

# Lithium-ion battery systems

Solar photovoltaic (PV) — Energy Storage Systems (ESS)



The system approach for outstanding performance and safety

Saft's Li-ion battery technology has established an unrivalled track-record in space vehicle and satellite programs that represent the most demanding and performance-critical environment for any battery. The same rigorous design and manufacturing principles have been applied as Saft has introduced Li-ion batteries across a number of sectors including aircraft, vehicles, rail, telecoms, data centers, industrial standby and energy storage.

Saft has a unique capability that spans the entire lithium-ion (Li-ion) battery design, development and manufacturing chain from individual cells, through battery modules to fully integrated battery systems. In the majority of ESS applications for PV installations a Saft battery system offers the optimum route for ensuring the highest levels of performance, availability and safety over a long service life.

## What are the key battery system functions?

A Li-ion battery system provides a number of key functions in an ESS application:

- Deliver power and energy as required
- Ensure safe system start-up, sleep mode, shut down (connection with charger)
- Ensure battery operation in optimum conditions
  - Supervise voltage, current, temperature at system, module, cell levels
  - Indicate in real time the available charge and discharge power / current to the inverter
  - Ensure balancing of cells, modules, strings
  - Provide alerts when operating conditions are "out of normal"
  - Put the battery into safe operation mode in case of an anomaly
- Present information to the user / inverter system
  - Operational parameters in real time (current, voltage, temperature)
  - State of Charge (SOC) and State of Health (SOH)
  - Alerts
- Ensure safe operation
  - Detect anomalies
  - Send alarms to trigger corrective action (e.g. reduce charge voltage, lower power...)
  - Disconnect the battery (interrupt charge / discharge) if a critical threshold is reached and put the battery into a safe mode condition
  - Re-connect battery and allow charge/discharge if the anomaly has cleared



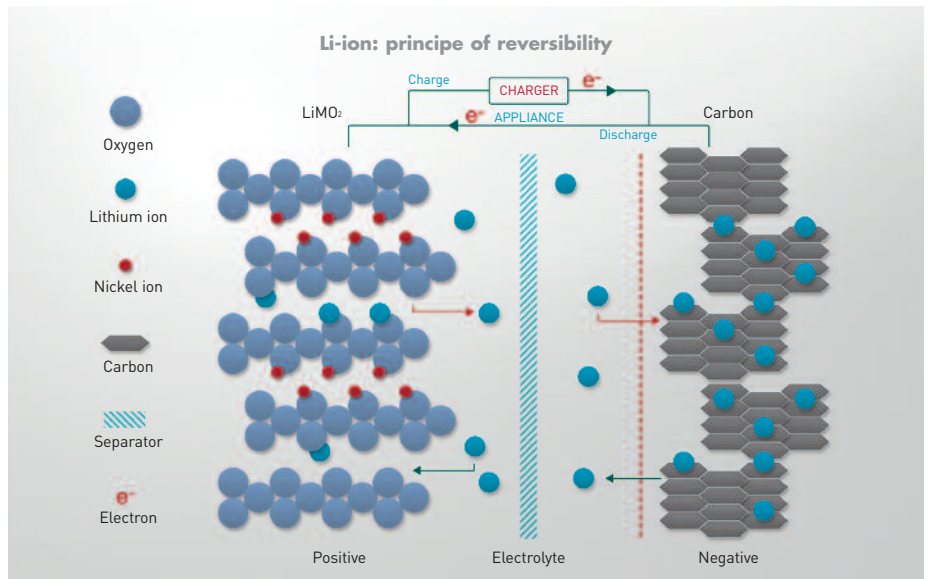
**SAFT**

# VL Li-ion cells

A Li-ion cell comprises:

- A positive electrode made from lithiated metal oxides (LiNiCoAlO<sub>2</sub>, LiFePO<sub>4</sub>...)
- A negative electrode generally made of carbon material
- An electrolyte made of lithium salts dissolved in organic carbonates
- A separator made of porous polymeric materials (for insulation between the electrodes and to allow the ionic exchanges)

When the battery is charged, the lithium atoms in the cathode become ions and migrate through the electrolyte toward the carbon anode where they combine with external electrons and are deposited between carbon layers as lithium atoms. This process is reversed during discharge.



Saft Li-ion cells are manufactured on a volume basis at factories in Jacksonville, US and Nersac, France. An R&D centre in Bordeaux also supports the development of new battery technologies.

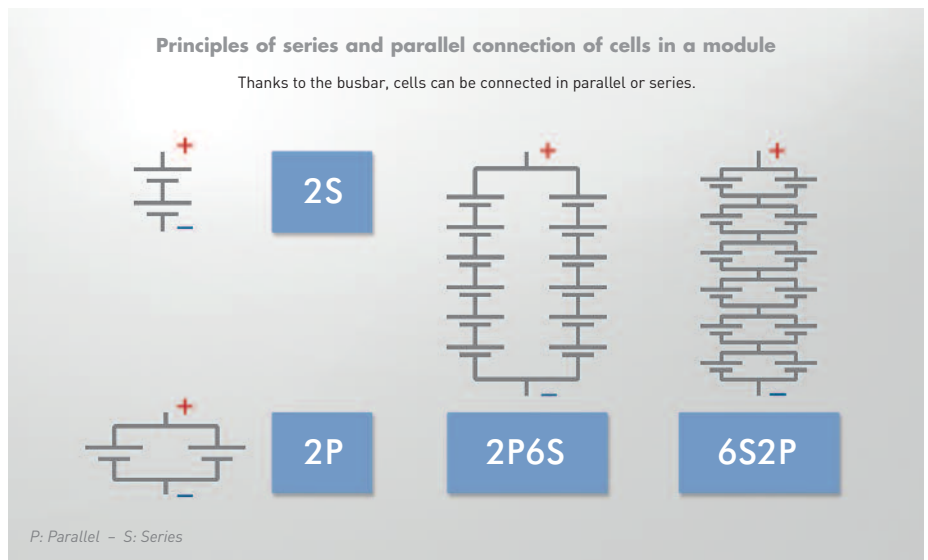
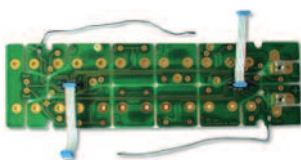
Saft ESS batteries are based on cylindrical format VL cells available in 3 different versions to suit various power and energy requirements.

# Synerion<sup>®</sup> Li-ion battery modules

Saft Synerion<sup>®</sup> Li-ion battery modules integrate a number of cells assembled in series and/or parallel configuration to provide the required voltage and capacity. They are available in 24 V or 48 V versions from 2 to 12 kW.



The bus bar provides the electrical interconnection between the individual cells and also carries the circuits and components for managing charge/discharge management (the bus bars often integrate the SMU function as well).



Each module incorporates an electronic control board known as the SMU (safety monitoring unit). Its functions are:

- monitoring the individual cell voltage during charge and discharge
- monitoring battery internal temperature
- balancing cells
- data communication with the BMU (Battery Management Unit)

## Keeping things in balance

Although Li-ion cells are manufactured to the very highest quality standards there are always slight variations in their characteristics, especially the rate of self-discharge. The SMU balancing function uses a resistor to discharge the cells with the highest voltage to bring them to a uniform level.

## Intensium<sup>®</sup> Max battery systems

In Saft's Intensium<sup>®</sup> battery systems, Synerion modules are connected in series and associated with one BMM (Battery Management Module). The BMM contains two main functions: BMU (battery management unit – to manage all the battery functions) and an EDU (electrical disconnect unit – to enable the safe disconnect of a single string). It is responsible for:

- Operations supervision (U,I)
- Charge/discharge management →IMR/IMD
- Thermal management
- Warnings/alarms
- SOC (State of Charge)
- SOH (State of Health)
- First level safety
- Watchdog
- Blackbox
- Maintenance/Diagnostics

Several strings can be connected in parallel through an MBMM (Master BMM, managing the parallel connection and balancing between strings) This architecture ensures a high level of redundancy and maintainability: it is possible to disconnect a single string whilst all others continue operation. The BMM and MBMM provide superior CAN Bus communication capability by delivering key information on the battery operation to the charger and the next level Energy Management System. This includes its SOC and SOH, available power and energy and, if necessary, warnings and relevant information for maintenance.

Saft also provides a tool for battery diagnostics: it can be connected to the BMM and provides in-depth data on components and operation history – helping identify, isolate and repair quickly any component defect.

## Saft has developed three main battery system ranges for PV installations



### Intensium<sup>®</sup> Home

Integrated energy storage system for residential applications



### Intensium<sup>®</sup> Smart

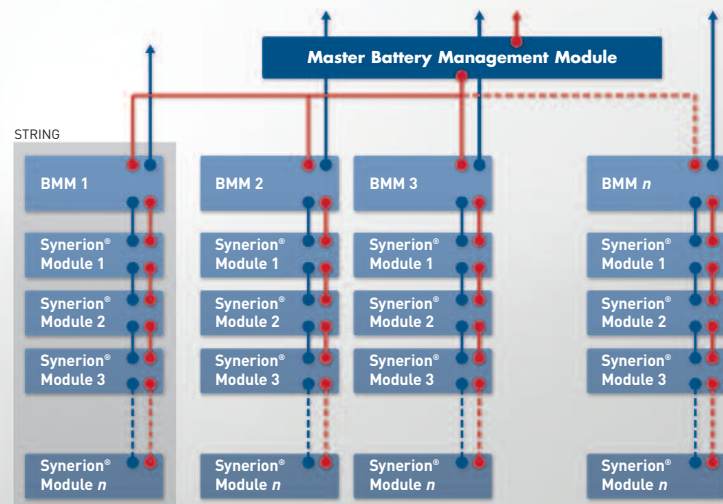
Energy storage to support smart grid applications



### Intensium<sup>®</sup> Max

A containerised system that provides energy storage capacity of up to 1 MWh or power of up to 1.8 MW in a standard 20 foot container that integrates Li-ion battery modules, power management and control interfaces, air conditioning and safety devices in a comprehensive package, delivered to site ready to install and commission.

### Components: Master Battery Management Module



● Power (series connection in string/parallel connection to application)

— Communication (CAN open protocol)

Arrows: Application connection

## Total system support

Saft's scope of supply extends well beyond the system to include:

- Pre-project support: modelling the behaviour of both the battery and the entire system over its projected lifetime enables accurate and reliable simulation of each customer application – a vital capability to ensure the optimum sizing of the ESS
- After sales: installation, commissioning, maintenance contracts, spare parts

## Leading the way in ESS

Saft battery systems continue to lead the way in ESS:

- First ESS project at MW scale in 2003
- First ESS project with Li-ion systems in 2007
- First ESS containerised Li-ion storage system delivered in 2012

Currently, with over 50 MWh of containerised systems installed or on order, Saft has one of the largest installed bases of battery system manufacturer.



## Useful acronyms

	Full name	Comprising	Functions
<b>BMC</b>	Battery Management Controller	BMU plus casing	Cell management
<b>BMM/BMS</b>	Battery Management Module/System	BMU/BMC plus EDU	Cell protection and management
<b>BMU</b>	Battery Management Unit	SMU plus managing electronics	Cell management and communication
<b>CAN Bus</b>	Controlled Area Network Bus		Communication between modules and BMM, and BMM or MBMM to charger
<b>EDU</b>	Electrical Disconnect Unit		Enables the safe disconnection of a single battery string
<b>MBMM</b>	Master Battery Management Module	Several BMCs plus EDUs	Management of modules in series or in parallel
<b>SMU</b>	System Management Unit		U and T, data acquisition and balancing



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