BATTERY STATE OF CHARGE INDICATION ON THE CHARGE CONTROLLER

BASIC PRINCIPLE OF OPERATION

Charge controllers that provide the user with battery state of charge information (via an LED indicator or display) typically use the voltage of the connected battery to calculate this value. With commonly used lead-acid battery technologies[1], the battery voltage is directly proportional to its state of charge (within the operating voltage limits of that battery), making it a suitable basis for an indicative battery status reading.

WHY DOES THE CONTROLLER SHOW 100% STATE OF CHARGE DURING CHARGING, BUT THE VALUE IS SIGNIFICANTLY LOWER WHEN THE SOLAR PANEL IS NOT PRODUCING?

This phenomenon is related to exactly how charge controllers indicate the battery state of charge – via voltage. During charging, the battery is subjected to the voltage from the charge controller, which is higher than the upper operating voltage limit of the battery, causing the state indicator to evaluate the battery as fully charged.

When the photovoltaic panel stops delivering energy, the voltage at the battery terminals drops suddenly, which the controller interprets as a discharge. Even though the battery is no longer charging, its voltage continues to be influenced by the connected load – when consumers are connected to the battery, its voltage drops slightly.

BATTERY VOLTAGE IN VARIOUS SITUATIONS

Battery state	Battery voltage	
	12V (nominal)	24V (nominal)
Equalisation charging phase	> 15V	> 30V
Nearly full during charging	14,4 – 15,0V	28,8 – 30,0V
Nearly empty during charging	12,3 – 13,2V	24,6 – 26,4V
Nearly empty during discharging	10,2 – 11,2V	20,4 – 22,4V
Fully charged + small load	12,4 – 12,7V	24,8 – 25,4V
Fully charged + large load	11,5 – 12,5V	23,0 – 25,0V
100% – at rest[2]	12,7V	25,4V
80% – at rest	12,5V	25V
60% – at rest	12,2V	24,4V
40% – at rest	11,9V	23,8V
20% – at rest	11,6V	23,2V
Fully discharged – at rest	11,4V	22,8V

[1] Lithium battery voltage is less stable – less reliable

[2] Battery is neither charging nor discharging (at least 3 hours, ideally 6 hours)

HOW TO OBTAIN A RELIABLE APPROXIMATE STATE OF CHARGE READING USING THE BUILT-IN INDICATOR?

Given the facts above, the ideal approach is to measure the actual battery voltage (and thus its state of charge) when it is neither being charged nor discharged (i.e. at rest).

HOW TO DETERMINE THE REAL STATE OF CHARGE (REMAINING CAPACITY) OF THE BATTERY?

For accurate monitoring of battery state of charge, the method known as "Coulomb counting" is used. It works on the principle of measuring the discharge (charge) current (A) over time (s). Using the entered initial battery capacity (Ah), this method can precisely determine the state of charge and thus the remaining capacity. However, this method is significantly more complex to implement, which is the main reason why ordinary (less advanced) charge controllers typically do not use it.