THE REAL STORY BEHIND LEAD-ACID REPLACEMENT BATTERIES

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PREFACE

We are delighted to welcome you to the world of cascadable lead-acid replacement batteries and the many benefits they provide. This guide has been created to assist you in understanding the bottlenecks and potential problems of this technology.

Motive power applications such as golf cars and utility vehicles, floor cleaning machines, AGVs, RVs, AWPs (Aerial Work Platforms), MH (Material Handling), marine, and medical carts have traditionally used lead-acid batteries or in other words a group of 12V lead-acid batteries cascaded in series, parallel, or both series and parallel.

Lithium batteries that are used in place of lead-acid batteries are known as ***lead-acid replacement batteries***.

Increasingly more people are using lithium batteries because of their high energy density, light weight, and long lifespan. The advantages of lithium over lead-acid batteries, however, are not the focus of this article.

PROBLEMS AND SOLUTIONS RELATED TO THE REPLACEMENT OF LEAD-ACID BATTERIES WITH LITHIUM BATTERIES

Initially, "drop-in replacement" is a very common and fancy marketing slogan used by lithium battery suppliers, however, users quickly discovered that switching from lead-acid to lithium batteries is not as simple as it appears.

CHARGERS REFUSE TO CHARGE

First of all, the original lead-acid battery charger might not be able to fully charge the lithium counterpart. The charging methodology for lead-acid batteries revolves around bulk, absorption, and floating charge, but in the world of lithium, it is now CC & CV. Even some lead-acid chargers can also be set to CC/CV mode, when there are protections, the MOSFETs inside the lithium batteries will occasionally shut off their output, this is considered normal behavior, and all lithium batteries should exhibit it. However, the majority of lead-acid chargers will consider battery output shutoff as a dead or malfunctioning battery and will not charge the batteries.

SOLUTION

Let the battery to supply the charger with the identification voltage while ensuring low power consumption.

CAN'T CHARGE THE BATTERY AT LOW TEMPERATURE

Charging the battery at sub-zero temperatures is strictly prohibited, however, charging the battery at low temperatures with normal current will also endanger the battery, in reality, users always want to charge the battery in a low temperature location, such as a garage, this greatly limits the battery's usage scenarios.

Solution

Install a heater inside the battery to keep the temperature of the battery cells at an appropriate level.

CAN'T DETERMINE ADEQUATE CHARGE CURRENT

The charge temperature range of most lithium batteries is 0~45°C, but this makes users confuse, because on the one hand, users may require high charge current throughout the entire temperature range in order to maximize charge efficiency, but in low temperatures, even it is above 0°C, high charge current may still endanger the batteries.

Solution

Let the battery to communicate with the charger in order to output the appropriate current at various temperatures.

CELL BALANCING DOES NOT WORK

For battery applications, capacity is a crucial metric, however, the cell-inconsistency of lithium batteries, particularly the LFP type, is in general not good enough, that causes the effective capacity to decline more quickly than anticipated, issue continues to worsen as cycle number rises.

Lithium batteries with few hundred watt-hour capacities may use the cell balancing function to solve this issue, however, when the battery capacity exceeds 800Wh, this function is rendered ineffective and even useless.

Solution

Despite the fact that large balancing current is extremely difficult to achieve, find way to improve the cell balancing function in order to deliver efficient current.

THE CHARGING PHASE ENDS PREMATURELY

Compare with NMC, even with careful design, LFP type lithium batteries consistently behave premature charging phase completion, this is reflected as the disappearance of their CV phase during the charging cycle. Therefore, the charging capacity is insufficient compared to the design capacity.

Solution

Find way to get the CV phase appear.

POOR FUEL GAUGE ACCURACY

The majority of lead-acid applications, such as golf carts, forklifts, and floor cleaning machines, have fuel gauges that are based on voltage level. These fuel gauges worked well in lead-acid systems, but when switched to lithium, the flat voltage versus capacity characteristic of lithium batteries became a burden for these fuel gauges, particularly for the LFP type.

Inaccurate fuel gauges can result in sudden power cut-off, users may need to turn off the battery output a lot in advance to avoid this problem, but then the effective capacity of the battery will be greatly reduced.

Solution

Use the current integration approach (coulomb counter ADC) rather than the voltage method.

SAFETY CONCERN

When compared to lead-acid batteries, lithium batteries are well known for their ability to deliver large amounts of power, this ability is due to their extremely low internal resistance, which allows the battery to instantly emit a large amount of energy, however, when the battery undergoes a special accident, such as short circuits or overheating caused by structural or circuit reasons, this ability has become a source of risk.

Solution

Design the battery carefully (both electronically and mechanically) such that this extreme condition does not occur and if it does occur, have several sensors to detect it early on, remove the primary energy source to put it out, and use fireproof material to stop it from spreading.

HUGE MUTUAL CHARGING CURRENT

By theory, battery cells inside a lithium battery can be connected in series or in parallel. Lithium batteries, on the other hand, unless there is a special design, can neither be connected in series or parallel.

One of the serious problems caused by parallel connection is the mutual charging current between batteries of different capacities, although it is difficult to prove by experiment that mutual charging current causes fire or explosion, but it is true that in theory the mutual charging current's magnitude could be more than the short-circuit current, users should be aware of this potential risk.

Because there were no such restrictions in the lead-acid world, many users, including manufacturers, felt it was safe to connect lithium batteries in series or parallel. While most of the lithium batteries in the field claiming that they can be connected in parallel, however the truth is that they rely on the battery cells to resist the huge amount of mutual charging current.

Solution

Implement an advanced circuitry and an algorithm to limit the mutual charging current to a safe level until the SOC between batteries reaches equilibrium.