

Appendix 2-3:
Power Electronics Inverter Data Sheets



FREEMAQ DC/DC

BI-DIRECTIONAL DC/DC CONVERTER



MODULAR DESIGN



OUTDOOR DURABILITY



CLIPPING RECOVERY CAPABILITY



FOR NEW AND EXISTING PLANTS

THE MOST COST COMPETITIVE SOLUTION FOR SOLAR + STORAGE INSTALLATIONS

The new Power Electronics Freemaq DC/DC is a bi-directional DC converter designed to maximize the benefits of the large-scale solar plants with a solar-plus-storage approach, offering a cutting-edge technology product that is able to reduce the CAPEX of PV installations coupled with energy storage systems, avoiding the installation of an additional station with a dedicated MV transformer. The best solution to minimize the LCOE for hybrid power plants.

Following the Power Electronics philosophy, the Freemaq DC/DC is a modular outdoor solution available from 525 kW to 3150 kW, fully compatible with different battery technologies and manufacturers, with a voltage range up to 1500 Vdc and the highest efficiency in the market. This product has been designed to be the lowest LCOE solution in the market. It is easy to be integrated with a Freesun inverter in new or already installed PV power plants, being the most cost-competitive solution for battery storage systems paired with PV installations.

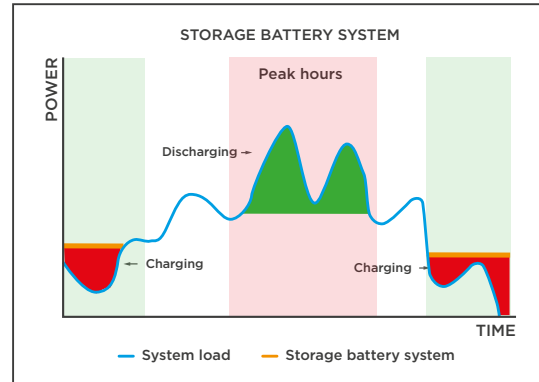
By coupling the Power Electronics Freemaq DC/DC converter with a Freesun solar inverter, it is possible to perform functions such as: energy shifting, ramp control rate, frequency response, and most importantly, clipping energy recovery, that will boost customer revenues.

ENERGY STORAGE APPLICATIONS



LOAD LEVELING

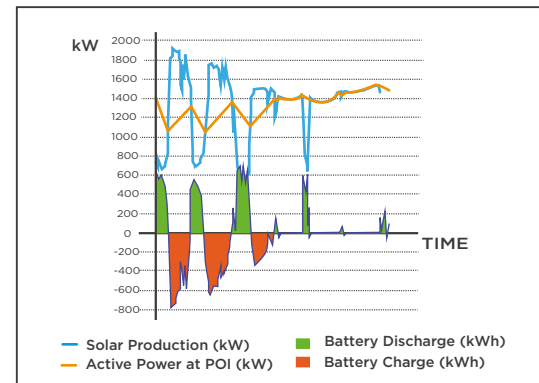
Freemaq DC/DC series are able to store energy during periods of low demand from the grid, in order to later supply this energy when there is a higher demand. This has the benefit of selling the energy at a higher market price during peak periods. It also allows grid operators to supply electricity with a higher renewable origin. Since PV generation may not be at the same time as peak demand, this facilitates the flexibility and integration of renewable generation into the grid.



RENEWABLE INTEGRATION

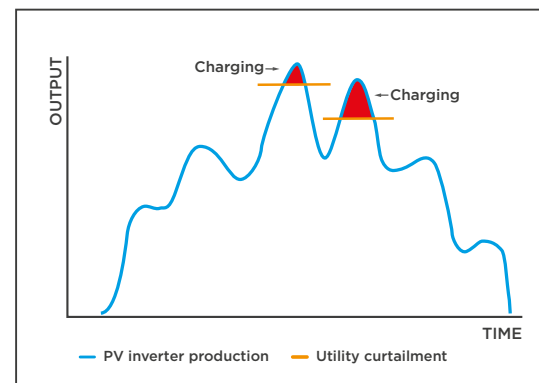
The Freemaq DC/DC series attenuates the intermittent nature of renewable energy sources, to provide a smoother power output. The Freemaq DC/DC controls the ramp rate at which power is injected into the grid, and thus reduces the impact of rapid power fluctuations due to sudden or transient conditions experienced by the PV array.

The system monitors the PV inverter output to inject or consume power accordingly to ensure the output remains within the ramp requirements.



UTILITY CURTAILMENT RECOVERY

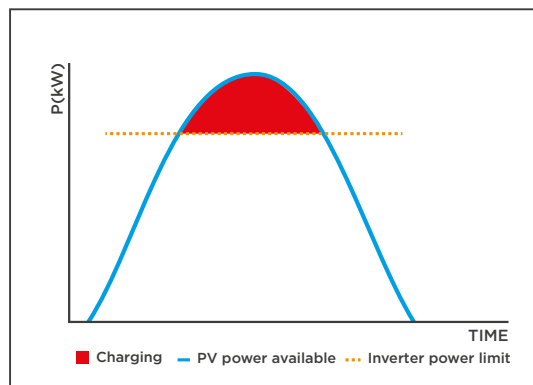
Utility scale inverter production can be curtailed by the grid operator, due to the high energy sources penetration in the grid during certain periods. With this DC-coupled energy storage system, the excess energy from the PV field can be stored in the Battery Energy Storage System (BESS) and then delivered when needed.





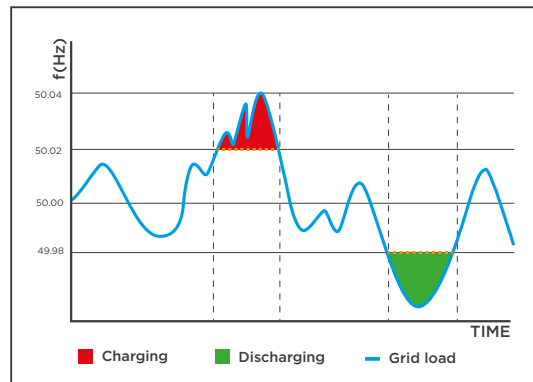
CLIPPING RECOVERY

The Power Electronics Freemaq DC/DC gets the maximum revenues from the PV generator, by charging the battery storage system when the PV inverter is clipping the output power, due to the high DC/AC power ratios. This stored energy can be exported to the utility grid when the price per KWh is high.



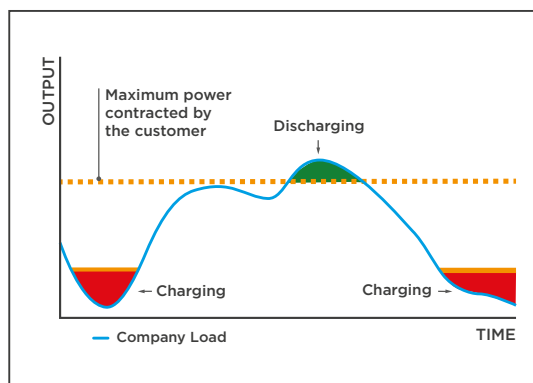
FREQUENCY REGULATION SYSTEM

Freemaq DC/DC provides ability to regulate grid frequency in both directions. When there is a grid overfrequency (generation>demand) inverter power output is curtailed and this energy is stored through charging batteries. When there is a grid under-frequency (generation<demand) inverter power output is increased by discharging the batteries and injecting more power to the grid.

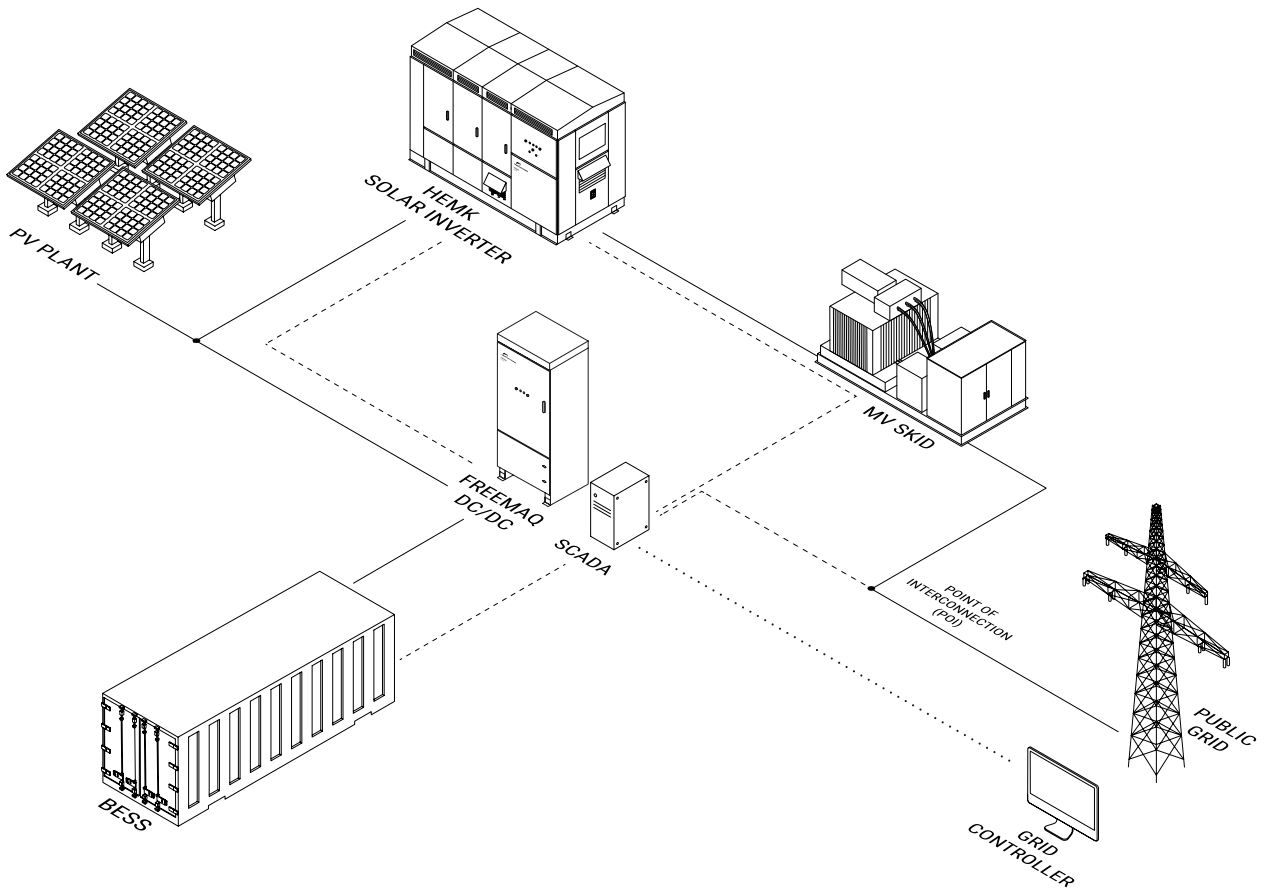


PEAK POWER SHAVING

By delivering stored energy to the grid during periods of high demand, it reduces the burden on the distribution network and increases significantly its efficiency. Energy is stored during periods of low demand increasing the load on the grid. During peak periods this stored energy is then injected into the grid reducing the demand at this time. The result is a more flattened demand curve which means the grid can avoid switching on more expensive and polluting generators.



CONFIGURATION



- Power connections
- — — Plant communications
- Grid controller communication

MODULAR DESIGN

Its unique modular design provides the flexibility needed to design your project, choosing the amount of storage power to be dispatched, according to the specific grid requirements.

From 525 kW to 3.15 MW



TECHNICAL CHARACTERISTICS

REFERENCE	FD0525	
DC INPUT & OUTPUT	DC Rated Power (kW)	525
	DC PV Voltage Range (Vdc)	700 to 1500
	DC ESS Voltage Range (Vdc)	700 to 1500
	Maximum DC PV Input Voltage (Vdc)	1500
	DC Voltage Ripple	<3%
	Maximum DC output current (A)	600
	Battery Technology	Compatible with all battery technologies
EFFICIENCY	Efficiency (Max)	98,9%
	Max. Standby Consumption	< approx. 50W
CABINET	Dimensions (mm)	1215 x 970 x 2250
	Cooling	Forced air
	Enclosure Rating	NEMA 3R / IP54
CONNECTIONS	Number of connections	3 positive / 3 negative
	Terminals	Lugs Rated 90°C
	Max. positive and negative input wire size	500kcmil / 253mm ² (2 cables per terminal)
ENVIRONMENT	Operating Temperature range ^[1]	-35°C to 50°C
	Relative Humidity	4% to 100% non condensing
	Max. Altitude	4000m; >2000m power derating
	Audible Noise level	<79 dBA
CONTROL INTERFACE	Interfaces	Emergency pushbutton and indicator lights
		USB, RJ45 and RS 485
		Freesun App
	Communications Protocol	Modbus TCP, Modbus RTU
PROTECTIONS	Ground Fault Detection	Insulation monitoring device
	PV disconnection & protection	Switch + Fuses
	BESS disconnection & protection	Contactors + Fuses
CERTIFICATIONS	Safety Certification	UL-1741

[1] Heating resistors kit option below -20°C.