CAP-XX
Units 9-10/12 Mars Road
Lane Cove NSW 2066
Australia
Tel +61 2 9420 0690
Fax +61 2 9420 0692
www.cap-xx.com
CAP-XX Pty Limited
ABN 28 077 060 872
ACN 077 060 872

HS206 SUPERCAPACITOR
Datasheet Rev 2.1

Features

- High capacitance (600mF @ DC)
- Low ESR (70mΩ @ step change in current);
- High peak current
- High pulsed power
- Thin form factor

Typical Applications

- High power LED Flash
- Improved audio performance
- Automatic Meter Reading
- PC Cards, Compact Flash Cards & USB
- Load leveling for PDAs & cell phones
- Power support during battery contact bounce

Electrical Specifications

Table 1: Nominal Characteristics

Device	Nominal Capacitance[1]	Nominal ESR[2]	Tolerance about nominal value	Footprint	Thickness[3]
HS206F	600mF	70mΩ	±20%	39mm x 17mm	2.50mm
HS106F	1200mF	36mΩ	±20%	39mm x 17mm	1.20mm
HS206G	Electrically identical to "F" products. Double sided tape added to underside for more secure mounting. Adds 0.1mm to Thickness.			39mm x 17mm	2.60mm
HS106G				39mm x 17mm	1.30mm

[1]At 25ºC DC. [2]Measured using a 0.5A step in current @ 25ºC. [3]Refer Figs 14 & 15.

Table 2: Absolute Maximum Ratings

Parameter	Name	Conditions	Min	Max	Units
Terminal Voltage	Vc			5.8	V
Temperature	T		-40	+85	°C

Table 3: Electrical Characteristics

Parameter	Name	Conditions	Min	Typical	Max	Units
Terminal Voltage	Vc				5.5	V
Leakage Current[4]	I_L	4.5V, 25°C 72hrs		3.5	5	µA
RMS Current[5]	I_{RMS}	25°C			5	A
Peak Current[6]	I_P	25°C			22	A

[4]Refer to cap-XX for details.[5]See Fig 10. [6]Single pulse, non repetitive current.

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 figure 2. In this figure the supercapacitor is pre-charged and then discharged with a current pulse (I). The ESR is found by dividing the instantaneous voltage step (ΔV) 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 (ΔQ_n) by the voltage lost by the capacitor (ΔV_n). Note that ΔV, 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.

In the example of Fig 1, using an HS206, ΔV = 4.97V – 4.89V = 0.08V, I = 1.34A, so ESR = 0.08V/1.34A = 59.7mΩ. Similarly for a ΔV_n = 4.88V – 4.83V = 0.05V, Δt_n = 0.02s, and I = 1.4A. Therefore, C = 1.4A X 0.02s/0.05V = 560mF.

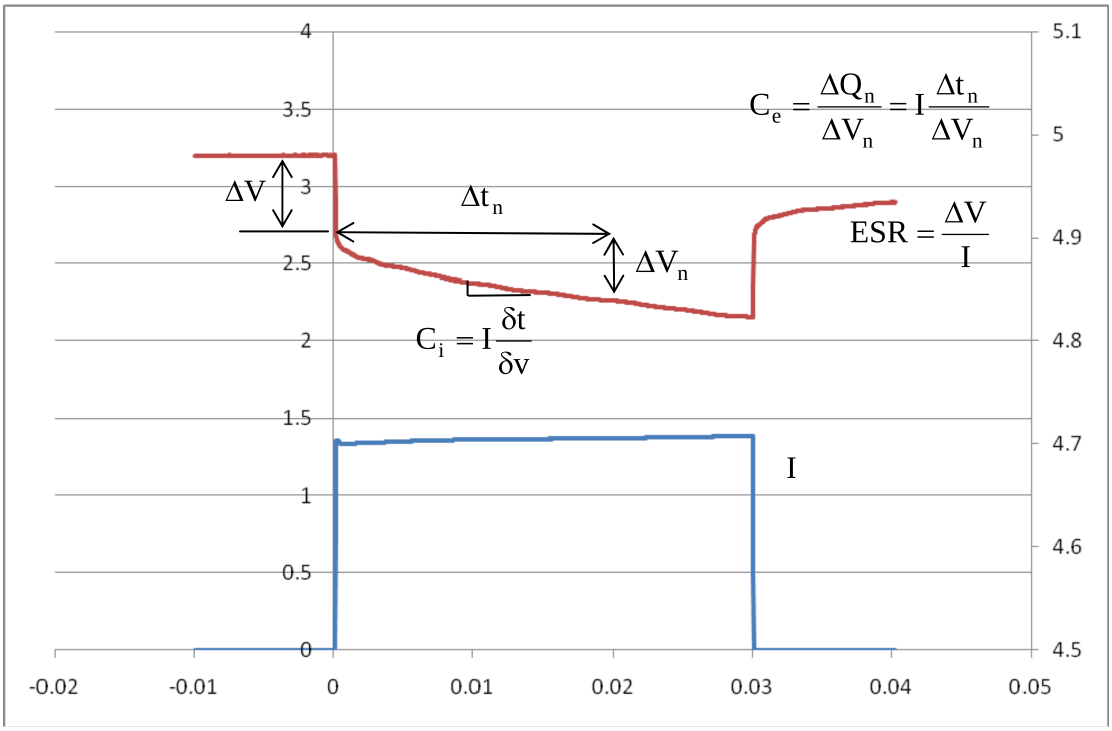


Figure 1: definitions for Effective Capacitance, Instantaneous Capacitance and ESR

DC Capacitance

CAP-XX measures DC capacitance by charging the supercapacitor to 4.5V then disconnecting the supercapacitor from the source, and applying a constant current discharge of 100mA. We measure the time taken to drop from 3V to 1V, so C = 100mA x time taken to drop from 3V to 1V/2V.

In the example of Fig 2, for a ΔV_n = 3.0V – 1.0V = 2V, the corresponding Δt_n = 22.52s – 11.72s = 10.8s. C = I X $\Delta t_n/\Delta V_n$ where I = 0.105A, therefore C = 0.105x11.2s /2.0V = 567mF.

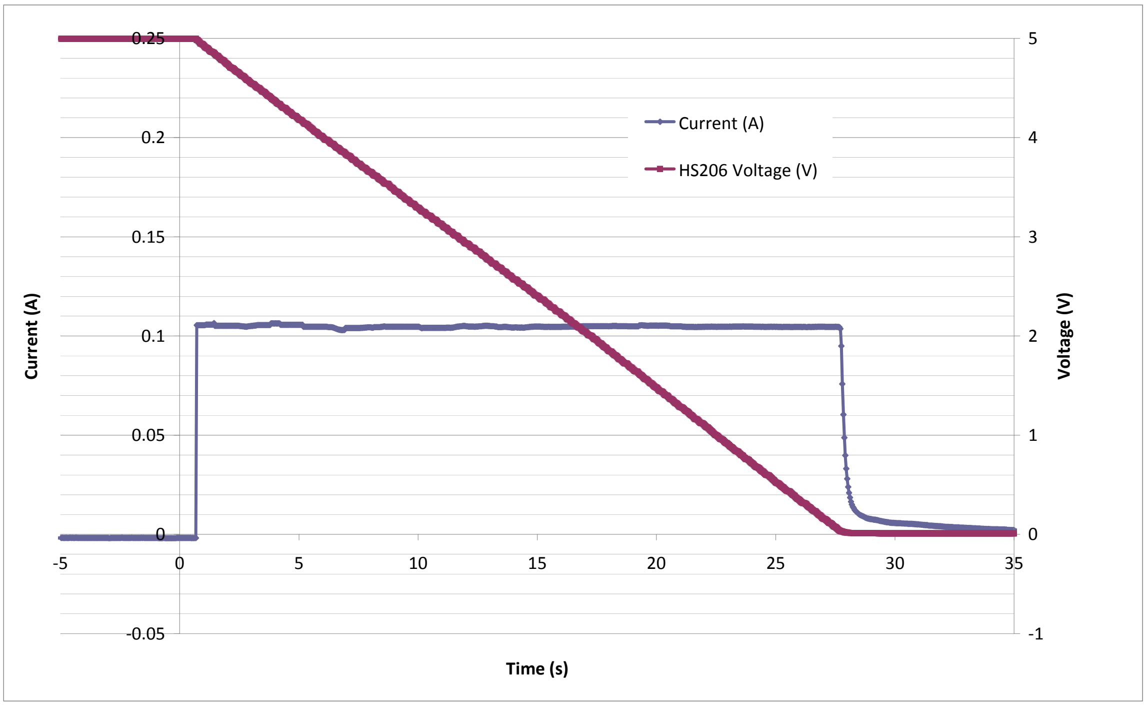


Fig 2: Measurement of DC capacitance

ESR Measurement

CAP-XX measures ESR by measuring the voltage drop across the supercapacitor when a current step is applied to a supercapacitor. The supercapacitor is first charged to 4.5V then disconnected from the source, and finally the current step applied and the voltage drop measured.

In the example of Fig 3 below ΔV = 4.98V – 4.90V = 80mV and ΔI = 1.33A (load pulse), therefore ESR = ΔV/I = 60mΩ.

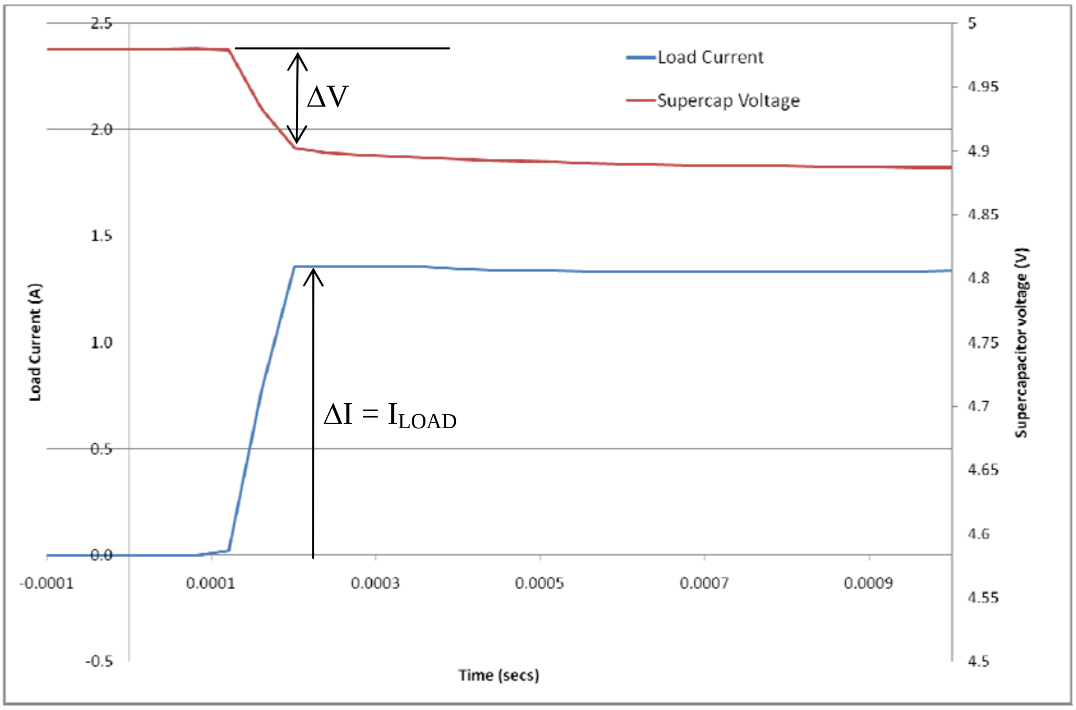


Fig 3: Measurement of ESR

Effective Capacitance

Figure 4 shows the Effective Capacitance for the HS206 @ 25°C. The supercapacitor was charged to and held at 4.5V until the current drawn by the supercapacitor dropped to less than 100µA. The supercapacitor was then disconnected from the source and a constant current discharge of 100mA was applied for 10 secs.

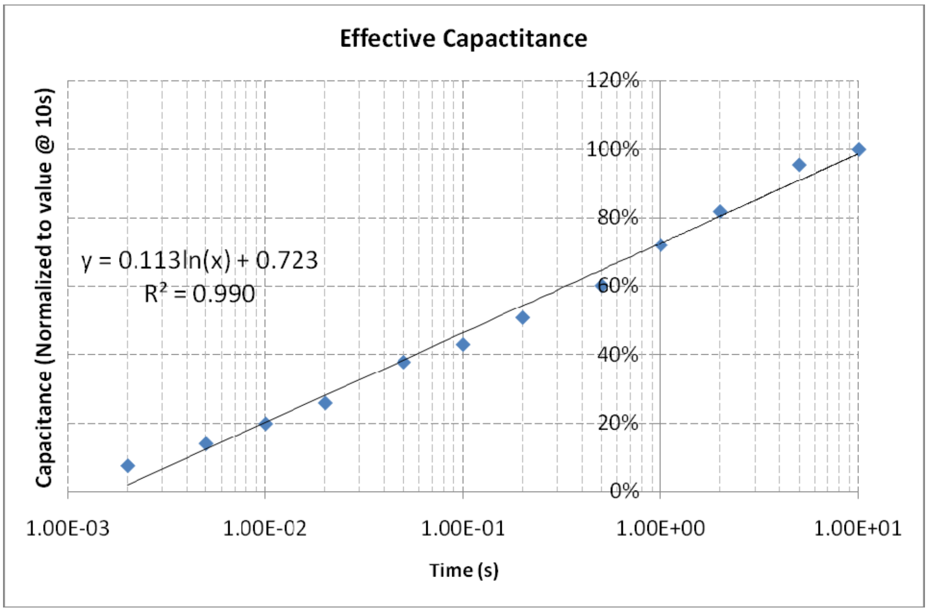


Figure 4: Effective Capacitance – charged to 4.5V and discharged with a 100mA pulse

Pulse Response

Figure 5 shows the voltage ripple for a class 10 GPRS pulse. A HS206 provides a 1.8A load pulse of 1.15ms duration @ 25% duty cycle and the source current is limited to 600mA, though there is some source current overshoot evident in the first 200µs. The low supercapacitor ESR and high effective capacitance result in the load seeing a voltage ripple of only 110mV. The supercapacitor is supplying the difference between the 1.8A load current and the 0.6A source current.

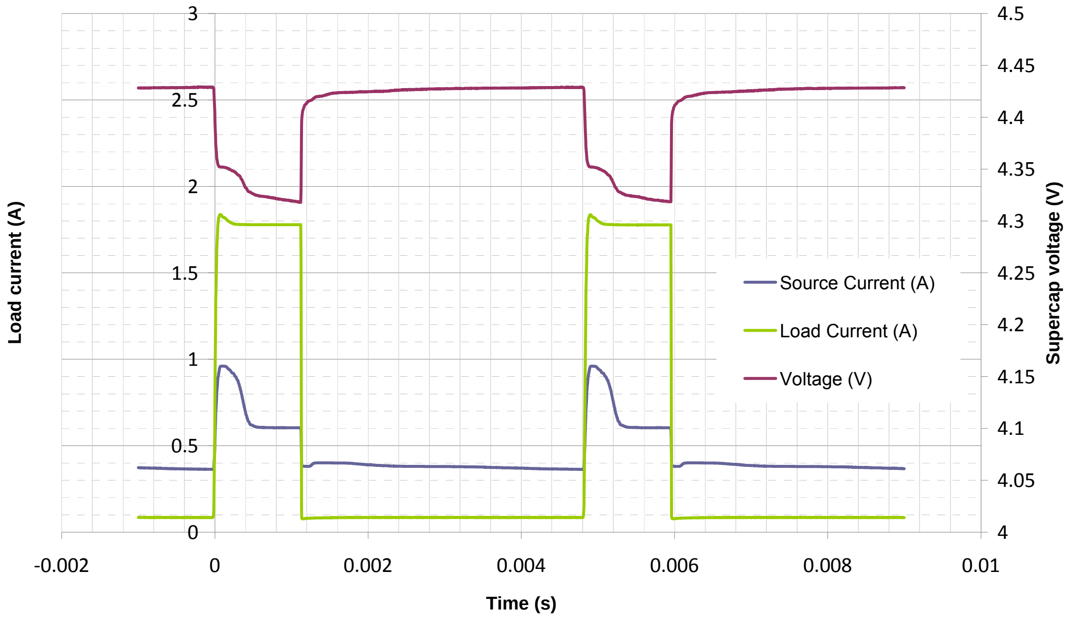


Figure 5: Supercapacitor voltage ripple for GPRS class 10 pulse with 1.8A peak load current

Capacitance and ESR with temperature

Fig 6 below shows that DC capacitance does not vary over the operating temperature range.

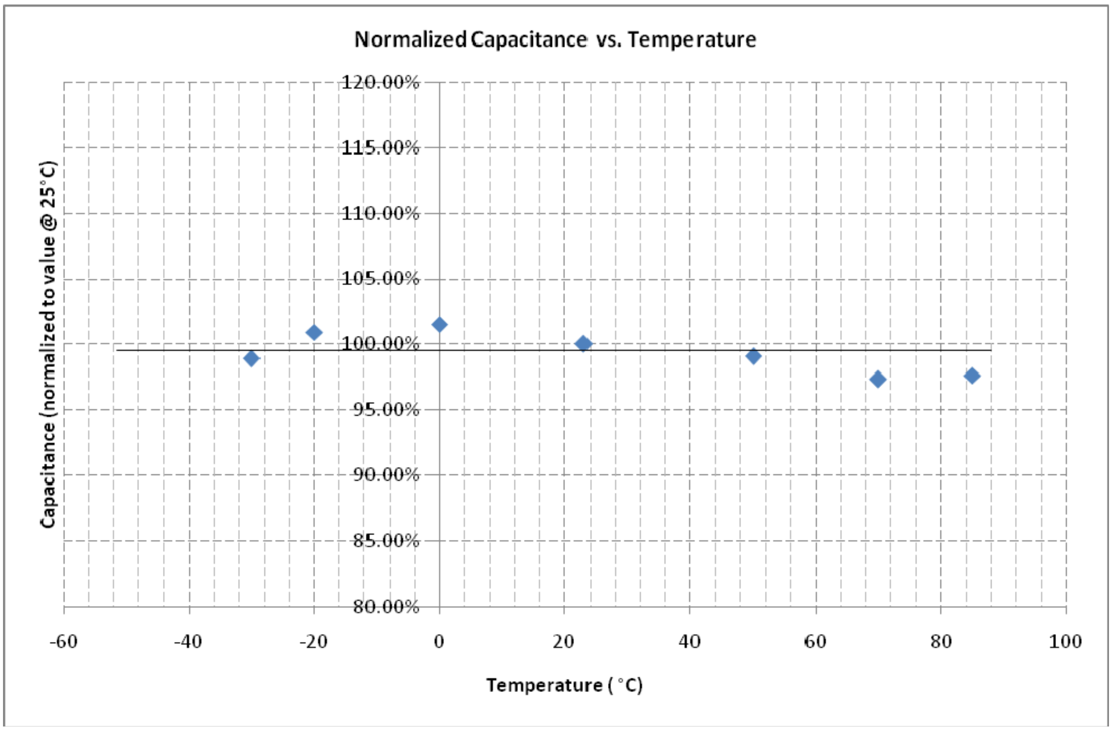


Figure 6: Capacitance change with temperature

Fig 7 shows the relationship between ESR and temperature. ESR at -40°C is ~ 350% of ESR at 25°C.

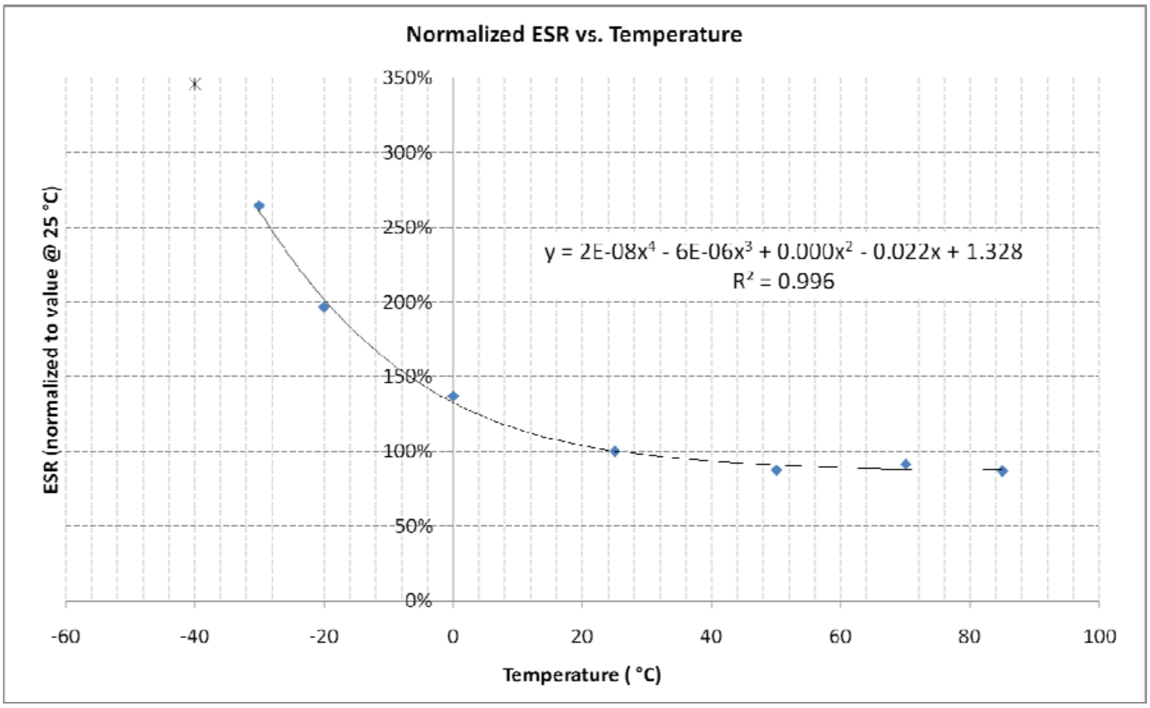


Figure 7: ESR change with temperature

Frequency Response

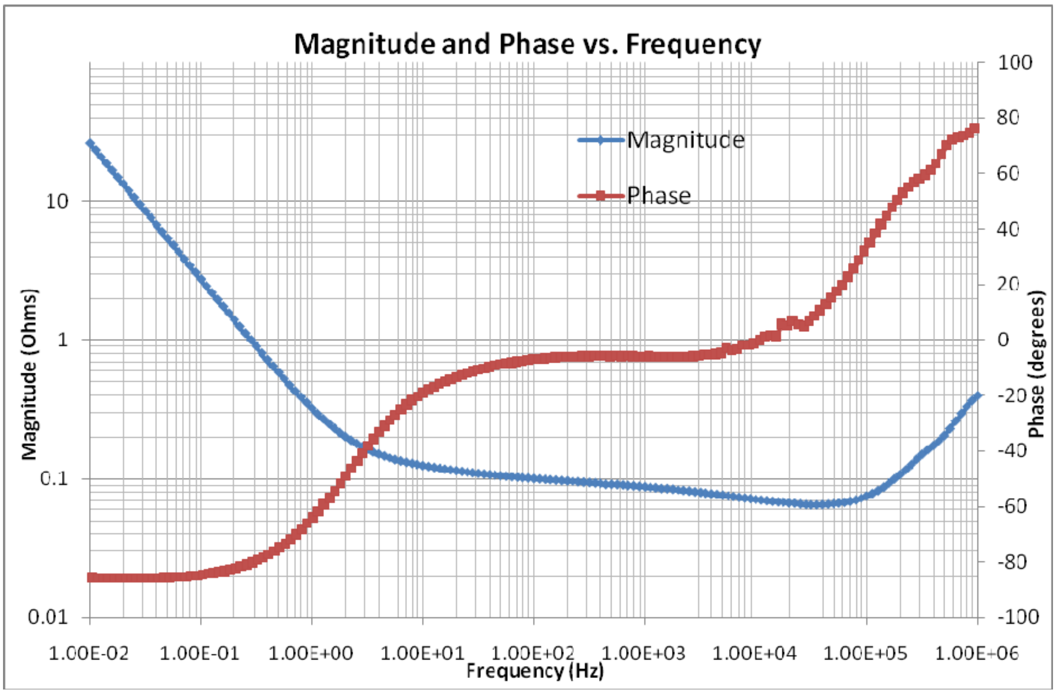


Figure 8: Frequency Response of Impedance (biased at 4.5V with a 50mV test signal)

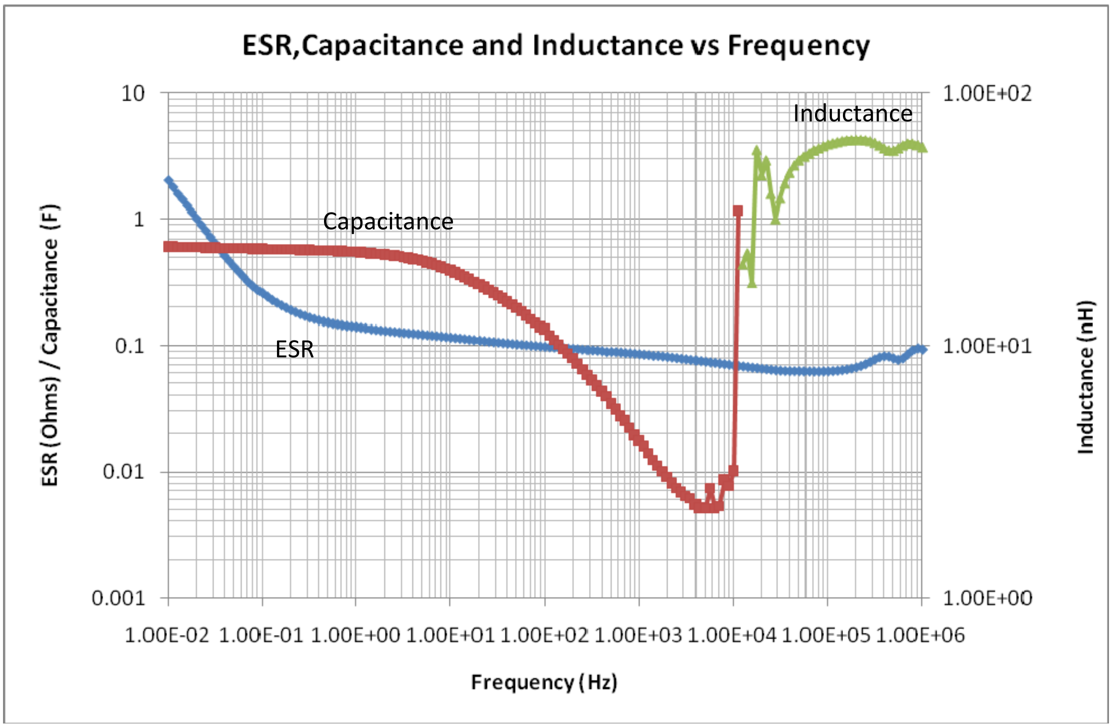


Figure 9: Frequency Response of ESR, Capacitance and Inductance

Fig 8 shows the supercapacitor behaves as an ideal capacitor until approx 3Hz when the magnitude no longer rolls off proportionally to 1/freq and the phase crosses -45°. Performance of supercapacitors with frequency is complex and the best predictor of performance is figure 4 which shows the effective capacitance as a function of pulse width. Inductance becomes significant above 10Khz and is approx 25nH. The HS206 is self resonant in the 3 KHz range.

RMS Current

Continuous current flow into/out of the supercap will cause self heating, which limits the maximum continuous current the supercapacitor can handle. This is measured by a current square wave with 50% duty cycle, charging the supercapacitor to 4.5V at a constant current, then discharging the supercapacitor to 0.5V at the same constant current value. For a square wave with 50% duty cycle, the RMS current is the same as the current amplitude. Fig 10 shows the increase in temperature as a function of RMS current is approximately 9°C/A. From this, the maximum RMS current in an application can be calculated, for example, if the ambient temperature is 40°C, and the maximum desired temperature for the supercapacitor is 70°C, then the maximum RMS current should be limited (70-40)/9 = 3.3A.

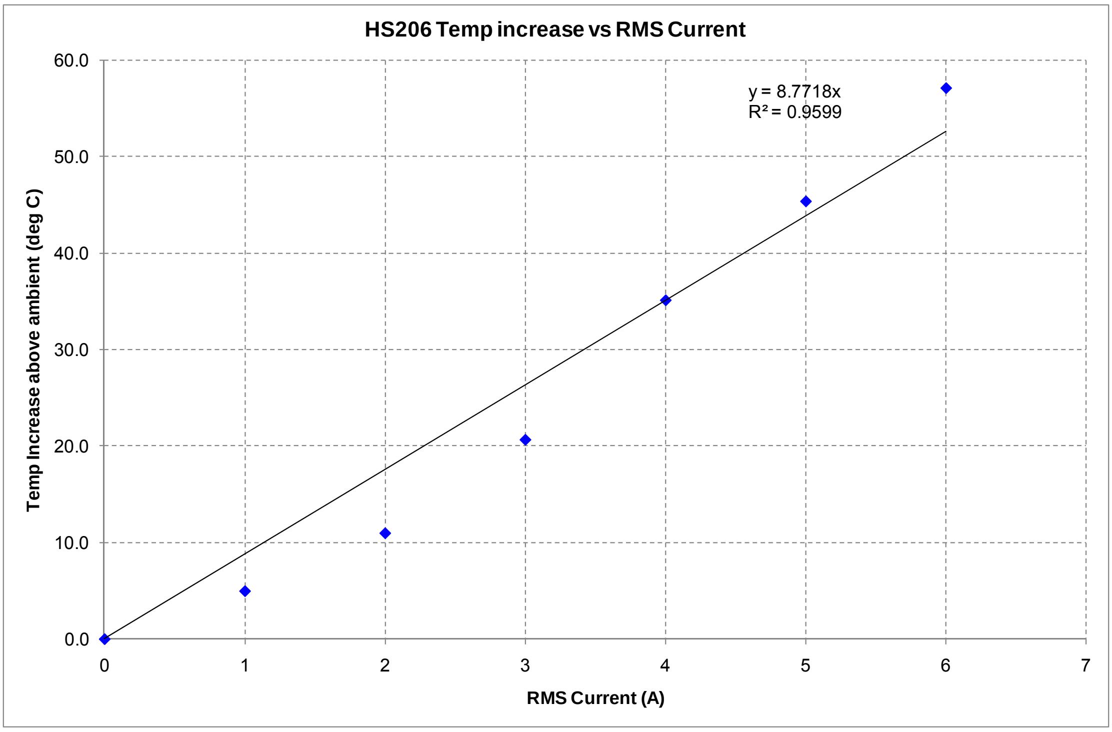


Figure 10: Temperature increase as a function of RMS current

Spice Model

Please refer to www.cap-xx.com for a SPICE model of our supercapacitors. Note that the spice model predicts freq and pulse response, not leakage current over the first 120hrs, prior to equilibrium being reached.

Leakage Current

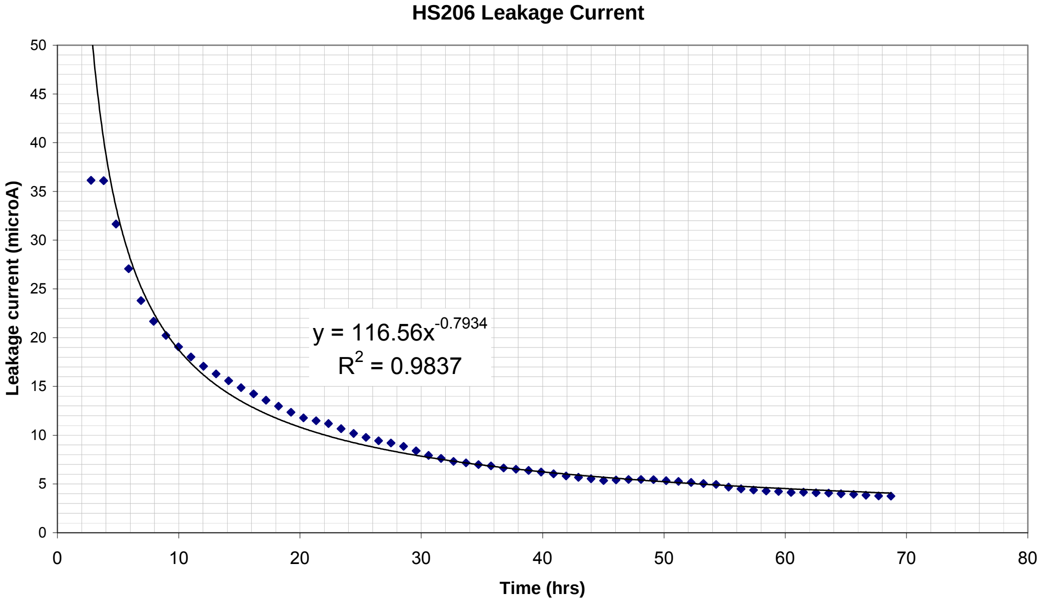


Figure 11: Average leakage current @ 25°C, 4.5V

Figure 11 shows how average leakage current decays with time. After 24hrs @ 25°C, leakage current has decayed to approx 10µA and after 72hrs it has decayed to less than 5µA. This is because the capacitance in a supercapacitor is distributed. This means that although the final terminal voltage has been reached, the device still draws some charge current which continues to decay until it reaches a final equilibrium value of leakage current. At 50°C, leakage current is approximately double the leakage current at 25°C.

Charge Current

Supercapacitors require a minimum charge current before they behave as expected, i.e. they follow ΔV = I x Δt / C, for constant current charging from 0V. For the HS206 this minimum charge current = 50µA. Figure 12 illustrates the voltage over time for a single cell of the HS206 using 500µA, 200µA, 100µA, 50µA and 35µA to achieve a final voltage of 2.25V. Note that the minimum charge current at which charging follows ΔV = I x Δt/C is 200µA.

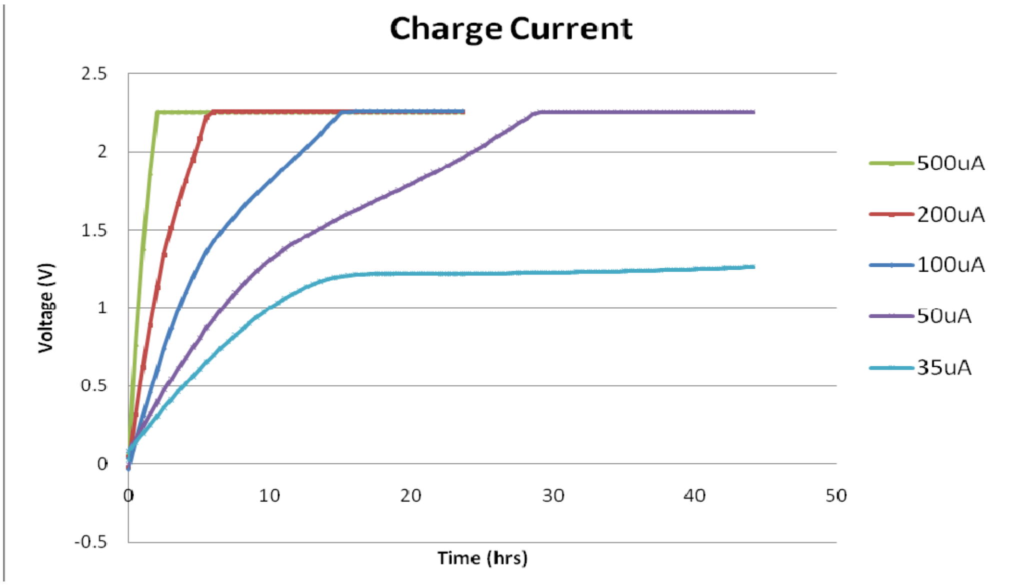


Figure 12: Voltage v. Time for 500µA,200µA,100µA,50µA and 35µA Charge Currents at 25°C

Soldering

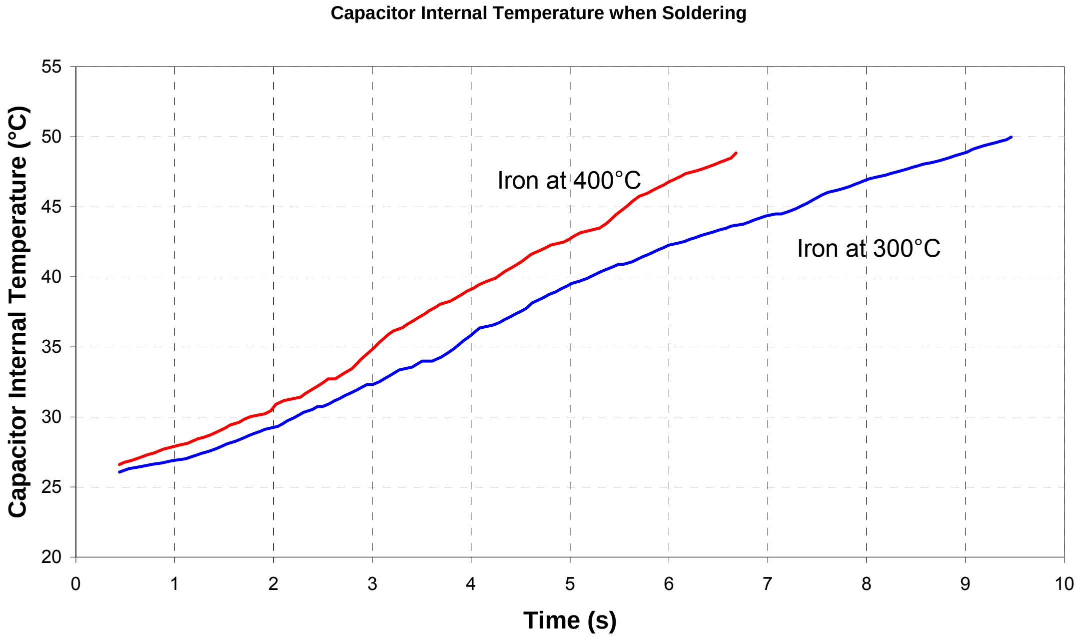


Figure 13: Capacitor temperature rise when soldering

The recommended maximum soldering time is 5 seconds when using an iron at 400°C in an ambient temperature of 25°C.

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)

Fig 14: Mechanical drawing for dual cell HS206

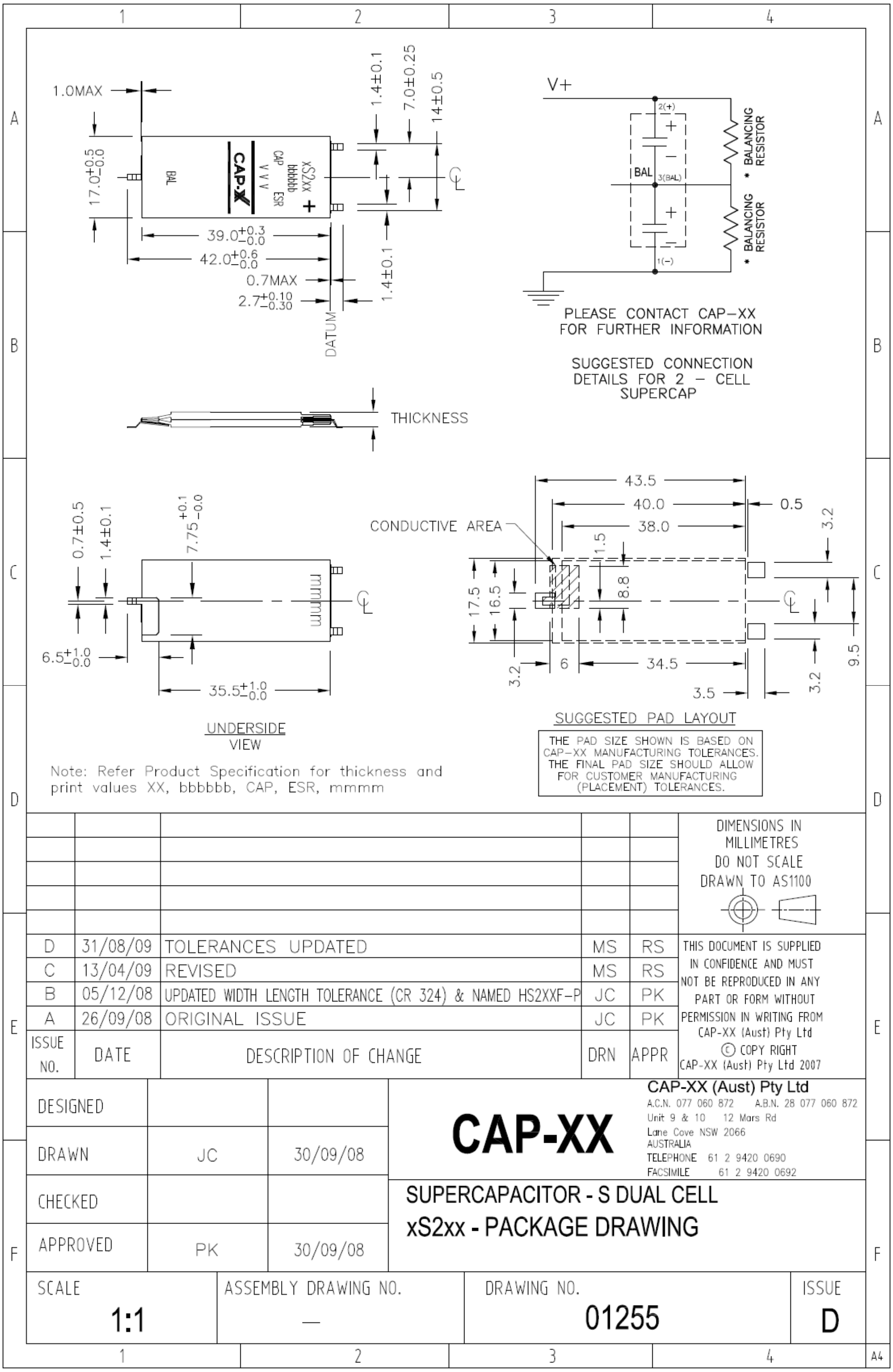
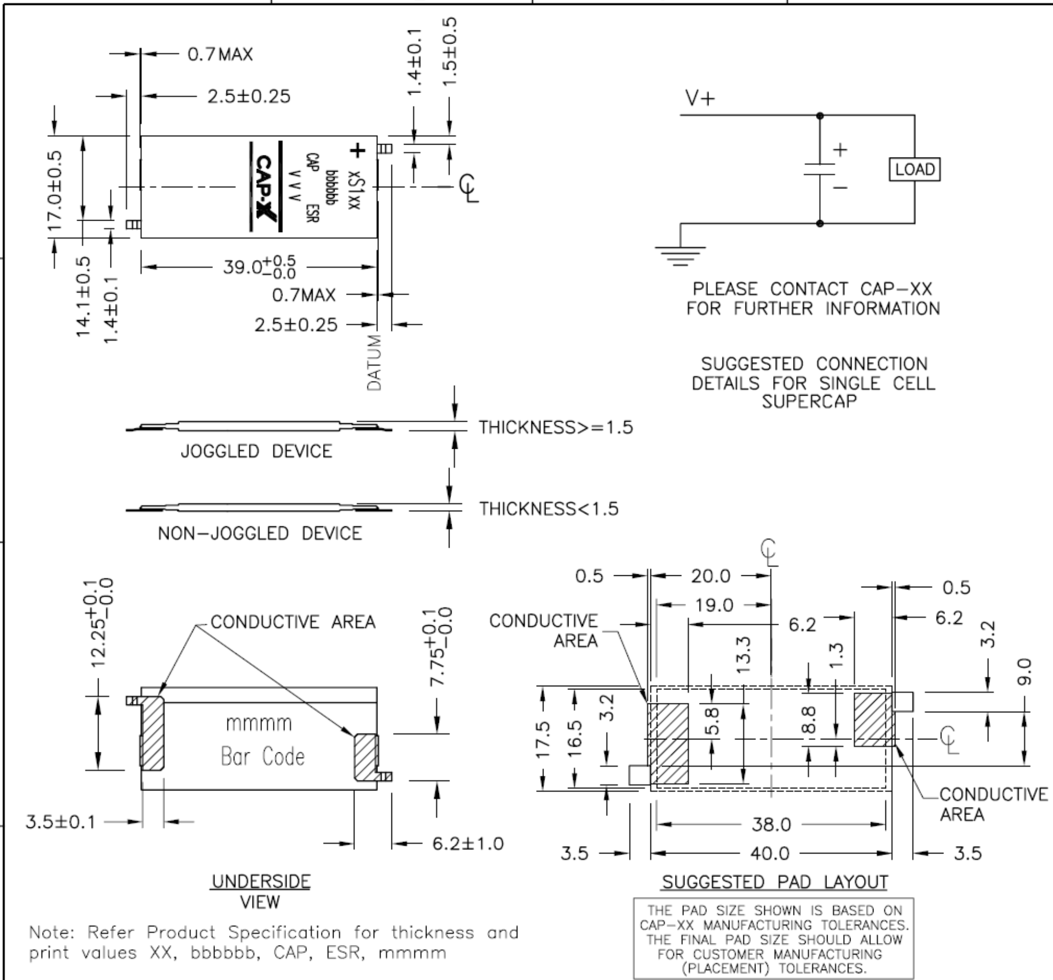


Fig 15: Mechanical drawing for single cell HS106



Note: Refer Product Specification for thickness and print values XX, bbbbbb, CAP, ESR, mmmm

ISSUE NO.	DATE	DESCRIPTION OF CHANGE	DRN	APPR
E	18/04/10	ECN 351	MS	JPM
D	13/04/09	REVISED	MS	RS
C	12/01/09	ADDED SECTION VIEW NON−JOGGLE DEVICE	JC	PK
B	05/12/08	UPDATED LENGTH TOLERANCE (CR 324) & NAMED HS1XXF−P	JC	PK
A	26/09/08	ORIGINAL ISSUE	JC	PK

DIMENSIONS IN MILLIMETRES
DO NOT SCALE
DRAWN TO AS1100

DESIGNED		
DRAWN	JC	30/09/08
CHECKED		
APPROVED	PK	30/09/08

CAP-XX
CAP-XX (Aust) Pty Ltd
A.C.N. 077 060 872 A.B.N. 28 077 060 872
Unit 9 & 10 12 Mars Rd
Lane Cove NSW 2066
AUSTRALIA
TELEPHONE 61 2 9420 0690
FACSIMILE 61 2 9420 0692

SUPERCAPACITOR - S SINGLE DRAWING
xS1xx - PACKAGE DRAWING

SCALE	ASSEMBLY DRAWING NO.	DRAWING NO.	ISSUE
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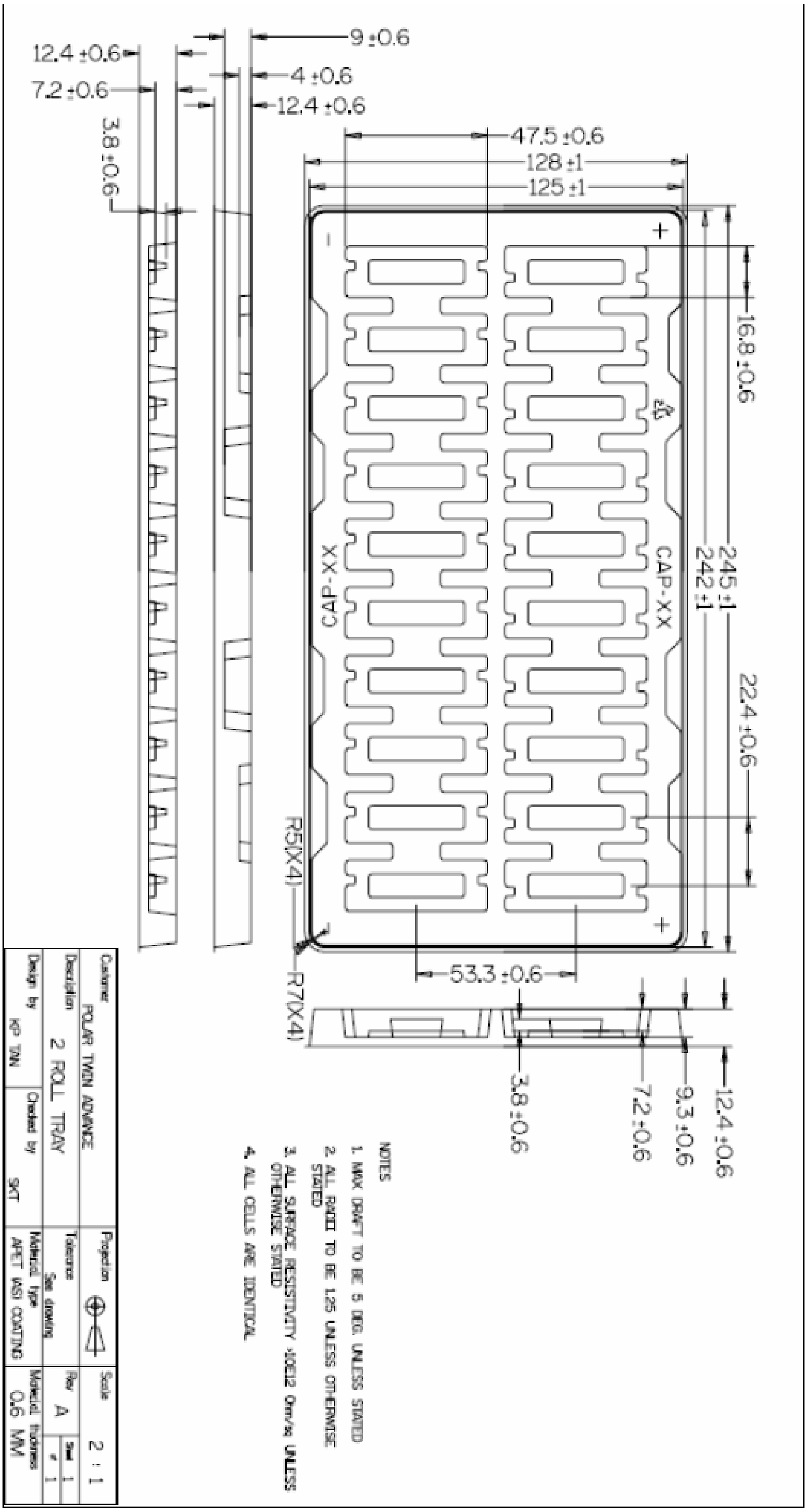

Fig 16:
Packing Tray