If the cap fits . . .

How supercapacitors can help to solve power problems in portable products. By **Graham Pitcher**.

Portable products pose some interesting problems for design engineers – some apparently diametrically opposed. On the one hand is operating life; everyone wants the time between battery changing or charging to be as long as possible. On the other hand are features; everyone wants more and more 'buttons to push'. But the penalty for this is higher power consumption and less operating life.

You could specify a larger battery. But consumers expect the next generation of the products that they use should be significantly smaller than the last.

So there are design decisions to be made. Is operating life more important than features? Or is size more important? And can other technologies help?

The answer to the latter question – at least in the opinion of two companies – is yes. And that technology is the supercapacitor. Regular electrolytic capacitors often have values in the picofarad range; with supercapacitors, you're talking Farads. Yet the devices are small and thin, so how is it done and, more importantly, why are they finding increasing use in portable products?

Anthony Kongats is ceo of Australian supercapacitor specialist CAP-XX (**www.cap-xx.com**). He noted several factors that pertain: "They are thin, they have high energy density and low impedance."

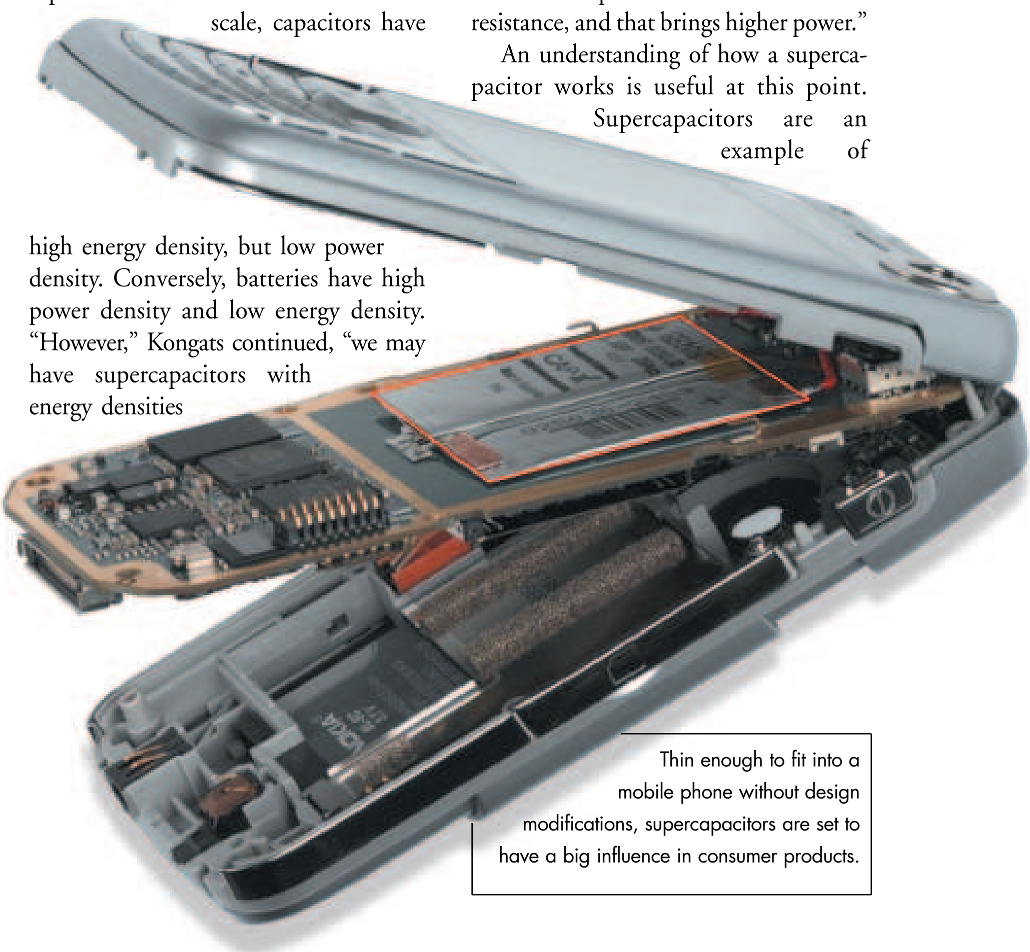
Kongats claims CAP-XX is the leader in supercapacitors. "We've been selling them since 2003, but there have been technology issues to solve before that, along with manufacturing issues."

The benefit of supercapacitors is they bring greater run time, lower operating temperatures, smaller size and – hopefully – lower cost to portable products. "As a technology," Kongats continued, "they sit between regular capacitors and batteries." What supercapacitor developers are aiming to achieve is to fill the gap between capacitors and batteries. At one end of the scale, capacitors have high energy density, but low power density. Conversely, batteries have high power density and low energy density. "However," Kongats continued, "we may have supercapacitors with energy densities approaching that of a lead acid battery in a couple of years."

Adrian Schneuwly, senior director of worldwide sales and marketing for Maxwell Technologies (**www.maxell.com**), noted that supercapacitors work in a different way to batteries. "The technology will never be able to get to the energy densities of batteries. However, they have high power densities and this depends on voltage and internal resistance."

He said Maxwell focuses on reduction of equivalent series resistance. "Our devices are optimised for lower internal resistance, and that brings higher power."

An understanding of how a supercapacitor works is useful at this point. Supercapacitors are an example of



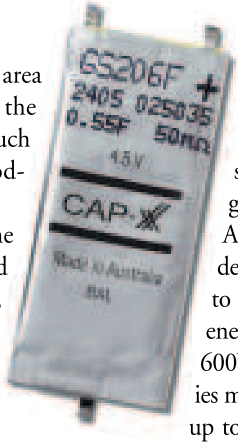
Thin enough to fit into a mobile phone without design modifications, supercapacitors are set to have a big influence in consumer products.

"The battery supplies a continuous current, whilst the supercapacitor handles peak requirements."

Adrian Schneuwly, **Maxwell Technologies**

nanotechnology in action, with their performance underpinned by the use of high surface area carbon particles. Kongats and Schneuwly both note the carbon particles used in their products give an effective surface area of $2000m^2/g$. Schneuwly noted that in Maxwell's devices, the carbon particles were deposited on electrodes, with a porous separator between them. Both approaches use the double layer effect, which allows for double the charge to be collected on each electrode.

The other characteristic that differentiates supercapacitors from regular devices is their thinness. Kongats explained: "Capacitance is inversely proportional to electrode separation. Capacitance is also proportional to area." So, the closer together you can get the electrodes and the more surface area you can provide, the higher the capacitance. "They are very much materials science based products," Kongats continued.



Schneuwly added: "The thickness of the layer deposited on the electrode is critical, because the thicker this layer is, the deeper the ions have to go – and that takes time. A thinner layer means more power and the closer together you can get the electrodes, the better."

So where can supercapacitors be used? "Anywhere there's a variable power requirement," said Kongats, "and the power supply can't meet that variation." An example, he noted, might be where the peak current drawn from a battery is twice the average level. "We see supercapacitors as a complement to a battery," he added.

PCMCIA cards are an example of where supercapacitors are already being used to good effect. "There's a limit as to how much power you can draw through a pcmcia card," Kongats continued. "The peak is 1A, but if you want to drive an rf radio, you need 2A, so how can you get enough power without breaking the spec?" The answer is to use a supercapacitor.

Schneuwly said supercapacitors are suitable for use in portable products where there is a high energy density requirement and where the device needs to run for as long as possible. He pointed to flash devices in digital cameras: "These require huge power pulses, which can't be delivered by the battery. So you either oversize the battery or use another power device. By simply connecting a supercapacitor, the battery continues to supply a continuous current, whilst the supercapacitor handles peak requirements."

With characteristics more like a battery than a capacitor, is it possible that supercapacitors may, one day, supplant batteries? The short answer is no. Kongats noted: "Even if you build a supercapacitor pack the same size as a battery, you won't get the same energy density." According to CAP-XX, the energy density from supercapacitors is up to 5Whr/kg, but batteries will have energy densities ranging from 8 to 600Whr/kg. Similarly, whilst batteries may only boast a power density of up to 0.4kW/kg, supercapacitors can offer up to 100kW/kg.

Schneuwly was in agreement. "We will never be able to get to the energy density offered by batteries, but supercapacitors have higher power densities. We can achieve that by working on the voltage and the internal resistance. If we can optimise for lower internal resistance, then we can generate higher power."

Kongats believes supercapacitors have huge potential and one target for CAP-XX is driving the flash in mobile phones. "More than 800million mobile phones were sold last year," he claimed, "and around 40% of those had a camera. This is likely to exceed 80% in 2009." Already, the company has developed a technology demonstrator which uses the Nokia 6680 (see picture on previous page).

Another target is the MP3 market. "If you want a player with more than 2Gbyte of storage, the hard disk is the more efficient way. Hard disks have a large current surge when spinning up and that's where supercapacitors can extend battery life."

Schneuwly says automated meter reading is a typical application where battery lifetime can be increased by putting a supercapacitor in parallel with the battery. "But the greatest opportunities for supercapacitors in consumer electronics are those ideas which currently can only be accomplished by addressing power and energy needs separately. The right approach is to use a battery for energy and a supercapacitor for power," he concluded.