Supercapacitors Enable Wearables & IoT

From smart watches to health monitoring patches, wearable devices are becoming indispensable for many people. They need to be small, thin, long lasting and be connected to smart phones for convenience. This presents a significant challenge for choosing a suitable energy source, one that a CAP-XX supercapacitor can help alleviate.

Supercapacitor to extend battery life

Advances in modern electronics have enabled extremely low power sensors and microprocessors that draw less than 1mW power. As consumers demand more connectivity for convenience, most wearable products have integrated wireless technology. Wireless systems such as Bluetooth Low Energy, BLE, consume significantly less power than older Bluetooth protocols but a single BLE transmission still draws ~15mA for around 50ms. If a non-rechargeable wearable device uses a CR2032 battery, which typically has an internal resistance, IR = ~10Ω when new, then this will result in a 150mV droop. As the battery is discharged, the internal resistance will increase many fold even with the battery still containing significant energy. Fig 1 is an accelerated test with two CR2032 batteries, one by itself (green trace), and the other coupled with an HA202, 120mF, 120mΩ supercapacitor (blue trace), both powering a short ranged BLE TX module. The test in Fig 1 transmits once per second until the battery...
voltage drops to cause the module to brown-out. As
the battery depletes, the internal resistance
increases beyond 60Ω. Drawing 15mA sees the
battery voltage drop to ~2V, causing the module to
brown out even though there is still plenty of energy
left in the battery. Most electronics will brown out at
~2V. Fig 1 shows that the CR2032 paralleled with
a HA202 is still ~2.8V when the unsupported
battery fails. This reduced voltage drops allowed
the BLE Tx to utilise nearly all the energy in the
battery before brown-out, hence the 55% increase
in battery life can be observed in Fig1.

**Supercapacitor / Battery current split**

The supercapacitor and battery will share load
current inversely proportional to their impedance:

\[
\frac{i_{\text{Batt}}}{i_{\text{Load}}} = \frac{ESR}{ESR + R_{\text{Batt}}} \cdot \frac{R_{\text{Batt}}}{ESR + R_{\text{Batt}}} \cdot i_{\text{Load}}
\]

Refer to Coupling a supercapacitor with a battery.

**Supercapacitor stores energy from a harvester**

Some wearable devices such as health monitoring
tags are designed to be very thin and low power.
An energy harvester theoretically allows the device
to run indefinitely but energy harvesters like micro
generators and RF harvesters cannot supply the
peak power required for data transmission and are
an intermittent energy source as the device may
not always be moving or near a RF source.

Supercapacitors store ~1000 x more energy than a
traditional capacitor with capacitance in the Farad
range. A supercapacitor can store enough energy
for the wearable electronics to operate for a long
period when the harvestable energy source isn’t
available and can be charged at average current
from either an energy harvester of battery.

The energy harvester can charge the
supercapacitor directly or supply a power
management IC which charges the supercapacitor
at very low power. The supercapacitor provides the
peak power burst for data transmission as well as
maintaining a steady supply voltage.

The following are some examples of
supercapacitor and energy harvester:

- Solar cells to power sensors (Charging a
Supercapacitor from a Solar Cell Energy
Harvester) reporting data wirelessly.

- RF for rapid wireless charging of a supercapacitor
(Wireless Charging) that enables the
supercapacitor to power the wearable for example
to monitor an exercise session.

- Vibration transducers (micro-generator or piezo
electric), eg in a shoe, to power sensors (Charging
a Supercapacitor with Vibration energy harvester).

**Size matters CAP-XX prismatic supercapacitor**

CAP-XX produces some of the thinnest
supercapacitors in the world which allows CAP-XX
supercaps to be elegantly integrated in even the
thinnest wearable device. See CAP-XX’s latest
range of DMF low ESR high power, DMT long life
high temp or DMH ultra-thin supercapacitors.
Some supercaps, e.g. DMH may be slightly bent to
conform to the contours of the wearable device.

**Sizing your supercapacitor**

Supercapacitors, which can deliver high power due
to their low ESR, have high C to supply sufficient
energy to support the data capture and
transmission for its duration, have “unlimited” cycle
life, and can be charged at very low current are the
perfect power buffer between the energy harvester
and sensor (Powering Pulse Loads).

A range of ICs are available to charge
supercapacitors from energy harvesters. To select
your IC consider the characteristics of your energy
harvesting transducer, the minimum voltage the IC
requires to start, if the IC has peak power tracking
and the method it uses, min and max power levels
and efficiency at those levels.

**Inrush Current Limiting**

A CAP-XX very low ESR supercapacitor will try to
draw very high inrush current when initially
charging from 0V. In many cases the battery’s
internal impedance will be a sufficient current limit,
but if inrush current limiting is required, then see
Current Limiting for Supercapacitors.