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Lithium titanate capacitors

Conventional capacitors in lithium-ion technology such as lithium manganese or lithium cobalt dioxide have a high energy density but have their well-known weaknesses. On the one hand, this is aging, a gradual loss of capacity that renders the battery unusable after 1000 to 2000 charge/discharge cycles. On the other hand, the battery can only be operated optimally at room temperature; use at low temperatures severely limits performance or requires integrated heating. The batteries react sensitively to overcharging and deep discharge, so that processor-controlled and therefore complex charging electronics are necessary.

Our alternative is the lithium titanate oxide capacitor (LTO for short). It also belongs to the family of lithium batteries. However, the negative graphite electrode is replaced by a sintered electrode made of a titanium spinel ($Li4Ti5O12$). The lithium titanate electrode has a much larger effective surface area than a graphite electrode by a factor of 30. For this reason, very high charging and discharging currents in the range greater than 10C can be achieved. The power density is therefore around 1,200-3,500W/kg (2,700-7,500W/l). The energy density of 70-90Wh/kg (120-200Wh/l) is lower and is in the range of that of conventional lead batteries.

The chemical bond of the lithium in the titanate is relatively strong. This prevents the formation of an insulating layer on the LTO electrode, which promotes aging in the graphite electrode of conventional lithium-ion batteries. The service life of LTO capacitors is specified as 20,000-25,000 charge/discharge cycles and is correspondingly high. An LTO capacitor can easily be fully charged in around 10 minutes. The advantage is that charging and discharging at maximum power does not have as serious an effect on aging as with lithium-ion batteries.

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LTO capacitors are easy to handle and behave like a capacitor. Deep discharge is not critical and overcharging is not possible with suitable balancing. LTO capacitors can be charged with a simple and stable direct voltage source. Because the titanate cannot react with oxides from the negative electrode, "thermal runaway" is prevented in this type of battery, even in the event of mechanical damage. LTO capacitors can be used at low temperatures without any problems; a reduction in performance is only noticeable below approx. -20°C; some LTO capacitors are specified for temperatures down to -40°C.

LTO cells generally have a nominal voltage of 2.4V. As with all other capacitors, it is necessary to connect cells in series or parallel for higher voltages and capacities. In this case, a battery management system (BMS) is required, which balances the charge levels of the individual cells (balancing). The use of LTO capacitors is interesting wherever the advantageous properties of fast charging, high power density, operation at low temperatures and longevity can be exploited in whole or in part.