5 Criteria For a Better Balancing System

When we started looking for a better balancing system, we set five design goals:

1. **Keep the battery in perfect balance**

   Our first goal was to develop a technology that completely eliminates out-of-balance conditions in any battery, for the entire life of the battery, regardless of variations in cell capacities and impedances

2. **Safe**

   The technology must be safe. Specifically, system design must assure the battery and the system electronics are not exposed to adverse or hazardous conditions

3. **Efficient**

   A good balancing system will be highly efficient, keeping as much energy as possible in the battery

4. **Highly reliable**

   The largest and fastest growing market for large lithium-ion battery packs is the automotive industry. Any new balancing technology must comply with automotive reliability standards.

5. **Low-cost**

   No new product will succeed if its cost is excessive. We set aggressive cost targets for our new technology.

Did We Meet Our Criteria?

Here’s what we did:

- We established five criteria for a better balancing system
- We came up with a design concept that became “True Balancing”
- We built three generations of True Balancing systems
- We ran extensive tests on each generation to measure performance against the criteria

Did we meet our goals?

Please continue reading to see how we fared.

1 Keep the Battery Balanced

We created test conditions that were intended to cause True Balancing to fail. We used test cases that would make existing balancing systems flash red lights and shut down.

We did tests with cells that have wide variations in capacity and internal impedance.

We created initial conditions in which the cells in the battery have grossly different SOCs, such as half the cells at 0% SOC and half the cells at 100% SOC.

In every test, True Balancing brought the battery into perfect balance and brought every cell up to true 100% SOC* in one fast, efficient charge cycle.

Our tests confirm that True Balancing can keep any battery in perfect balance for the entire life of the battery, regardless of battery chemistry, cell size, battery architecture and (most importantly) regardless of variations in cell characteristics.

** Note: We define "100% SOC" as the state of charge of each cell at the end of a complete CCCV charge cycle. This is a higher standard than existing balancing systems use. True Balancing raises the bar for BMS performance.*

Safe

We performed rigorous safety tests with our True Balancing prototypes. The tests were intended to create excessive and/or hazardous current conditions. In every case, True Balancing's safety mechanisms worked exactly as intended and prevented unsafe conditions from occurring.

The current sensors on the balancing legs are the keys to safety in True Balancing.

We establish a threshold value for current on the balancing legs. The threshold can be set to have any margin of safety that is desired.

Whenever True Balancing is active, the microcontroller monitors the current sensors.

If the current on any balancing leg reaches the threshold, the microcontroller immediately adjusts the output voltage on the relevant switch mode divider to bring balancing current back below the threshold value.

Our firmware and hardware have redundant levels of safety as a back-up to the current sensors. We are confident that True Balancing can meet all safety standards for the automotive industry.

Efficient

One weakness of passive balancing is its inherent inefficiency. With passive balancing systems, all of the balancing energy is bled from the battery and is burned off as heat in load resistors. This is 100% inefficient.

In every True Balancing system we have built to date, every transfer of energy from one cell to an adjacent cell has efficiency of 97% or more.

This means that when True Balancing is working to keep your battery in balance, almost all of the energy stays in the battery.

An added benefit of this is that True Balancing generates very little heat. Your battery and your BMS stay cooler with True Balancing.

Highly Reliable

The EV industry dominates the market for large lithium-ion battery packs – and the automotive industry has strict standards for system reliability.

We have many years of experience designing products that must comply with extremely high standards of reliability, including for medical, military and aerospace applications.

Our design for True Balancing incorporates design-for-reliability principles that are stipulated by the US military for mission-critical electronics used in battlefield environments.

We are confident that True Balancing can comply with all worldwide standards for reliability in the automotive sector

Low-Cost

True Balancing systems can be assembled with readily available low-cost electronic components – mainly resistors, capacitors, inductors and diodes.

Building a True Balancing system does not require any components that are high priced, single-sourced or exotic.

For absolute lowest cost (and smallest PCB size) True Balancing can be designed with a small ASIC or a tiny FPGA and few external components.

True Balancing systems can be assembled on any high-speed pick-and-place SMT line.

True Balancing adds less than 1% to the cost of a typical EV battery pack and provides added value to the pack of 20% or more.

Did We Meet Our Criteria?

Yes!

And more…

Our ongoing evaluation of True Balancing has revealed numerous benefits above and beyond the five criteria that we established at the start of this project.

True Balancing can lower the cost and improve the performance of your battery pack in many ways.

Please visit www.truebalancing.com to learn more.