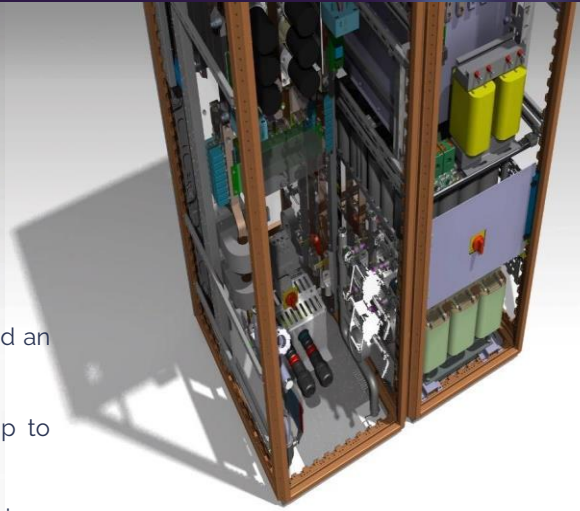


# SIRIUS Converters Family

Powering for a sustainable future



## Main Features

- CERN proven design, with more than 300 operating units and an industrialized design
- 4 Quadrants – Switch Mode Power converter
- Regenerative converter with integrated energy recovery up to 360 KJ/600 KJ (with extra cabinet)
- Modular power converter (up to four units)
- Specifically designed for fast cycling loads (Transfer Lines electromagnets in Particle Accelerators)
- Parallel or Series configuration
- Each unit 450V and 450A or continuous (DC) 80V and 200A, constant RMS power of 16kW
- Peak cycling power deliverable to the magnet 202.5kW, up to 810 KW in 4 units configuration
- High precision current measurement DCCTs
- Current Accuracy (One Year): 100 ppm
- Current Reproducibility (One day): 20 ppm
- Current Stability (1/2 hour): 20 ppm
- Standardized integration two standard 19-inch racks

## Sirius is primarily suitable for:

- Cycling applications with considerable amounts of recoverable energy
- RMS loss minimization and magnet field conditioning (with FGC3)
- Long life and fast cycling

## Why SIRIUS?

In today's world, for any company or institution, sustainability and environmental impact minimization, are key objectives.

Annual cost of electricity of each 1kJ of losses: 268 €\* (Non-recoverable/consumed every 1.2 seconds)

Magnet type	Total (1.2sec)	Recoverable	Thermal loss (1.2sec)
Quadrupole (26Gev)	11kJ	6kJ	5kJ
Small Dipole (26Gev)	31.5kJ	25kJ	6.5kJ
Large Dipole (26Gev)	101kJ	82kJ	19kJ

\* Assuming an electricity cost of 0.050 €/kWh. 1kJ of energy over a 1.2sec cycle corresponds to 1kJ/1.2sec=0.83kW of average power. Assuming this 1.2sec (PS) cycle repeats for 24hours over 270 working days the total energy required from the power network (for each 1kJ) is 5378kWh/annum. If this energy is not recovered in capacitor banks after every magnet cycle it is returned to the power network and is not remunerated by the provider.

# EP@WERSYS

your preferred electronics supplier

BCH RPSu 2.0.1-1121

**SIRIUS: EPOWERSYS 4 Quadrants – Switch Mode Regenerative Power converter**

■ **General SIRIUS**

SIRIUS is a family of regenerative power converters. The family has been designed for cycling current application, typically as an electromagnet power supply. Inductive energy is recovered in a scalable capacitor bank and is reused in the following current cycle.

Modular power converter specifically designed for fast cycling loads such as the electromagnets of Transfer Lines in Particle Accelerators. It is a regenerative converter with integrated energy recovery of up to 90kJ in its simplest configuration - SIRIUS S(ingle). Its basic building block (the "module" or "brick") is built with the possibility of series or parallel output connection, up to four units, in order to supply a wide range of electromagnet loads.

The converter is rated for a cycling rated voltage and current of 450V and 450A respectively or for a continuous (DC) output voltage and current of 80V and 200A. The unit can therefore provide a constant RMS power of 16kW to the load whereas the peak cycling power deliverable to the magnet is 202.5kW.



The power converter employs a grid supply unit, that consists of a passive rectifier unit with boost converter that acts as grid current regulator (limiter). The grid supply unit limits the power taken from the power grid to just 20kVA with a modest 32A/400V 3-phase line voltage. This unit serves to improve power quality towards the power network by limiting the input power fluctuation.

A capacitive energy storage is employed to recover energy from the magnet during the current ramp down. The built in energy storage to each module is 90kJ with a possible extension by the addition of an extension rack. Finally, a standard magnet supply unit is used to regulate the output current to high precision as required by the application.



SIRIUS S(ingle)



SIRIUS 4P

The converter integration is done in two standard 19-inch racks. One rack is the standardized "module" converter and the second rack houses the output filter capacitors, high precision current measurement DCCTs, the Function Generation Controller crate and the cooling distribution equipment.

## ■ Magnet Protection

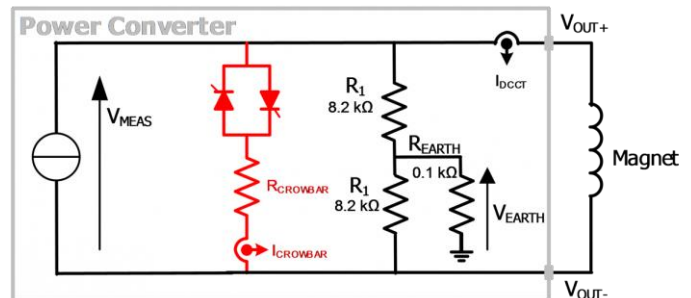
Power Converter is part of magnet protection scheme, even if not directly fully responsible of the monitoring and diagnostic of the magnet status. PIC/WIC (Power/Warm Interlock Controller) can interlock Power Converter if magnet safety requires it. Power Converter is then expected to:

- Always ensure that external protection system can stop the Power Converter through a safe signal called Fast Abort.
- Stop powering the load in safe way (handling the magnet energy even when stopping, through dedicated system called Crowbar). This active system provides a safe resistive discharge path for magnet current (energy).
- Monitor Earth current of the total circuit: converter + load (magnet and its DC cables), and take the right action if threshold reached.

## ■ Active Crowbar

Each SIRIUS module is equipped with its own active crowbar. The system is based on a 2.2  $\Omega$  power resistor connected to two thyristors which are triggered when there is a faulty condition on the converter or when the voltage  $V_{meas}$  goes beyond a predefined threshold (BOD protection).

### CROWBAR



## ■ Earth fault detection

The Detection system is a converter configuration independent (serial or parallel). It's composed of a voltage divider connected between positive polarity, the negative polarity and earth:

- The voltage threshold  $V_{EARTH}$  is set to 0.5V hence limiting the fault current to 5 mA ( $R_{EARTH} = 100 \Omega$ )
- $R_1$  is chosen considering the requested system sensitivity:

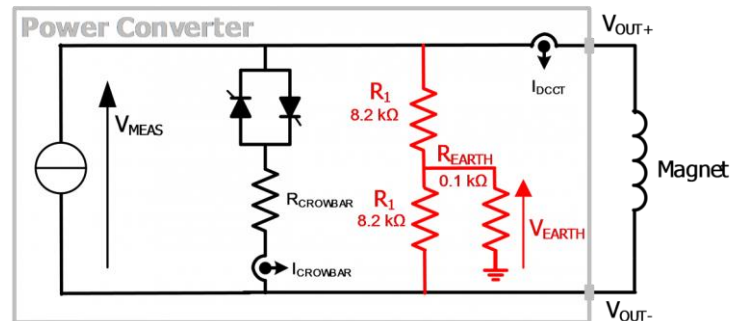
$$R_1 = (k \cdot V_{NOM}) / I_{EARTH} - 2 \cdot R_{EARTH}$$

$V_{NOM}$ : Nominal value of the voltage,

$k$ : voltage unbalance factor(0.05...0.1),

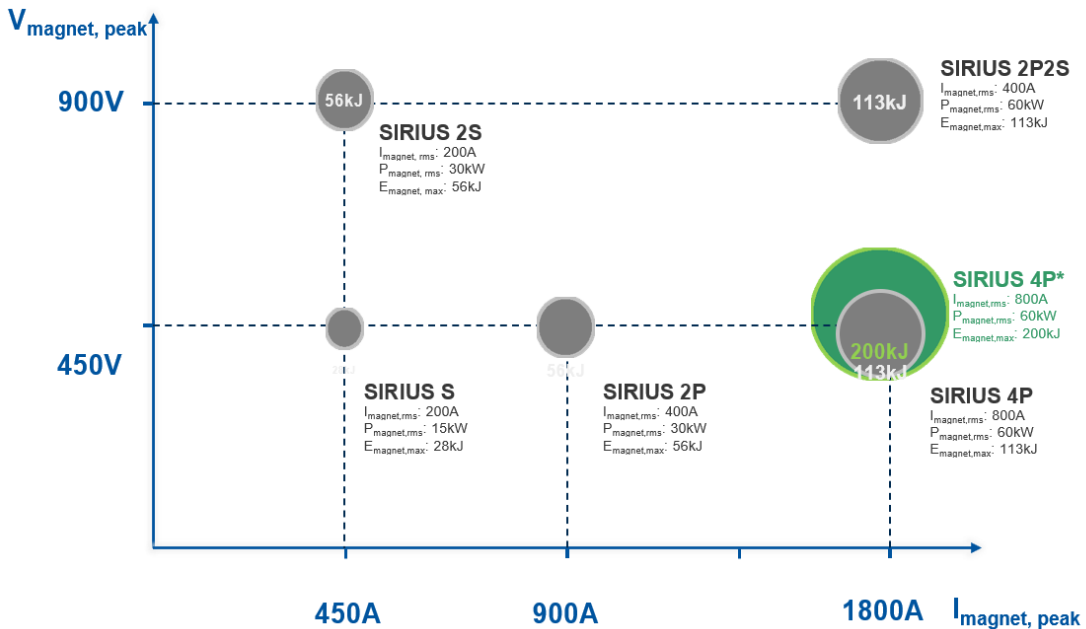
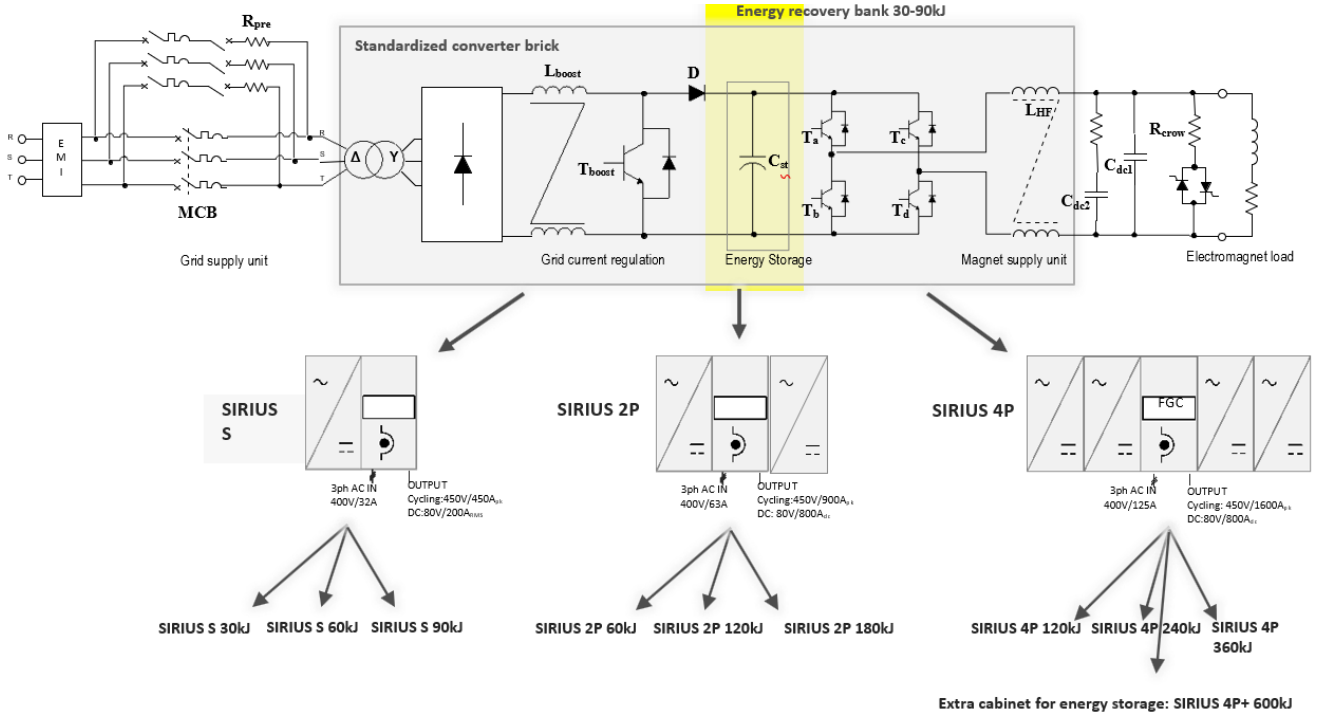
$V_{NOM}$ : Nominal value of the voltage,  
 $k$ : voltage unbalance factor(0.05...0.1),

### EARTH SYSTEM



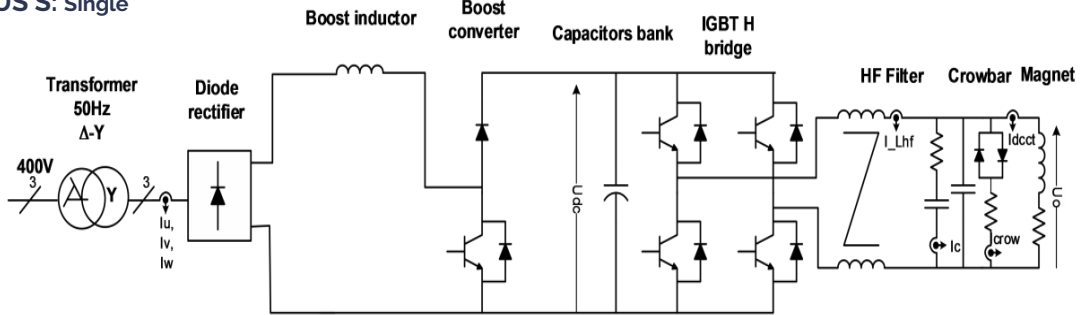
■ **Power Converter for Transfer Lines**

Family	Type	Configuration	Grid Supply (RMS values)	Output	
				Continuous RMS	Cycling peak
SIRIUS	<b>S</b>	Single module	400V/32A	±80V/±200A	±450V/±450A
SIRIUS	<b>2P</b>	2 modules in parallel	400V/63A	±80V/±400A	±450V/±900A
SIRIUS	<b>4P</b>	4 modules in parallel	400V/125A	±80V/±800A <sub>RMS</sub>	±450V/±1600A

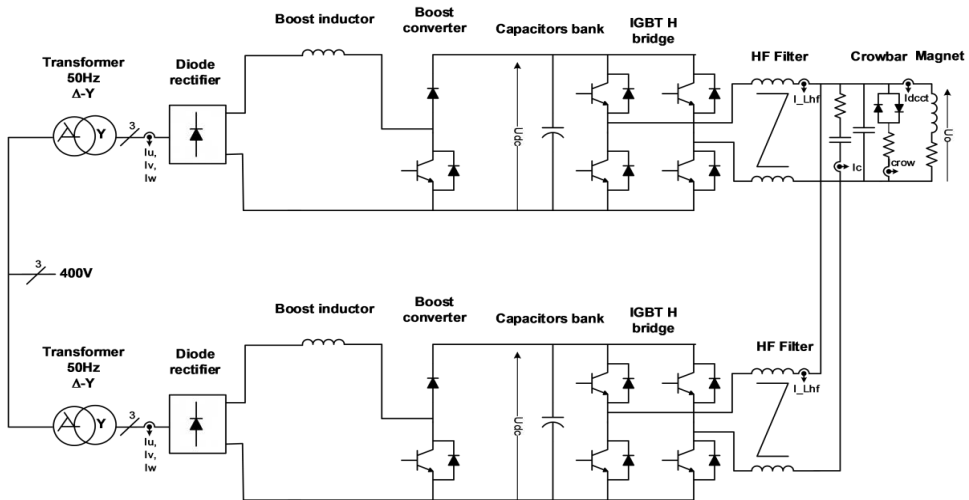


■ SIRIUS CONVERTERS TOPOLOGY

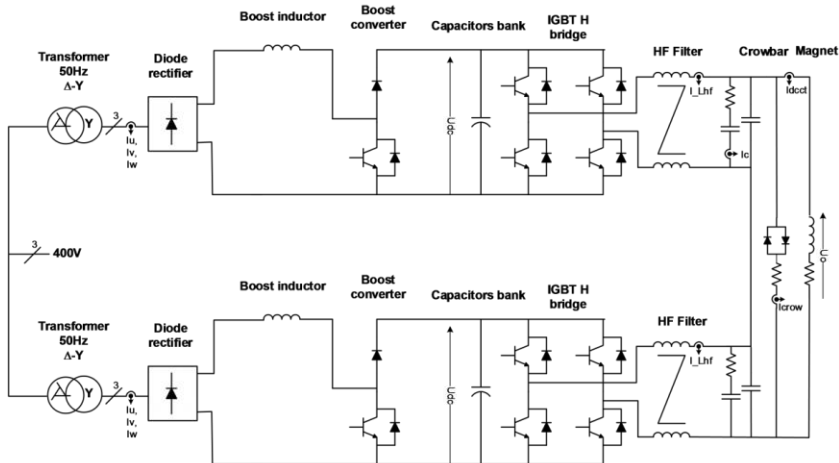
**SIRIUS S: Single**



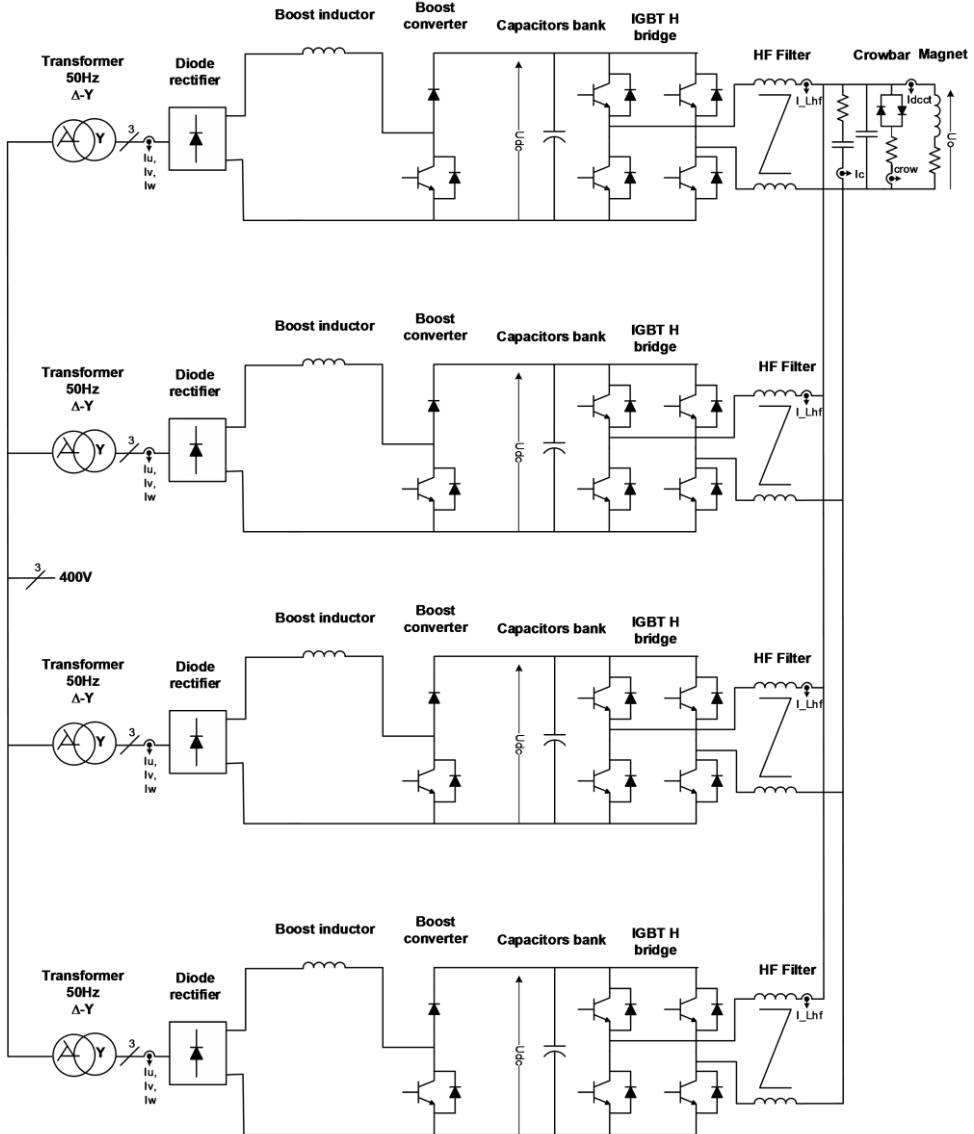
**SIRIUS 2p: Two modules in parallel to increase current capability**



**SIRIUS 2s: Two modules in series to increase voltage capability**



## SIRIUS 4s: FOUR modules in parallel to increase current capability



## ■ Power Converter Characteristics

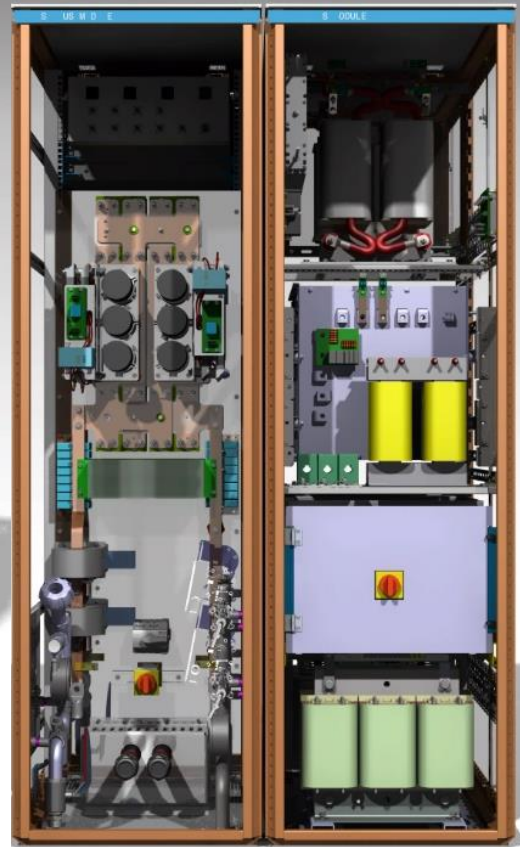
<b>FAMILY NAME</b>	SIRIUS - Power System for rapId Regulation with Internal controlled Unit of energy Storage			
<b>CONFIGURATION</b>	Main brick	Parallel configuration	Serial configuration	Parallel configuration
	<b>SIRIUS</b>	<b>SIRIUS_2p</b>	<b>SIRIUS_2s</b>	<b>SIRIUS_4p</b>
<b>HCR CODE</b>	HCRPAEJ	HCRPAEK	HCRPAEL	HCRPAFB
<b>CYCLING</b>	<b>V<sub>out</sub></b>	450V	450V	900V
	<b>I<sub>out</sub></b>	200Arms/450Apeak	400Arms/900Apeak	200Arms/450Apeak
<b>CONTINUOUS</b>	<b>V<sub>out</sub></b>	80V	80V	160V
	<b>I<sub>out</sub></b>	200ARMS	400Arms	200Arms
<b>POWER IN</b>	3x400V / 50Hz - 32Arms	3x400V / 50Hz - 63Arms	3x400V / 50Hz - 63Arms	3x400V / 50Hz - 125Arms
<b>LOAD CONDITIONS</b>	1...100 mH 10 mΩ...1 Ω	1...100 mH 10 mΩ...0.5 Ω	1...100 mH 10 mΩ...2 Ω	1...100 mH 10 mΩ...0.25 Ω
<b>DIMENSIONS</b>	Height: 2000 mm Width: 1200 mm Depth: 900 mm Weight: 700 kg	Height: 2000 mm Width: 1800 mm Depth: 900 mm Weight: 1100 kg	Height: 2000 mm Width: 1800 mm Depth: 900 mm Weight: 1100 kg	Height: 2000 mm Width: 3200 mm Depth: 900 mm Weight: 2200 kg
<b>TYPE</b>	4 Quadrants - Switch Mode Power Converter F <sub>sw</sub> = 6.5 kHz Modulation: 2LF <sub>sw</sub> (two level) or 3L2F <sub>sw</sub> (three level with frequency doubling)			
<b>APPLICATION</b>	This Power Converter is used in Experimental areas, Injector Machines and test benches to power warm magnets for pulsed applications			
<b>ENERGY STORAGE</b>	30 kJ	60 kJ	60 kJ	120 kJ
	60 kJ	120 kJ	120 kJ	240 kJ
	90 kJ	180 kJ	180 kJ	360 kJ
<b>CONTROL TYPE</b>	RegFGC3 Crate Type 10 / Ethernet			
<b>PRECISION PERFORMANCES</b>	Current Accuracy (One year): 100 ppm Current Reproducibility (One day): 20ppm Current Stability (1/2 hour): 20 ppm Current Resolution: 16 bits			
<b>VOLTAGE RIPPLE</b>	EDMS <a href="#">1575714</a>			
<b>POWER CYCLING</b>	Typical PS loading cycle: Cycle period: 1.2 s - Rise time: 0.1 s - Flat_top time: 0.17 s - Fall time: 0.1 s I <sub>Flat_top</sub> = I <sub>out_peak</sub> Lifetime > 247.10 <sup>6</sup> cycles			
<b>GENERAL DESIGN</b>	Altitude above sea-level: up to 2000 m Operating ambient temperature: 0...+30°C Storage temperature: -25...+50°C Relative humidity: 30...85% @30°C Pollution degree: II according to IEC 62103 Overvoltage category: III according to IEC 62103 Isolation level (to ground): 3 kVAC RMS (50Hz, 1 min)			
<b>COOLING</b>	Water Forced (WF) <u>Losses</u> SIRIUS: 1300 W <sub>Air</sub> / 2900W <sub>water</sub> _12L/min SIRIUS_2p : 2600 W <sub>Air</sub> / 5800W <sub>water</sub> _24L/min SIRIUS_2s : 2600 W <sub>Air</sub> / 5800W <sub>water</sub> _24L/min SIRIUS_4p : 5200 W <sub>Air</sub> / 11600W <sub>water</sub> _58L/min			

## ■ SIRIUS Family Power Converters S / 2P / 2S / 4P



# SIRIUS Converters Family

*Powering for a sustainable future*



**Gorka Esteve**  
*Sales Manager*

Phone: +34 91 411 09 63  
Mobile: +34 636 423 785  
email: [gorka.esteve@neureus.com](mailto:gorka.esteve@neureus.com)

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