

# DATASHEET

## HS208 SUPERCAPACITOR

### Features

- High capacitance (900mF DC)
- Low ESR (55mΩ @ 1kHz)
- High peak current, high pulsed power
- Thin form factor

### Typical Applications

Interim power, energy storage & load leveling. Examples include:

- Cache protection in Solid State Drives (SSD) and Hybrid Hard Drives (HHD)
- Drop test protection, battery hot swap, graceful shutdown & last gasp transmissions in industrial electronics such as handheld computers, PDAs, portable point of sale terminals, bar code scanners, data loggers, etc.
- RF power support for data cards, USB modems, PDAs, location trackers, sensors, etc.

### Electrical Specifications

**Table 1: Absolute Maximum Ratings**

Parameter	Name	Conditions	Min	Max	Units
Terminal Voltage	V <sub>c</sub>		0	5.8	V
Temperature	T		-40	+85	°C

**Table 2: Electrical Characteristics**

Parameter	Name	Conditions	Min	Typical	Max	Units
Terminal Voltage	V <sub>c</sub>		0		5.5	V
Capacitance	C	DC, 25°C		900 ± 20%		mF
ESR	ESR	1kHz, 25°C		55 ± 20%		mΩ
Leakage Current <sup>1</sup>	I <sub>L</sub>	4.5V, 25°C 72hrs		1.0		μA
RMS Current	I <sub>RMS</sub>	25°C			5	A
Peak Current <sup>2</sup>	I <sub>p</sub>	25°C			20	A

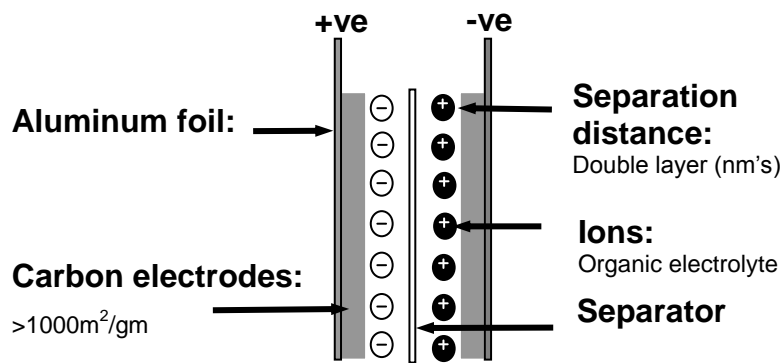
<sup>1</sup>Refer to CAP-XX for details. <sup>2</sup>Non repetitive current.

## Description

A traditional capacitor stores energy in the electric field created by charge separation. The electric field normally exists in a dielectric which becomes polarised. The capacitance is proportional to the permittivity of the dielectric and the area of the plates, and inversely proportional to the separation distance of the plates.

There is no intervening dielectric material in a supercapacitor. Most of the potential is dropped across the double layers, not a dielectric. Supercapacitors have a much higher capacitance than traditional capacitors because of the large equivalent area of the plates and the small effective separation distance of the plates. One gram of the electrode material can have an equivalent area of  $2000\text{m}^2$ , and the separation distance between an electrode and the layer of ions, the double layer, is in the nanometre range.

Fig. 1 shows one cell of a typical carbon double layer supercapacitor. The physical construction is similar to that of a battery, with two electrodes immersed in an electrolyte and a separator between them. Unlike a battery however, there is no chemical energy storage. Within each supercapacitor, there are effectively two capacitors in series, each consisting of a carbon electrode and the adjacent layer of ions in the electrolyte. The ions are free to move anywhere within the electrolyte, penetrating the pores of the carbon electrodes and passing through the separator membrane insulating the two electrodes.



**Figure 1: A carbon double layer supercapacitor**

The actual capacitance of a supercapacitor is a complicated function of voltage, current, frequency, temperature and time. There are also parasitic inductances and resistances.

## Typical Applications

Supercapacitors with high ESR, suitable for low power applications such as memory backup, have existed for years. The breakthrough in CAP-XX technology is supercapacitance with low ESR, which offers a high power supercapacitor suitable for use in applications with higher current loads. CAP-XX supercapacitors have much higher power density than batteries, and far greater energy density than traditional capacitors.

High power supercapacitors such as the HS208 act as both a filter and an energy reservoir for the source and the load. It will smooth out the load seen by the power supply, reduce the source impedance seen by the load, stiffen the voltage rail to the load, and offer emergency power in the event of an interruption or loss. In principle, the source supplies the energy and the supercapacitor supplies the power.

With the use of a supercapacitor, battery-powered devices can benefit from the selection of a battery optimised for energy density, and in many cases, of a reduced size. And because supercapacitors continue to operate at sub-zero temperatures (CAP-XX supercapacitors are rated to  $-40^{\circ}\text{C}$ ), the device will continue to perform at very low temperatures - well beyond the range supported by batteries.

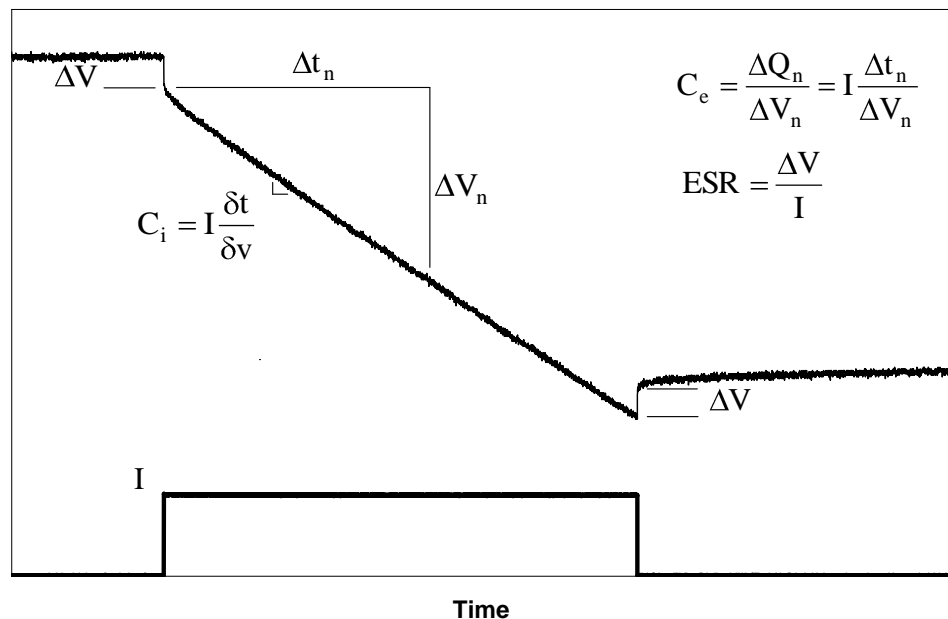
Unlike batteries, supercapacitors also offer rapid - and effectively unlimited - charge/discharge cycling, allowing them to be used in applications which must be charged and discharged repeatedly over extended periods. The rapid charging is particularly beneficial in energy harvesting applications, where a battery would not be able to capture the recovered energy quickly enough to maximise efficiency.

Supercapacitors are thin, light and to a certain extent can be conformal. These are impressive features, especially in portable electronic devices and other space-constrained designs.

Pulse power applications include GPRS modems, which require up to 2A peaks during transmission (12.5%, 25% and 50% duty cycle), but are often powered by current-limited supplies such as USB, PCMCIA or Compact Flash ports, or high impedance primary batteries. Energy storage applications include battery-free condition monitoring equipment powered by renewable sources, as well as in mains-powered and battery-powered devices such as solid state drives and other mission critical electronics, in which they provide an emergency power supply in the event of a loss of, or interruptions to, the primary source. Additional information on the applications of supercapacitors can be found at [www.cap-xx.com](http://www.cap-xx.com).

### Definition of Terms

In its simplest form, the Equivalent Series Resistance (ESR) of a capacitor is the real part of the complex impedance. In the time domain, it can be found by applying a step discharge current to a charged capacitor as in Fig. 2. In this figure, the supercapacitor is pre-charged and then discharged with a current pulse (I).



**Figure 2: Effective capacitance, instantaneous capacitance and ESR**

The ESR is found by dividing the instantaneous voltage step ( $\Delta V$ ) by  $I$ . The instantaneous capacitance ( $C_i$ ) can be found by taking the inverse of the derivative of the voltage and multiplying it by  $I$ . The effective capacitance ( $C_e$ ) is found by dividing the total charge removed from the capacitor ( $\Delta Q_n$ ) by the voltage lost by the capacitor ( $\Delta V_n$ ). Note that  $\Delta V$ , or IR drop, is not included because very little charge is removed from the capacitor during this time.  $C_e$  shows the time response of the capacitor and it is useful for predicting circuit behavior in pulsed applications.

## Test Data - Capacitance

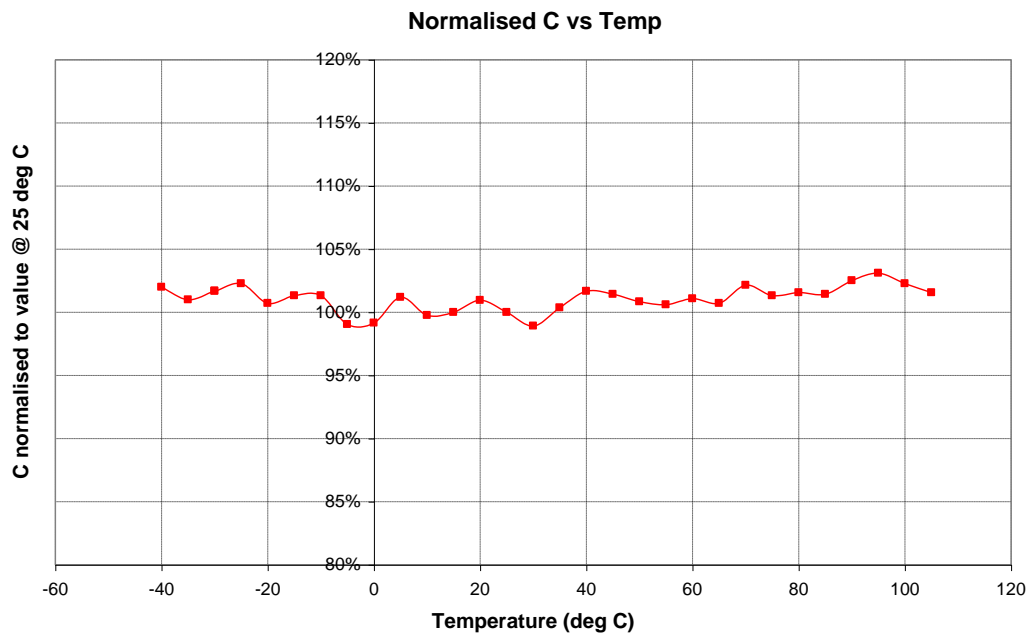


Figure 3: Effective Capacitance for a 100mA discharge

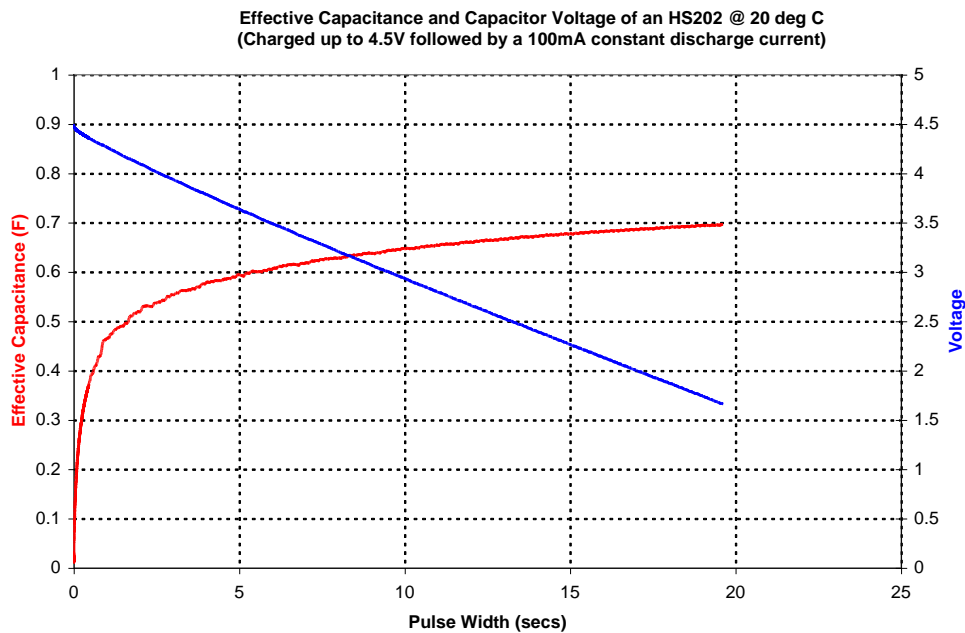


Figure 4: Capacitance change with temperature

## Test Data - ESR

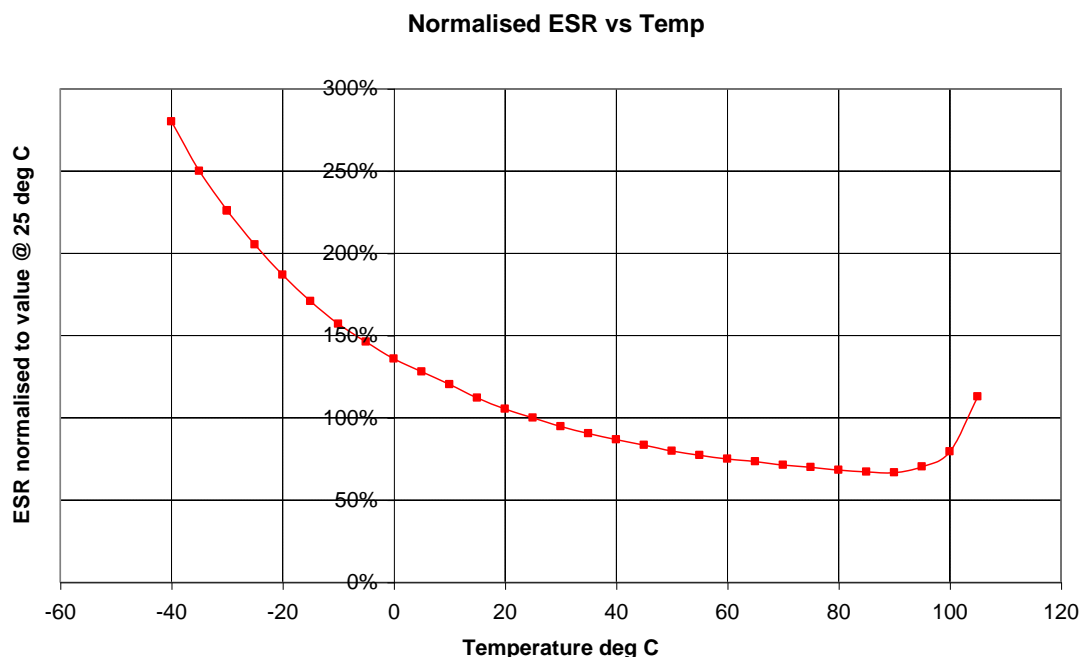


Figure 5: ESR change with temperature

**Balancing**

An HS208 is made up of two 1.8F supercapacitor cells in series, each with a maximum operating voltage of 2.75V. This forms a dual cell device with  $C = 0.9F$ . Voltage imbalance may occur due to differences in leakage current between the two cells, so to ensure long life, a balancing circuit is required to equalize the voltage across the two cells and prevent one cell from going over-voltage. In its simplest form, this may be a pair of balancing resistors as shown in Fig. 6.

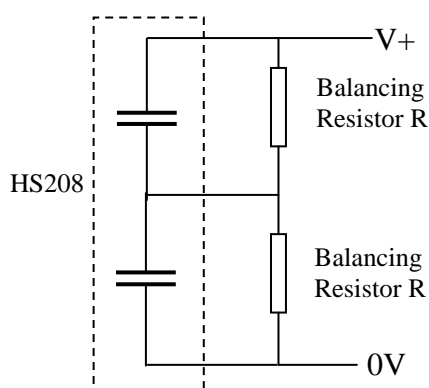


Figure 6: Passive Balancing

The maximum value of resistor required to balance the cells will depend on the application. For example, a lower value will be required if the supercapacitor is expected to be charged and discharged repeatedly, either when the circuit is turned off/on or due to deep discharge by the load. Similarly, a lower value will also be required if the supercapacitor is exposed to a high temperature operating environment, since the leakage current of each cell will increase with temperature, exacerbating any differences at room temperature. Table 3 lists some maximum recommended resistor values, depending on voltage conditions.

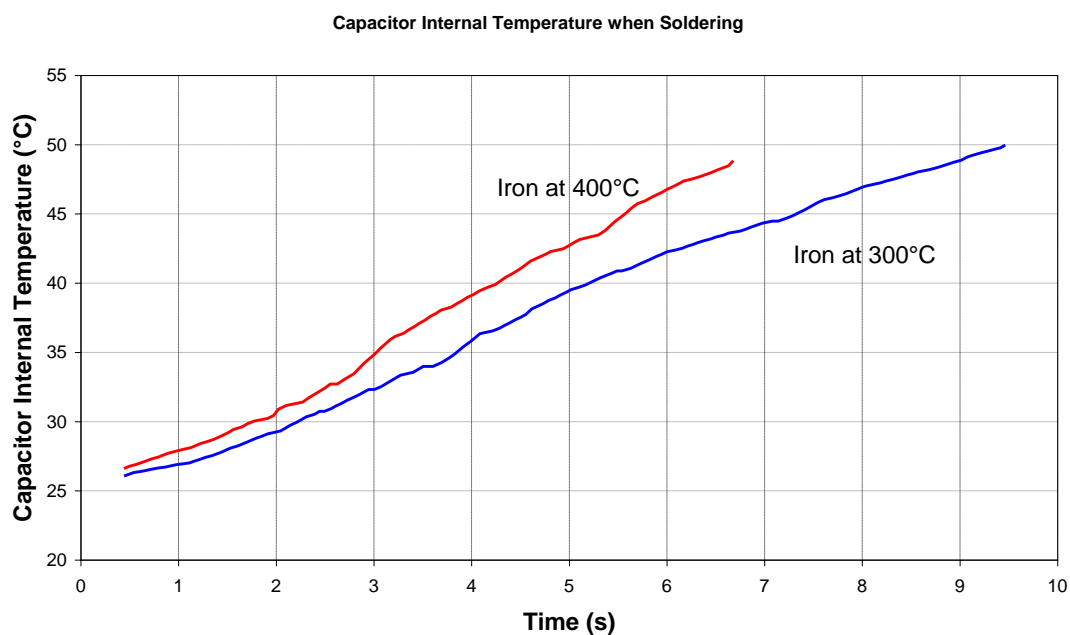
**Table 3: Balancing resistor values**

Application Condition	Application Voltage at Room Temperature		
	3.6V	4.5V	5.5V
Supercap always charged	39K $\Omega$	27K $\Omega$	18K $\Omega$
Periodic deep discharge	15K $\Omega$	10K $\Omega$	2.7K $\Omega$

If extremely low leakage current is required, CAP-XX recommends using an active balancing circuit, which will limit the leakage current of the supercapacitor to the leakage current of whichever cell has the greater leakage current. The active balancing circuit should limit the leakage current to  $< 1\mu\text{A}$ .

### Soldering

Supercapacitors cannot be The recommended maximum soldering time is 5 seconds when using an iron at 400°C in an ambient temperature of 25°C.

**Figure 7: Capacitor temperature rise when soldering**

**Vibration**

Tested to IEC68-2-6

Type	Sinusoidal
Frequency	55Hz-500Hz
Amplitude	0.35mm±3dB (55Hz to 59.55Hz) 5g±3dB (59.55Hz to 500Hz)
Sweep Rate	1 Oct/min
No. of Cycles	10 (55Hz-500Hz-50Hz)
No. of Axis	3 orthogonal
Results	No electrical or mechanical degradation (adhesive not required)

**Shock**

Tested to IEC68-2-27

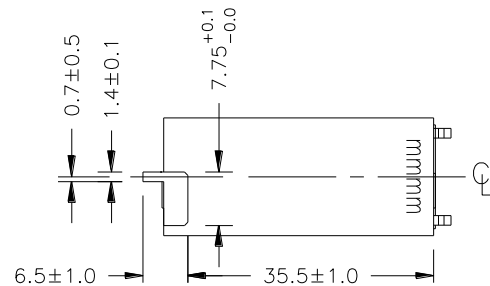
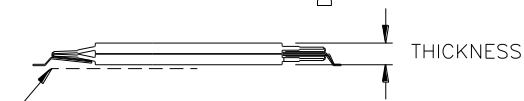
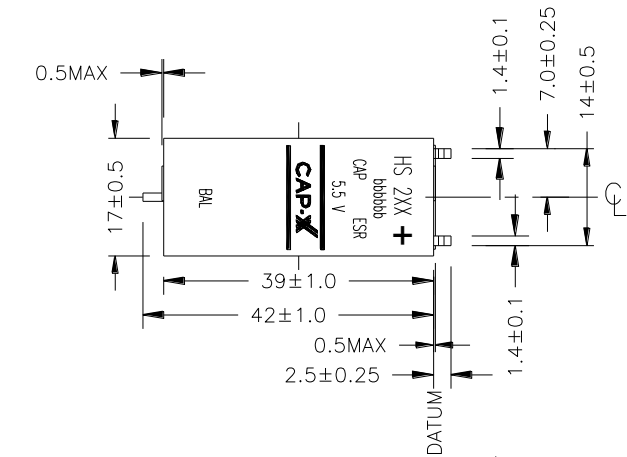
Pulse Shape	Half Sine
Amplitude	30g±20%
Duration	18ms±5%
No. of Shocks	3 in each direction (18 in total)
No. of Axis	3 orthogonal
Results	No electrical or mechanical degradation (adhesive not required)

**Drop Test**

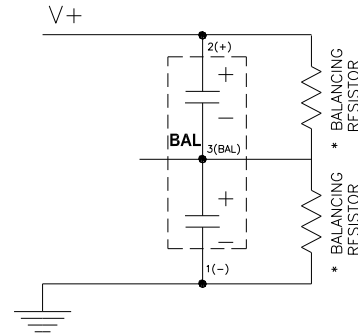
Tests performed	Three drops of test jig, each axis from 6 feet onto concrete.
Results	No electrical or mechanical degradation when following the mounting rules.

**Mounting:**

Unconstrained	If the supercapacitor is unconstrained then some form of adhesive should be used to affix the supercapacitor to the PCB.
Constrained	If the supercapacitor is constrained with a maximum clearance of 1mm then the adhesive is not required

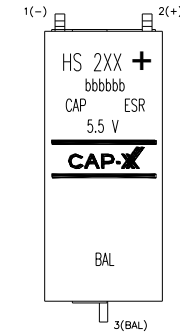


UNDERSIDE  
VIEW

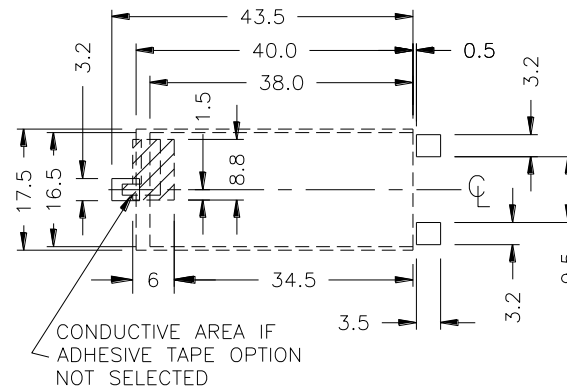


PLEASE CONTACT CAP-XX  
FOR FURTHER INFORMATION

SUGGESTED CONNECTION  
DETAILS FOR 2 - CELL  
SUPERCAP



1(-) NEGATIVE/GROUND VOLTAGE CONNECTION  
2(+) POSITIVE VOLTAGE CONNECTION  
3(BAL) BALANCE CIRCUIT CONNECTION



SUGGESTED PAD LAYOUT

THE PAD SIZE SHOWN IS BASED ON  
CAP-XX MANUFACTURING TOLERANCES.  
THE FINAL PAD SIZE SHOULD ALLOW  
FOR CUSTOMER MANUFACTURING  
(PLACEMENT) TOLERANCES.