APPLICATION BRIEF No. 1006

Pulsed Load Applications

August 2001

Case 1 - Customer's Requirements

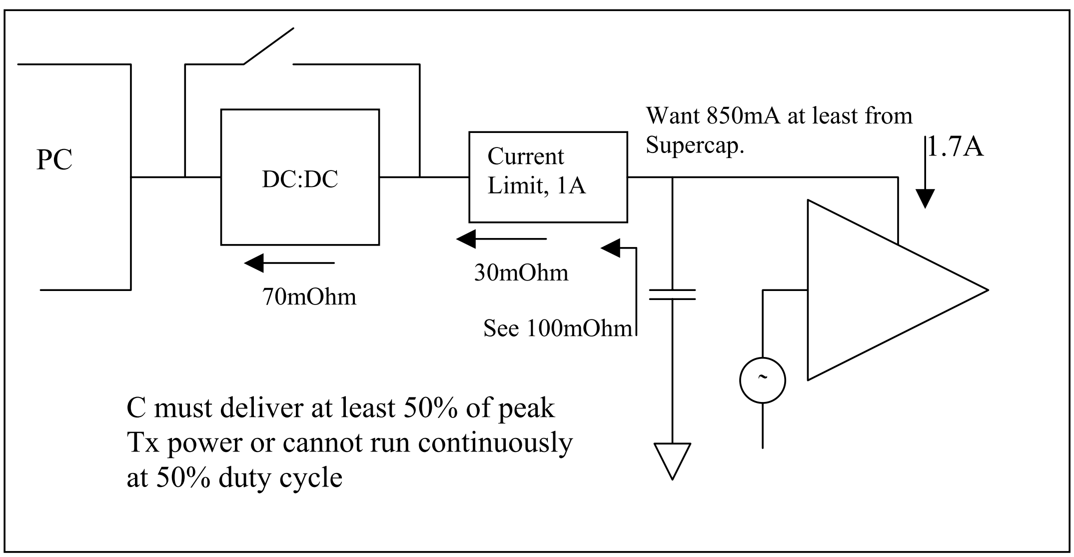
The figure below shows a simplified circuit diagram of the customer's requirement. The load drew a 1.7A pulsed current from the source, and the voltage of the supply was not to drop below 3V during the pulse. The maximum voltage of the source (at the capacitor) was 4.5V.

The pulses were 2.35ms in duration, with a maximum duty cycle of 50%.

Looking into the DC-DC converter from the load side, the source impedance seen was 70mΩ, and that contributed by the current-limiting circuit was 30mΩ, giving a total source impedance of 100mΩ as seen from the connection at the capacitor. The DC-DC converter is used in certain circumstances, when the system is powered by a reduced-voltage source, but the design takes into account the worst case.

A supercapacitor was required for this application that would be able to deliver at least half of the load current (850mA) for the duration of the pulse. The maximum voltage drop on the supercapacitor was not to exceed 200mV during the pulse. The ESR (equivalent series resistance) of the supercapacitor was not to exceed 100mΩ at –20°C. The DC capacitance was required to exceed 10,000µF at room temperature and 5,000µF at all operating temperatures.

The desired dimensions of the supercapacitor were 24mm x 15mm x 2mm, with a maximum size of 27mm x 17mm x 2.1mm.



cap-XX Pty. Ltd.• ABN 28 077 060 872
Units 9&10, 12 Mars Rd
Lane Cove NSW 2066, Australia
Tel: +61 2 9420 0390; Fax: +61 2 9420 0692
http://www.cap-xx.com E-mail: sales@cap-xx.com

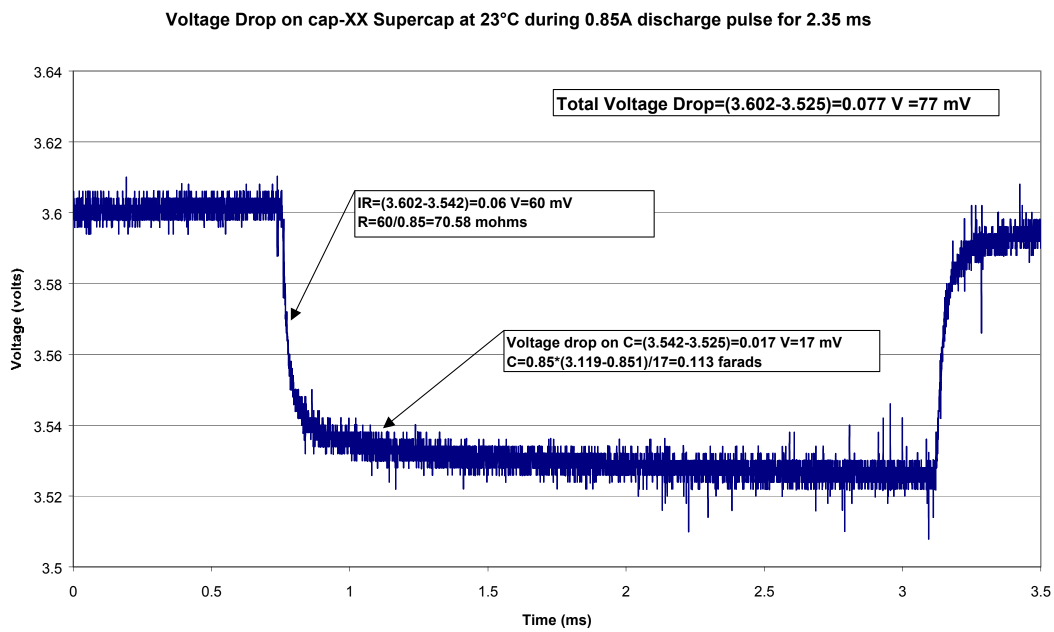
The cap-XX Solution

cap-XX solved the customer's problem with a supercapacitor having the following characteristics:

Parameter	Value
DC Capacitance (measured at 0.1A constant discharge)	0.25F
ESR at 21°C	70mΩ
ESR at -20°C	100mΩ
Dimensions	17mm x 25mm x 2.1mm

Test Results with cap-XX Supercapacitor

When the cap-XX supercapacitor was tested with a pulse of 0.85A, the following result was obtained. A pulse of this current was chosen for the test as the customer agreed that, during the load pulse, the supply would contribute half of the current. (Note that the capacitance observed over this short period, using only the linear portion of the curve, is less than the "DC" value.)



Clearly, the voltage drop under load was less than the maximum required by the specification. It can be shown that, during the load pulse, the voltage drop on the supercapacitor in an actual circuit would be less than 80mV at room temperature, and less than 120mV at –20°C.

The cap-XX solution therefore exceeded the requirements of the specifications.

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http://www.cap-xx.com E-mail: sales@cap-xx.com

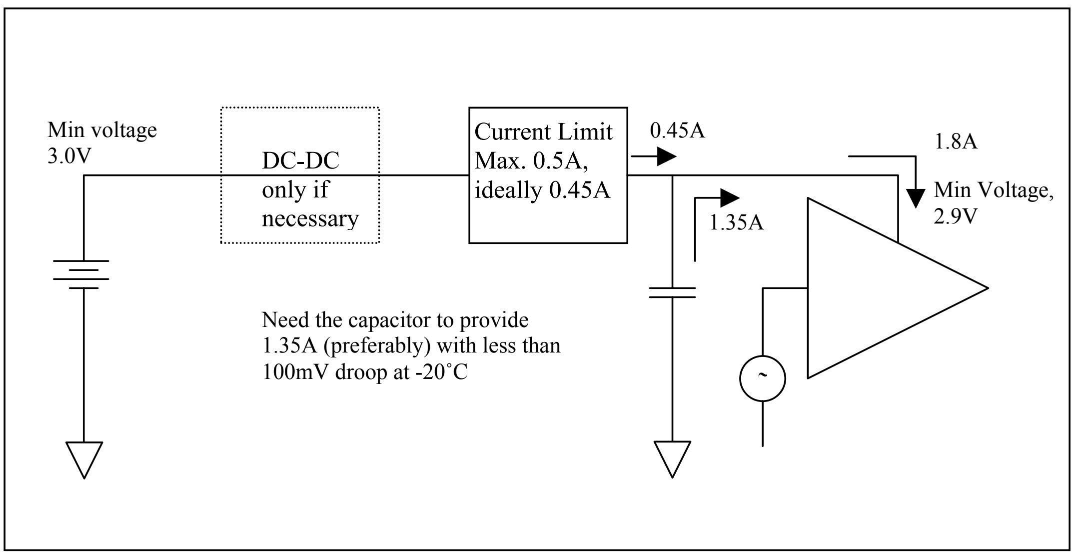
Case 2 - Customer's Requirements

The figure below is a simplified circuit diagram of the customer's requirement. The load was powered by a lithium-ion battery that had a minimum 3V output when discharged. The load could operate normally with a supply voltage of 2.9V (minimum) at all operating temperatures down to –20°C. The customer had the option of using a DC-DC converter to maintain the voltage at the load, if necessary, but preferred not to have to add the extra circuit and standard decoupling capacitors.

When the load was operating, it drew a 1.8A current for 1.154ms at 25% duty-cycle, i.e. the period was 4.616ms, and the time between the end of one pulse and the start of the next was 3.462ms. The customer wished the supercapacitor shown to deliver 1.35A of the load, or as close to this value as possible. There was a current-limiting circuit in the supply, and the customer wished to restrict its output to not much more than 450mA. (This was the desired value, with a maximum design value of 500mA if necessary, limited by thermal considerations.) Since the *average* of the load current with the above pulse width and duty cycle was 450mA, the limit obviously would need to be at least slightly above 450mA, because of charge-discharge fluctuations and any losses. The customer's specification stated that the voltage drop across the current-limiter was to be regarded as negligible.

The voltage drop at the supercapacitor under load was required to be no more than 90mV (100mV maximum), so that the load could continue to operate until the battery had discharged fully to 3.0V.

The supercapacitor's dimensions were limited to 40mm x 60mm x 1.2mm.



The Proposed cap-XX Solution

Since the voltage drop in the battery and current-limiter under load could be neglected, the voltage behaviour of the circuit depends primarily on the supercapacitor. cap-XX is able to produce a supercap with the following specifications that fits in the space permitted:

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Lane Cove NSW 2066, Australia
Tel: +61 2 9420 0390; Fax: +61 2 9420 0692
http://www.cap-xx.com E-mail: sales@cap-xx.com

- Capacitance = 0.9F (0.46F at -20°C).
- ESR = 35mΩ at 23°C (49mΩ at -20°C) (Equivalent Series Resistance).

The predicted voltage drop at the supercapacitor resulting from resistive (ESR) and capacitive voltage drops during the pulse is as follows:

- Resistive voltage drop = I x ESR = 1.35A x 0.049Ω = 66.2mV.
- Capacitive voltage drop = I x t/C = 1.35A x 0.001154s/0.46F = 3.39mV.
- Total = 69.6mV.

If the capacitor is being charged with the maximum current immediately before the load pulse occurs (the worst case), then the voltage increase across the ESR resulting from the charging current is as follows (using the desired lowest current limit):

- Resistive (charging) voltage increase = I x ESR = 0.45A x 0.049Ω = 22.1mV.

Therefore, with the lowest current limit desired, the predicted maximum voltage drop as the load pulse occurs and the supercapacitor changes from charging to discharging is 22.1mV + 69.6mV = 91.7mV. This is approximately equal to the 90mV desired limit, and less than the maximum value specified, 100mV.

In order to be sure that the load could be adequately supplied at all times without its supply voltage declining, the recommended value of the current limit is slightly greater than the minimum, 450mA. A value of approximately 460mA (or more) is considered adequate.

The current limiter will act during the load pulse, and during the first part of the supercapacitor's recharge cycle, when the load is off. The greater the value chosen for the limit, the shorter will be the period of current-limiting during the recharge cycle. Other effects are that the voltage increase during the recharging of the supercapacitor will increase, but the resistive and capacitive voltage drop during the load pulse will be reduced, as the current required from the supercapacitor will be reduced.

Re-calculating the above results with a current limit of 460mA (and a corresponding supercapacitor discharge current of 1.34A) yields the following results:

- Resistive voltage drop = I x ESR = 1.34A x 0.049Ω = 65.7mV.
- Capacitive voltage drop = I x t/C = 1.34A x 0.001154s/0.46F = 3.36mV.
- Total of above = 69.1mV (rounding).
- Resistive (charging) voltage increase = I x ESR = 0.46A x 0.049Ω = 22.5mV.
- Total ripple voltage is 69.1mV + 22.5mV = 91.6mV

The cap-XX solution therefore will meet the specification.

Further Information:

cap-XX will be pleased to supply you with detailed data and design information. For further details use the contact information at the foot of this page.

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