

## Active Cell Balancing increases effective battery capacity and reduces capacity variance.

Active Cell Balancing alleviates a number of problems associated with the efficient use of multi-cell, Lithium chemistry batteries.

### Cell Manufacturer

Lithium Ion cell manufacturers experience variations in individual cell capacities as a result of the cumulative effect of inconsistencies in the production processes and materials. This results in differences in individual cell capacities ranging from fractions of percent into double digits. Capacity variations are further exacerbated by variations in internal cell impedance which can prevent access to capacity at high rates of discharge. Also, the variations in cell capacity and impedance change as the cell ages, this is caused primarily by charge/ discharge cycles, depth of discharge & environmental conditions.

In an attempt to reduce the problems caused by cell mismatch, when used in multi cell battery packs, cell manufacturers employ screening at the end of their process and batch cells according to their capacities. The outcome is that although individual cells are closely matched to other cells of a similar capacity, the overall variation follows a normal Gaussian distribution. When assembled into multi cell battery packs of a nominal capacity the packs will also follow a normal distribution.

Although cell capacity screening alleviates the problems of cell mismatch within an individual battery pack it does not address the capacity distribution of battery packs. This is illustrated by the blue curve in the graph below. The distribution of battery capacities follows that of their component cells.

By using Active Cell Balancing technology cells of varying capacity can be randomly mixed in battery packs thus eliminating the need for a screening process. Active Cell Balancing evenly distributes capacity across the component cells within a battery and results in significantly lower capacity variance. This is illustrated by the green curve in the graph as compared with the standard variance illustrated by the blue curve.

### Battery Pack Manufacturer

A battery pack is only as good as the weakest cell. During charge and discharge the battery management and protection circuitry will disable the battery when the weakest cell reaches its upper or lower operational limits. By supporting weaker cells during discharge, using energy from the cell stack, or moving energy away from weaker cells during charge cell balancing can be achieved. Active Cell Balancing overcomes the problems of cell miss match interacting with the battery packs electronic management and protection system. This enables maximum energy to be stored in a battery pack, permits maximum energy delivery, increases time between charges and improves overall battery lives. Current state of art balancing systems are passive and only function in charge mode. Active Cell Balancing functions in both charge and discharge and the technology can also function as an integral charger.

Active Cell Balancing provides higher effective battery capacities with significantly lower variance, extended battery life, extended time between recharges and offers an integral charger.

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