Use case
Material handling

Supercapacitor modules help transform modern material handling

Automation is a key trend in today's material handling industry. When something is to be shipped, it needs to be retrieved quickly, inexpensively, and efficiently. Facilitites increasingly are upgrading and building distribution warehouses with automated systems. These modern warehouses are comparable to a metropolitan street grid, crisscrossed with automated pathways for various pallets. Up until now, most of these automated vehicles were powered by batteries.

Batteries can be problematic in material handling applications. They can store a lot of energy but are generally limited in how they can discharge without effecting lifetime. For material handling applications, a lithium-ion battery is expected to have less than 10,000 full cycle lifespan. This means they incur relatively higher maintenance costs due to the need for frequent replacement. Batteries are heavier, and they contain hazardous materials that require special disposal after replacement. Alternatively, supercapacitors can be fully charged within seconds or minutes, and they efficiently deliver their entire charge just as quickly, operating over a wide temperature range.

A popular trend is food or meal delivery services. These services require the product to stay frozen until it's delivered. With supercapacitors, pallet shuttling services can retrieve products from freezers without drastically impacting their performance. Unlike batteries, supercapacitors do not require as much derating while working in low temperatures. Eaton supercapacitors are lightweight and can operate over a wide operating temperature range of -40 °C to +65 °C.

In material handling, energy is primarily drained by lifting the material or during initial acceleration. When the equipment returns to the floor level position or decelerates, the recapturable kinetic energy is often lost. However, since supercapacitors recharge during the transfer times of material handling, they take only seconds or minutes to regain the kinetic energy used to store or retrieve.

Customizable sizing is desired to meet a wide spectrum of applications by either delivering power over a set amount of time or planning to move heavy materials over a defined distance. Supercapacitor modules are modular in nature, providing easy sizing for both situations. They are passive electronic components that have no moving parts and no hazardous materials offering lifetimes of up to 20 years given the millions of charge/discharge cycles and require no maintenance.

Eaton supercapacitors cover a wide range of working voltages and capacitances. The XVM-16 module is rated at 16.2 V and 65 F with the capability of providing 3.0 kW peak power and the XLR-48 module is rated at 48.6 V and 166 F with the capability to provide 118 kW of peak power. Both can be wired in series and/or parallel to meet power requirements.

Eaton supplies individual supercapacitors or compact modules for energy storage needs. Supercapacitor modules help modern warehouses run consistently and reliably without maintenance downtime or replacement part costs.

Powering Pallet Movers

Recognizing these benefits, one of the largest global material handling companies has integrated the XVM-16 module with three in series and integrated into a 48 V distribution system. Depending on the individual system and project, additional strings of modules are simply paralleled to meet heavier weights or longer distances than standard systems, providing easy scalability. Similarly, the XLR-48 module has been selected for larger pallet mover systems with the same scalability offered by the XVM-16 strings.

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Use Case
Transportation

Supercapacitor modules accelerate the future of electric vehicles

More commercial vehicle OEMs have been designing and launching multiple vehicle platforms that feature electrified drivetrains with the reasons for doing so well documented: increased energy efficiency, lower emissions, environmental sustainability, but also potentially improved performance and lower total cost of ownership.

One of the most heavily investigated components of electrified drivetrains are the batteries that store the electrical energy in HEV, PHEV and BEV systems. In this investigation, determining the lifetime of the battery over the estimated drive cycles is quite often the one the top priorities. Even with the dynamic advances in technology for automotive batteries, primarily Lithium Ion technologies, there still will be maximum lifetimes and drive ranges that can be achieved. The lifetime of batteries, and all energy storage devices, is impacted by the number of charge/discharge cycles, duty cycle and ambient temperature to name a few. The more cycles, the higher the duty cycle and higher temperatures all result in abbreviated lifetimes.

In just about all electrified drivetrains, regenerative braking is a feature that is implemented to improve the energy efficiency of the vehicle. This results in higher duty cycles and an increase in charge/discharge cycles, thus limiting the lifetime of the battery. For vehicles designed for frequent start/stop drive cycles, such as public transportation or delivery vehicles, this increases drastically. Supercapacitor modules have been increasingly integrated in the ESS (Energy Storage System) drivetrains due to the high power density and long lifetime. Supercapacitor modules are much more resilient compared to battery technologies to the number high power charge/discharge demonstrated in these heavier systems.

Large bus OEMs have long selected higher voltage supercapacitor modules to integrate into their hybrid drivetrains due to these features, including Eaton's ruggedized XLR modules. By doing so, the supercapacitor modules provide higher peak power during acceleration which could result in reducing the overall size of the onboard internal combustion engine (ICE) required to power the vehicle. Depending on the configuration, this can demonstrate up to a 30% improvement in fuel economy. Also, given the longer lifetime compared to batteries, the overall life cycle costs can be reduced through fewer ESS replacements.

Similarly, a hybrid energy storage systems (HESS) in battery electric vehicles have been deployed that feature a tandem of batteries and supercapacitors in full BEV (Battery Electric Vehicles). Because supercapacitors offer lower ESR than batteries, it is possible to wire the two energy storage solutions directly in parallel and still provide advantages. This topology can offer battery lifetime improvements and some extension of drive range between charges. However, the greatest improvement with HESS is to have integrated power electronics to control which storage technology provides the necessary energy to the drivetrain. Supercapacitors, due to their higher power density would provide more power during acceleration and capture more energy during regenerative braking. This can help stabilize the use of the battery for longer range. By doing this, Eaton has simulated lifetime benefits of up to 3x given this topology[1]. Supercapacitor modules can demonstrate dramatic improvements in the lifetime costs of BEVs.

1 Battery life estimation model and analysis for electronic buses with auxiliary energy storage systems

Results may vary by energy source specifications, drive cycles and environmental conditions.

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Use case
Frequency regulation

Providing grid resiliency with supercapacitors

A long standing challenge faced by electrical utilities is balancing the supply, or generation, and the demand, or load, when transmitting and distributing electrical energy across connected and isolated grid systems. This balance ensures grid reliability and stable voltage frequency. The risk with a gap of supply versus demand is dropping frequency which can cause grid operators to start load shedding to protect generation assets as the stress increases. When this gap is larger, load shedding is not sufficient which overstrains assets forcing plants to be shut down for protection, resulting in cascading power outages. Conversely, where instantaneous supply is higher than demand, this power could be dissipated as heat via condensers or load banks to keep the voltage surge or increase in frequency from harming generation assets or other connected elements.

Due to the constant variability of grid demand, balancing can be very difficult. However, there are systems and measures that can be implemented. Traditional generation assets, such as fossil fuel, nuclear or hydroelectric plants with spinning turbines, provide inherent inertia to help provide some frequency regulation. There are also other ancillary services that can be dispatched for longer term supply gaps to ensure reliable and quality power.

The increase of grid tied, distributed renewable generation and the retirement of traditional plant assets reduces the inherent grid inertia, introducing increased risk to grid reliability and resiliency on the supply side. Furthermore, the renewable sources can be unreliable, such as scattered cloud cover over photovoltaic arrays or varying weather conditions for wind turbines[1].

Energy storage systems are being deployed to help respond to imbalances in grid supply and demand. The XLM supercapacitor module and XLR supercapacitor module can provide ultra-fast response due to the low ESR construction of the XL60 supercapacitor cells. This feature, along with their maintenance free nature, helps ensure the energy storage system is always available for ultimate resilience.

Eaton's supercapacitor modules are capable of millions of charge/discharge cycles with no replacements or maintenance which can provide up to a 20-year lifetime depending on operating environmental conditions. The physics of supercapacitor construction allow for minimal effects on lifetime and the depth of discharge, from near full discharge to smaller, limited cycles.

The high power density (kW/L) can help reduce the footprint of the energy storage required to meet the needs of the grid when compared to battery or kinetic energy storage. This power density can help reduce capital expenditures by reducing the amount of energy storage oversizing needed to meet the instantaneous power required for improved grid reliability.

With the deployment of energy dense lithium-ion battery systems for longer term services and operational reserves, supercapacitor modules can be installed in parallel to reduce the number and intensity of very high peak discharge currents that can rapidly degrade the lifetime of the batteries. By extending the life of batteries with supercapacitor modules, operational expenses and maintenance costs are reduced for the transmission and distribution assets.

Eaton's XLR and XLM supercapacitor modules provide an ultra-fast response, long lifetime, maintenance free and cost-effective energy storage as a sole solution or by augmenting battery systems to help ensure a balanced and resilient utility grid.

1 Eaton renewable firming use case

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