cap-XX APPLICATION BRIEF No. 1012

Battery Run-Time Extension for Digital Still Cameras

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Outline

Pulsed loads occur in Digital Still Cameras (DSC). These loads can cause enough voltage-drop to prevent photos being taken when there is still plenty of energy left in the battery. This is especially so with AA or AAA alkaline batteries that have a high internal impedance. At low temperatures (such as < 0°C), the situation can be still worse, as common batteries, like Alkaline, Lithium-ion and NiMH (Nickel-Metal Hydride), exhibit vastly reduced capacity and increased internal resistance. A **cap-XX supercapacitor** used in a parallel hybrid combination with the battery can reduce the voltage excursions under load, permitting the DSC to operate reliably until most of the battery's energy has been used, or allowing it to function in cold conditions in which it would normally fail or shut down after a short time.

The Problem

- DSC's are subject to pulsed loads such as motor drive for opening and closing the camera or auto-focus. The load pulses may be many times the resting current, causing a large drop in battery voltage, which can cause system shutdown.
- In cold weather, batteries are much less capable of supplying the loads than they are when warm, because of their reduced capacity and increased internal resistance.
- The large voltage drop when load pulses occur may be detrimental to the battery. Conventional capacitors usually cannot support high currents, given the space restrictions in DSC's.
- Effective battery run-time is reduced by the need to maintain the voltage above a threshold value at all times. When load pulses drop the voltage below the minimum level, the camera must turn off.
- At the time the DSC shuts down, there may be much useful energy remaining in the battery.

The cap-XX Solution

- Connect a cap-XX supercapacitor with low Equivalent Series Resistance (ESR) in parallel with the battery to obtain a high-performance, low-impedance hybrid with superior characteristics. cap-XX supercapacitors can have ESRs of just a few milliohms, with capacitance from a few millifarads to Farads, and leakage currents of only a few micro-amps.
- The supercapacitor-battery combination can be designed to deliver the current demand during peak loads without the terminal voltage dropping to unacceptable levels. Low ESR provides cap-XX supercapacitors with an unprecedented ability to deliver high currents.
- During the low-load intervals, the supercapacitor is re-charged by the battery.
- In low temperatures, the supercapacitor delivers the current peaks that the battery is not able to deliver.
- cap-XX supercapacitors can be designed to suit the application, in shapes, sizes and packaging to fit the space available, such as thin prismatic forms.

The Benefits

- Reduced voltage drop during load peaks at all temperatures, resulting in extended run-time.
- Reduced source impedance compared with that of the battery alone.
- Designers can use smaller batteries than normal, with higher internal resistance, at reduced cost.
- DSC's that work in cold conditions; for example, photos in the snow fields
- Low-battery thresholds can be reduced, since voltage ripple is reduced, giving increased voltage margin before shutdown occurs. This allows the battery to deliver more of its energy before shutdown, extending battery run-time.
- The possibility of damage to Lithium-ion batteries from low voltage or from high-current pulses is reduced.
- cap-XX supercapacitors can be designed to fit the space available.

Battery voltage, current and power were recorded for camera using 2 x AA alkaline batteries during camera on/opening, shooting a photo, and camera closing. The graph in Fig 1 over the page shows these waveforms for shooting a photo without a supercapacitor. The orange trace is battery voltage (500mV/division), the blue trace is battery current (200mA/division), the red trace is battery power (500mW/division), with a timebase of 1 sec/division. The peak power was drawn driving the motor during auto-focus. The auto-focus phase lasted approx 0.4 secs and drew a peak power of 3W and peak current of 1.5A. During auto-focus the battery voltage dropped 560mV from 2.58V to 2.02V. Fig 2 shows the auto-focus phase with the battery supported by a cap-XX supercapacitor. The supercapacitor, with its much lower ESR delivered most of the peak current. The peak battery current is now only 640mA or approx 40% of the peak without a supercapacitor. The battery voltage droop has been reduced to 44mV, down from 560mV.

cap-XX Application Briefs are produced as a means of providing product designers with useful information about cap-XX supercapacitors and their applications. They are revised periodically to include new information. For detailed specifications of cap-XX products, the reader is referred to the data sheet of the relevant product, which is available on request.

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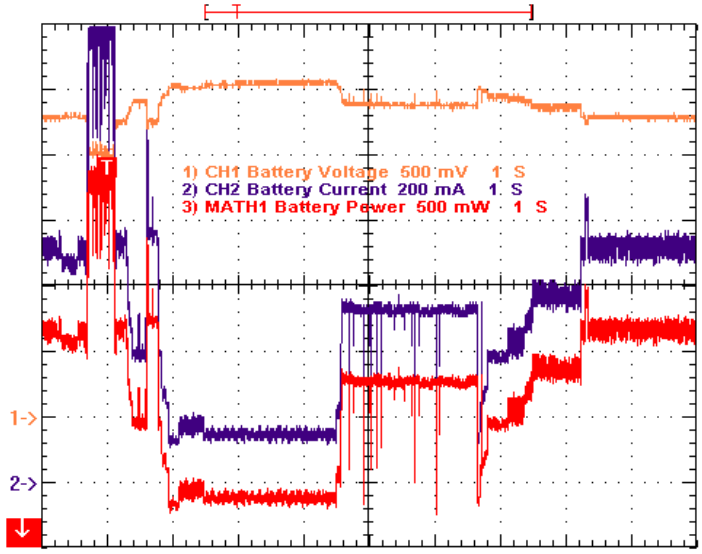
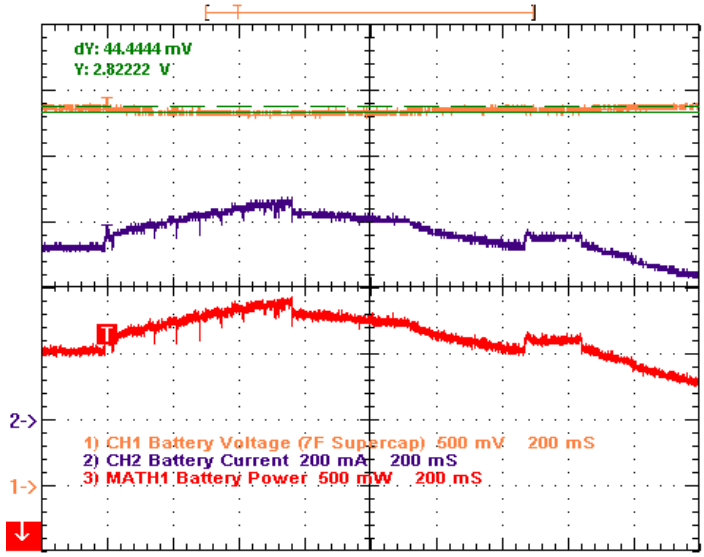


Fig 1 DSC battery voltage, current & power during photo shoot without a supercapacitor

Fig 2 DSC battery voltage, current & power during photo shoot with a supercapacitor



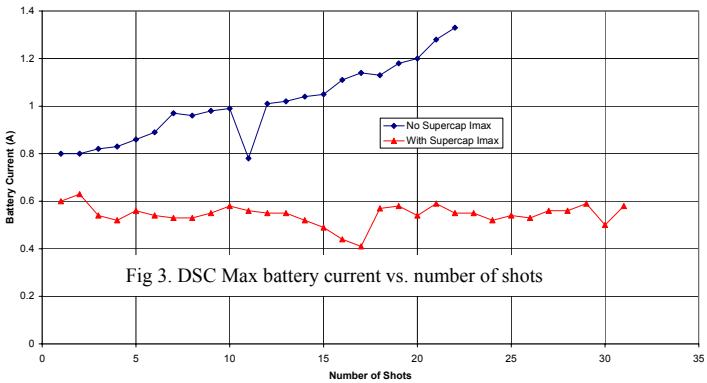


Fig 3. DSC Max battery current vs. number of shots

The supercapacitor had a dramatic effect in reducing the voltage ripple. This means that substantially more energy can be extracted from the battery before the camera fails to operate, significantly increasing battery run time. This is illustrated in Fig 3. Each dot represents the max battery current for a complete shot cycle: camera open, shoot photo, camera close. The X axis is the number of shot cycles. The blue dots represent the maximum battery current without a supercap. The red dots represent the maximum battery current with a supercap. The key points to note are:

- 31 shots were able to be taken with a supercap versus 22 shots without. The supercap gave a 40% increase in the number of shots taken.
- The battery current without the supercapacitor started at 0.8A when the AA batteries were fresh and increased to 1.3A as the battery voltage dropped. The cap-XX supercapacitor supplied the peak current, so the battery current remained relatively constant at approx 0.6A throughout the 31 shots.
- Without a supercapacitor, a vicious cycle eventuates. The DSC appears as a constant power load. As the battery voltage reduces, the battery current increases to maintain the power. With the high battery impedance, the increased battery current causes the battery terminal voltage to drop even further. The cap-XX supercapacitor, by supplying the peak current, prevented this cycle, enabling the battery to supply 40% more energy before the camera shut down.

The supercap needs to be chosen so that its ESR is very low compared to the battery impedance, and it has enough capacitance to supply the peak load for the duration required. To determine a suitable supercapacitor, please use the Pulsed Load Design Aid on the Calculator page of the cap-XX web site.

Further Information: cap-XX will be pleased to supply you with detailed data and design information. Please use the contact information listed at the foot of this page.

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