APPLICATON BRIEF

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Locks secured with supercapacitor

Centrally controlled electronic lock systems are ubiquitous in commercial buildings. Such systems are often hardwired into a network, which provides power for the lock mechanisms as well as control signals. Many high security facilities require battery backup or for the lock to enter a predefine state during a power failure. This brings additional challenges which CAP-XX supercapacitors can solve.

A supercapacitor delivers pulse power for the lock mechanism

Electronic lock mechanisms rely on an electromechanical actuator in the form of a solenoid or geared motor to perform the lock and unlock actions and conveniently provide centralized access control. Most commercial buildings hardwire the locks into a network supplying 12V or 24V power. By default, most e-locks will enter either a locked or unlocked state during a power failure, whichever is deemed the safe state. However, if may not be acceptable in some buildings to leave sections either locked or unlocked. Often battery backup is used to so the lock can operate in the event of power failure.

With limited space inside the lock housing the battery choice is a trade-off between energy and power.

It needs to match the minimum energy required for the e-lock to operate for a set period but must also have high discharge current rating to provide the pulse current to drive the actuator. This factor limits the maximum energy density of the battery.

Supercapacitors, like traditional capacitors have physical charge storage so are not limited in power by the rate of a chemical reaction as in a battery. They can deliver 100's – 1000's times more power than a battery and have Equivalent Series Resistance (ESR) typically in the 10's – 100's of mΩ range. Including a supercapacitor to handle the high peak current allows the battery to be rated for only the average current. As the result, higher energy density batteries can be chosen to extend battery life, and/or smaller batteries can be used.

The other key attribute of CAP-XX supercapacitors that make them ideal to place across a battery is their very low leakage current (IL), ~1 - 2µA/F. For example, the supercapacitor DMF 470mF (45mΩ ESR) has a typical IL of ~2µA. Leakage current is drawn from the battery continuously so it can be a significant drain on energy. With only 2µA IL, a DMF 470mF only draws ~17mAh/yr, less than most batteries' self-discharge rate.

Current limiting to protect the battery

With its very low ESR, a discharged supercapacitor can draw large inrush current, particularly when initially charging from 0V. In some cases, the battery's internal resistance may be sufficient to limit the inrush current to a safe level, but if inrush current limiting is required to protect the battery, then see Current Limiting for Supercapacitors. However, the average current supplied from the battery still needs to be high enough to fully recharge the supercapacitor during the minimum period between actuation, see Coupling a supercapacitor with a battery.

Supercapacitor enables programmable fail-safe state

All reputable electronic lock or door strike systems guarantee a defined fail-safe state after a loss of power. This feature is usually implemented using a mechanical spring fitted at the factory that sets the safe state as open or locked. This precludes the safe state of the lock from being programmed on site, reducing flexibility. Instead of mechanical energy in a spring, the electrical energy stored in a supercapacitor can set the lock in the safe state in the event of power fail. This can now be programmed on site, e.g. with a link read by a micro-controller.

Sizing your supercapacitor

Supercapacitors, which can deliver high power due to their low ESR, have high C to supply sufficient energy and power to drive the lock, please see Powering Pulse Loads. Factors to consider when selecting your supercapacitor include:

1. How much energy is required to allow the actuator to finish the action?
2. What is the peak and average power?
3. What is the initial voltage the supercapacitor is charge to?
4. What is the minimum voltage needed by the lock system?
5. The voltage drop due to Equivalent Series Resistance (ESR) for the supercapacitor = I_{LOAD} x ESR. Many engineers select C = 2E/(V^2init – V^2final), where E is the energy required for the lock actuation and Vinit and Vfinal are the supercapacitor initial and final voltages. This calculation implicitly assumes supercapacitor ESR = 0 and will undersize the supercapacitor.
6. The supercapacitor's frequency response – if the lock activation is short, in the order of 100ms or less, then use the effective capacitance for the pulsewidth of activation, refer to CAP-XX datasheets. In this case, for constant current, voltage drop = I_{LOAD} x ESR + I_{LOAD} x PW/Ceff(PW), where Ceff(PW) is the effective capacitance for pulsewidth PW.
7. What space do you have? Many applications require a slim, unobtrusive and elegant form-factor. CAP-XX's thin prismatic supercapacitor range meets the need. Where space is not constrained, lower cost CAP-XX cylindrical cells can be used.

Depending on the initial voltage the supercapacitor is charged to, you can select a single cell supercapacitor or a dual cell module. If using a 3V battery, then CAP-XX has cylindrical 3V cells available, GY13R0 series . We will also soon have 3V prismatic cells available. Another alternative is to use a low power LDO, such as a TPS78227 which draws 500nA to charge a single cell to 2.7V. For a higher voltage supply, e.g. 5V, or battery such as Lithium Thionyl Chloride at 3.6V, which has excellent energy but poor power, a dual cell supercapacitor must be used such as DMF low ESR high power, DMT long life high temp or DMH ultra-thin. This requires cell balancing.

CAP-XX can assist with your supercapacitor circuit design.