

### 5.9.1 Battery Monitor - External

The external **Battery Monitor** measures the in/out battery current and calculates the SoC based on the capacity set, but also dependent on losses in the battery (ref Peukert's law). The Battery Monitor has a certain measurement error of the current, about +/- 0.4% (Victron BMV712). The Battery Monitor also has an error in calculating the losses, that can be at the same number.

The total estimated SoC error is +/- 0.5 - 1% at best. Such error is for one cycle and has minor significance. However, if the battery is cycled several times but not at 100% charge, this error will accumulate and can cause the Battery Monitor to show a State of Charge error of 5 - 10%.\*

In addition, estimated SoC is based on capacity set which usually does not match the true capacity of the lowest cell. This error can be up to 25% which can be added to measurement and calculation errors. **It's a great advantage to calibrate capacity (Ah) settings based on the X2 BMS LED indications.**

The SoC error will be synchronized every time the battery is fully charged, as the Battery Monitor adjusts the set value to 100% at that cycle. However, incorrect setting of true capacity is never calibrated but must be set.

### 5.9.2 Adjusting / tune the SoC estimate

The Peukert and CEF settings can be adjusted to obtain a more accurate measurement for the particular system. However, it can be challenging to set due to variations in the rate of charge/discharge and battery temperature, from one cycle to another. We advocate keeping the settings recommended and displayed in the Installation Guide.

Capacity varies among different cell brands and among different cell sizes (Ah). For different cell brands, we have measured a range of 100 – 127% as true capacity compared to the nominal rated Amp hour capacity.



#### Note!

**Please note**, one of the most important adjustments that should be made is to **specify true capacity** (Ah) in the Battery Monitor's setting. If the true capacity is not set, the Battery Monitor will show errors.

It is advisable to make the settings when the cells are new because then it can be compared after many years of service with the SoC displayed by the Battery Monitor versus LED alert by the X2 BMS. This comparison will be a good indication of the battery's State of Health.\*\*

When testing true SoC, it should be a single full cycle from 100% to 18-20% SoC (to avoid accumulated measurement error by SoC calculation). The LED indications by the X2 BMS are based on true voltage for the lowest cell, measured with high accuracy (+/- 0.1 mV).

When the Low Battery yellow LED starts flashing during discharge, the Battery Monitor should show about 18 - 20% SOC. The test must be performed during low-medium discharge without voltage drop.

If the SoC differ from the value(s) 18 – 20% when “Low Battery” LED starts => Adjust the Battery Monitors setting of capacity (Ah). For example, if the Battery Monitor showing 14% when yellow LED starts flashing, then increase the capacity setting with 5%. If the Ah is set to 400 Ah, adjust the capacity setting with 5% to 420 Ah.

Battery life is often quoted as 2000 cycles for 100% DoD, and about 3000 cycles for 90% DoD. However, if the discharge is shorter, the number of life cycles increases. If a half cycle (45 - 50%) doubles the number of cycles, the life will be the “same” since it takes two half cycles compared to one 90% DoD cycle – for the same capacity used.

Please Note, it is important to achieve maximum cycle life, the voltage should not be outside the normal range where the voltage profile is flat. The X2 BMS Pro ensures that all cells are within the normal range at both low and high voltage. The BMS disconnect all chargers and does not float/abs charge.

A deep discharge never goes below the safe level, due to LVP1 will be triggered after three stages of pre-alerts.

\*) Data provided is consistent with tests conducted since 2017 as well as on customer feedback. It can also be added that tests have shown that external Battery Monitors (e.g. Victron BMV712) are outstanding in comparison to other BMS on the market that have the SoC feature built in.

\*\*) A battery's cycle life “ends” when 80% of the original capacity remains (=definition of cycle life). Cycle numbers will be displayed in the Battery Monitor (for example Victron). An indicator of SoH, can be calculated by the cell resistance (impedance) and number of cycles, but is not good. That type of estimated SoH works only in theory due to the internal resistance always varies for a house battery, affected by both discharge and charge as well as SoC.