



Eaton supercapacitors for marine applications

Overview

Electrical power is critical for enabling many different functions in marine applications. Marine vessels, such as sailboats, yachts, tanker ships, and offshore ships help transport people and cargo over varying distances. Due to their size, weight, and scale of operations, marine vessels have higher power requirements, consequently producing an ever-increasing environmental impact. The maritime sector, as a subset of the transport industry, is a significant contributor to annual global emissions. For example, emissions from cruise ships accounted [for more sulfur oxides \(SOx\) emissions in 2017 than all cars in Europe.](#)

Increased electrification is one of the most effective ways to lower maritime emissions, as is evident with leading marine vessel manufacturers replacing more combustion/hydraulic systems with electrical energy storage. Power management units in today's sea vessels rely on batteries, although in specific cases supercapacitors are a more efficient solution. Battery usage faces several limitations, including short life, engine starting difficulty, thermal runaway risk due to higher operating temperatures, and more. Supercapacitors are stable and power-efficient, with millions of charge/discharge cycles (resulting in life times up to 20 years, depending on operating conditions).

Eaton supercapacitors in marine applications

Eaton supercapacitor and supercapacitor modules are robust power management solutions ideal for use in a host of marine vessel applications. They can function as sole energy storage or in combination with batteries for performance improvements, increased operating life, size/weight reduction, and emission control. Below are some applications of Eaton supercapacitor in state-of-the-art power management systems in marine vessels.

Engine starting

Supercapacitors provide reliable engine-starting in marine vessels. Compared to batteries, they function optimally over a wide range of operating temperatures, including cold operating temperatures (Eaton supercapacitors have operating temperatures down to $-40\text{ }^{\circ}\text{C}$). Eaton supercapacitor modules provides reliable starting in marine engines up to 60 kW (e.g., in sailboats). Active cell balancing and low discharge rates ensure starting reliability, even in harsh environments. As an example, 2 series connected Eaton XVM-16R2656-R modules can offer a solar-charged reliable engine starter unit providing 200 A + Cold Cranking Amps (CCA) weighing less than 2 kg with up to 20 years maintenance free.



Figure 1. Eaton XVM-16R2656-R (16.2 V/65 F supercap module)

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For larger marine vessels requiring higher voltage and more starting power, Eaton provides additional modules based on its XL 3000 F cells (pictured below):



Figure 2. Eaton supercap modules for rugged environments

High peak power drive cycle

In order to reduce in-harbor pollution, harbor operators offer incentives for vessels using electrical power during maneuvering in and out and offering shore-to-ship power options in order to charge batteries and power ships to avoid combustion engines running while parking. Typical power requirements of hybrid electric-powered vessels include:

- High power disembarking and maneuvering in and out of the harbor (5 minutes) with 50 - 100% power
- Mid power acceleration, usually 50% max power
- Low power cruise, usually 20% of max power (several hours – using downsized combustion engines)
- High power maneuvering with full throttle peaks to brake the ship (5 minutes). High-power maneuvering and braking events stress batteries and reduce expected lifetime and autonomy time with one charge.

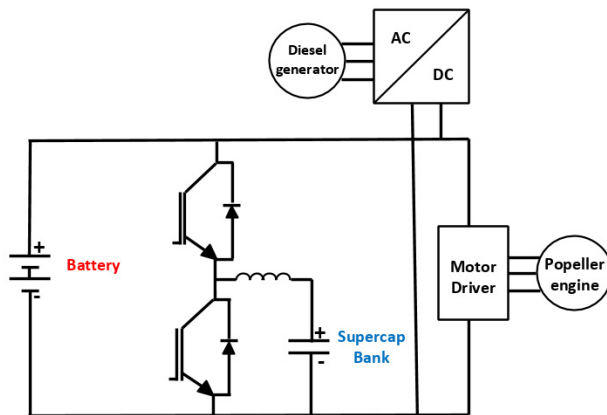


Figure 3. Battery-supercapacitor hybrid power unit

Figure 3 illustrates a diesel-electric network of a marine vessel with supercapacitors. Depending on the ship distance coverage, there may be fully electrical or hybrid solutions implemented. Full electricals are typical for city cruisers or taxi boats, while hybrids can cover hundreds of miles. Noticeable is that:

1. For cruising, about 20% of the full power is needed; this gives a chance for a significant diesel generator size reduction which accounts for most of the pollution.
2. For maneuvering, significant power is needed (but just for a few seconds, normally) that challenges the batteries and often requires battery oversizing.

When it comes to marine applications, size and weight are among the highest costs. Hybrid power systems allow cutting down on the combustion engines size, but it adds a bank of batteries which can add significant weight and cost. Supercapacitors can contribute in two ways to resolve the battery challenge:

1. **Improve overall power density:** supercapacitors represent the highest power density electrical energy storage devices that can ideally contribute to the battery's high energy density. A properly sized supercapacitor solution can manage the highest pulse power requirements during maneuvering to avoid unnecessarily oversized battery banks to manage these situations.
2. **Improve battery life and runtime:** batteries are suffering in cases where currents over 1C need to be delivered. Delivering high power (even for short times) reduces battery range significantly, and the long term effect leads to earlier battery wear out. Supercapacitors protecting batteries from high power pulses help with both.

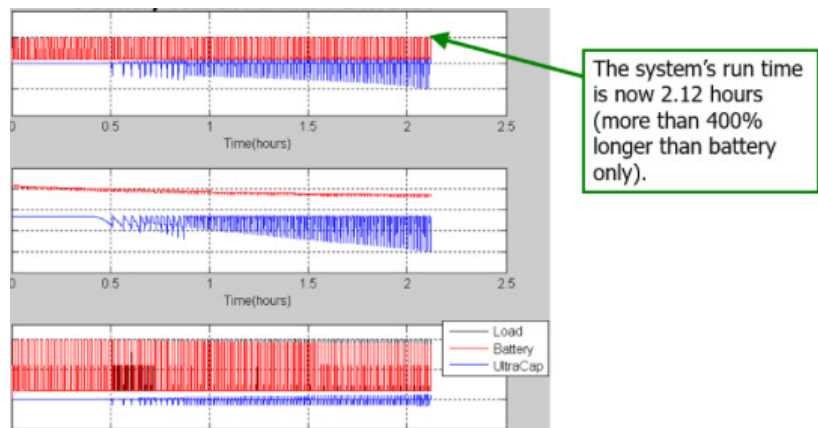


Figure 4. Supercapacitor increase system runtime in marine vessel applications
Figure 4. Supercapacitors increase system runtime in marine vessel applications has gone from 30 minutes to 2.12 hours with battery only compared to battery plus supercapacitor

Canting keel power units

The canting keel of sailboats and race yachts improves the vessel's righting moment and counteracts the sail's heeling force. The system uses a hydraulic drive that requires high power for a short period to move the heavy-weighted keel (up to 10 tons) one direction to the other. Eaton supercapacitors can power the operation of the canting keel and regenerate power during release periods, thereby increasing efficiency. This design consists of 6 cells of series-connected 3000 F supercapacitors.



Figure 5. Eaton's XLM 16v supercapacitor module, usable in a keel power unit

Dynamic positioning systems (DPS)

Offshore support vessels need to stay in position when not in transit, which is not possible with only anchoring. A sophisticated multi-engine maneuvering system for dynamic positioning helps to achieve this. DPS utilizes a variable frequency electric drive, as a combustion engine is not suitable. However, electric drives face the challenge of fluctuating loads due to adverse winds, water currents, etc. Typically, vessel manufacturers will oversize vessels' diesel generator drives to compensate. However, Eaton supercapacitors deliver high-density power to meet periodic peak requirements. This design allows for smaller electric drives, saving weight, cost, and fuel.

As a typical example, for each thruster engine, a wave effects put a peak current requirement on the system with a 3 - 10 second frequency. Further, thruster engines need to balance the current with a load fluctuation between 500 A - 2000 A. Using Eaton's supercapacitor bank consisting of 350 - 400 pieces of 3000 F supercapacitors in series provides 300 kW - 400 kW boost power and up to 1000 A current.

Using Eaton supercapacitors allows the diesel generator load to level off, and it is possible to use a 20 - 30% lower power engine (direct savings for vessel manufacturers). Fuel consumption lowered by about 20% (indirect savings for users).

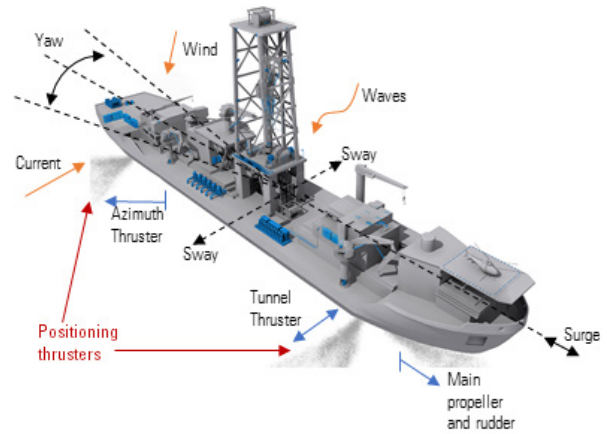


Figure 6. Marine vessel dynamic positioning system. Supercapacitors deliver high-density power to meet periodic peak requirements.

The future of supercapacitors in marine applications

Marine vessels continue to remain a critical part of the global transportation infrastructure - although the internet has the world closer together than ever before, many industries are heavily dependent on marine vessels for fast, efficient global transportation. Eaton's supercapacitors contribute to the reduction of maritime emissions by allowing for increased electrification of key systems within marine vessels. Supercapacitors allow for stable, power-efficient solutions with millions of charge/discharge cycles and look to lead the way into the next generation of environmentally conscious maritime applications.

For more information visit eaton.com/supercapacitors.

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