NeverDie® Battery Management System
Section 1: Overview

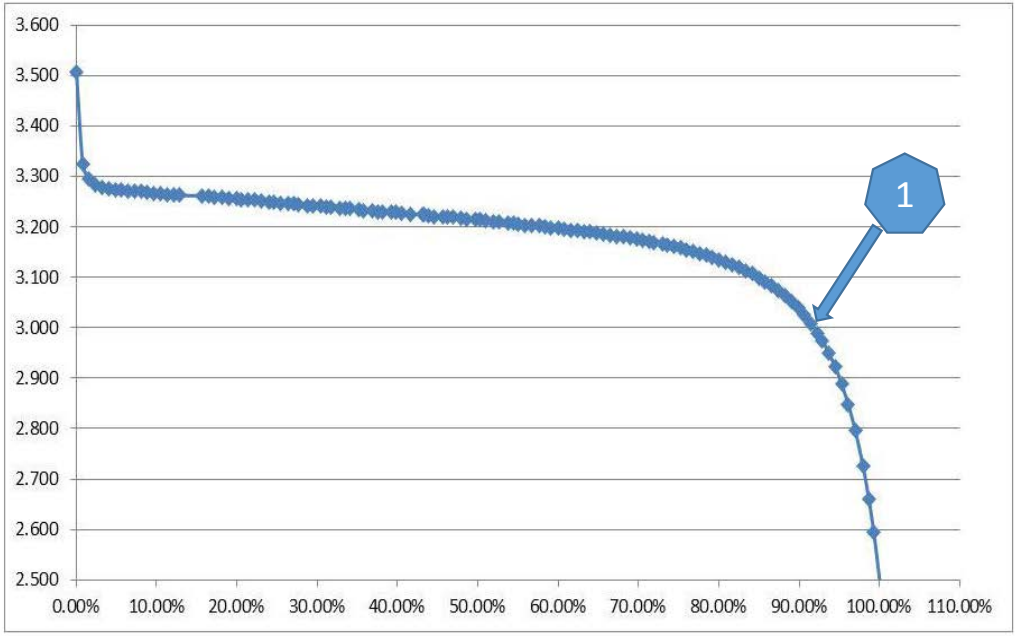
Key Terms and Definitions:

- BMS: Battery Management System, Necessary for Battery Safety and Cell Life
- BMS Ensures that all Internal Cells are Acting in Union During Charge and Discharge Cycling.
- BMS Monitors and Takes Action to Shut-Down the Battery if Just One Cell is Failing
- LVC: Low-Voltage Cutoff, or, the Point Where the NeverDie® BMS Will Force the Battery into Sleep-Mode, with or without a Power-Reserve
- LVC is Required to Prevent Cell Failure by Over-discharging and Reverse-Polarity
- HVC: High-Voltage Cutoff, or, the Point Where the BMS Will Stop Charging Current to Prevent Thermal-Runaway
- HVC Also Occurs When Cell-Balancing is Underway but becomes Excessive
- Shunting: A Necessary Function to EQUALIZE Individual Cells with Natural Small Differences in Capacity and Resistance/Impedance. Used to Ensure All Cells are Brought to near-100% State-of-Capacity. Shunting Occurs Near the End of the Charging Stage (Called Top-End Shunting.)

LITHIONICS BATTERY

www.lithionicsbattery.com

NeverDie® Battery Management System
Section 1: Overview



LiFePO4 Power-Type Cell Discharge Curve (Per Cell)

- At a discharge rate of ½-Capacity or .5C (50 amps continuous on a 100 amp hour cell for example) the graph represents voltage readings take at various depths-of-discharge
- 12 Volt: Multiply the Voltages X 4 (Cells)
- 24 Volt: Multiply the Voltages X 8 Cells
- 36 Volt: Multiply the Voltages X 12 Cells
- 48 Volt: Multiply the Voltages X 16 Cells
- 72 Volt: Multiply the Voltages X 24 Cells

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Example: Point 1 is 3.0 Volts at Approx. 90% Depth of Discharge Under Load: 4 Cells X 3.0 = 12.00 Volts Provided at just 10% of Remaining Capacity! It is for this reason that Lithium Batteries Consume Fewer Amp Hours to Maintain Watts (or, Volts X Amps)

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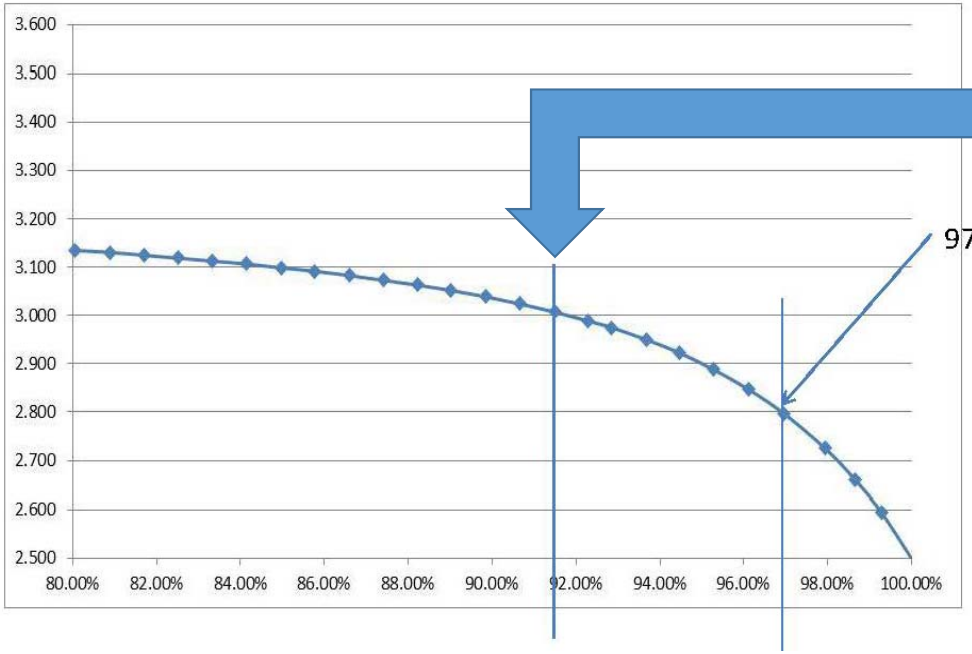
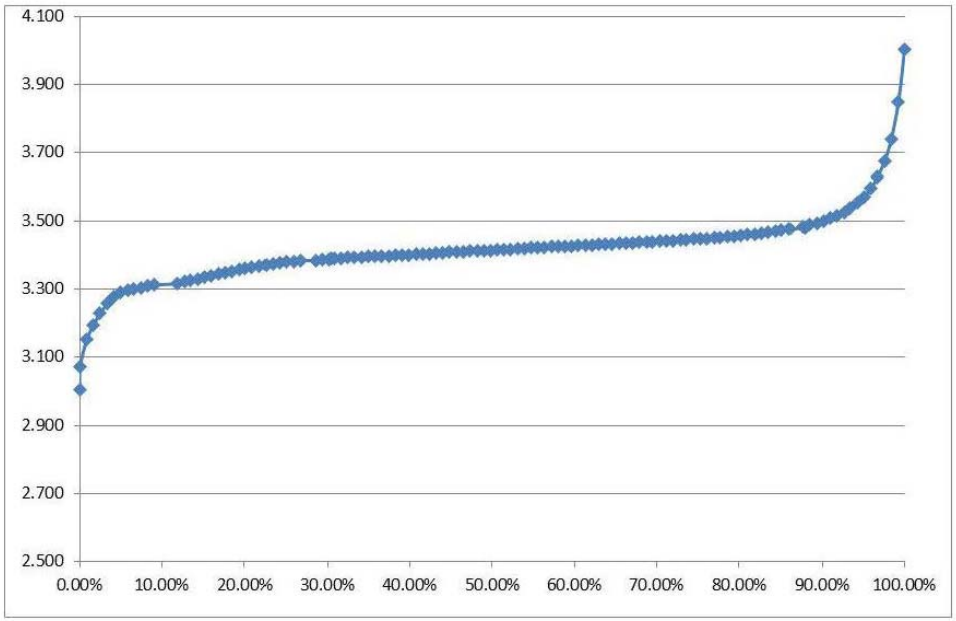
NeverDie® Battery Management System
Section 2: Managing LVC or Low-Voltage-Cutoff



LiFePO4 Power-Type Cell Discharge Curve (Per Cell)

- At 2.95 Volts Per Cell (or, 11.8 Volts on a 12.8V System) the NeverDie® BMS Enter 'Power Reserve Sleep Mode', Leaving Sufficient Power to Re-Start an Engine
- For a Propulsion Battery System, The Power-Reserve May be Accessed by the Customer to Allow a Second Discharge between 2.95 Volts (or 92% Depth-of-Discharge) and 2.80 Volts (or 97% Depth of Discharge.) At 2.80 Volts, the NeverDie® is Turned Off and Mandatory Recharge is Required.

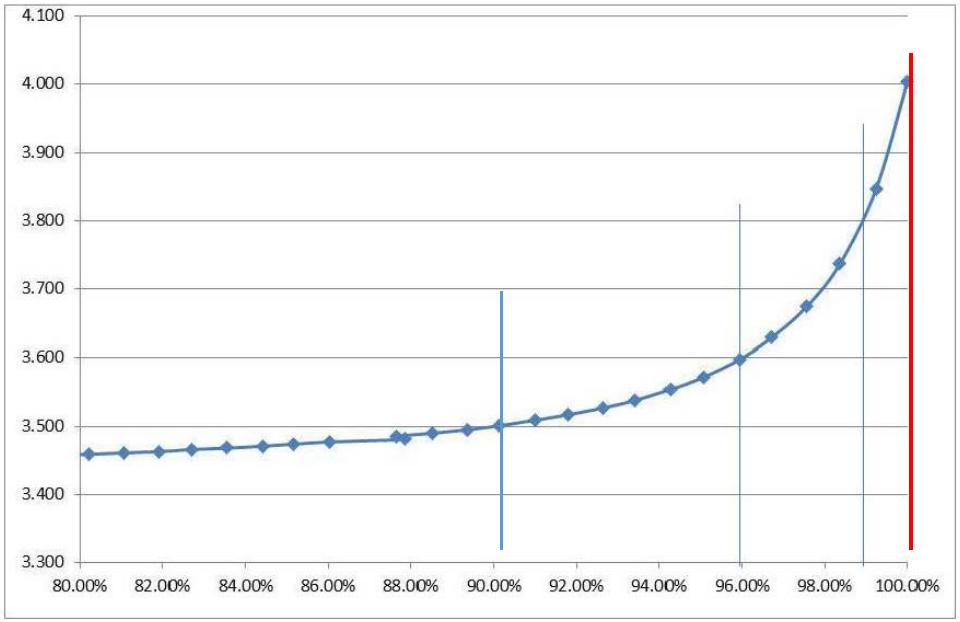
NeverDie® Battery Management System
Section 2: Managing HVC or High-Voltage-Cutoff
OVERVIEW



LiFePO4 Power-Type Cell CHARGE Curve (Per Cell)

- This Section Describes How the NeverDie® Controls Safe Recharging
- Notice How the Lithium Cell Exhibits a Rapid Voltage Rise Near the End of Its Charging Cycle
- It is for This Characteristic That Many Lithium Cell Failures Are Caused By Charging Close to the Point of "Exponential" Voltage Rise or By Using Incorrect Chargers

NeverDie® Battery Management System
Section 2: Managing HVC or High-Voltage-Cutoff
EXPLANATION



LiFePO4 Power-Type Cell CHARGE Curve (Per Cell)

- The Graph is Now Enlarged to Show the END of the Charging Cycle
- All Lithium Cells Must Be Re-Balanced or Equalized During Recharging to Account for Differences in Capacity. This is Called Shunting. When the First Cells Reaches 100 Percent 'Fill' It Begins to Shunt or Bleed-Off Excess Charging Current Waiting for the Weaker Cells to 'Catch Up' to 100% State-of-Charge
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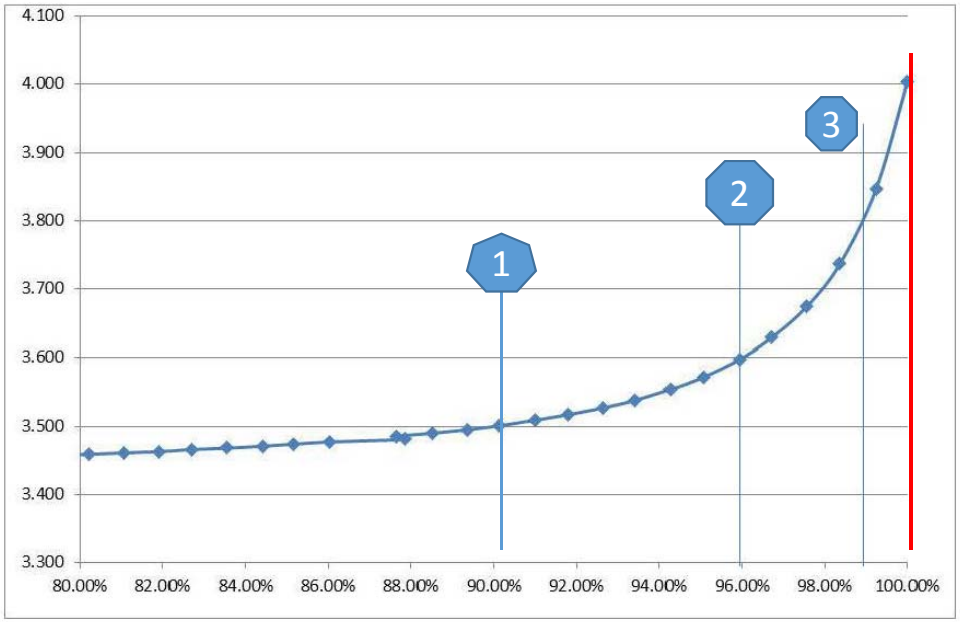
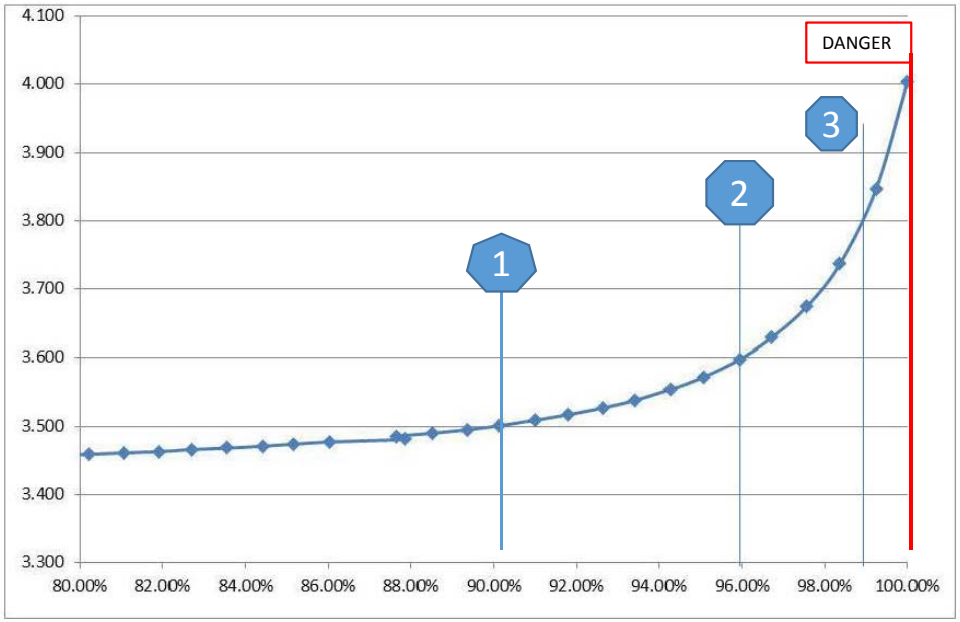
NeverDie® Battery Management System
Section 2: Managing HVC or High-Voltage-Cutoff
EXPLANATION



LiFePO4 Power-Type Cell CHARGE Curve (Per Cell)
Point 1:

- The recommended charging volt of NeverDie® Batteries, AKA, the GEL Battery Charging Algorithm: 14.0, 28.0, 42.0 and 56.0 Volts for Common Voltage Systems. The GEL Algorithm for Lead-Acid Batteries Deletes the EQUALIZE Function (Voltage Spikes) and Our NeverDie® is Designed to Charge with GEL Settings
- The Voltage at Which We Begin to SHUNT Each Cell to Achieve Cell Balancing (Re-Balancing)
- From Point 1 to Point 2 We Perform 'Soft-Shunting' or Variable-Rate Shunting to Prevent Stress to the Balancing Electronics

NeverDie® Battery Management System
Section 2: Managing HVC or High-Voltage-Cutoff
EXPLANATION



LiFePO4 Power-Type Cell CHARGE Curve (Per Cell)
Point 2 to Point 3:

- At 3.6 Volts Per Cell, the NeverDie® Balancing System is Shunting at a Full Rate. This Allows for Some Voltage Inaccuracy When Non-Lithium Chargers are in Use by the Customer (Magnum, Outback, Xantrex for example)
- Full Shunting Continues from 3.6 to 3.8 Volts per Cell. In this Range the BMS Permits Full Charging with 'Tripping' the HVC Disconnect. For a '12V' Battery, the Voltages would be 14.4 to 15.2 Volts. Not Recommended, but, Tolerated by the BMS
- For Safety Reasons, The BMS will Trigger HVC (Disconnect) if Either 1 Cell Reaches >3.8 Volts or The Temperature Sensors Detect High Heat from Shunting

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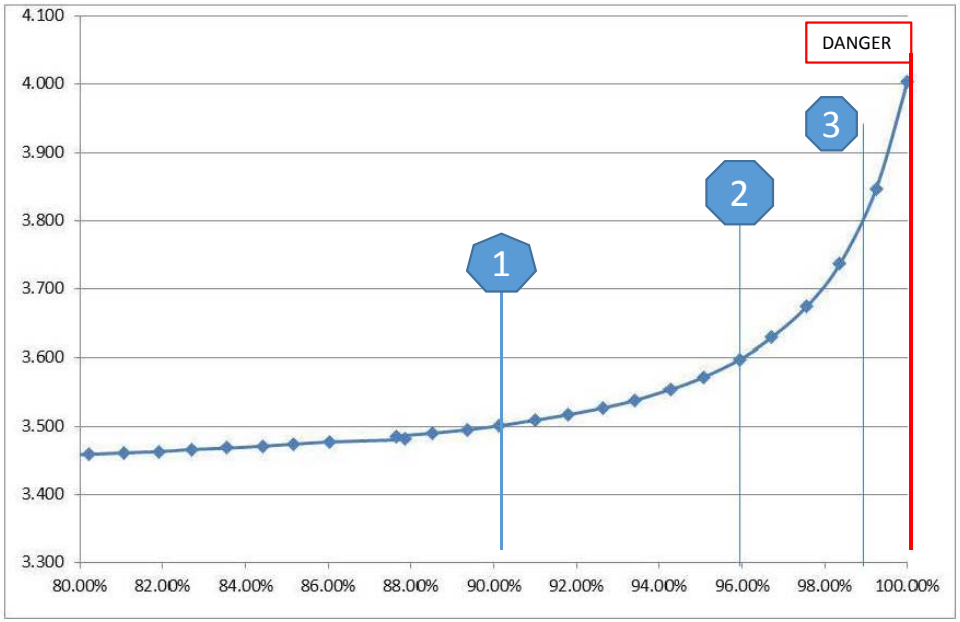
EXPLANATION



LiFePO4 Power-Type Cell CHARGE Curve (Per Cell)

SUMMARY

- If the NeverDie® BMS Trips the HVC Disconnect Point, it Simply is Entering Sleep Mode and Taking the Battery Off-Line to Prevent Further Charging.
- When SHUNTING is Complete, the NeverDie® Will Automatically Turn the Battery Back to ON.
- Some Customers will Require a Dual-Channel NeverDie® BMS to Permit HVC Disconnect of CHARGING Inputs but Still Permit DISCHARGING Power to be 100% Available if HVC is Tripped.