FastCap® Ultracapacitors

CHARLIE: The high-energy density chip-capacitor that saves board space in Solid State Drives and extends your backup time while reducing costs.

Experience the cutting-edge technology of Charlie- the reflow solderable chip-cap and improve your energy storage capabilities today.

Nanoramic Laboratories
FastCap® Ultracapacitors

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BACKUP POWER FOR DATA LOSS PROTECTION IN SSDS

INTRODUCTION

Figure 1: Example of SSD card with power loss protection function

Solid state drives (SSDs) are rapidly growing in the storage market as they present several benefits. Among the main benefits, a high writing/reading speed and a low power consumption are the most relevant. SSDs are faster than hard disk drives (HDDs) during data writing/reading and consume less power as they do not have any mechanical moving parts typical of hard disks. However, in the event of a power failure or an incorrect shut down, the cache memory disappears and very valuable data can be lost. To eliminate this problem, several medium and high end SSD cards have an interim power supply that provides power for tens of milliseconds allowing the transfer of data from the volatile cache memory to the permanent flash memory. The power loss protection system is a common feature especially in SSD cards for enterprise and industrial applications, where a loss of data could potentially be catastrophic.

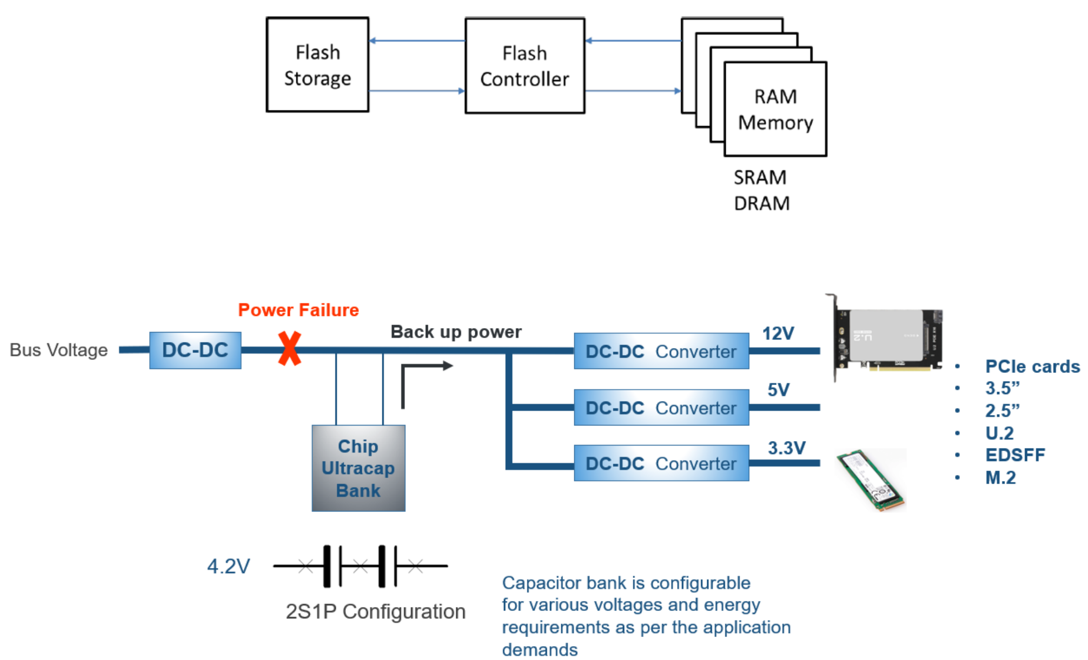


Figure 2: Schematic of a SSD and the power back up system using a supercapacitor

ENERGY STORAGE SOLUTIONS FOR BACKUP POWER

There are currently three main types of energy storage used for interim power supply in SSDs, each of them with significant drawbacks:

- Aluminum electrolytic capacitors

  They are the least expensive solution, but they have low energy density and short lifetime. In addition, these devices do not operate well at the high operating temperature of the SSDs (>70°C) due to dry-out of the electrolyte. Also, these components are not slim enough to fit on the same board where the memory chips are.

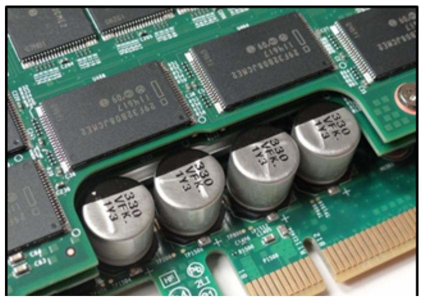


Figure 3: Aluminum electrolytic capacitors

- Polymer Tantalum capacitors

  They have larger energy density than aluminum electrolytic and better lifetime performance, however they are significantly more expensive, and several pieces (20 to 100) are required in applications that require more than 5W for tens of milliseconds. This means that a substantial portion of the available space of the memory card is occupied by tantalum capacitors (roughly 30%). In some cases tantalum capacitors are mounted on a separate dedicated board and represent the second most expensive item in the bill of materials of the whole SSD. Moreover, tantalum capacitors are not forgiving in case of overvoltage events, since the failure mode is a short circuit that in some cases causes a catastrophic system failure.

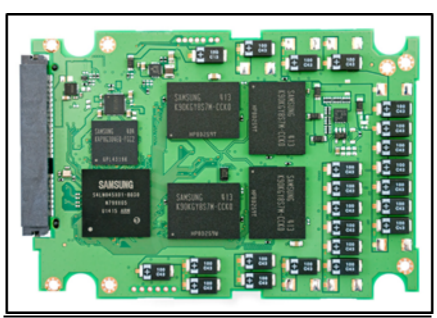


Figure 4: SSD with several tantalum capacitors

- Ultracapacitors or EDLCs

  Ultracapacitors have 5-10x higher energy density than tantalum capacitors, solving the problem of the number of parts that have to be mounted on the board. Ultracapacitors are forgiving in case of overvoltage events, since they are less sensitive to voltage spikes lasting for milliseconds, and their failure mode is an open circuit. However, they have two major drawbacks: lifetime at high temperatures and non-reflowability. Currently, board mountable ultracapacitors have to be hand soldered to the board, which makes the process expensive and not scalable for high volume applications. The reason why ultracapacitors are not reflowable is because they have volatile electrolytes that cannot withstand the temperature encountered during reflow process. Nanoramic has addressed these issues with the FastCap SD85-500 Chip Ultracapacitor presented in the next section

Figure 5: examples of non-reflowable ultracapacitors

FASTCAP® CHIP ULTRACAPACITOR

NANORAMIC HIGH TEMPERATURE TECHNOLOGY

Nanoramic's unique technology has roots in binder-free technology that has proven to have superior properties in several applications. The company's core technology is built around binder-free electrodes, and non-volatile high temperature, high voltage ionic liquids as electrolytes for EDLCs or ultracapacitors. Our products have unique performance and rely on this core technology.

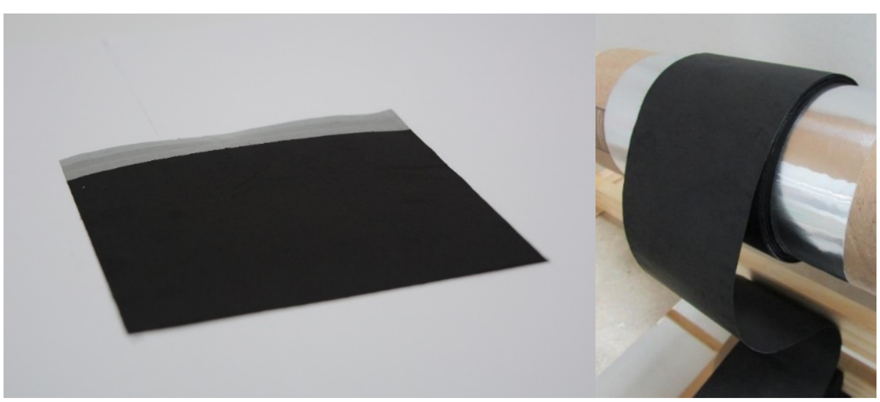
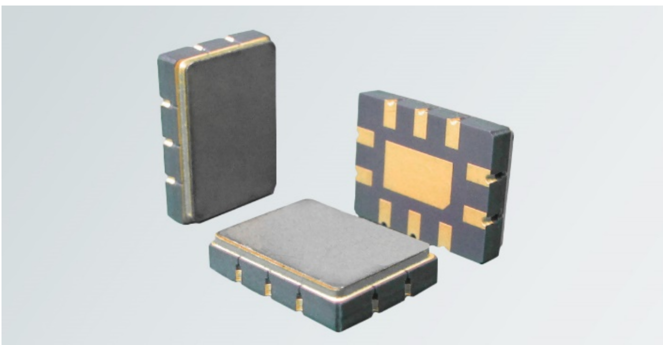


Figure 6: Nanoramic binder-free electrodes

SD85-500: THE FIRST REFLOWABLE THIN PROFILE CHIP ULTRACAPACITOR

We developed the first low-ESR and thin profile reflowable ultracapacitor that can be board-mounted and pick-placed on electronics boards. This is a big step forward for ultracapacitors, as all board mountable ultracapacitors today need to be hand soldered, adding complexity and cost. The reflowability is a key feature that is possible thanks to our non-volatile electrolyte and a robust ceramic package. This is an ideal component for back-up power applications that require reliability at high temperature and a small footprint. Despite their low energy density, tantalum capacitors are preferred to EDLCs in back up power applications because of their inability to operate reliably at high temperature as well as the inability to be reflown.

The ceramic package is hermetically sealed and has a thin profile (2.3 mm), which make it compatible with SSD and IoT application requirements.



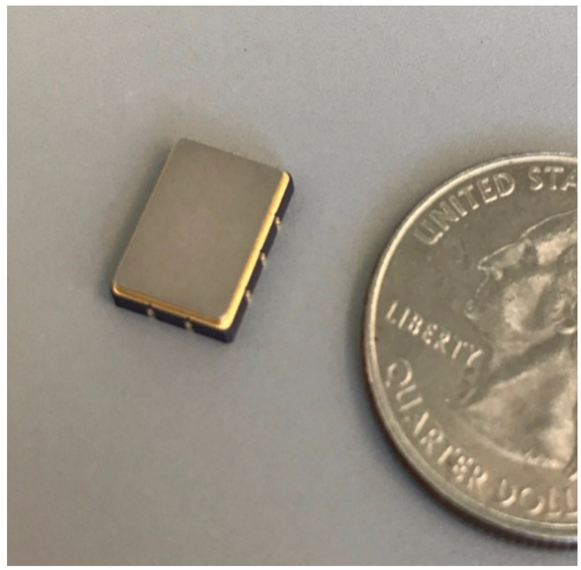


Figure 7: FastCap® SD85-500 Chip Ultracapacitor

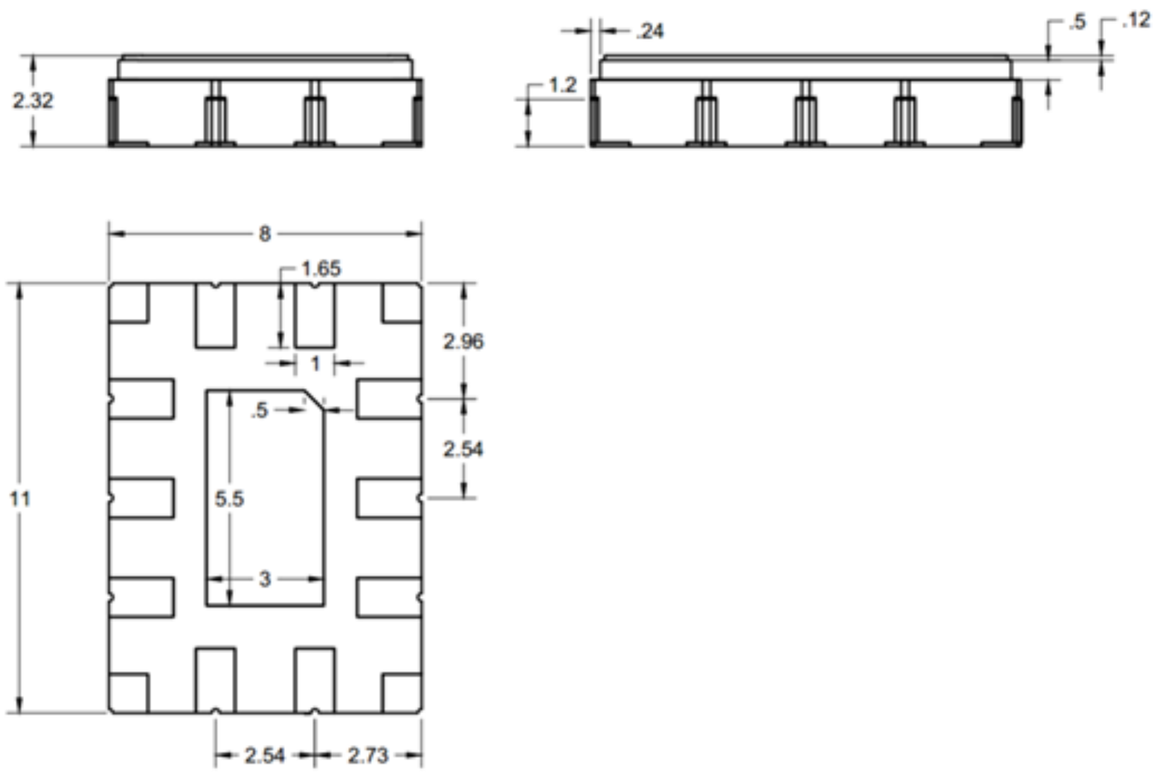
Advantages of the FastCap® Chip Ultracapacitor are:

- **Reflowability - it can be reflown at 260°C**
- **Thin profile à Available from 1.9 mm to 3.5 mm**
- **Board mountable**
- **Pick-placeable**
- **Sealed ceramic package**
- **Highest energy density board mountable ultracapacitor**
- **Small footprint à 11.0 x 8.0 mm and 9.0 x 22.0 mm**
- **RoHS compliant**
- **Pb-free reflow compliant**

Technical details:

Prototype Specifications	
Rated Capacitance	270 mF*
Operating Voltage	2.1 V
Surge Voltage	2.5 V
ESR at RT	160 mΩ*
ESR at 85°C	80 mΩ*
Operating Temperature	-20°C - 85°C
Size LxWxH	11.0 x 8.0 x 2.3 mm
Weight	0.6 g*

*+/- 20% variation



*units are in mm

Using the same technology, Nanoramic Laboratories is currently developing higher capacity versions of the FastCap Chip Ultracapacitor, 9mm x 22mm x 1.9mm and 9mm x 22mm x 3.5mm. These products would give more than three times the holdup time than the SD85 for about twice the footprint. The 1.9mm thick version is designed to target future high-performance SSDs that require components be no thicker than 2mm and the 3.5 version expands the application to IoT markets where high capacity reflowable cells are desired for manufacturability and ruggedness.

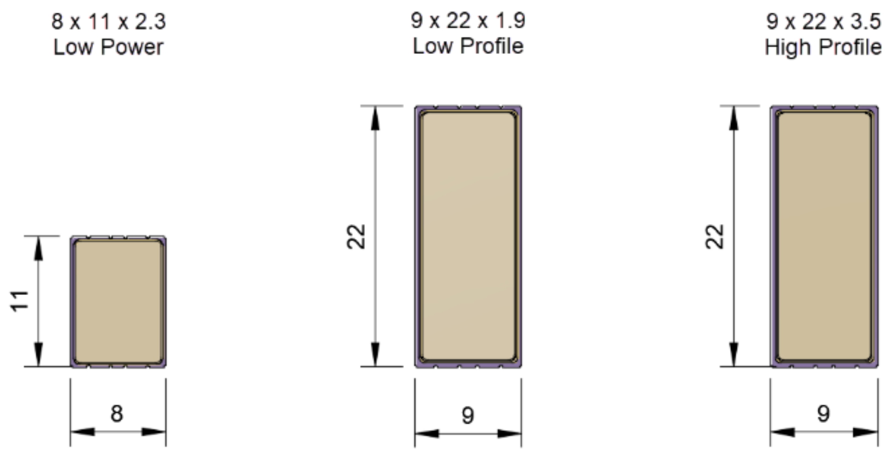


Figure 8: FastCap® Chip Ultracapacitor successfully reflown and mounted on a board

REFLOWABILITY

Nanoramic's FastCap® Chip Ultracapacitor is compatible with all reflow processes and can withstand temperatures as high as 260°C encountered in some reflow temperature profiles. Other board mountable ultracapacitors bulge or explode during a reflow process (Figure 10), because the electrolytes inside the package start boiling and create high pressure.

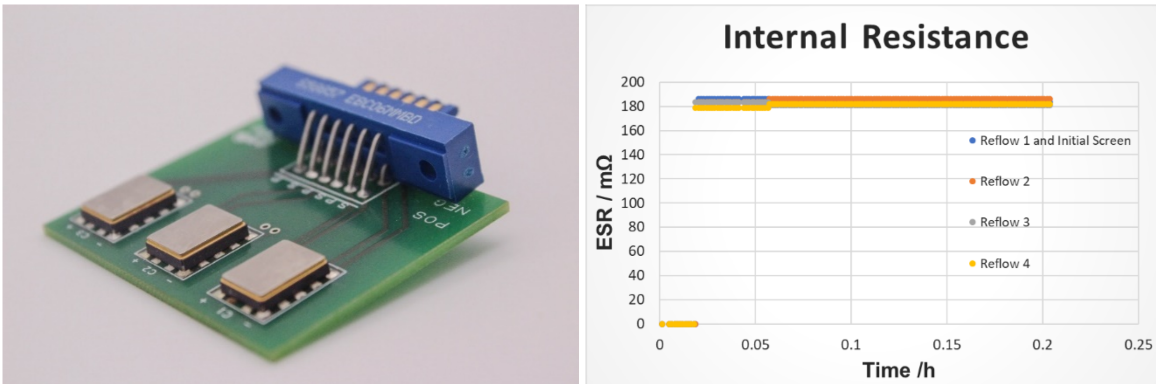


Figure 10: FastCap® Chip Ultracapacitor successfully reflown and mounted on a board, internal resistance plot over 4 reflow cycles

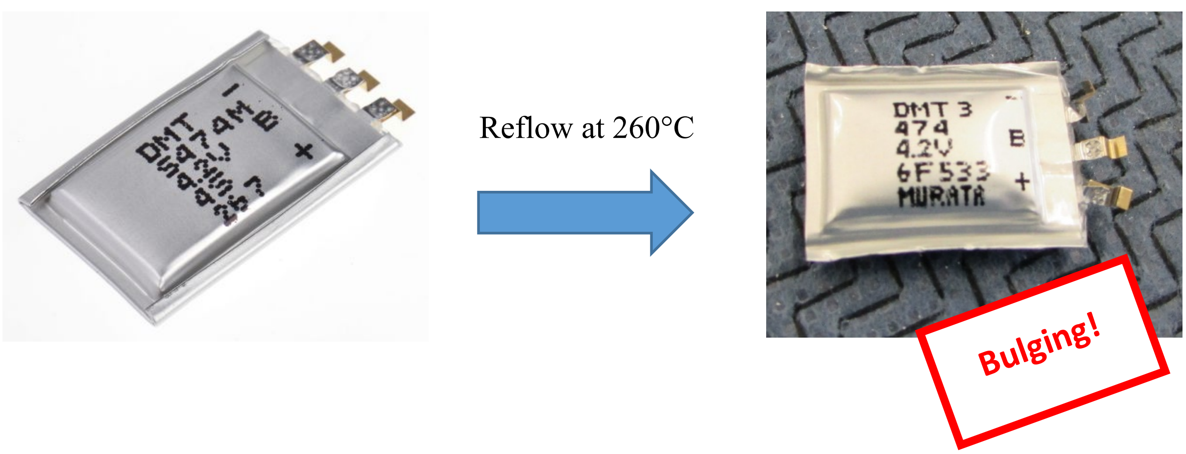
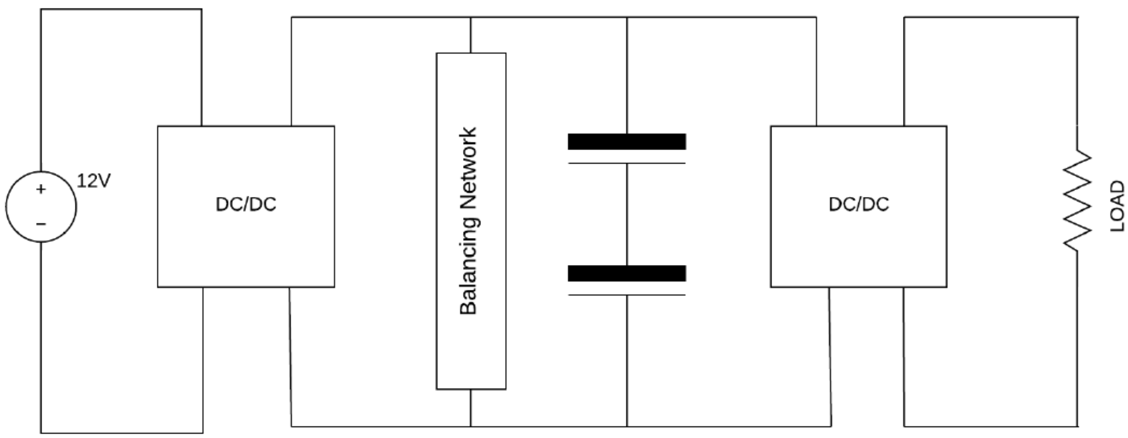


Figure 11: A Murata DMT ultracapacitor after one reflow cycle. The capacitor bulged, and it is not functioning

USE CASE

Nanoramic's FastCap® Chip Ultracapacitor has 10x higher energy density than the polymer tantalum ultracapacitors, therefore SSD designers can benefit from a high energy interim power supply in a small and slim design. Such benefits allow for more available space on the PCB, longer back up time, and comparable or lower cost than tantalum capacitor solutions. Designers can utilize the additional space for other crucial components like more DRAM or flash memory. This is a significant advantage, as SSD designers are finding ways to increase the memory density on standard size SSD cards (e.g. M.2, 2.5-inch).

Each Chip Ultracapacitor has a rated voltage of 2.1V. Below we consider a simple design with only two SD85-500 Chip Ultracapacitors connected in series serving a load of 5W for 100ms.



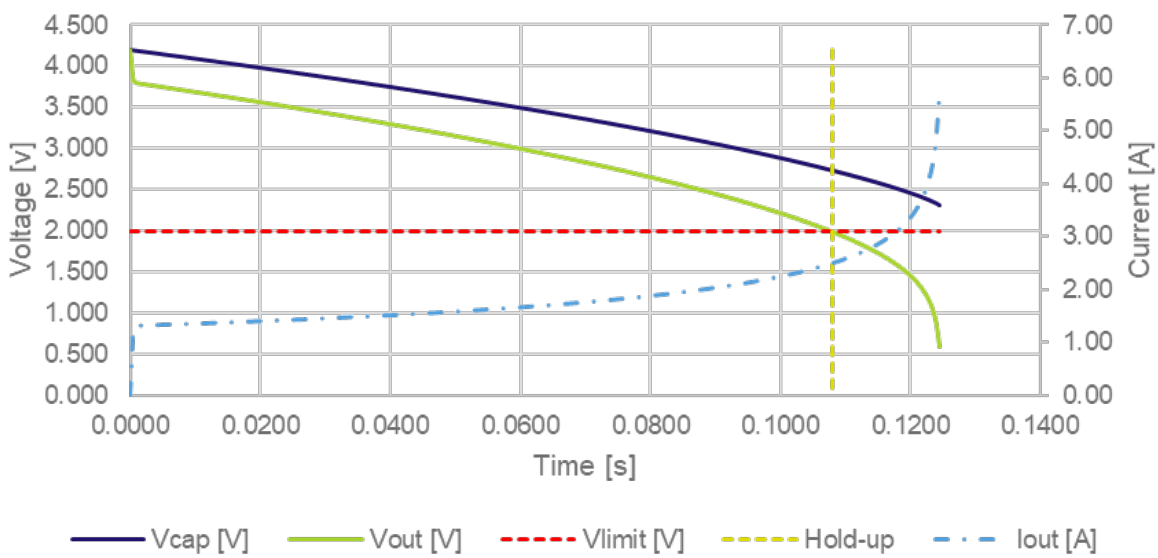
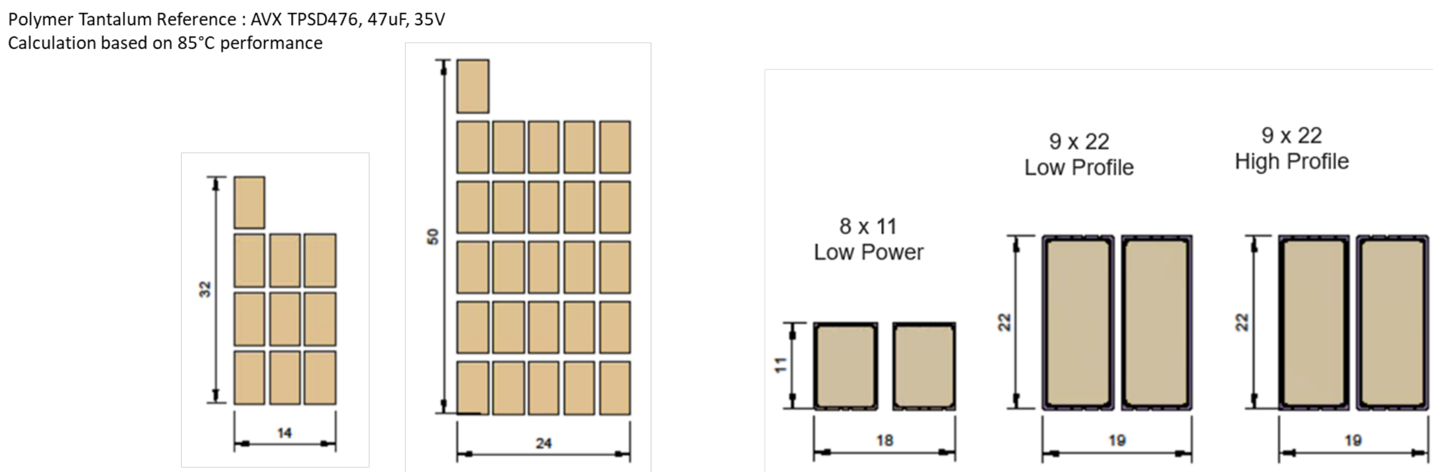


Figure 8: example of interim power supply with a 2s1p configuration. We assume a minimum voltage of 2V. Only two capacitors in series deliver 5W for 100ms.

In figure 11 we show a general comparison between the SD85-500 and the polymer tantalum capacitor, AVX TPSD476 (47µF, 35V). For a 4W load a designer would need 15 polymer tantalum capacitors to hold the power for a maximum of 70ms, however only two SD85-500 capacitors would be needed for the same power load and duration. **Using the FastCap® SD85-500, the designer has 66% more available space, while nearly doubling the holdup time.**



Total Area:	373 mm²	1040 mm²	198 mm²	418 mm²	418 mm²
Available Energy:	0.18 J	0.47 J	0.94 J	1.71 J	3.41 J
Energy per mm²:	0.48 mJ/mm²	0.45 mJ/mm²	4.75 mJ/mm²	4.09 mJ/mm²	8.16 mJ/mm²
4W Holdup time:	45ms	120ms	180ms	405ms	825ms
10W Holdup time:	<10ms	30ms	25ms	90ms	175ms

Figure 9: Comparison between solutions using the polymer tantalum capacitor AVX TPSD476 (47uFµF, 35V), and the FastCap® SD85-500

SUMMARY

- Compatible with automated manufacturing process –FastCap® Chip Ultracapacitor is the only reflowable product available.
- Using the FastCap® SD85-500, the designer has 66% more available space, while nearly doubling the holdup time.
- Nanoramic's FastCap® SD85-500 Chip Ultracapacitor has 10x higher energy density than polymer tantalum ultracapacitors.