Application Brief

Meeting the Power Demands of 12V Auxiliary and Supercapacitor Batteries in Automotive Applications

Saeed Sharifi *BMS-BMP*

As vehicles continue to evolve with increased electrification and smarter systems, traditional 12V lead-acid batteries are gradually being replaced by more advanced energy storage solutions. Whether in electric, hybrid, or internal combustion engine (ICE) vehicles, the 12V rail plays a crucial role in powering essential components like lighting, infotainment, door locks, windows, steering systems, and electronic control units (ECUs). This system is typically supported by a 12V auxiliary battery or, more recently, a supercapacitor bank for fast-response and high-power delivery.

This shift toward lithium-based batteries and supercapacitors is driven by the need for improved performance, efficiency, and space savings. However, it also introduces new challenges that call for smarter battery monitoring solutions to maintain system safety, reliability, and cost-effective operation.

Use of 12V Batteries in New Vehicles

High-voltage batteries drive the motors in xEVs, but the 12V system remains indispensable. It activates critical vehicle functions during startup and keeps essential electronics running even if the main battery is disconnected or fails.

Lead-acid batteries have traditionally supported this role due to their simplicity and reliability. However, their bulk, weight, and limited lifespan present challenges. Today, lithium iron phosphate ($LiFePO_4$) and other lithium-ion technologies are emerging as more viable alternatives. These newer chemistries offer energy density, faster charging, greater durability, and improved performance in extreme temperatures.

To support this transition, European legislation such as the EU Batteries Regulation (EU) 2023/1542 promotes lithium-based chemistries through stricter requirements on recyclability, durability, and performance which are areas where lithium technologies excel.

A typical 12V lithium battery uses between 4 or 6 cells in series, depending on the chemistry. These batteries require precise monitoring to maintain safe voltage levels, prevent overvoltage or undervoltage conditions, and provide accurate state-of-charge readings. As more safety-critical features rely on the 12V supply, compliance with Automotive Safety Integrity Level (ASIL) standards is becoming increasingly important.

Supercapacitors: Meeting High-Power, Fast-Response Demands

While lithium batteries are ideal for storing energy over longer periods, supercapacitors are designed to deliver it quickly. They are increasingly used in 12V systems for applications like stop-start technology, short-term backup during power interruptions, or in crash power modules where immediate power delivery is critical. In crash scenarios, for example, systems must remain powered long enough to bring them to a safe state, even if the main battery is disconnected or damaged.

Supercapacitors can charge and discharge rapidly and operate across a broad temperature range, making them ideal for handling brief, high-power demands. However, because each cell operates at a relatively low voltage (approximately 2.7V), systems require several cells in series to meet 12V requirements. Since supercapacitors store less total energy than batteries, their voltage can drop sharply under load, making real-time monitoring essential to maintain consistent performance.

Monitoring Requirements for 12V Lithium-Based and Supercapacitor Systems

Developing reliable 12V systems with lithium-ion batteries or supercapacitors requires addressing a range of technical considerations.

- Accurate Voltage and Current Measurement

  Each cell must be monitored precisely to avoid overvoltage, undervoltage, or thermal issues. Lithium cells operate within narrow voltage ranges, while supercapacitors degrade quickly if overcharged. Real-time current monitoring also helps manage system load and efficiency.
- Cell Balancing and Longevity

  Imbalances between cells in a series-connected stack can lead to early wear or failure. Passive or active balancing helps correct this and can be optimized for low power use in systems that remain on continuously. TI's Cell Balancing With BQ7690x Battery Monitors provides useful techniques that apply to both industrial and automotive use cases.
- Temperature Monitoring and Fault Detection

  Battery systems must withstand temperature fluctuations and heat from nearby components. Monitoring temperature at the cell and system level is key to avoiding overheating. Built-in fault detection for short circuits, open-wire conditions, and voltage anomalies is essential for safety and ASIL compliance.
- Compact Integration and Cost Efficiency

  As ECUs become more compact and integrated, there is increasing demand for battery monitoring solutions that deliver multiple features in a small footprint. Devices that combine monitoring, balancing, and fault protection can help reduce board space and system cost without compromising reliability.

Use Case: BQ76907-Q1 in 12V Lithium-Based and Supercapacitor Systems

In applications where uninterrupted operation is crucial, such as domain controllers, crash power modules, or safety systems, auxiliary batteries and supercapacitor stacks provide reliable backup power. The BQ76907-Q1 enables accurate monitoring, effective balancing, and robust fault protection to keep these systems running smoothly.

In a 7-cell configuration, whether using lithium-ion or supercapacitors, the BQ76907-Q1 helps maintain system stability while supporting compliance with functional safety requirements.

Conclusion

As the automotive industry advances toward more efficient and intelligent systems, the role of 12V auxiliary power continues to evolve. Lithium-based systems and supercapacitors are emerging as the preferred technologies, driven by the need for greater efficiency, durability, and safety.

The BQ76907-Q1 provides a comprehensive solution tailored to these evolving needs. With integrated protections, balancing, and small size (3.5 x 3.5 mm2) in QFN package, it allows engineers to confidently develop next-generation 12V systems that meet both technical and safety requirements.

Additional Resources

- European Commission, Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries.
- Read Cell Balancing With BQ7690x Battery Monitors.
- Download the BQ76907-Q1 2-Series to 7-Series High Accuracy Automotive Battery Monitor and Protector for Li-Ion, Li-Polymer, LiFePO4 (LFP), and LTO Battery Packs and Supercaps data sheet.

Trademarks

All trademarks are the property of their respective owners.

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265