

Protection in Smart Grids with Ultra-Fast Solid-State Circuit Breakers

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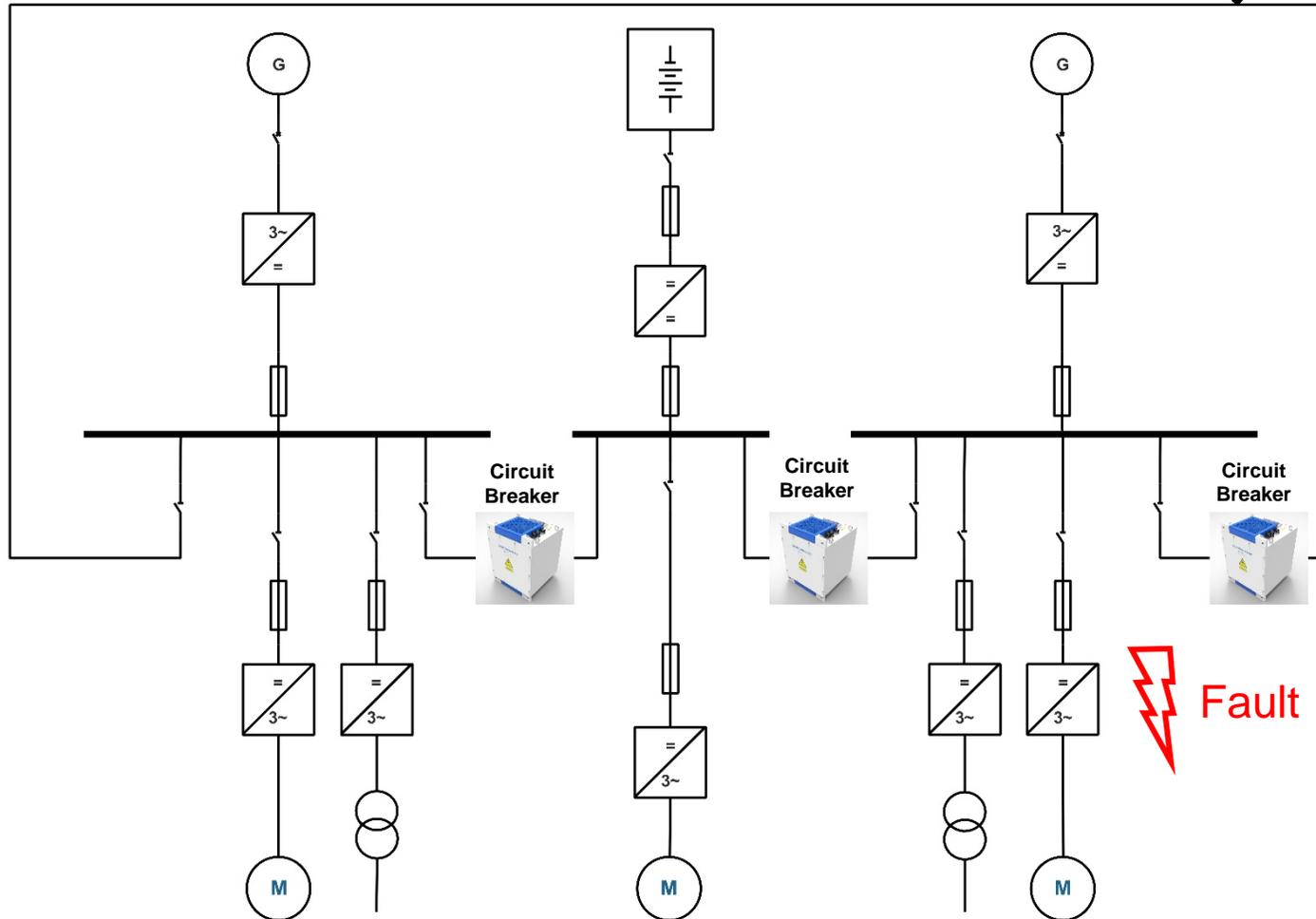
*2. Konferenz «Die
Bedeutung der
Versorgungsnetze in
den nächsten 25
Jahren»*



Example of a DC-Ring on a ship



DC-Ring



Requirements for Solid-State Circuit Breaker

- Ultra-fast
- Suitable for AC and DC:
no zero crossing of current required
- Short-circuit and overload protection
- Zone protection
- No added inductance
- Autonomous, system independent
- Highly reliable, compact design

1996

2001

2006

2010

2011

2016

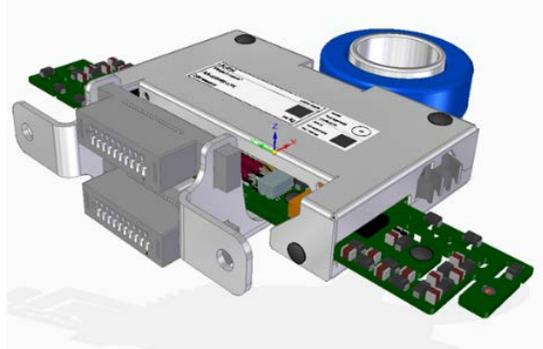
2020

Customized Electronic Solutions



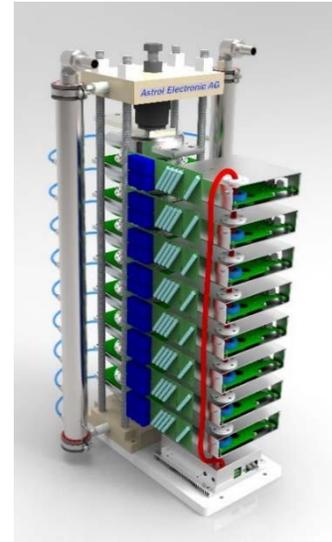
Over 50 customers benefit from electronic solutions designed and manufactured by Astrol.

Gate Drive Units and Power Supplies



Gate Drive Units for various industries, including 500kV HVDC-Breaker

MV and HV Switch Assemblies



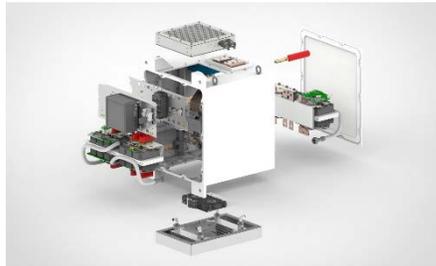
Thyristor, IGCT and IGBT switches for railways, radars, material treatment, environment protection, and others..

MV Solid-State Circuit Breakers (AC and DC)



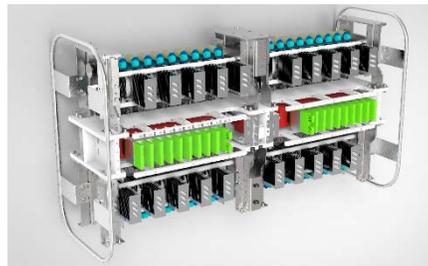
Various breakers delivered for marine, smart-grid and industrial applications.

Solid-State Circuit Breakers



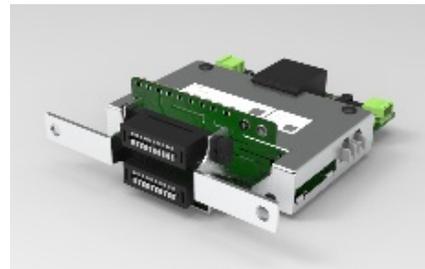
1.5kV - 1.25kA Marine DC-Breaker

Solid-State Power Switches



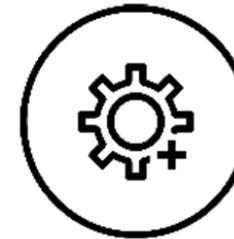
25kVac Railway Neutral Section Switch

Gate Drive Units and Isolated Power Supplies



Dual IGBT Gate Unit for 500kV HVDC-Breaker

Customized Electronics



Further Products



Largest product variety in the market

- Marine DC-Grids
- Smart-Grid DC and AC
- Industrial / Research

Our breakers are based on IGBT technology, IGCT-based breakers and hybrid breakers available upon request

Pulsed Power

- Up to 100kV, 200kA*
- High di/dt up to 30kA/us
- Fusion Power
- Research Laboratories
- Industrial Applications

AC-Switches

- Railway neutral section switch
- Maglev traction

Crowbar Switches, and more..

Customized Gate Drive Units for

- IGBT
- BIGT*
- SiC*
- GCTs
- Thyristors

Fully programmable to optimize switching behaviour

Inductive power supply solutions up to 100kV

Electronics design and manufacturing

- HW and SW design
- Prototype
- Industrialization
- Series production

Various controllers and optical interfaces

Battery Cyclers

Semiconductor Testing Equipment

FADEC 3 (Thyristor tester)

* (higher ratings) upon request

Ultra-fast switch-off of AC and DC



Current threshold

Overcurrent detection

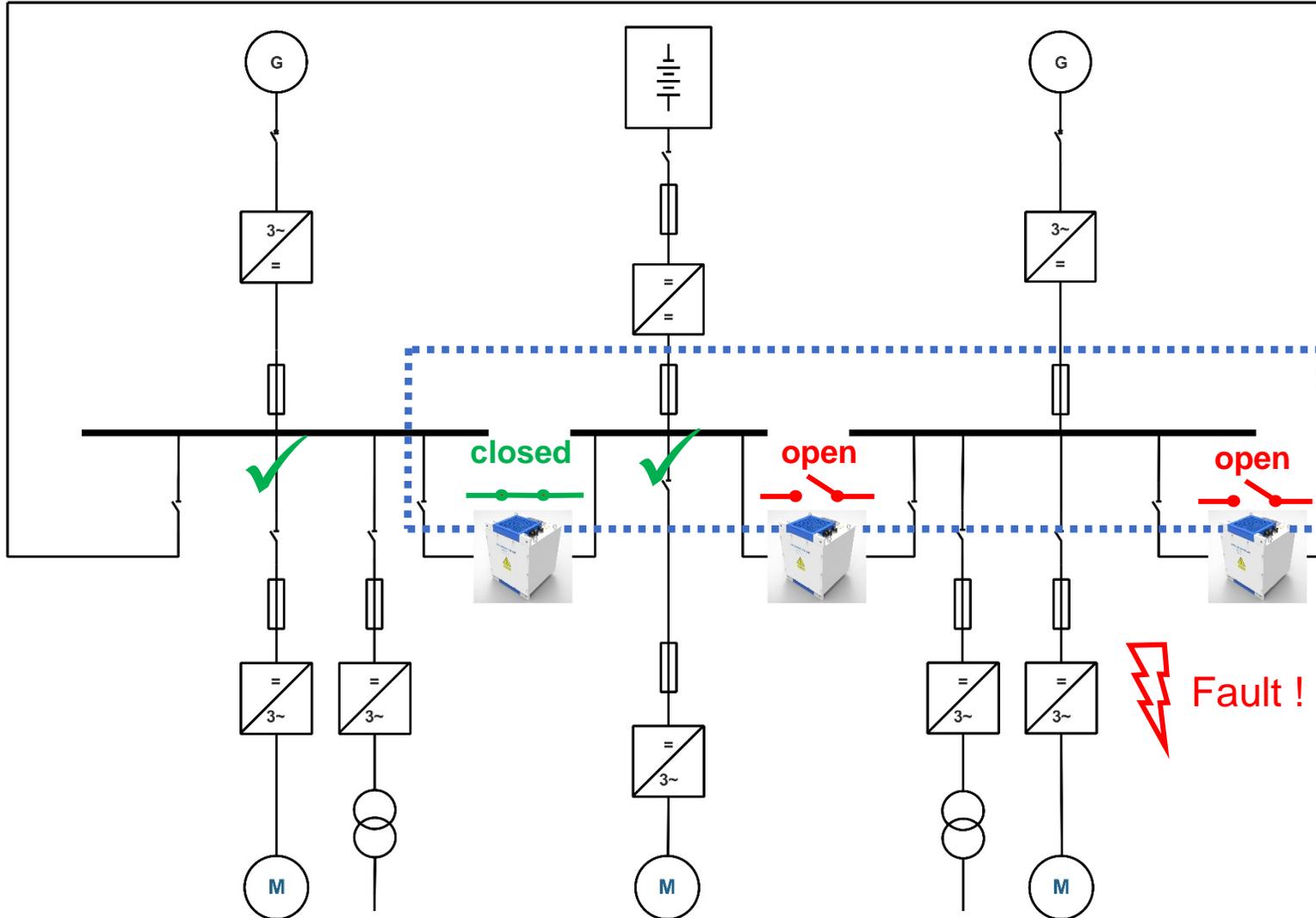
Switch-Off IGBTs

Breaker current

Breaker voltage

- Fault detection in about 2µs
- Switch-off process starts within 4-5µs after fault detection
- Ultra-fast switch-off allows low-inductive system design
- Short circuit currents limited to safe levels

Zone Protection



If a fault occurs in one zone of the grid, the fault is measured by all breakers in the system.

The breakers need to determine the location of the fault within microseconds.

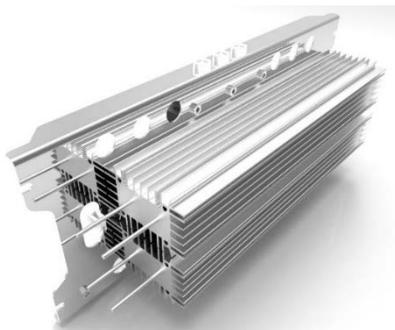
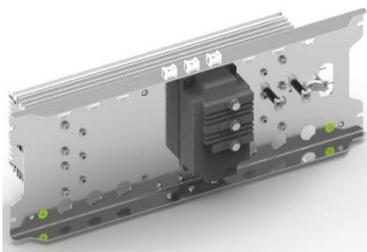
Astrol Circuit Breaker allow efficient zone protection. Key elements are:

- Ultra-fast detection
- Direct optical link between each breaker and its neighbours in the system.
- Configurable current thresholds and switch-off timing

..... **Optical direct link between breakers**

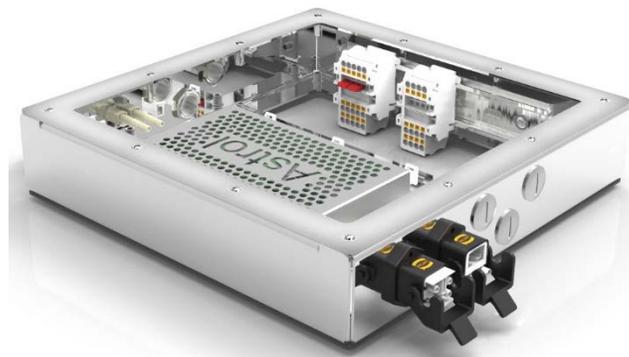
Voltage Balancing

- Integrated voltage balancing for controlled (pre)charging of the circuit via charging resistor.
- Automatic or remote control startup



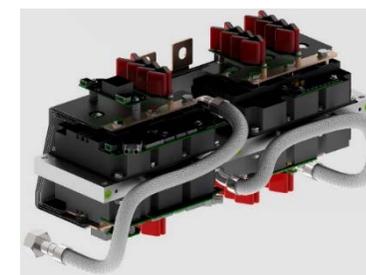
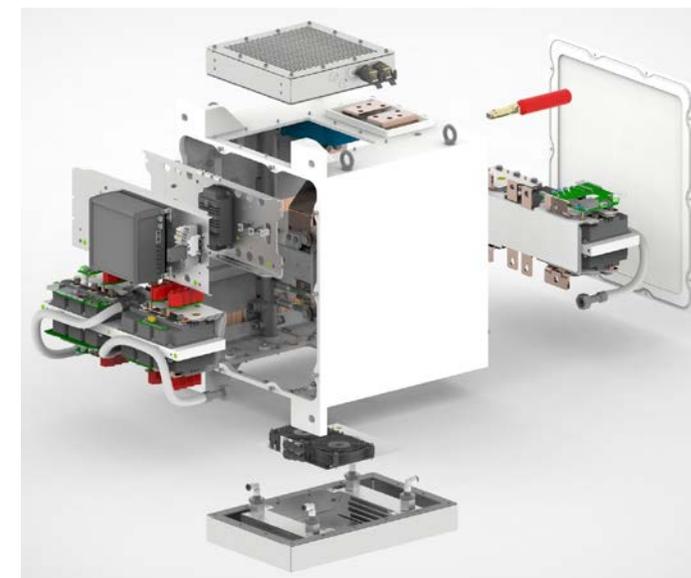
Interface to host system

- Ethernet based Protocols
 - Modbus TCP/IP
 - Profinet
 - Others on request
- Optical Interface
 - Custom specific via glass or plastic fiber
- Ruggedized connector
- Vibration proof design (marine version)
- Power connection
 - Bus bar
 - Cable

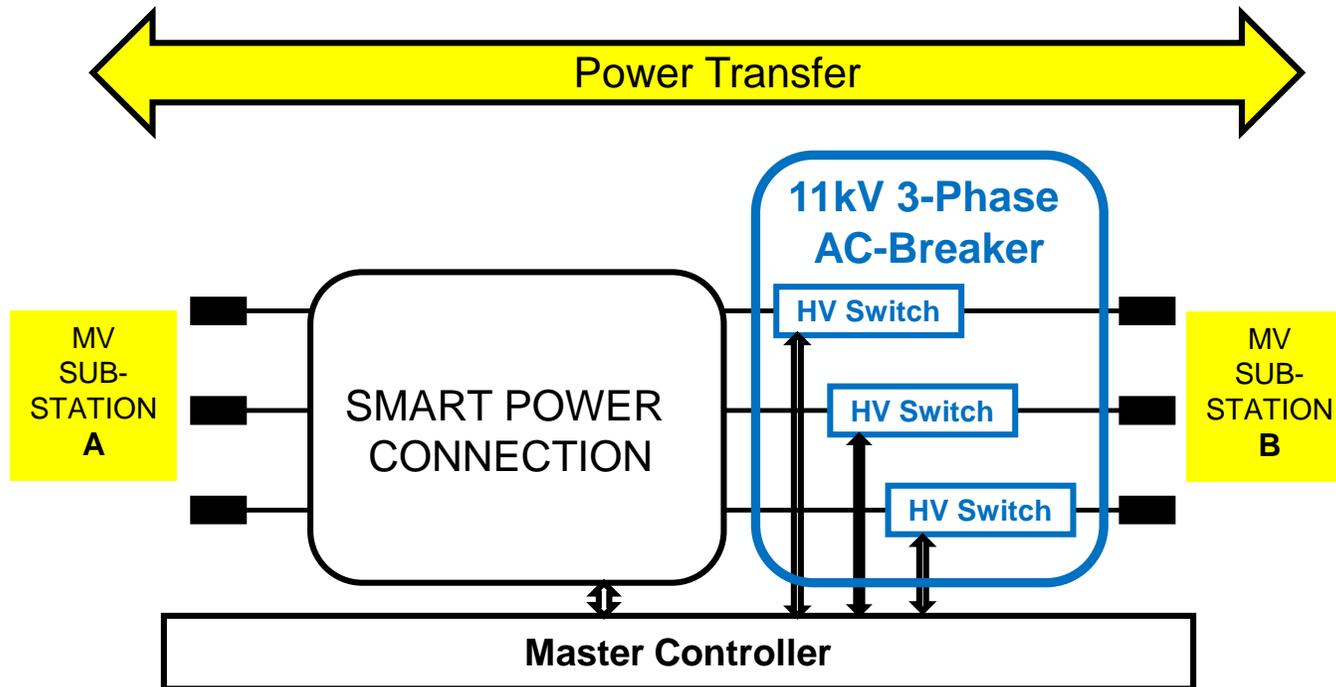


Unique modular design

- Autonomous detection and switch-off
- Maintenance free in normal operation – no moving parts
- Self-diagnostic



Power Exchange between substations 11kV – 3-phase



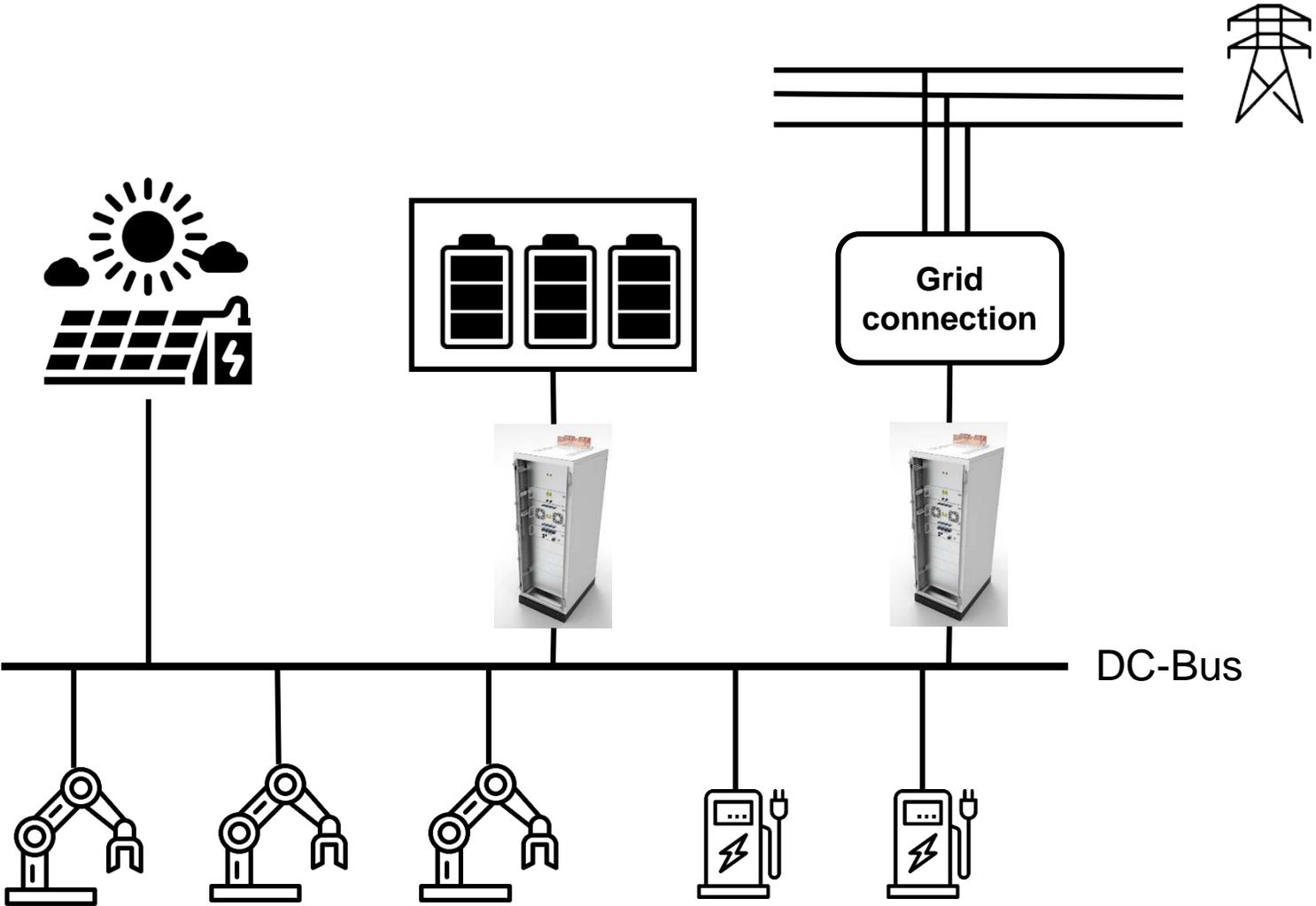
3-Phase 11kV
AC-Breaker



12-level IGBT assembly
with series connected
StakPak modules



Industrial DC Grid



1kV Industrial DC-Breaker
Modular design
19-inch rack



Marine DC-Breaker



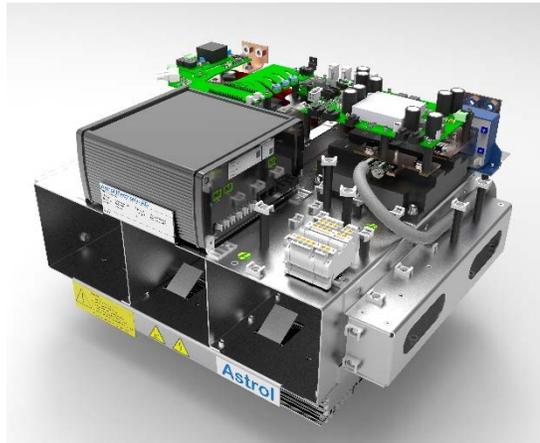
1kV - 200A, 500A, 1250A

Reference projects in all current ratings

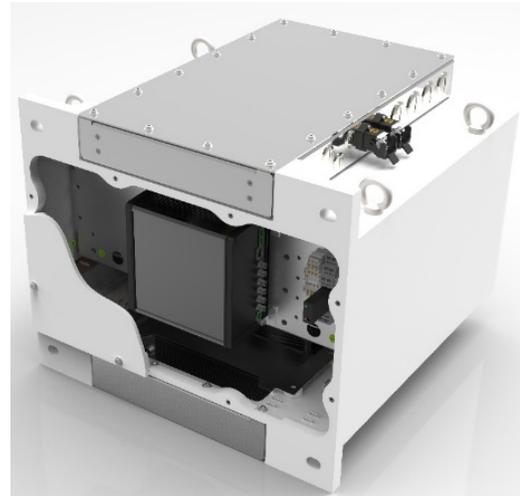
1kV - 3kA

Available for order now!

3kV versions upon request



1kV – 200A
Air cooled



1kV – 500A
Liquid cooled



✓ *Certified*



1kV – 1250A
Liquid cooled



✓ *Certified*



1kV – 3kA
Liquid cooled



In Q3 2021

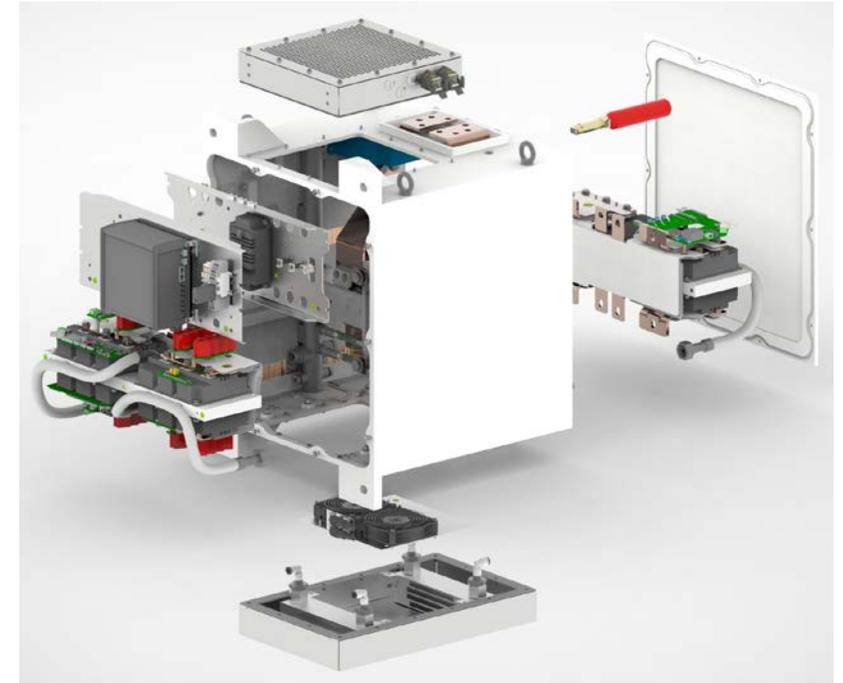
Product Overview Solid-State Circuit Breaker



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	4kA
Phase / Pole design	3-phase AC	Bi-directional DC - one pole	Bi-directional DC - one pole
switching speed	Ultra-fast (<10μs)	Ultra-fast (<10μs)	Ultra-fast (<10μs)
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, Smart Grid
First delivery	2019	2018	2020
Picture			

Summary

- Ultra-fast solid-state circuit breakers allow reliable fault current protection in smart-grids
- Astrol offers the most comprehensive range of solid-state MV circuit breakers in the market, with reference projects in
 - Marine
 - Smartgrid
 - Industry
- 25 years of experience in designing and manufacturing MV and HV power switches, measurement and control electronics form the basis for our state of the art AC and DC breakers.



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