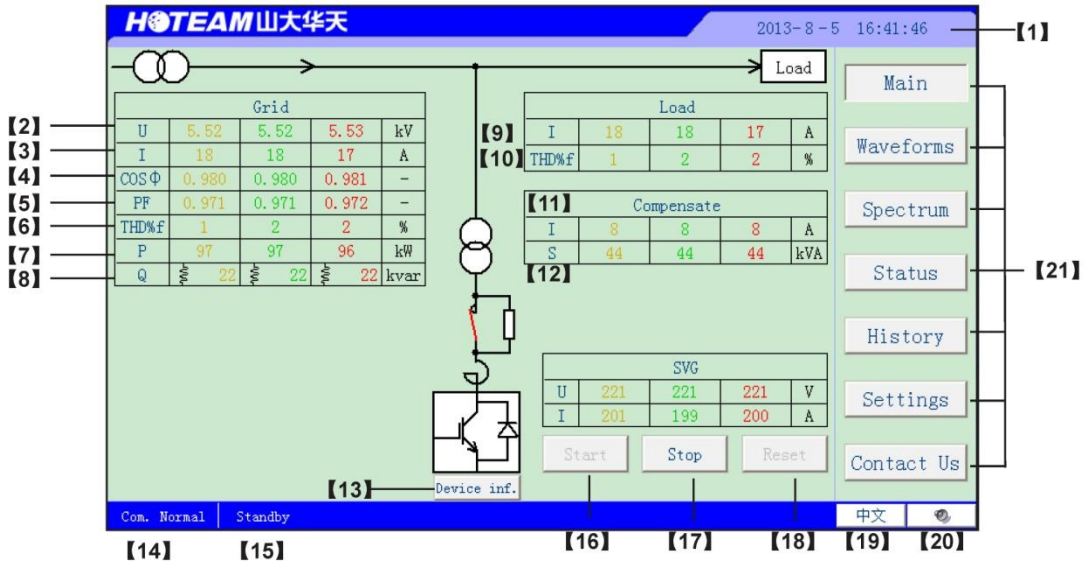

Fig.11: Main page of HMI

Item	No.	Designation	Description
System clock	1		Real-time clock which also serving as time base for event log
Grid voltage	2	U	The RMS value of line-to-neutral voltage at the connection point in the grid
Source current	3	I	The RMS current value at the source side, which is indicated as I_S in Fig 1
COSø	4	COSø	Value of COSø at the source side
PF	5	PF	Value of PF at the source side
THDi at the source side	6	THD%f	Value of THDi of the source current I_s in Fig.1
Active power at the source side	7	P	Value of active power at the source side
Reactive power at the source side	8	Q	Value of reactive power at the source side
Load current	9	I	The RMS current value of the load current, which is indicated as I_L in Fig 1.
THDi at the load side	10	THD%f	Value of THDi of the source current I_L in Fig.1

Compensation current	11	I	The RMS current value of the compensation current, which is indicated as I_C in Fig.1. If the STATCOM is connected to the grid with a step-up transformer, the compensation current is the current at the primary side of the transformer.
Output power	12	S	The value of apparent power of the STATCOM
“Device Inf. ”button	13		A pop-up window containing specific parameters of inverters would display when clicking this button
Communication status	14		Indicating the communication status between the touch screen and the controller
Equipment status	15		Indicating the system status, i.e. “Normal”, “Standby” or “Fault”
“Start” button	16		Click this button to start the STATCOM and then a dialog box will pop up for user to confirm this operation.
“Stop” button	17		Click this button to stop STATCOM operation and then a dialog box will pop up for user to confirm this operation
“Reset” button	18		Click this button to reset a failure which is already fixed
Language button	19		Click this button to switch between system languages, i.e. English or Chinese
Mute button	20		Click this button to mute the alarm when failure
Navigation Buttons for all individual pages	21		Click those buttons to enter corresponding pages

Table 5: Parameters and status on the Main page

Please click the “Device inf.” button to view the inverter information in a pop-up window shown as below:

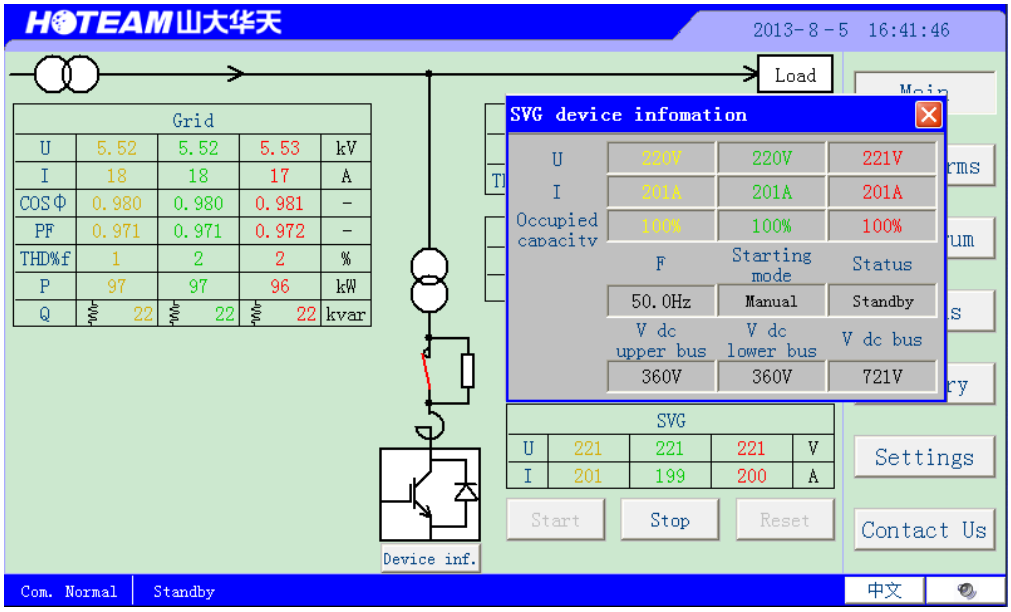

Fig.12: Pop-up window for inverter information

6.5.1.2. Start and Stop button on the Main page

The starting or stopping operation of HTSVG STATCOM can be done by the following four methods:

1. Manual control via “Start” or “Stop” buttons. When the STATCOM in the standby mode, click the “Start” button and then a dialog box will pop up for confirmation. Click the “OK” button and the STATCOM will be in operation. Likewise, when the STATCOM in operation, click the “Stop” button and a dialog box will pop up. Click the “OK” button to stop the STATCOM and the equipment will enter into standby mode.

2. Automatic power-on starting mode: The HTSVG STATCOM will perform a POST (power-on self test) upon being energized. In this mode, the STATCOM will start automatically immediately if the POST is past. Users can set the HTSVG LV STATCOM to this mode by setting the “Power-on starting mode” to “Automatic” in the “Customer Settings” page in the Section. Please refer to Section 6.5.6.2.1 for more information.

When the automatic power-on starting is enabled, users can still stop the HTSVG LV STATCOM manually by click the “Stop” button mentioned above.

3. Remote control via digital input signals: the equipment can be stopped and started via digital input signals. This function is only available on request when placing order.

4. Remote control via communication interface: the equipment can receive start or stop instructions via RS232/485 or TCP/IP interface. Once again, this function is only available on request when placing order.

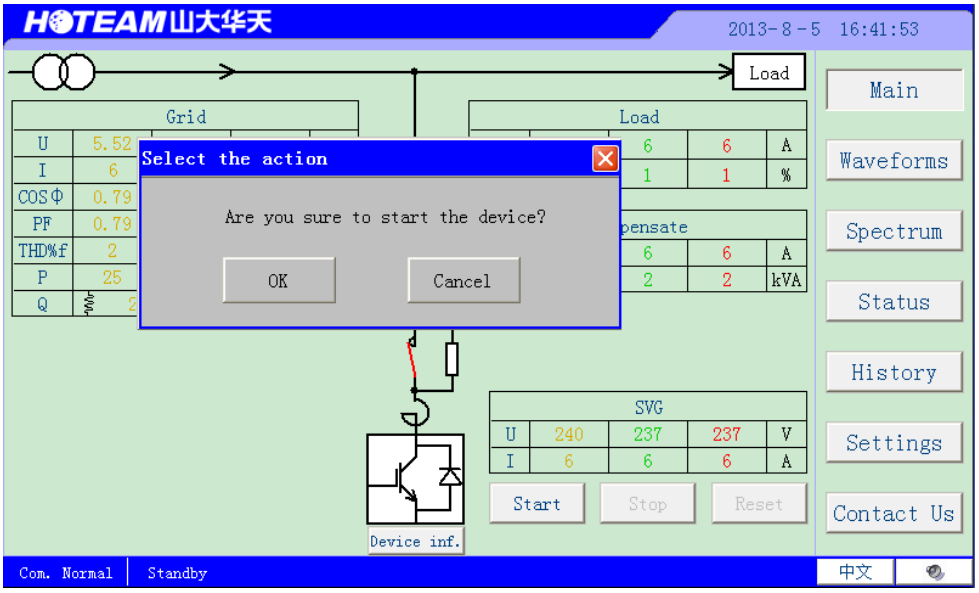

Fig.13: Pop-up dialog box for confirmation of starting the STATCOM

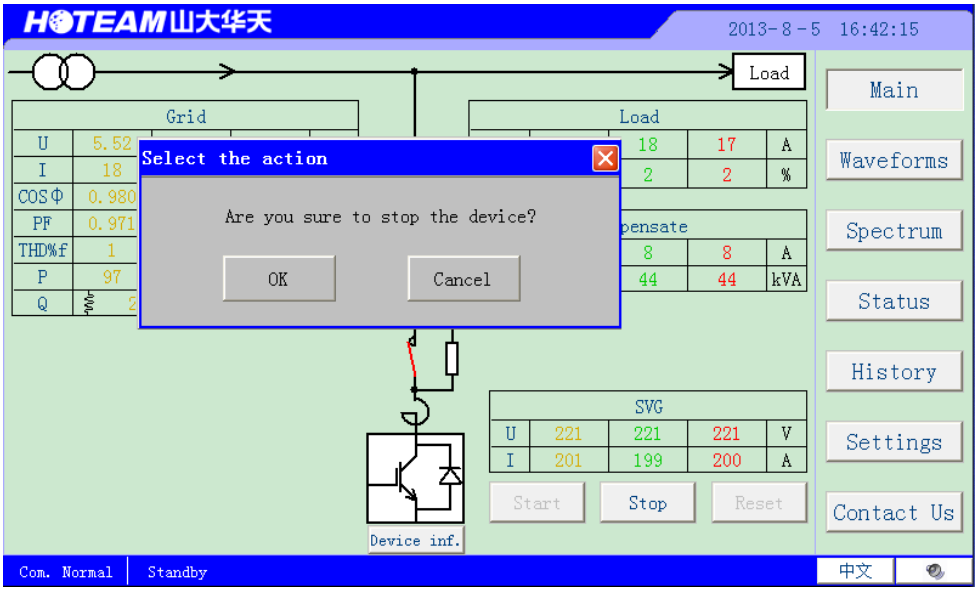

Fig.14: Pop-up dialog box for confirmation of stopping the STATCOM

6.5.2. Waveforms page

HTSVG LV STATCOM can display real-time waveforms of a variety of electrical parameters. The waveforms are correct only if the connections of CTs are done correctly. The waveforms in yellow, green and red are for Phase L1, L2 and L3 (also known as Phase A, Phase B and Phase C) respectively, and the waveform in blue is for neutral current or voltage.

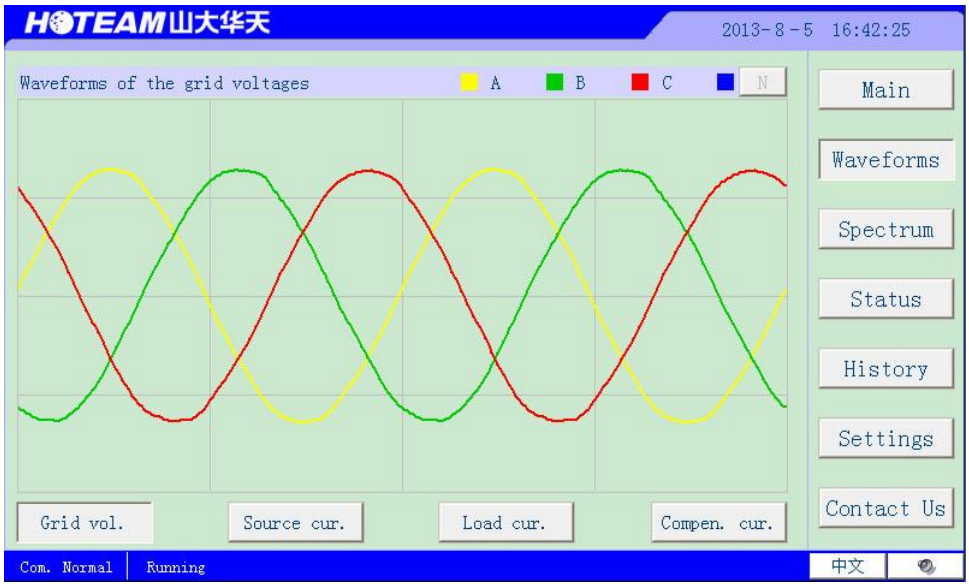

Fig.15:4 Grid voltage waveforms

Fig.16: Source current waveforms

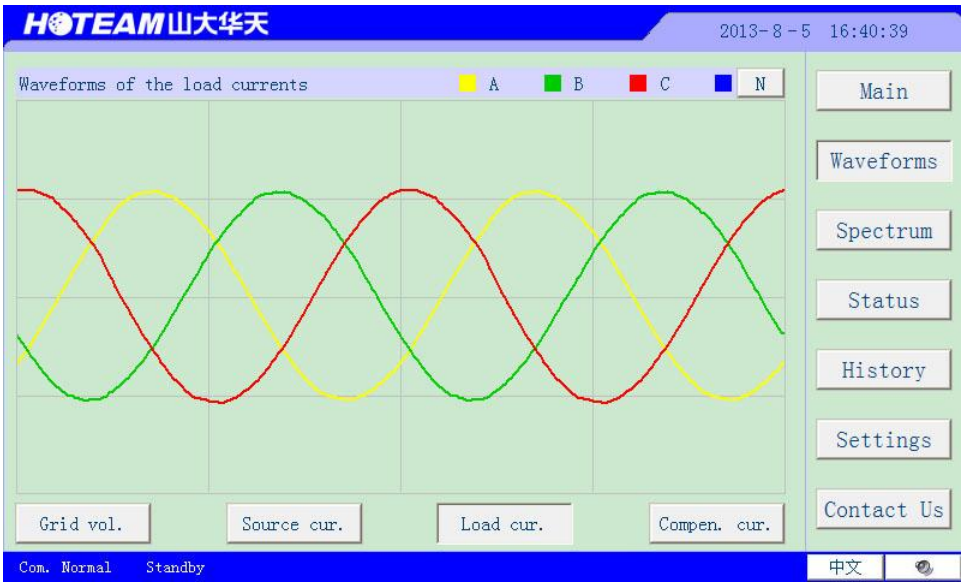

Fig.17: Load current waveforms

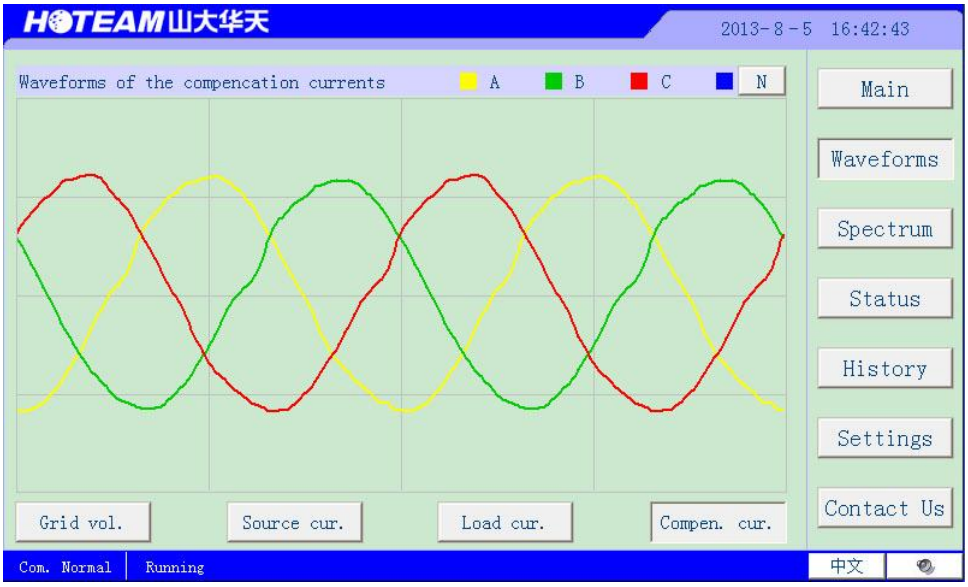

Fig.18: Compensation current waveforms

6.5.3. Spectrum page

HTSVG STATCOM can display the bar chart with percentage composition of harmonic components as well the RMS values of fundamental current and harmonic currents. Please note that the percentage composition of harmonics displayed is defined as:

Percentage composition (%) = current value of a certain harmonic order/fundamental current value*100%.

So in case the fundamental current is near zero, the bar chart will exceed the limit of 100%

Fig.19: Spectrum page

6.5.4. Status page, alarms and warnings

6.5.4.1. Status display on the Status page

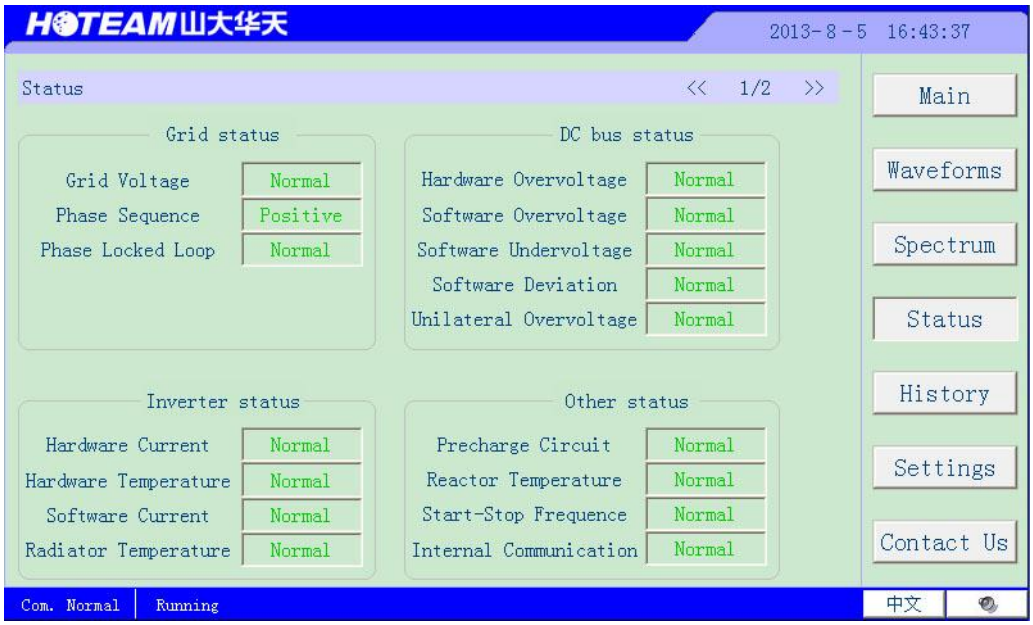

Fig.20: Status page (1/2)

Fig.21: Status page (2/2)

Designation	Description	Related location	Abnormal condition
Grid Voltage	Grid voltage status	Grid connection point	Display as “Abnormal” due to under-voltage or over-voltage
Phase Sequence	Phase sequence status		Display as “Abnormal” due to positive phase sequence
Phase Locked Loop	PLL status		Display as “Abnormal” due to PLL loss of lock
Hardware Current	Current value signal from sensor within the inverter	Inverters	Display as “Protection” and Hardware over-current protection tripped
Hardware Temperature	IGBT temperature sensor signal		Display as “Protection” and IGBT over-temperature protection tripped
Software Current	Controller calculation value of output current		Display as “Protection” and Software over-current protection tripped
Radiator Temperature	Radiator temperature senor signal		Display as “Protection” and Radiator over-temperature protection tripped
Hardware Overvoltage	Sensor signal of DC bus voltage	DC bus	Display as “Protection” and Hardware overvoltage protection tripped
Software Overvoltage	Controller calculation value of DC bus voltage		Display as “Protection” and Software overvoltage protection tripped
Software Under-voltage	Controller calculation value of DC bus voltage		Display as “Protection” and Software under-voltage protection tripped
Software Deviation	Controller calculation value of voltage difference between the two DC buses		Display as “Protection” and Software Deviation protection tripped due to large voltage difference.
Unilateral Overvoltage	Voltage sensor value of single DC bus		Display as “Protection” and Unilateral Overvoltage protection tripped
Pre-charge Circuit	ON/OFF position of the pre-charge contactor	Other	Display as “Abnormal” due to the pre-charge contactor in OFF position

Reactor Temperature	Reactor temperature sensor signal		Display as “Protection” and Reactor temperature protection tripped due to over-temperature
Start-stop Frequence	The frequency of equipment start-stop operation		Display as “Protection” and Start-stop Frequence protection Tripped due to frequent start-stop operation of HTSVG
Internal Communication	Controller internal communication status		Display as “Abnormal”
External CT	Operation status of external CTs		Display as “Abnormal”
Circuit Breaker	Status of the incoming circuit breaker		Display as “Abnormal” when it’s faulty
Load Current	Load current status		Display “Low” when load current is very small
Overload	Harmonic overload status		Display as “Yes” when harmonic current overload occurs
Inside CT	Operation status of CTs within the STATCOM		Display as “Abnormal”
Remote lockout	Remote lockout enabling signal status		Display “Enable start” or “Disable start”

Table 6: Equipment status information table

6.5.4.2. Failure alarms

In case of failure during operation, the buzzer will go off. The alarm will stop if the cause is no longer present. Please note that, during the POST, failure alarms might go off and will stop automatically if the POST is past.

Click the Mute button to stop the alarm before the cause is rectified. However, when a new failure happens, the alarm will go off again.

6.5.4.3. Warning messages

In the event of abnormal conditions during operation, warning messages will pop up. These warning messages can be closed manually. When there are multiple warning messages popping up, users can enter into the “Status” page to check specific

information. These warning messages will be closed automatically after the causes are no longer present.

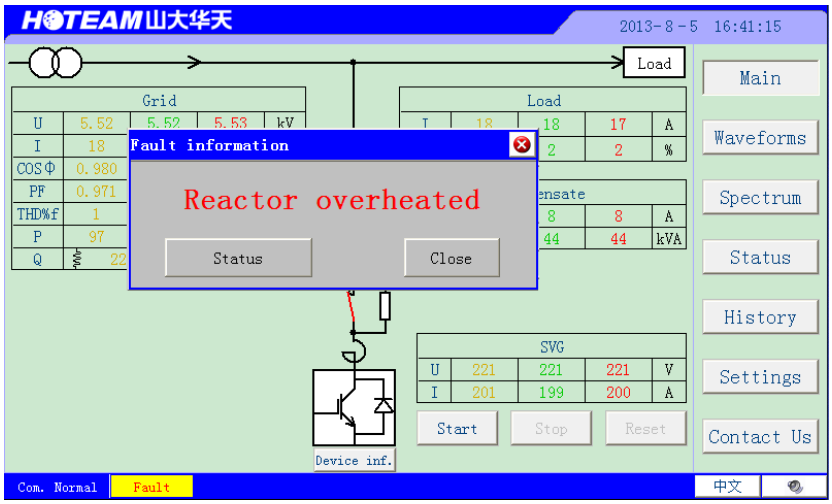

Fig.22: Pop-up warning message

6.5.5. History page

Click the “Page up” button or “Page down” button to view all the failures, warnings, operation records and status within the last month. Please calibrate the system clock regularly due to the fact that it serves as the time base for logged events.

Fig.23: History page

6.5.6. Settings page

6.5.6.1. Entering into Settings page and changing settings

There are three levels of settings, i.e. “Customer settings”, “Service settings” and “Factory settings”, which are only accessible to personnel with different levels of access authorities.

To ensure operation safety, all the settings are password protected and only qualified technical personnel can be allowed to change them. **Please note that change of all settings can only be done when the STATCOM into standby mode and some settings are not changeable. For example those harmonic related settings cannot be changed on standard HTSVG LV STATCOM without harmonic compensation.**

Fig.24: Login window

Click the “Settings” button on the Main page and a login window as shown in Fig.24 will pop up. The default user account is “User” and the password is “1” as default. Click the “OK” to enter the Customer settings page. Click the pull-down menu and choose “Service settings”, type the password acquired from the manufacturer to enter into Service settings page.

To change the numeric-type settings, such as “Target COSø”, click the text field and a numeric input window will pop up. Type the desired value and click “OK” to close the input window. View the value in the text field to check if the setup is done successfully.

To change character-type settings, such as “Power-on starting mode”, click the text field and choose the desired setting from the options.

6.5.6.2. Customer settings subpage

Due to the fact that there are too many items of customer setting, all the items are grouped into three sections by their functions. Users can click three buttons at the bottom, i.e. “General”, “Harmonic” and “Remote commu.” to change various settings.

6.5.6.2.1. General customer settings

Fig. 25: General customer settings

Designation	Function description
Filter mode	This setting allows user to choose H-type HTSVG working mode
Target COSø	Target COSø
Current to stop fans	The output current threshold (in terms of percentage of rated output current) determining if the fans needed to be turned off to extend lifespan
Energy saving mode	This setting allows HTSVG entering into standby mode when the grid current is very small
Energy saving threshold	The current threshold value of energy saving mode
Power-on starting mode	This setting allows HTSVG LV STATCOMs starting automatically when powered on without pressing the Start button manually. It can be set to “Automatic” or “Manual”
External CT ratio	The value should be consistent with the ratio of

	external CTs
External CT position	The external CTs of HTSVG can be either on load side or on source side depending on site conditions. This setting should be set according to actual CT position.

Table 7: General customer settings

6.5.6.2.2. Harmonic settings" subpage (only effective on H type HTSVG STATCOM)

Users must log into the "Customer setting" page first and click the "Harmonic" button at the bottom to enter into the "Harmonic settings" subpage.

Click the input boxes labeled as "Select" to switch on or off the compensation of a certain harmonic order

Change the harmonic compensation settings randomly can cause system resonance, or protective relay tripping and damage to STATCOM in extreme cases. For this reason, this operation should be done by professional personnel only!

Fig.26: Harmonic customer settings

6.5.6.2.3. Remote communication customer settings

Remote communication can be done between the touch screen and a master PC. The default interface is RS232. If RS485 interface is required, an additional converter module is needed and please specify when placing the order. Whether RS232 or RS485 is used, Modbus RTU protocol is mandatory.

Remote communication settings can be changed according to user's requirements, which are given below in Table 6.

Parameter	Options
Communication protocol	Modicon Modbus RTU protocol
Communication mode	One master to one slave, one master to multiple slaves where PC serves as the master and HTSVG the slave
Device ID	1～247，1 as factory default setting
Baud rate（bps）	2400, 4800, 9600 as factory default setting, 19200, 38400, 57600, 115200
Data bits	8
Stop bit	1 as factory default setting, 2
Parity bit	EVEN Parity as factory default setting, ODD Parity, NONE
Minimum cycle time	1000ms

Table 8: Remote communication settings

Please note that communication error such as data loss may occur when the operating cycle of PC master to HTSVG is less than 1000ms

Fig.27: Remote communication customer settings

6.5.6.3. Service settings page

The parameters in this page should be set according to the specific site conditions. Failure to do so can cause malfunction of HTSVG LV STATCOM.

This page is dedicated to parameter settings before HTSVG put into operation and it is password protected. The password is not available for end users. Only the after-sales engineers of the manufacturer or authorized distributors can set parameters in this page. The meanings of the parameters in this page are shown in Table 9 below.

Fig.28: Service settings page

Designation	Description
T primary	Primary voltage class of the step-up transformer
T secondary	Secondary voltage class of the step-up transformer
Connection mode	Set to “Four-wire” when equipment connected to neutral conductor Set to “Three-wire” when equipment is not connected to neutral conductor. This is a preset setting by factory. Usually no need to change it
Grid F	Grid frequency, 50Hz as default

Output percentage	This setting allows for assigning compensation current between multiple HTSVGs in parallel. For single unit, this setting should be 95~100%. For multiple units in parallel, please refer to Table 10 for proper value.
Voltage feedback	Change this setting to mitigate or reduce system resonance. It is usually set to 0%. If need to be changed, please contact the manufacturer. Impropriate change of setting will only make system more unstable.
Target THDf	The target THDi of source current (only effective on H type model). It's usually set to 0% for best harmonic compensation effect
P factor	This setting is the percentage of rated power used for three-phase active power unbalance compensation. 0% means no compensation and 100% means all rated power used for unbalance compensation. Usually P factor is set to 0% to save equipment capacity
Remote lockout	Setting for enable or disable the remote lockout function. When remote lockout is enabled, the HTSVG LV STATCOM can be started only if the digital input signal of remote lockout is "enable starting"
Harmonic compensate	Indicate the maximum capacity used for harmonic compensation (only effective on H type model)

Table 9: General customer settings

6.5.6.4. Factory settings page

The "Factory settings" page is only accessible to factory commissioning engineers. Users have no access to this page.

Entering into "Factory settings" page to change settings would lead to equipment damage or electrical distribution system disturbance.

6.5.7. “Contact US” page

Fig.29: Contact Us page

6.6. Touch Screen Maintenance

6.6.1. Set the clock

Click the system clock display area on every page. Type the right time value into the numeric input window popped and click “YES” .

System clock as the time base for event log should be kept precise.

6.6.2. Replace battery

During operation, if system clock is obviously slower or back to initial value, this is possible because system clock backup battery is nearly dead. Please replace system clock backup battery.

Battery model is used is CR2032 3V non-chargeable lithium battery.

6.6.3. Touch screen calibration

When the process bar shows up after touch screen powered on，click any place on the screen using a touch pen or finger tip to enter into calibration page. Wait for 30 seconds and the system will start the calibration process automatically.

During calibration, keeping pressing the center of the cross cursor via touch pen or finger tip and release when the cross cursor moves to next point. Repeat the step above with the new center of the cross cursor until the prompt indicating the calibration has been effective. Then click anywhere on the screen to quit calibration program.

7. Commissioning instructions

7.1. Commissioning steps

1. Check the mechanical installation, electrical connections in accordance with this manual

2. Supply the mains power to HTSVG STATCOM. Measure the grid voltage with voltmeter to make sure grid voltage is normal.

3. Switch on the incoming circuit breaker and then check the grid voltage and current waveforms are normal. The “Power” indicator should be lighted up at the same time.

4. The HTSVG STATCOM enters into power-on self test (POST) automatically. The POST period would last for a period from one to five minutes. Upon the POST, the equipment will enter into standby mode.

5. For more detailed information, please follow the flow chart as shown in Fig.30.

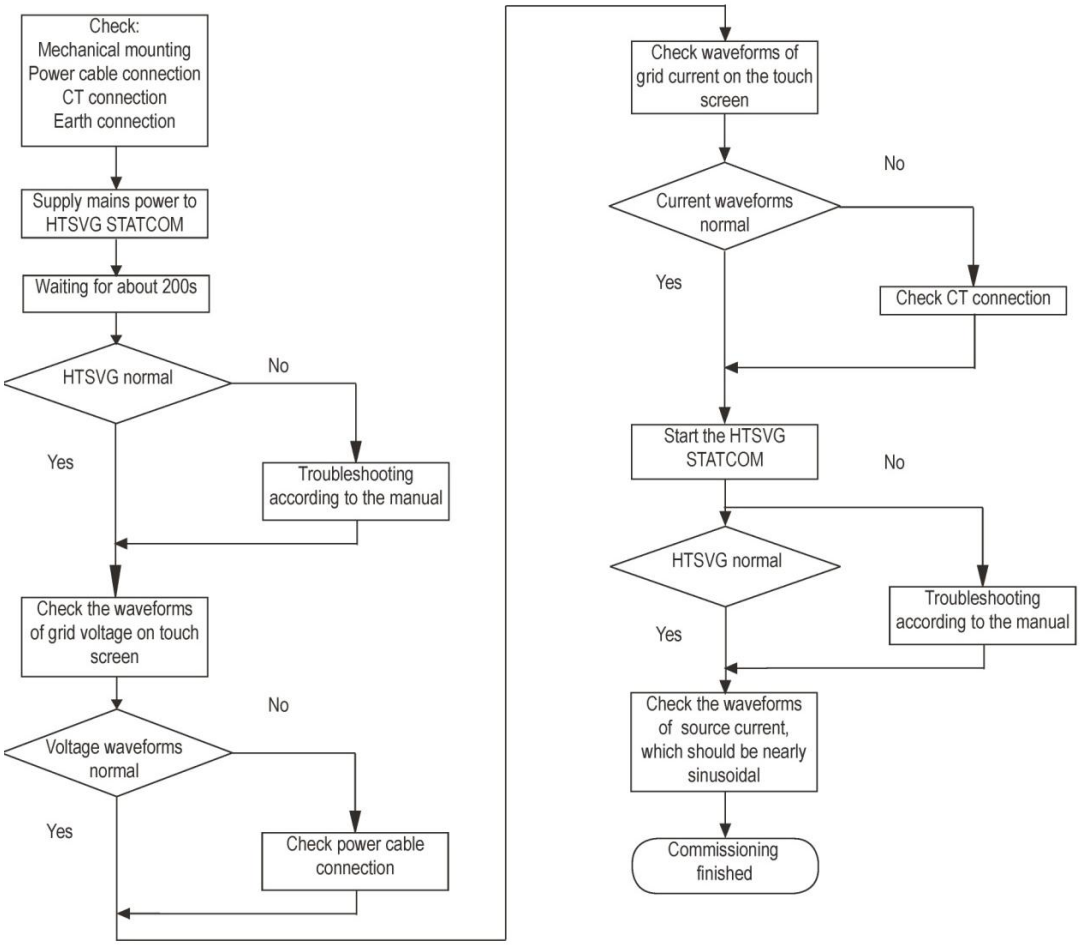

Fig.30: Commissioning flow chart for HTSVG LV STATCOM

6. Use a power quality analyzer to check waveforms of voltage or current displayed on the touch screen are normal. To do this, compare the waveforms and readings of voltage and current on the power quality analyzer to those on the touch screen. In case there is no power quality analyzer available, please compare waveforms display to the waveforms as shown in Fig.15 and Fig. instead as an improvised measure.

7. If the phase sequence status shows “Negative”, please disconnect the HTSVG LV STATCOM from the mains power, which is required to turn off the dedicated switch in the upstream switchgear. Swap any two of the power cables and make sure the phase sequence of CTs correspond to that of power cables, and repeat Step 3. After the phase sequence status is normal, proceed to the next step.

8. Use power quality analyzer to compare the power factor values before and after HTSVG LV STATCOM is started. The fact that the power factor after HTSVG is started is raised to target value indicates that the equipment is working normally.

9. Set the power-on starting mode and working mode according the custom’s requirement.

7.2. Special commissioning for parallel operation

When multiple HTSVG STATCOMs in parallel, commissioning steps mentioned above should be done on all the STATCOMs individually. After it’s done, set the “Output percentage” on the “Service settings” page on every HTSVG LV STATCOM to assign compensation current, according to the guideline in Table 10.

Configuration methods		HTSVG A	HTSVG B	HTSVG C	HTSVG D
1	Output capacity	X	X		
	Output percentage	50%	50%		
2	Output capacity	X	X	X	
	Output percentage	33.3%	33.3%	33.3%	
3	Output capacity	X	X	X	X
	Output percentage	25%	25%	25%	25%
4	Output capacity	X	Y		
	Output percentage	X/(X+Y)	Y/(X+Y)		
5	Output capacity	X	Y	Z	
	Output percentage	X/(X+Y+Z)	Y/(X+Y+Z)	Z/(X+Y+Z)	
6	Output capacity	X	Y	Z	W
	Output percentage	X/(X+Y+Z+W)	Y/(X+Y+Z+W)	Z/(X+Y+Z+W)	W/(X+Y+Z+W)

Table 10: Output percentage setting guideline

8. Operation instructions

8.1. HTSVG primary circuit operation

Connection to or disconnection from the mains power can be done by means of switching on or off the main incoming circuit breaker of the equipment. For those circuit breakers with electrical operating mechanism, user can perform this operation via switch-on or switch-off button on the panel of circuit breaker. User can also perform fast switch-off via “Emergency stop” button of the HTSVG LV STATCOM. Make sure the “Emergency stop” button is released when switching on the incoming circuit breaker.

8.2. Start and Stop operation

The HTSVG LV STATCOM can be put into normal operation after gone through commissioning. To completely stop the equipment, press the “Stop” button on the main page and then switch off the main incoming circuit breaker.

During operation, please keep the front doors closed to avoid electrical shock or accidental operation by unprofessional personnel.

8.3. Emergency stop

Press the “Emergency stop” button or switch off the main incoming circuit breaker on the front door, to disconnect the equipment from mains power under emergency situations.

The operation of pressing “Emergency stop” button in order to disconnect equipment from mains power is allowed in case of abnormal noise, smell and smog from HTSVG LV STATCOM, or severe grid voltage fluctuation as well as distribution system resonance.

9. Maintenance

Pay attention to the warnings, cautions in this manual and particularly the instructions in this section to avoid equipment damage or electrical shock during maintenance operation

1. Check the equipment regularly during operation in order to find and deal with abnormal conditions timely.

2. Keep the ambient environment clear and ensure good ventilation. Clean the air inlets as well as outlets and the dust within the equipment regularly. Disconnect the equipment to the mains power when performing the cleaning operation.

3. The ventilation fans are designed for continuous operation. The lifespan is 5 years. Check the ventilation fans regularly and replace faulty fans timely.

4. For the first time HTSVG STATCOM is powered on after being disconnected to mains power or stored for more than 3 months, please switch on the incoming circuit breaker and let the equipment in the standby mode for at least 10 hours before operation, in order to restore the withstanding voltage of DC capacitors. This purpose of this process is to reform (or reage) the DC capacitors. Without reforming, capacitors may be damaged when the filter starts to operate.

5. Check the system clock regularly to make sure the time error is less than one minute.

10. Troubleshooting

In case of any abnormal circumstance during operation, users can find the possible cause with reference to the Table 11. Then, the user can rectify the cause on his own, if he is capable. If not so, please contact the manufacturer. Please provide at least ten pieces of fault record logged by the equipment and detailed description of the situation.

When a certain failure persists, pressing the “Reset” button no more than three times.

Related location	Abnormal conditions	Possible cause	Solution
Grid connection	Grid Voltage Abnormal	Over-voltage or under-voltage of grid voltage	Check the values of grid voltage and troubleshoot
	Phase Sequence Abnormal	Wrong phase sequence of power cables	Swap any two of the power cables to correct the phase sequence.
	Phase Locked Loop Abnormal	The variation of grid frequency is larger than±2.5Hz or the THDv is too large.	Check the grid and troubleshoot
Inverters	Tripped Hardware Current protection	Severe grid voltage fluctuation	Press the “Reset” button and then restart the equipment
	Tripped Hardware Temperature protection and Radiator Temperature protection	Ventilation fan failure	Replace the faulty fan with the same model
		Clogged air vent	Clean the air vent to keep good ventilation
		Random EMC interference	Press the “Reset” button and then restart the equipment
	Tripped Software Current protection	Grid or load fluctuation	Press the “Reset” button and then restart the equipment
		Internal hall senor failure	Contact the manufacturer
DC bus	Tripped Hardware Overvoltage protection, Software Overvoltage and Software Undervoltage protection	Severe grid voltage fluctuation or random EMC interference	Press the “Reset” button and then restart the equipment
		Internal component failure	Contact the manufacturer
	Tripped Software Deviation protection	“External CT position” setting is not consistent with real CT position	Set the “External CT position” setting according to real CT position
		Internal hall senor failure	Contact the manufacturer
Other	Precharge Circuit Abnormal	Blown fuse in the auxiliary power supply	Replace the blown fuse with the same model
		Grid voltage too low	Check the grid and troubleshoot
	Tripped Reactor Temperature protection	Ventilation fan failure	Replace the faulty fan with the same model
		Clogged air vent	Clean the air vent to keep good ventilation

		random EMC interference	Press the “Reset” button and then restart the equipment
	Tripped Start-Stop Frequence protection	Frequently stop and start the equipment manually	Press the “Reset” button and then restart the equipment
		Frequent stop and start caused by intermittent failure	Check the grid and troubleshoot
	Internal Communication Abnormal	Abnormal function of communications within the controller	Replace the main controller
No effect or worse power factor after compensation		The phase sequence of CTs doesn’t consist with that of the mains power	Check CT connections
		Wrong CT polarity	Check CTs and change polarity
		System resonance	Contact the manufacturer
		CT failure	Contact the manufacturer
Power factor is still lower after compensation		Load reactive current larger than rated reactive compensation current	No problem with equipment. Problem will be solved by increase compensation capacity
Sensitive load malfunction after HTSVG used		HTSVG LV STATCOM is oversized way too much	Contact the manufacturer
		The ripple current filter switch is not switched on	Put this switch in ON position
		System resonance	Contact the manufacturer

Table 11: Abnormal conditions and solutions

11. Specifications

Model	HTSVG□-□/□□□ Low-voltage STATCOM
Functions	
	Suitable for 3 phase, 3 wire system or 3 phase, 4 wire system. HTSVG LV STATCOM is connected to the three phases and provides reactive power compensation, harmonic compensation and 3-phase unbalance compensation
Capacity	20kvar～400kvar per cabinet, please refer to the Table 1 for dimensions
Input	
Nominal voltage	0.4/0.69kV ±15%
Nominal frequency	50/60Hz±2%
Performance	
Reactive power range	100% inductive to 100% capacitive, stepless
Reactive power output characteristic	Current source
Compensation function	Power factor correction, voltage flicker mitigation, harmonic compensation (only available for H type), load unbalance compensation
Response time	Instantaneous response time<0.1mS，full response time≤5ms
Patented technology	Ripple current double-interleaving technology to reduce ripple current
Overload current protection	Automatic current limitation of 100% rated output current
Efficiency	Higher than 97% at full load
CT requirements	3 CTs are required, Class 0.2 or better, secondary rating:5A
External CT position	Source side CT position or load side CT position can be programmable on site
Display and interface	
Language	English or Chinese
Touch screen	Rack-mount model: 4.3-inch touch screen floor-standing model：7-inch or 10-inch touch screen
Communication interface	RS－232，RS-485，TCP/IP
Communication protocol	MODBUS-RTU
Digital I/O	4 digital inputs，2 digital output
Operation configuration	
Single unit operation	YES
Parallel operation	Up to 10 units
Protection class	Rack-mount model：IP2X；Floor-standing model：IP3X；（Please contact manufacturer for higher protection class
Color	Rack-mount model：RAL9004（Black）；Floor-standing model：RAL7035（Light grey）
Dimensions	Depending on model

Operation environment	
Installation environment	Indoor and clean
Ambient te	－10～40℃
Storage temperature	－25～55℃
Humidity	Maximum 90％RH non-condensation
Altitude	Up to 1000m (Higher altitude application with derating)

Table 12: HTSVG LV STATCOM specification

12. Contact Us

Distributor in South Africa :

Energy insight (Pty) Ltd

Address: Route 21 Corporate Park, Nellmapius Drive, Irene, 0157

Tel: +27-12-3455215

Fax: +27-12-3452113

Website: http://www.energyinsight.co.za

Manufacturer:

Shandong Hoteam Electric Co. Ltd

Address：2600 Yingxiu Road，Hi-tech development zone, Jinan City, Shandong Province, China

Post Code： 250101

Tel：+86-0531-82959900

Fax：+86-0531-82670075

Website：http://www.huatian.com.cn/