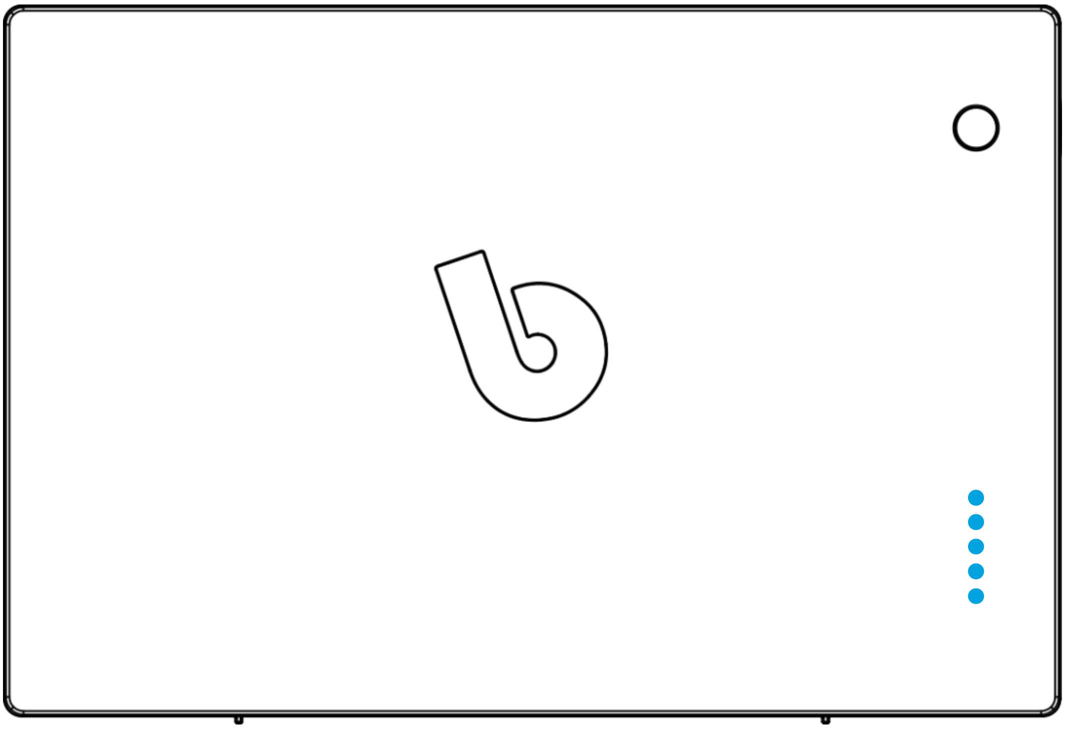
BBOXX Home

How ‘State of Charge’ is Calculated



13 June 2016

Introduction

This document discusses how ‘State of Charge’ is estimated such that the status lights of the BBOXX Home correctly indicate to the end user how much energy they have available to them.

This document is written as a supplementary document to the user guide UG-000005: BBOXX Home Status Lights.

Valid for Software Versions: 3.5 and before

Battery State of Charge vs. Useable Available Energy

Although in all previous work we state that the status lights represent the battery *state of charge* under normal operating conditions, this is not actually true. From a high level, this explanation is acceptable, but when looked at in detail we should move away from this concept.

State of charge is not a correct description of what the status lights represent because BBOXX Home controls how deep a user can discharge the battery based on protection settings and the payment plan in effect. This means what the user sees as 0% to 100% via the status lights is not the true 0% to 100% of stored energy in the battery.

So, the status lights only inform the end-user how much energy is available to them, and not how much energy is available in the battery.

Calculating Percentage of Usable Available Energy

Calculating the percentage of usable energy still available to the end user is done using voltage thresholds. The basic idea behind this estimation method is that the main operating region of a sealed lead-acid battery has a linear, and therefore proportional, relationship between battery voltage and stored energy. Therefore, we can carefully select a range of voltage thresholds which each represent approximately equal proportions of usable energy.

One problem in using voltage to estimate available energy is that the voltage can vary wildy. These variances are especially noticeable between a battery being charged, a battery being discharged and a battery at rest. To handle this we use different sets of voltage thresholds to handle the different situations a battery will find itself in (only charge and discharge/rest threshold sets defined).

The SoC thresholds for a resting and discharging battery are:

<table>
<tr><th rowspan="2">Available Energy</th><th colspan="3">Voltage Threshold</th></tr>
<tr><th>60Wh</th><th>100Wh</th><th>140Wh</th></tr>
<tr><td>100%</td><td rowspan="2">12.76 V</td><td rowspan="2">12.66 V</td><td rowspan="2">12.58 V</td></tr>
<tr><td rowspan="2">80%</td></tr>
<tr><td rowspan="2">12.62 V</td><td rowspan="2">12.42 V</td><td rowspan="2">12.26 V</td></tr>
<tr><td rowspan="2">60%</td></tr>
<tr><td rowspan="2">12.48 V</td><td rowspan="2">12.18 V</td><td rowspan="2">11.94 V</td></tr>
<tr><td rowspan="2">40%</td></tr>
<tr><td rowspan="2">12.34 V</td><td rowspan="2">11.94 V</td><td rowspan="2">11.62 V</td></tr>
<tr><td rowspan="2">20%</td></tr>
<tr><td rowspan="2">12.20 V</td><td rowspan="2">11.70 V</td><td rowspan="2">11.30 V</td></tr>
<tr><td>0%</td></tr>
</table>

The SoC thresholds for a charging battery are:

<table>
<tr><th rowspan="2">Charged Energy</th><th colspan="3">Voltage Threshold</th></tr>
<tr><th>60Wh</th><th>100Wh</th><th>140Wh</th></tr>
<tr><td rowspan="2">80%</td><td>14.60 V</td><td>14.60 V</td><td>14.60 V</td></tr>
<tr><td rowspan="2">13.76 V</td><td rowspan="2">13.66 V</td><td rowspan="2">13.58 V</td></tr>
<tr><td rowspan="2">60%</td></tr>
<tr><td rowspan="2">13.62 V</td><td rowspan="2">13.42 V</td><td rowspan="2">13.26 V</td></tr>
<tr><td rowspan="2">40%</td></tr>
<tr><td rowspan="2">13.48 V</td><td rowspan="2">13.18 V</td><td rowspan="2">12.94 V</td></tr>
<tr><td rowspan="2">20%</td></tr>
<tr><td rowspan="2">13.34 V</td><td rowspan="2">12.94 V</td><td rowspan="2">12.62 V</td></tr>
<tr><td>0%</td></tr>
</table>

There is no 100% threshold for charging because the fifth light will only turn solid once the charging algorithm reaches the float charge stage – when the charger will actually drop the applied voltage from 14.60 V to 13.80 V.

When float charging the battery is determined to be 100% charged.

This usable available energy estimation technique is generally reliable for healthy batteries but will become less reliable as the battery’s state of health deteriorates (normally as a result of age or damage).

BBOXX is aware of the drawbacks of this estimation technique and is exploring alternative options to better communicate users the BBOXX Home status with the end user.

If you're interested in learning more about what we're doing to improve usable available energy estimation and end user experience feel free to ask us at products@bboxx.co.uk