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IOXUS uSTART Ultracapacitor: Better Vehicle Battery Performance

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Abstract

The constant starting and stopping of vehicle motors consumes an excessive amount of fuel and rapidly degrades components. This testimonial explores the IOXUS uSTART® ultracapacitor that couples with a battery to provide high power during start and stop events, reducing fuel consumption, component degradation, and improving overall system performance.

Introduction

Start, stop, start, stop—trucks, cars, and all high power motion machines, such as cranes, constantly start, stop, and need to be restarted. A typical vehicle uses 10 times the amount of power to start, when compared to idling. In addition, these machines require peak power at various times, such as when using hydraulic pumps, further contributing to the unevenness of power consumption. The accumulation of harsh operation means consumption of fuel, wear and tear on systems, and exhaustion of the components. While harsh operation almost always results in greater fuel consumption, more frequent breakdowns, and higher maintenance costs, one innovative company reverses this paradigm with their smart ultracapacitor for automotive and large machine applications, feeding and storing bursts of energy. Further, the result offers improved system performance.

IOXUS Solution to Motor Starts and Stops

Enter IOXUS, the industry leader in ultracapacitor cell and module manufacturing, and their innovative uSTART ultracapacitor. The uSTART ultracapacitor is a Smart Power ultracapacitor module for automotive and transportation applications that utilizes the benefits of an ultracapacitor in combination with a traditional battery, creating a hybrid electrical system. The uSTART ultracapacitor connects in parallel with an automotive battery, shown in Figure 1, and provides high current during starting (cranking) and all other large current consumption scenarios, leveraging the fast discharge capability of the ultracapacitor. The battery provides power when current requirements are low and works in combination with the alternator to charge the uSTART ultracapacitor. Overall, the uSTART ultracapacitor actively manages the vehicle battery's energy profile, providing a stable voltage across all operating conditions.

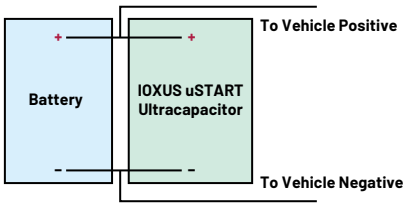

Figure 1. Configuration of the IOXUS uSTART ultracapacitor within a vehicle battery system.

The benefits of an ultracapacitor extend to a wide variety of areas. Most importantly, by accommodating high currents, the uSTART ultracapacitor prevents transients in the primary voltage. This stability reduces the wear and tear on the overall system, meaning longer operation of the vehicle without replacing components. The starter motor and battery both run much longer because avoiding both over- and undervoltage and current conditions protects the magnets and windings in the starter motor and protects the chemistry of the battery. Regenerative braking systems benefit by accommodating a wider range of power levels for charge acceptance, also provided by ultracapacitors. The entire electrical system can be downsized. Overall, these benefits result in less raw material mining, consumption, and distribution of rare earth and other critical elements. As a final benefit, the carbon for the ultracapacitor comes from renewable natural resources.

Figure 2. IOXUS' latest uSTART v5 Smart Power ultracapacitor.

However straightforward, these benefits do not translate into a simple development. Among the many challenges, the Smart Power ultracapacitor manages power across the entire system, both detecting and responding to demand conditions, such as a starting event, and managing the charging of the battery itself. These events require sourcing and sinking energy quickly, within milliseconds. The development requires consistent control of a complex array of gates through a multitude of load scenarios. Electromagnetic interference (EMI) adds to the challenge, as automotive environments add tremendous noise to system voltages, where both positive and negative voltage transients can be multiple times the battery voltage. Another design challenge is meeting stringent electromagnetic compatibility (EMC) emissions requirements for vehicle original equipment manufacturers (OEMs) across wide bands of radio spectra. Further, the chemistry and material connections require keen attention to source and sink power smoothly without unwanted resistance. IOXUS' portfolio features multiple patents on the chemistry of both electrodes and ultracapacitor.

Figure 3. An animated rendering of the electronics inside the uSTART Smart Power ultracapacitor.

IOXUS partnered with Analog Devices to develop the power management system. The primary functions include charge management of the ultracapacitor, protection, isolation, and system management. The LT8390 buck-boost controller manages the amount and timing of current to efficiently charge the ultracapacitor from zero volts up to its charge set point. It also features spread spectrum frequency modulation to reduce associated system radio frequency emissions for EMC. The LT8609S synchronous step-down regulator works within the system to provide an efficient and very stable voltage source for the control electronics. The LTC4368 provides over- and undervoltage as well as reverse current protection for the LT8390 while the MAX17613 does the same for the LT8609S and the low power control electronics. The vehicle power management system, utilizing multiple MAX253 and ADuM4221 devices to switch banks of power transistors, responds dynamically to loads and avoids going to a float voltage.

"When designing new, cutting-edge systems, it's nice to have a partner like ADI. Their high performance products and power expertise make them an excellent partner," said Joe Agrelo, senior electrical engineer at IOXUS.

Conclusion

Products like the IOXUS uSTART ultracapacitor improve system performance and reduce energy consumption. The uSTART ultracapacitor takes on the difficult challenge of constant motor starts and stops, including the associated fuel consumption and component wear, and solves it with an elegant product that also improves performance. Demand for mobility will grow in the coming years, requiring new solutions like the IOXUS uSTART ultracapacitor.

About the Author

David Andeen works in business development and marketing at Analog Devices. He joined Maxim (now part of ADI) in 2005 and previously worked in sales, marketing, and applications. He holds a Ph.D. degree in Materials from UCSB.