

Application Brief

Dead Battery Charging Safety



Wyatt Keller

Introduction

Safety is the most important aspect of a Battery Management System (BMS) and the charger is a critical piece used to protect the battery cells. When to allow, or prevent, battery charging can greatly impact the safety of a battery system. That's why a charger with the proper protection features in relation to zero-volt, or dead battery charging should be selected depending on the application requirements.

Over-Discharged Safety

If a battery is unused for a long period of time in an over-discharged state, it degrades at a faster rate. The accelerated degradation is caused from the copper anode foil dissolving into the electrolyte. As the copper anode dissolves it can also release gases into the pouch cell, leading to battery swelling. Furthermore, on the next charge cycle copper dendrites form and potentially cause Solid Electrolyte Interface (SEI) layer damage. Dendrite formation can lead to internal battery shorts which gets worse as the battery is used, and impacts the battery performance and safety.

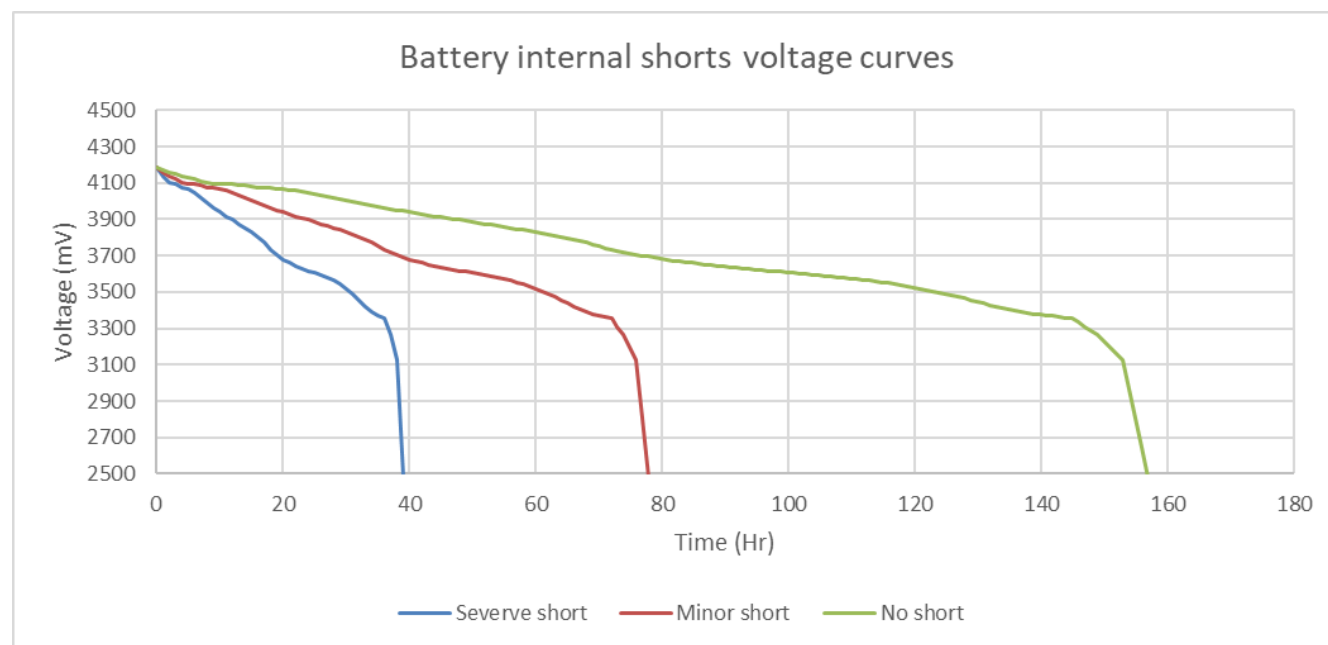


Figure 1. Example of Battery Voltage with Varying Internal Short Conditions

Many standards require some form of charge inhibit if the batteries are over-discharged, so that recharge below a voltage threshold is not allowed. GB 31241 and IEC 62133 are some of the industry standards which outline safety requirements for battery applications. The safety requirements from these standards do not define clear voltage thresholds to safely recharge a battery, but they rely on the battery manufacturers datasheet and the external circuitry to follow the battery manufacturer requirements for recharge from an over-discharged state.

Dead Battery Charger Features

For a standalone charger without external host control, it is important to review the safety features and select the best charger for the application. If the battery cell chosen forbids charging once it has discharged below a low voltage threshold, then a charger with dead-battery charge inhibit should be selected. The BQ25308 was designed for applications which don't allow for zero-volt charging. If the battery datasheet allows for recharging from an over-discharged state, then a charger like the BQ25300 can be selected. The BQ25308 also supports LiFePO4 chemistry with lower voltage thresholds for precharge and charge inhibit.

Table 1. BQ25308 Voltage Transition Points for Charge Inhibit, Precharge, and Fast Charge

Mode	Battery Voltage V_{BAT}	Charge Current	Typical Value
Battery short	$V_{BAT} < V_{BAT_SHORT}$	Charge inhibited	-1.5uA
Precharge	$V_{BAT_SHORT} < V_{BAT} < V_{BAT_LOWV}$	I_{PRECHG}	10% of I_{CHG} ($I_{PRE} > 63mA$)
Fast Charge	$V_{BAT_LOWV} < V_{BAT}$	I_{CHG}	Set by I_{CHG} resistor

Table 2. BQ25308 Voltage Thresholds for LiFePO4 and Standard Li-ion

Parameter	Description	Test conditions	Min	Typ	Max	Unit
$V_{BAT_SHORT_RISE_L_FP}$	VBAT short rising threshold for LiFePO4	Short to trickle, $V_{BATREG} = 3.6V$	1.1	1.2	1.3	V
$V_{BAT_SHORT_RISE}$	VBAT short rising threshold	Short to precharge, $V_{BATREG} = 4.05V/4.15V/4.2V$	2.05	2.2	2.35	V
$V_{BAT_SHORT_FALL_L_FP}$	VBAT short falling threshold for LiFePO4	Trickle to short, $V_{BATREG} = 3.6V$	0.9	1	1.1	V
V_{SHORT_FALL}	VBAT short falling threshold	Precharge to short, $V_{BATREG} = 4.05V/4.15V/4.2V$	1.85	2	2.15	V

When a battery cell datasheet allows recharge at low voltages, but the cell has an internal short, the charger may not be able to recover the voltage above the precharge to fast charge voltage transition. Precharge is a percentage of the fast charge current, for the BQ2530x devices it is 10% of the fast charge current. In the case the battery does not recover with the precharge current, the charger can catch potential unsafe batteries and stop charging using the precharge safety timer.

Table 3. BQ25308 Safety Timers

Parameter	Description	Test conditions	Min	Typ	Max	Unit
t_{SAFETY_FAST}	Charge safety timer	Fast charge safety timer 20 hours	15	20	24	hr
t_{SAFETY_PRE}	Charge safety timer	Precharge safety timer	1.5	2	2.5	hr

When using an I2C charger with host control and power path management, the decision to allow charging can be made by the host, therefore it is not as critical to select the charger with a dead battery charge inhibit feature.

References

1. Texas Instruments, *BQ25308 Standalone 1-Cell, 17V, 3.0A Battery Charger with Dead Battery Charge Inhibit*, data sheet.
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