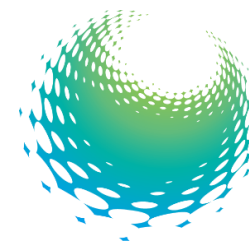


2019

Solid-state AC-Breaker

2020



Sun.King Power Electronics Group Limited
賽晶電力電子集團有限公司

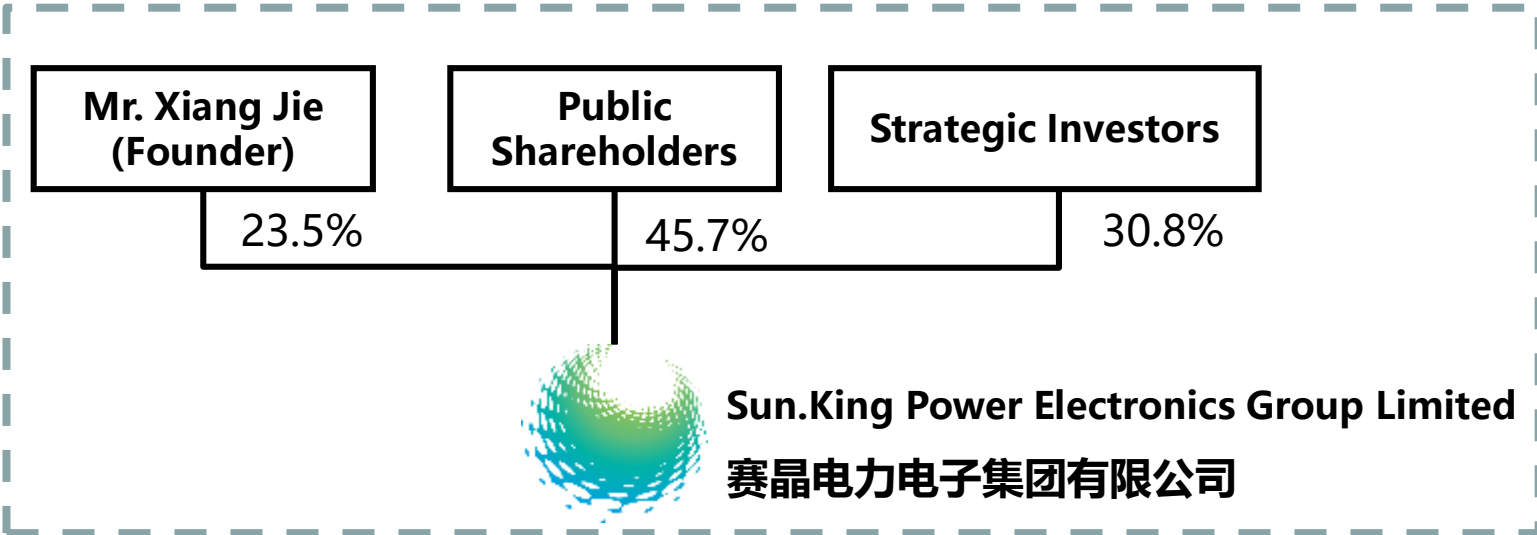
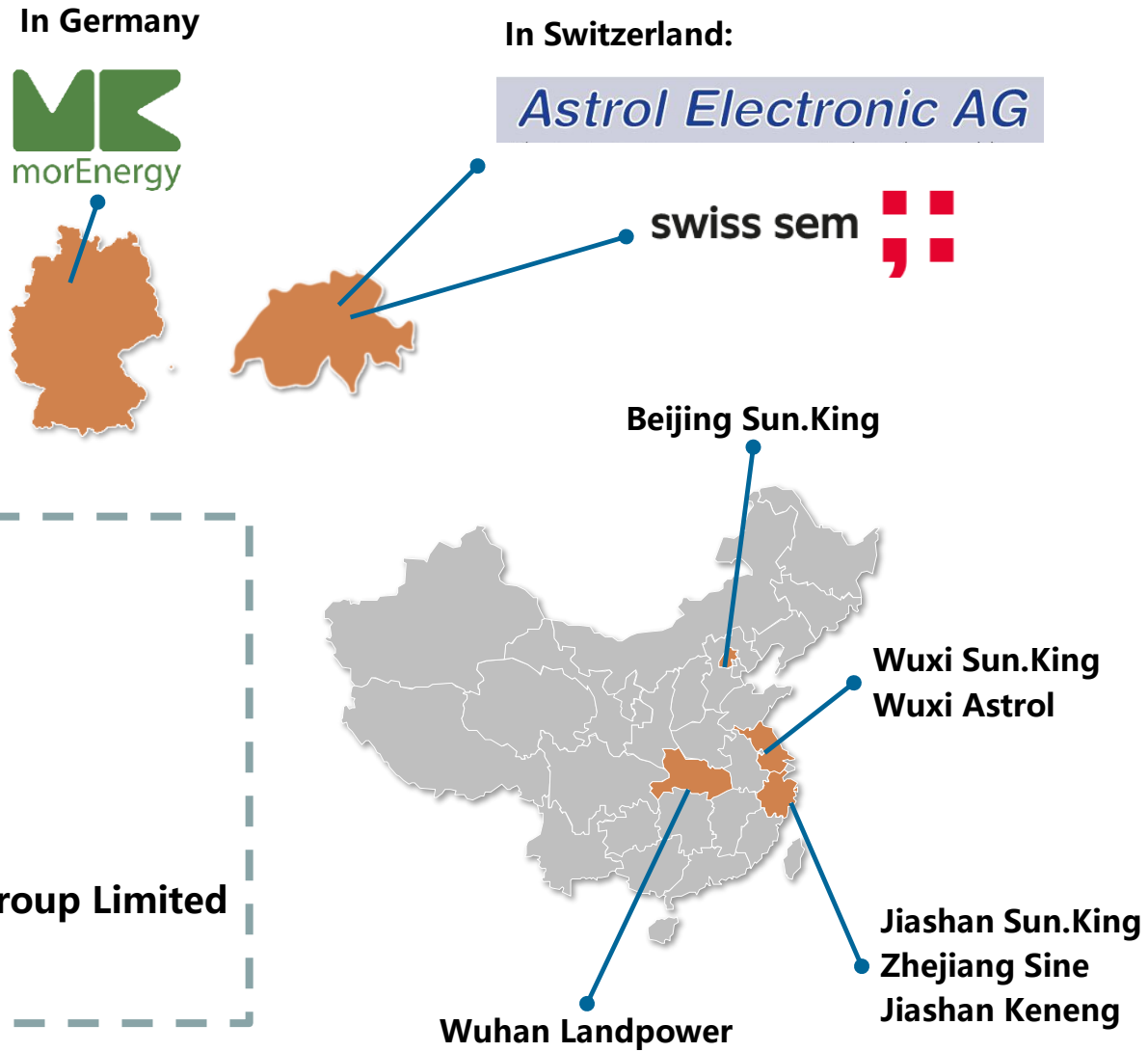
Astrol Electronic AG



Introduction

Stock Code	: 0580.HK
Listing Date	: October 2010
Issued Shares	: 1.616 Billion

Group Companies



Expansion of distribution business to drive growth

2002 - 2009

- 2002 , Sun.King is established and become ABB power semiconductors exclusive agent in China
- 2004 , Jiashan Sun.King was established
- 2008 , Wuxi Sun.King was established
- 2009 , Sun.King has become the **exclusive supplier of IGBT power module in China** for China North Railway 9600KW electric locomotive
- 2009 , anode saturable reactor was launched and Sun.King became the **sole provider in China**.

Remarkable R&D achievements to establish market leadership

2010 - 2015

- 2010 , the Company was listed on the main board of HKEx
- 2011 , its 4 subsidiaries (including Jiujiang Sun.King) were established.
- 2012 , it became exclusive **IGBT power module** supplier for Zhoushan flexible DC transmission project
- 2013 , it won the first **laminated busbar** contract for flexible DC project, the first **power reactor** contract from the centralized tender program of the State Grid
- 2014 , it won the first **power reactor** contract for UHVDC transmission project
- 2014 , it completed the **first aluminum electrolytic isolated operation project in China**
- 2014 , it became the **exclusive IGBT supplier** for Xiamen flexible DC transmission project

Globally leading technology to continue rapid growth

2016 - now

- 2016, the Company acquired Astrol and established its **R&D center in Europe**
- 2016, it launched **digital IGBT driver, solid-state DC circuit breaker, pulse power** and other products with cutting-edge technology
- 2017, **CHTC** and **CVCFL** became its strategic shareholders
- 2018, it successfully developed the **first prototype** of power electronic capacitor for flexible DC transmission in China
- 2018, it started R&D of **digital IGBT driver** for electric vehicles
- 2018, it started R&D of **new type of traction rectifier for railway transportation**
- 2019, it acquired MorEnergy and launched **impedance measurement products**
- 2019 , SwissSEM was established to leverage high-caliber European R&D team to carry out **IGBT development**



Wuxi Astrol Power Electronics Limited

Wuxi Astrol Power Electronics Limited is responsible for introducing products and technologies into Chinese market, including Digital IGBT Gate Unit, solid state DC circuit breaker, solid state AC switch and pulse power technology, which are developed by Astrol Electronic AG, and widely used in the field of high voltage and high power transmission. Wuxi Astrol is also responsible for the application and service of related products and the industrialization work in China.



Mr. Zhang: 180-1752-8812



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Huishan District, Wuxi City, Jiangsu Province



Astrol established
in Baden,
Switzerland

Astrol

Sun.King IPO in
Hong Kong



Astrol becomes part
of Sun.King Group



Astrol

1996

2001

2006

2010

2011

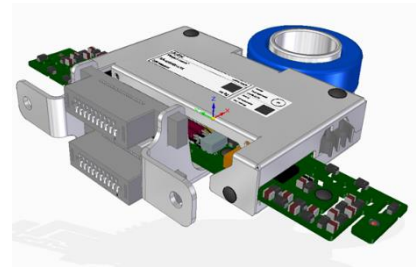
2016

2019

Customized Electronic Solutions



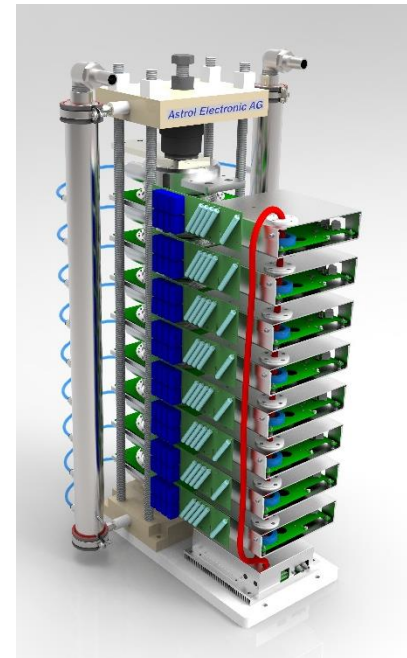
Gate Drive Units and Power Supplies



Trigger Controllers and Optical Interfaces



Power Switches



AC- and DC- Breakers





Solid-State Breaker Technology

What is the difference between Astrol Solid-State Power Switches and Astrol Solid-state Breakers?

Solid-State Power Switch

- Typically based on thyristors
- Current interruption needs zero-crossing of the current.
 - AC-Switches
 - Pulsed-power applications with capacitor discharge
- Not suitable for DC applications

Solid-State Breaker

- IGBT based
- Immediate current interruption at anytime – no zero-crossing required
- Ultra-fast reaction time (within microseconds)
- Suitable for DC applications



Solid-State Breaker Technology

What is the difference between a mechanical breaker and the Astrol solid-state breaker?

Mechanical Breaker

- Moving parts to create an air-gap
- **Standard** Current interruption within **milliseconds (ms)**
- High maintenance cost
- Arcing
- Efficiency close to 100% (only conduction losses of copper)

Astrol Solid-State Breaker

- No moving parts, no air-gap
- **Ultra-fast** current interruption within **microseconds (μs)**
- Low maintenance cost
- No arcing
- Efficiency >99% (conduction losses of IGBT)



Application Areas

Under the following conditions, Astrol Solid-State Breakers are typically the most favorable solution :

Fast Switching

In applications where fast interruption of fault currents is required, the solid-state breaker offers the highest level of protection.

A typical example are low-inductive grids, where fault currents can reach dangerous levels before a mechanical breaker reacts. The solid-state breaker is able to interrupt such currents before dangerous current levels are reached.

Frequent Switching

The arcing during switch-off in a mechanical breaker causes wear of the electrodes. In applications with frequent switching actions, the electrodes and other mechanical parts wear off quickly and need to be replaced after short time in operation, which leads to high maintenance cost.

The solid-state breaker has no moving parts and no arcing. In contrast to a mechanical switch, it can be considered maintenance-free.

Save Switching

In hazardous environments such as chemical plants, the breaker is not allowed to cause arcing. Explosive gases in combination with mechanical breaker are a potential danger for equipment and working personell.

With it's arc-free operation, the solid-state breaker is the solution of choice for hazardous environments.



Application Areas

Power Distribution – Smart Grid

New smart grid concepts focus on distributed power generation, energy storage and coordinated consumption and generation. In comparison to a traditional power grid, the much more complex smart grids require new solutions to protect healthy system parts and equipment from system faults.

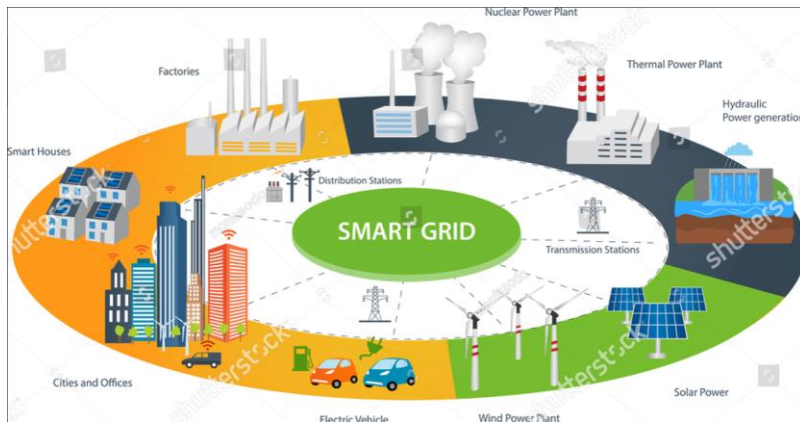
The ultra-fast breaker

- protects grid connected equipment such as batteries, power electronics etc. from short circuits and over currents.
- Disconnects faulty parts from the grid and limits the propagation of fault currents to other parts of the system

Marine On-Board DC-Grids

The ultra-fast DC breaker protects the onboard DC grids against short circuit currents in any part of the grid, enabling much more efficient topologies.

Electric systems on-board of ships are typically very low-inductive, which leads to extremely high di/dt in case of a short circuit. Ultra-fast switching and communication between several breakers can separate the faulty section from the healthy parts of the grid.





Switching Modes

Autonomous operation

ASTROL solid-state breakers are autonomous protection devices.

Fault currents are detected and switched-off automatically by the breaker.

This function can be extended to multi-breaker protection: If several breakers are installed in an electric grid, they communicate over a direct optical link without protocol overhead, which allowed ultra-fast coordinated swithing of several breakers to allow reliable separation of faulty system parts.

Customization

The switching behaviour and other important parameters are customized according to the requirements of the system designer. Certain values can be set via customer interface.

Controlled Switching / Balancing Switch

The breaker can be switched-on and -off by the overall controller at any time.

When the bus tie breaker is open, the capacitors on each side of the breaker can be charged to different voltage levels. The closing of the bus tie will cause an inrush current, which will immediately trigger the short circuit detection of the DC-Breaker. To solve this problem, the Balancing Switch option is available in connection with every Astrol DC-Breaker. The Balancing Switch is an IGBT controlled pre-charge device, which assures voltage balancing of inside the circuit and smooth closing of the DC-Breaker.

Short-circuit Protection




In case of a short circuit, the current increases and reached the triggering level of the breaker. The breaker opens automatically.

Overload Protection

Overload means a current increase which is allowed for a limited period of time. If the pre-defined overload limits are exceeded, the breaker opens automatically



Our Solid-State Breaker Offering

Model	3-Phase AC-Breaker	Marine DC-Breaker	Universal Solid-State Breaker
Voltage rating	11kV nominal 27kV peak	1kV	1kV
Current rating	300A nominal 600A peak	200A air-cooled 500A - 5kA water-cooled	2kA
Phase / Pole design	3-phase AC	Bi-directional DC - one pole	Bi-directional DC - one pole
switching speed	Ultra-fast (<10 μ s)	Ultra-fast (<10 μ s)	Ultra-fast (<10 μ s)
IGBT type	Stakpak IGBTs	Hipak IGBTs	Hipak IGBTs
Cooling	Deionized water cooling	Air cooling / water cooling / optional ambient air cooling	Water cooling
Product Certification	-	DNV, Lloyd's	-
Typical application	Power Distribution, Smart Grid, Industry	On-board DC distribution	Industry, Research
First delivery	2019	2018	2020
Picture			

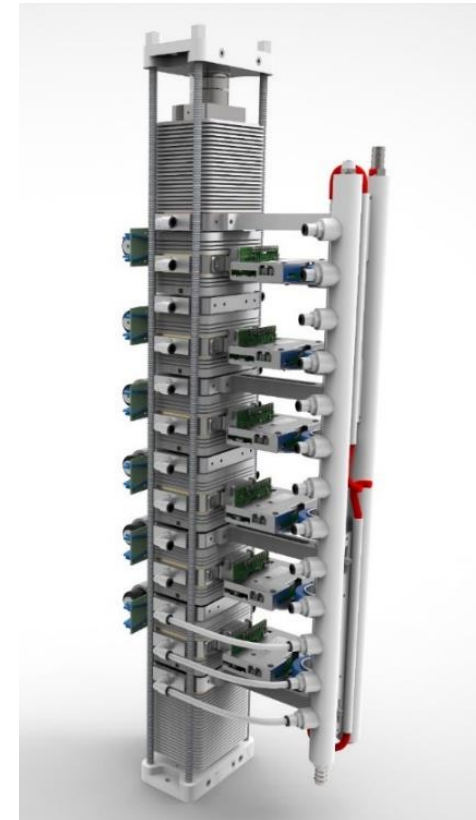


3-Phase AC-Breaker for Smart Grid Application AA-10755-001

Switch off in us



3-Phase 11kV
AC-Breaker



12-level IGBT assembly
with series connected
StakPak modules



Smart Node Application (Soft power processing)

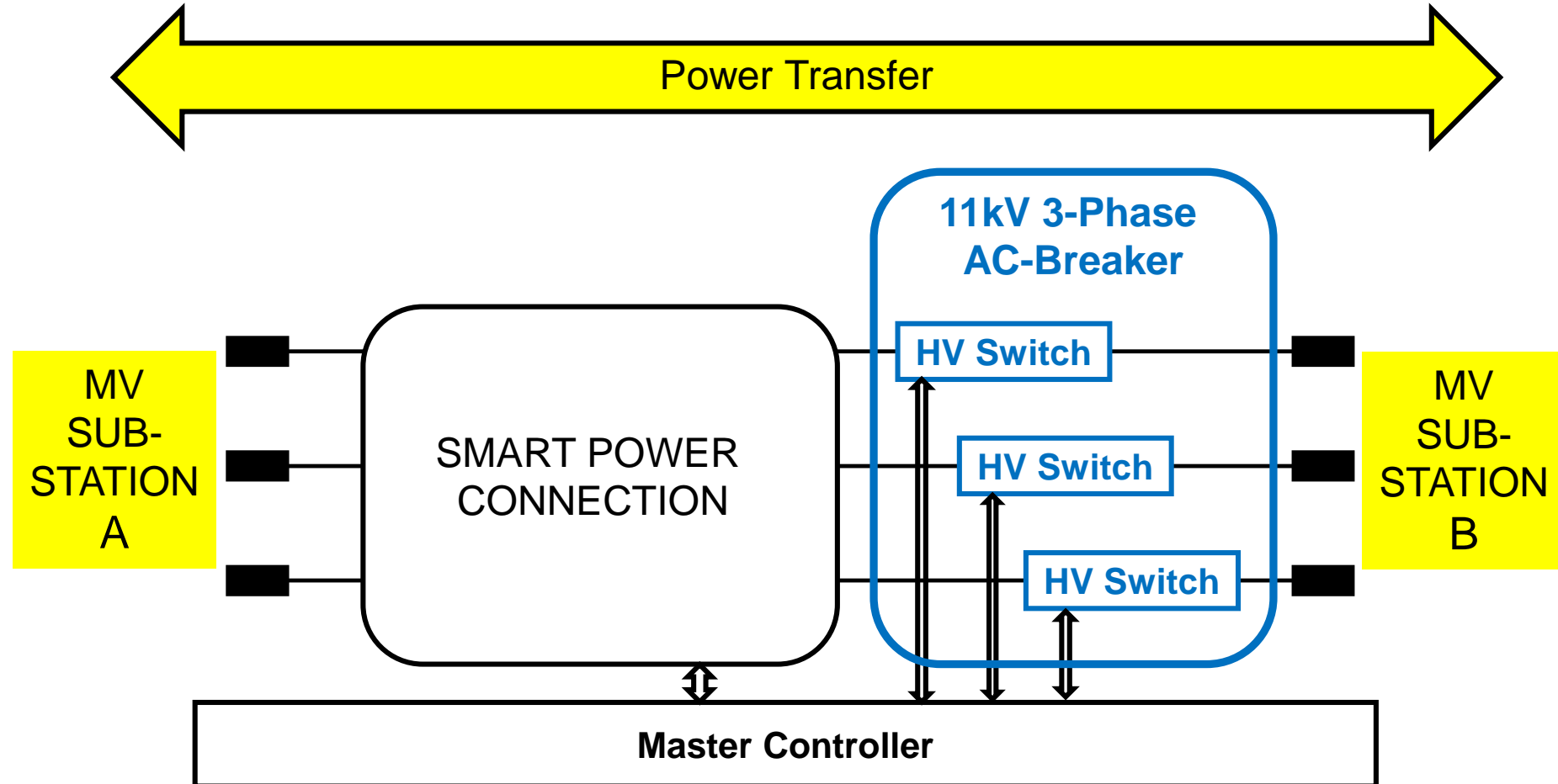
Primary objective of the project

To strengthen the power grid and improve flexibility to cope with changing power demand (for EV-charging etc)

System scope

Connection of two Medium Voltage Substations

The main purpose of the system is to act as a soft power processing unit between two neighbouring electrically connected MV substations. The system will facilitate a controlled transfer of power between the sub-stations bringing flexibility to the MV network and improving the utilisation of the existing infrastructure.





3-Phase AC-Breaker - Electrical and Timing Specifications

Parameter	Symbol	Remark	Min	Typ	Max	Unit
Rated Voltage	V_{nom}	RMS Voltage between phases	—	11	—	kV
Rated Current	I_{nom}	Phase Current	—	262	300	$Arms$
Mains Frequency	f_{mains}		48	50	62	Hz
Breaking Current	I_{break}	Threshold, when exceeded the Breaker trips	10	320	500	A
Breaking Time	t_{break}	Time after threshold exceed until current starts decreasing	—	—	10	μs
Breaking Voltage	V_{break}	Voltage applied between the ACB terminals of one phase until current is zero again	—	—	25	kV
Loop Inductance	L_{loop}	Inductance in the short circuit loop	1	—	5	mH
Total Power Losses	P_{vmax}		—	—	30	kW
Power Losses into Air	P_{vair}	Losses dissipated into ambient air	—	—	2.5	kW
Leakage Current	I_{Lmax}	Leakage Current at nominal Voltage	—	—	10	mA
Auxiliary Voltage	V_{aux}	Auxiliary Voltage to drive controller, fans, GU etc.	200	230	250	V
Auxiliary Power	P_{aux}	Auxiliary power consumption	—	—	500	W
Over Voltage Class	P_{aux}	According IEC60664	—	2		W
Operating Hours	t_{op}		—	—	24	h/day
Maintenance Period	t_{maint}	System has to be un-powered for the maintenance	—	TBD		$h/year$



3-Phase AC-Breaker - Environmental Specifications

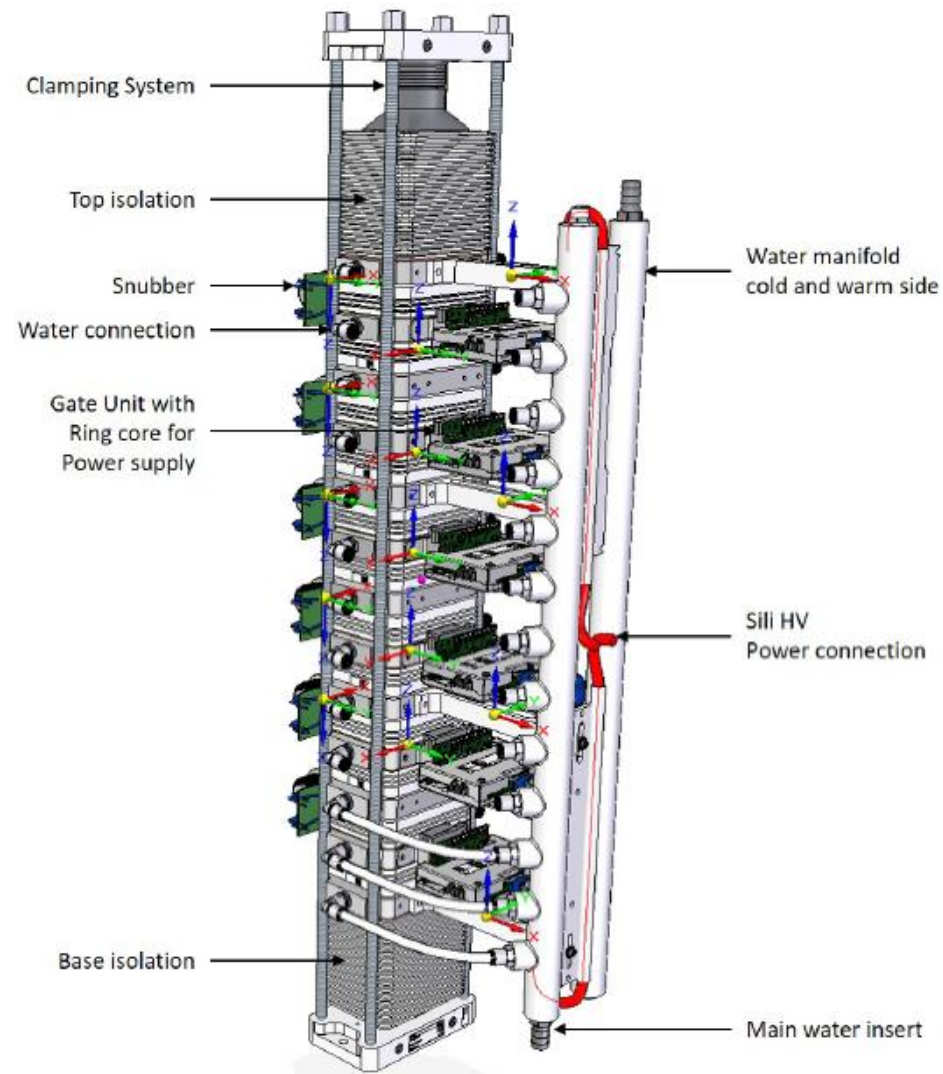
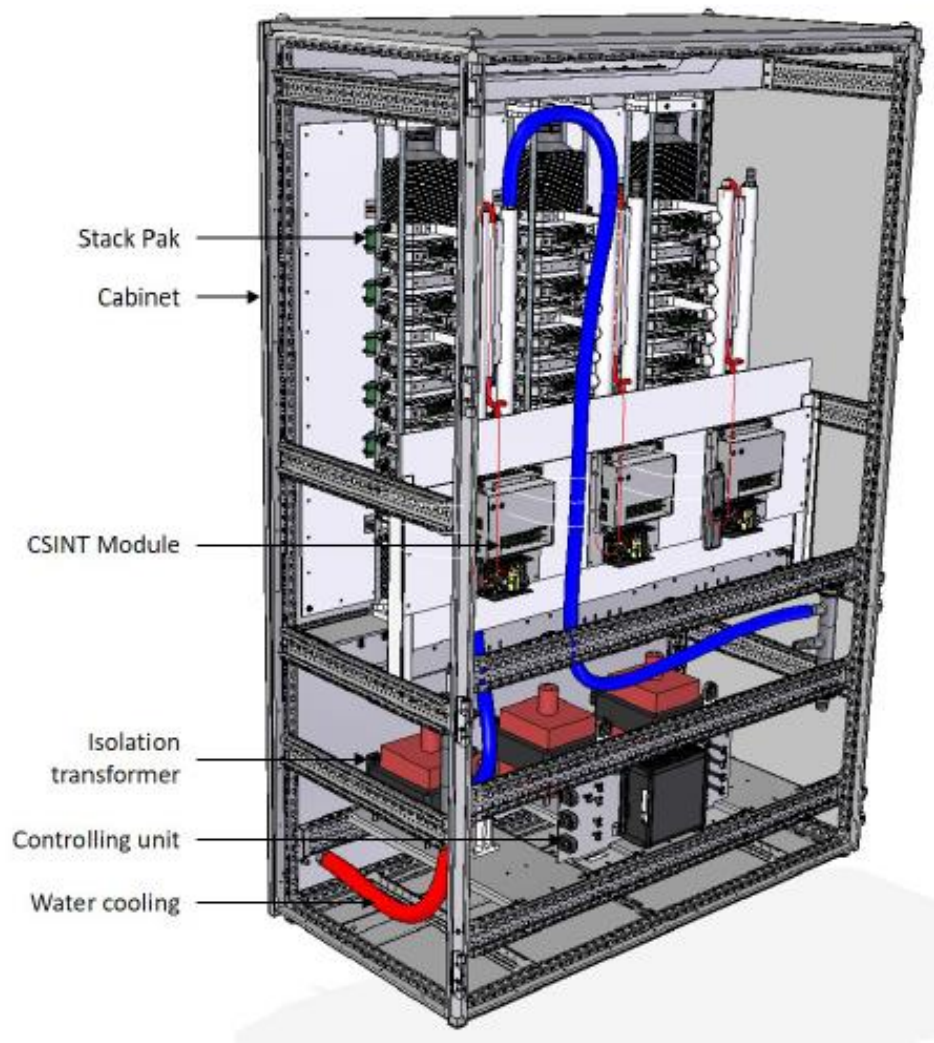
Parameter	Symbol	Remark	Min	Typ	Max	Unit
Ambient temperature	T_{amb}		10	—	40	$^{\circ}C$
Operating Humidity	Hum_{op}		30	—	80	%RH
Operating Air Preassure	AP_{op}		800	—	1100	mBar
Storage temperature	T_{store}		-25	—	70	$^{\circ}C$
Storage Humidity	Hum_{store}		20	—	95	%RH
Storage Air Preassure	AP_{store}		500	—	1100	mBar
Protection level	PL	According EN60529	$IP41$	—	—	
Pollution Degree	PD	According IEC60664	—	2	—	

3-Phase AC-Breaker - Cooling Water Specifications

Parameter	Symbol	Comment	Value	Unit
Maximum Water Inlet Temperature	T_{winmax}	Water Flow per cooler	50	$^{\circ}C$
Maximum Water Temperature Difference	ΔT_w	Temperature Difference oc Cooling Water between Inlet and Outlet	5	$^{\circ}C$
Min Water Flow	q_{tot}	For complete three phase system	156	l/min
Maximum Water Conductivity	S_{wmax}	-	10	$\mu S/cm$
Maximum Water Input Pressure	ρ_{in}	-	6	bar
Maximum Pressure Drop	$\Delta \rho_{in}$	Between inlet and outlet	1.5	bar



Mechanical Design



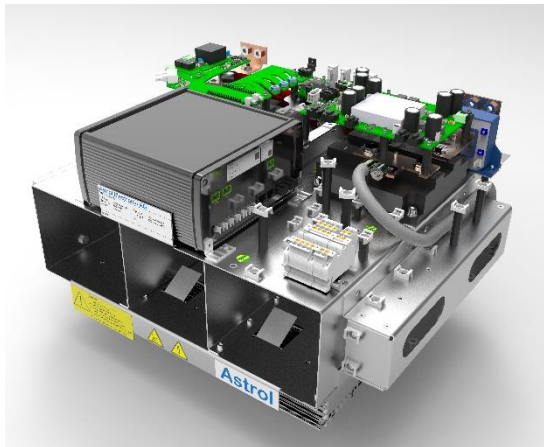


Marine DC-Breaker

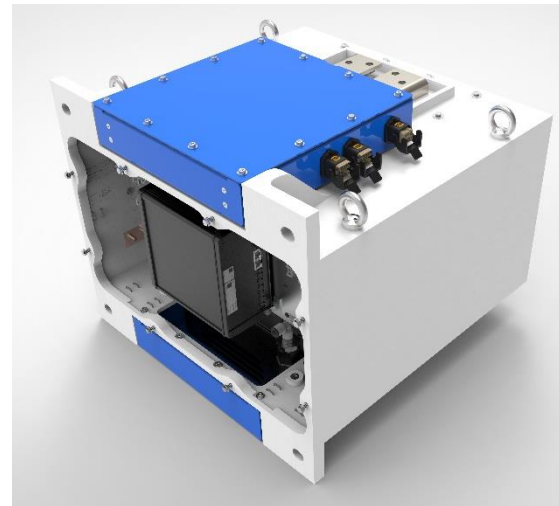
1kV - 200A, 500A, 1250A *Now available!*

3kA version coming soon

3kV versions upon request



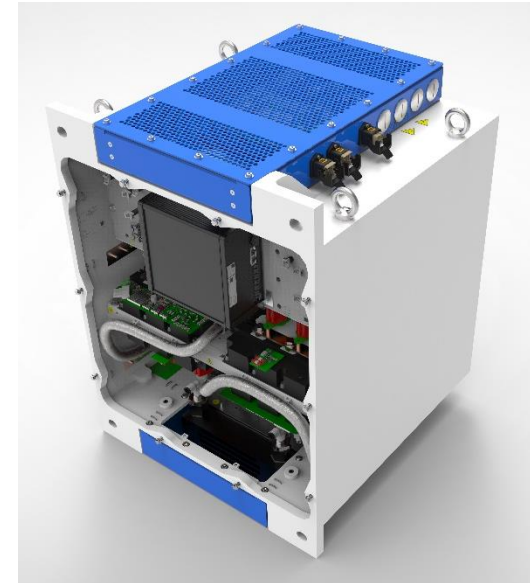
1kV – 200A
Air cooled



1kV – 500A
Liquid cooled



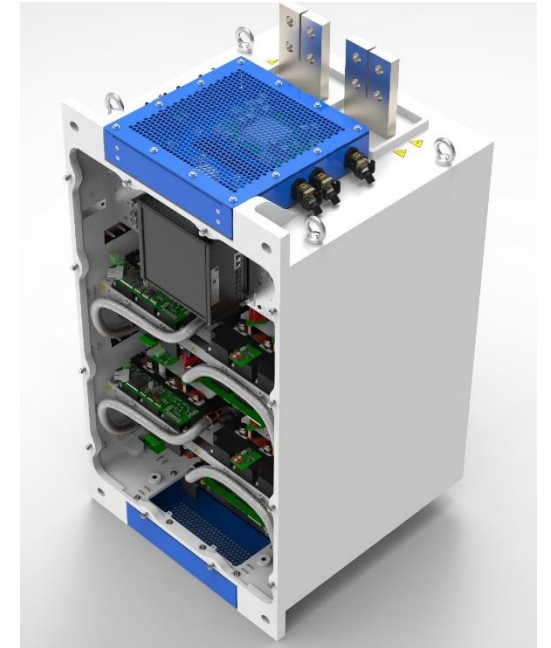
✓ *Certified*



1kV – 1250A
Liquid cooled



✓ *Certified*



1kV – 3kA
Liquid cooled



Universal DC-Breaker

1kV - 2kA DC-Breaker
Redundant protection with pyrofuse
Design optimized for reduced conduction losses



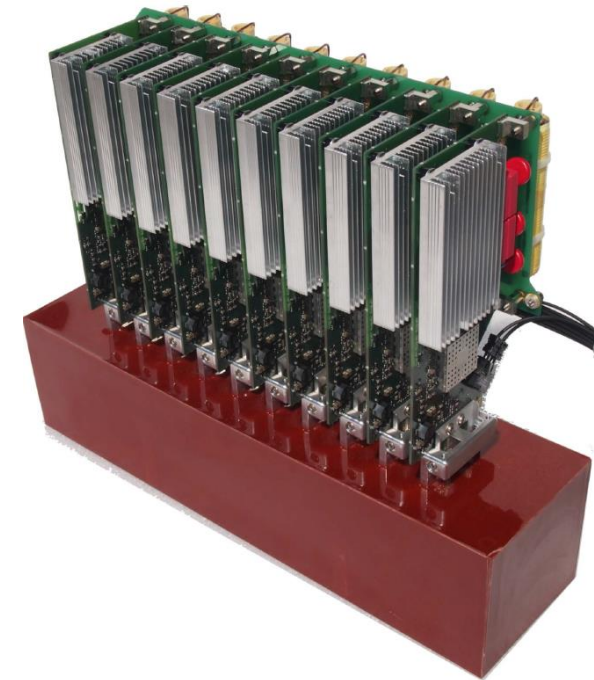
- **Modular Design**
19-inch rack
mounted 1kV- DC-
Breaker module
- **Compact Design**
Housing Dimensions
600 x 800 x 1700mm
- **1700V Hipak IGBT
Modules**

Compact HV-Switch

Rated Voltage up to 18kV - Modular Design for different voltage levels
Up to 10kHz operating frequency
Design optimized for reduced conduction losses

Features

- Rated voltage up to 18kV
- PD-free isolated power supply
- Up to 10kHz operating frequency
- Modular design for different voltage levels
- Compact design
- Air-cooled
- Integrated power moduls with IGBTs mounted on PCB
- Convection or forced-air cooling
- Programmable turn-on / turn-off behaviour
- di/dt limiting inductors





Wuxi Astrol Power Electronics Limited



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