



Unlocking the Power: Managing Multiple Batteries in Swappable Systems

Introduction

The increasing demand for higher energy storage capacity has led to the adoption of parallel battery configurations in various industries. These configurations offer advantages such as enhanced reliability, extended runtime, and the ability to transport energy. Industrial equipment manufacturers constantly seek innovations that minimize downtime, reduce costs, and enhance the flexibility of power systems. Traditional power solutions often fall short in providing the adaptability required for modern industrial applications. The Swappable AC Power Platform is engineered to meet this demand, delivering a streamlined, cost-effective solution that simplifies the power system design process.



Benefits of Swappable Batteries

Swappable batteries offer several benefits in mobile applications. Here are some key advantages:

- **Extended Runtime:** Swappable batteries allow for continuous operation without the need for downtime. When one battery depletes its charge, it can be quickly replaced with a fully charged battery, providing extended runtime for mobile devices or equipment. This is particularly valuable in applications where continuous operation is critical, such as in logistics, field services, or emergency response.
- **Flexibility and Portability:** Swappable batteries provide the flexibility to carry or store spare charged batteries and replace them as needed. It eliminates the need to find charging stations or wait for batteries to recharge, enabling uninterrupted mobility. This is especially advantageous in scenarios where charging infrastructure is limited or unavailable.
- **Reduced Downtime:** With swappable batteries, there is minimal downtime associated with charging. Instead of waiting for a battery to recharge, users can simply replace the depleted battery with a fully charged one, allowing them to resume their activities immediately. This is crucial in time-sensitive operations and can enhance productivity.
- **Scalability and Adaptability:** Swappable batteries offer scalability and adaptability in mobile applications. Users can adjust the number of batteries based on their specific energy requirements. If higher energy capacity is needed, additional batteries can be easily added to meet the demand. This scalability makes swappable batteries suitable for a wide range of mobile devices and varying power needs.
- **Ease of Maintenance and Serviceability:** Swappable batteries simplify maintenance and servicing processes. Faulty or aging batteries can be replaced individually without affecting the entire device or system. This eliminates downtime and lowers maintenance costs compared to integrated or fixed battery systems, where the entire device may need to be sent for repairs or battery replacements.
- **Reduced Weight and Size:** Swappable batteries can help reduce the weight and size of mobile devices. Instead of carrying bulky external power sources, users can carry lightweight spare batteries, which are generally more compact. This advantage is particularly valuable in portable devices, mobile workstations, and applications where size and weight considerations are crucial.
- **Future-proofing and Upgradeability:** Swappable batteries provide future-proofing and upgradeability options. As battery technologies advance, users can easily replace older battery models with newer, more efficient ones. This allows mobile applications to benefit from technological advancements and ensures compatibility with evolving energy storage solutions.



Technology

Battery Chemistry

Green Cubes Technology's swappable batteries rely on Lithium Iron Phosphate (LiFePO₄) chemistry, which has emerged as a leader in battery innovation due to its unmatched endurance and safety benefits:

- **Longer Lifespan:** LiFePO₄ batteries allow for significantly more charge cycles compared to traditional lithium-ion chemistries, reducing replacement costs and environmental waste.
- **Enhanced Safety:** With high thermal stability and lower risk of combustion, these batteries provide peace of mind during everyday use.
- **Consistent Performance:** Whether under high demand or extended periods of operation, LiFePO₄ ensures reliable and predictable energy delivery.
- **Better Environmental Footprint:** Iron is an abundant and non-toxic ore, unlike Nickel, Manganese and Cobalt, which are rare, generally available from unstable areas of the continent and difficult to mine.

Battery Management Systems and Nuisance Tripping in Swappable Systems

All lithium-ion batteries require a battery management system (BMS) to ensure safe operation by monitoring voltage, current, and temperature, and controlling power flow. Nuisance tripping refers to the undesired activation of the protection features of the BMS and is a design challenge for swappable systems. Several factors contribute to nuisance tripping in swappable systems, including overcurrent, high capacitance, mismatched states of charge (SOC), and inadequate load balancing. These issues are detailed below.

- **Overcurrent and High Capacitance:** The low internal impedance of lithium-ion batteries, which has the advantage of high electrical efficiency, carries the risk of high surge currents and fast transients. These characteristics, coupled with inadequate protection mechanisms or poor filtering in BMS circuitry can lead to overcurrent, which causes the BMS to shut down the battery output.
- **Mismatched SOC During Hot Swapping:** There may be a high surge of current due to charging of a low SOC battery by a high SOC battery when batteries with different states of charge are hot swapped, and this uncontrolled current flow between batteries with different impedances can exceed safety thresholds.
- **Inadequate Load Balancing:** Variations in current flow can occur due to uneven impedance paths, unequal cable lengths, or even simple contact resistance when multiple batteries are connected in parallel and cause the BMS to enter a protection mode if the current is more than limits on one battery.

Green Cubes' swappable system is designed with rigor and tested to ensure nuisance tripping is not an issue for our customers. Our patented design allows the battery to fulfil its fundamental value proposition of uninterrupted power

Components of the Swappable Power Platform

1. Battery Assembly

- **Technology:** Utilizes advanced LiFePO4 technology, known for its safety and longevity.
- **Capacity:** Offers 290Whr at 19.2 volts nominal, ensuring robust performance in demanding environments.
- **Output:** Provides a continuous power output of up to 300W, suitable for a wide range of applications.
- **Standards Compliance:** Meets IEC 62133 standards, ensuring global safety and performance benchmarks are met.



2. Cart Power Module

- **Flexibility:** Supports configurations of one or two batteries, with a stable 300 Watt continuous power output.
- **Versatility:** Available models providing 120VAC @ 60 Hz and 230VAC @ 50 Hz outputs. Features universal input from 100VAC to 230VAC @ 50 to 60 Hz, accommodating diverse power environments.
- **Backup and Charging:** Includes 2 minutes of integrated battery backup, allowing hot swap operations without interruption. Capable of charging both internal integrated and external swap batteries simultaneously.
- **Compliance and Options:** Meets stringent IEC 60601 standards, crucial for medical applications. Optional remote LCD display available for enhanced monitoring and control.

3. Charger

- **Efficiency:** Capable of charging two or four batteries simultaneously, reducing downtime. Universal input compatibility ensures operational flexibility.
- **Standards Compliance:** Fully compliant with IEC 60601 and 62368, affirming its suitability for medical environments.
- **Optional remote LCD display:** enhances user interface and operational insights.



Advantages of the Green Cubes Swappable Power Platform

Performance Excellence

The Green Cubes battery platform delivers exceptional performance for equipment manufacturers. Its highly accurate state-of-charge display, featuring a five-stage LED indicator, ensures users can confidently monitor battery levels. Advanced technology, including cell balancing, maximizes cycle life and runtime, providing long-lasting power solutions.

Operational Efficiency

By integrating swappable battery technology, OEMs can significantly reduce the time and cost associated with power system maintenance and upgrades. This technology enables seamless transitions between power sources, minimizing disruption and enhancing productivity.

Environmental and Economic Benefits

The use of LiFePO4 technology not only ensures safety and performance but also contributes to environmental sustainability. Longer battery life and improved energy efficiency translate to reduced waste and lower operational costs over time.

Conclusion

The Swappable Power Platform represents a paradigm shift in how industrial and medical workstations are powered. By offering a complete, pre-engineered energy storage solution, it simplifies the design process for OEMs and provides a scalable, efficient option for engineers. This innovative technology is set to redefine how power is managed in industrial applications, offering a glimpse into a future where energy solutions are as dynamic and adaptable as the systems they power. Swappable Lithium ion batteries are paving the way for a future where portable power solutions are as intuitive as they are high-performing.

For OEMs and engineers looking to stay ahead in the competitive industrial market, adopting the Swappable Power Platform is a strategic move towards achieving greater efficiency, reliability, and sustainability in their power systems. To learn more about integrating swappable Lithium ion batteries into your projects or operations, contact us for a consultation or explore our product solutions.

ABOUT GREEN CUBES TECHNOLOGY

Harnessing our 35 years of industry experience, Green Cubes Technology is committed to designing, manufacturing, and implementing Lithium-ion platforms that give you The Power to Perform. Our battery packs are sustainable, maintenance-free, environmentally friendly, and superior performing.

For more information, email info@greencubes.com or visit greencubes.com.