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BATTERY CELL SELF-DISCHARGE RATE GROUPING TO ENCHANCE BATTERY LIFE (BSGTEBL)

HP INC

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Battery Cell Self-Discharge Rate Grouping to Enhance Battery Life (BSGTEBL)

Abstract

• When battery is stored for a period (e.g. stored NB for a period), voltage of each cell in battery pack will result deviation. Higher the deviation (Delta V = voltage difference) higher inconsistency of voltage among each cell will be realized and finally leading to shorter battery life. This phenomenon is called “CIM (Cell imbalance)”.

• In order to decrease DeltaV (voltage difference), battery cells will be divided into several groups, then the consistency of each defined group with similar self-discharge rate.

• The general parameters used to group cells are open-circuit voltage (OCV), capacity, impedance. Self-discharge rate can be used as a grouping parameter to decrease battery cells DeltaV (voltage difference).
Self-Discharge Rate Measurement

- Self-discharge rate measure process
  1. High Temperature Aging
  2. Room Temperature Aging
  3. 1st voltage check
     Voltage record as: $V_1$
  4. Room Temperature Aging
  5. 1st voltage check
     Voltage record as: $V_2$

- Self-discharge rate calculation
  $V_1 - V_2$
  Time 3

- Self-Discharge rate measurement process is show as left picture.
- Self-discharge rate is calculated with right formula.
- Self-discharge rate unit is: mv/hour
- Self-discharge rate is used to measure battery cell self-discharge
  - For example: 0.03mv/hour means battery cell voltage decrease 0.03mv per hour.
- If cells Self-discharge rate are same, battery cell voltage should be similar after storage.
Self-discharge rate grouping to mitigate CIM (cell imbalance)

As shown in below picture:
- Bigger self-discharge rate takes bigger DeltaV
- Lower self-discharge rate takes lower DeltaV
- Self-discharge rate grouping can help to decrease DeltaV, e.g.:
  - K-value < 0.03 as a group
  - K-value > 0.03 as a group

DeltaV: voltage difference

Below table is general battery cell grouping parameter without Self-discharge.

<table>
<thead>
<tr>
<th></th>
<th>OCV</th>
<th>IR</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group1</td>
<td>XX v+5mv</td>
<td>XX mΩ+5mΩ</td>
<td>XXmah+1%</td>
</tr>
<tr>
<td>Group2</td>
<td>XX v</td>
<td>XX mΩ</td>
<td>XX</td>
</tr>
<tr>
<td>Group3</td>
<td>XX v-5mv</td>
<td>XX mΩ-5mΩ</td>
<td>XXmah-1%</td>
</tr>
</tbody>
</table>

Below table is battery cell grouping parameter with Self-discharge.

<table>
<thead>
<tr>
<th></th>
<th>OCV</th>
<th>IR</th>
<th>Capacity</th>
<th>self-discharge rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group1</td>
<td>XX v+5mv</td>
<td>XX mΩ+5mΩ</td>
<td>XXmah+1%</td>
<td>XX mv/hour + XX</td>
</tr>
<tr>
<td>Group2</td>
<td>XX v</td>
<td>XX mΩ</td>
<td>XX</td>
<td>XX mv/hour</td>
</tr>
<tr>
<td>Group3</td>
<td>XX v-5mv</td>
<td>XX mΩ-5mΩ</td>
<td>XX mah-1%</td>
<td>XX mv/hour-XX</td>
</tr>
<tr>
<td>--------</td>
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<td>-----------</td>
<td>---------------</td>
</tr>
</tbody>
</table>

**Advantage**

- Enhance battery life by mitigating battery pack CIM.
- Saving cost on replacing battery by user to gain better user experience

*Disclosed by Xiao Kai Mao, Jen-Hao Tai, Chien Kun Wang and Chang-Tai Lin, HP Inc.*