

Lithium Battery Management Systems (BMS)

There is no question that lithium battery technology has changed the world. The higher energy density and superior cycle life has enabled so many electronic devices to become smaller, lighter and more powerful. The range of products which use lithium batteries extends from hearing aids to power tools and electric vehicles.

There is a saying that simply goes 'You get nothing for nothing'. When it comes to lithium batteries, the improvement in performance comes with an increased risk of a thermal event. All batteries can suffer from thermal runaway, which is when the temperature inside the battery increases faster than it can dissipate that heat through the case resulting in an increase in the internal battery temperature. The problem with lithium batteries is that depending on the chemistry, thermal runaway can begin at around 60°C, and can escalate rapidly into a fire which is difficult to extinguish.

If you manage them correctly however and keep them away from that critical point, lithium batteries are safe and stable in the same way that we drive around with a tank of highly flammable gasoline in our cars, without having to worry about the risk of an explosion.

To achieve this, lithium batteries use a Battery Management System (BMS). A BMS uses battery temperature, voltage and current flow actively manage the battery and deliver maximum safety and service life. A BMS will intervene when one of the following situations occurs:

- **Over Temperature:** If a lithium battery becomes too hot it can suffer from thermal runaway. The BMS will isolate the battery before the temperature becomes high enough to risk an incident. When the battery temperature falls back within the normal operating range the BMS will re-connect the battery.
- **Under Temperature:** In general, lithium batteries do not like to operate below 0°C because their electrolyte can freeze. Some are able to operate down to around -20°C for discharge however they need to be above 0°C for charging. If the battery becomes too cold, the BMS will isolate the battery to protect it from any damage. When the temperature increases and is within the operating range the BMS will re-connect the battery.

- **Over Voltage:** If the voltage of a lithium battery exceeds its maximum during charging, heat is generated which can damage the cell and result in thermal runaway. The BMS will isolate the battery as soon as the voltage exceeds the maximum allowable to protect it.
- **Under Voltage:** Lithium batteries also have a minimum voltage. When the cell voltage falls below this minimum value, the cell is permanently damaged and will not recover. The BMS will isolate the battery before the voltage falls below this lower limit to ensure the battery is not damaged, allowing it to be re-charged.
- **Cell Balance:** In lithium batteries there are multiple cell groups connected in series to achieve the desired voltage range. The BMS monitors the cell group voltage to ensure that the voltage of each group is the same (i.e. balanced). If an imbalance occurs, the BMS will apply a small load to the cell group with the higher voltage until it falls back within the range of the other cell groups in the battery. This also ensures that when a load is applied to the battery, each battery is loaded equally.
- **Over Current:** All batteries have a maximum charge and discharge current. When you exceed this, heat is generated and the risk of thermal runaway increases. The BMS will isolate the battery if the maximum allowable current is exceeded.

As an example, the table below is taken from the ALLiON Product Data Sheet. It shows the BMS protection triggers and reset criteria for voltage, current and temperature. Note that the BMS also has over temperature protection for the MOSFETs (transistors) used in the BMS.

	Item	Characteristic	Specification
4.1	High Voltage (Vmax)	High voltage protection	3.75V \pm 0.03V per cell
		Reset voltage	3.60V \pm 0.05V per cell
		Reset trigger	Below reset voltage
4.2	Low Voltage (Vmin)	Low voltage protection	2.50V \pm 0.05V per cell
		Reset voltage	2.80V \pm 0.10V per cell
		Reset trigger	Begin charging
4.3	Overcurrent (Imax)	Maximum charge current protection	100-120A, delay time 30s \pm 5s
		Charge current protection reset	Discharge or auto reset after 1min
		Maximum discharge current protection	100-120A, delay time 30s \pm 5s
		Discharge current protection reset	Charge or auto reset after 1min
		Short circuit protection	Do not short circuit the electrodes
4.4	Temperature	Maximum charge temperature	Protect @ 65°C \pm 5°C Reset @ 50°C \pm 5°C
		Minimum charge temperature	Protect @ -10°C \pm 5°C Reset @ 0°C \pm 5°C
		MOSFET over temperature protection	Protect @ 103°C \pm 10°C Reset @ 65°C \pm 10°C

The RELiON & ALLiON range of batteries all have a BMS integrated into the battery to ensure maximum safety and service life.