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

GW109 / GW209 SUPERCAPACITOR
Datasheet Rev 1.0

Features

- High capacitance GW109 280mF / GW209 140mF
- Low ESR GW109 36mΩ / GW209 70mΩ
- 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 levelling 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	Height	Weight[3]
GW109F	280mF	36mΩ	±20%	28.5mm x 17mm	1.10mm	0.70 gm
GW109G	280mF	36mΩ	±20%	28.5mm x 17mm	1.20mm	0.75 gm
GW209F	140mF	70mΩ	±20%	28.5mm x 17mm	2.20mm	1.30 gm
GW209G	140mF	70mΩ	±20%	28.5mm x 17mm	2.30mm	1.35 gm

[1] At 23ºC DC. [2] Measured using a 0.5A step in current @ 23ºC. [3] To the nearest 50mg

Table 2: Absolute Maximum Ratings

Parameter	Name	Conditions	Device	Min	Max	Units
Terminal Voltage	Vc(max)		GW109		2.5	V
			GW209		5	V
Temperature	T			-40	+85	°C

Table 3: Electrical Characteristics

Parameter	Name	Conditions	Device	Min	Typical	Max	Units
Terminal Voltage	Vc		GW109 / GW209			2.3 / 4.5	V
Leakage Current[3]	I_L	2.3V 23°C 72hrs	GW109		< 1	1	µA
		4.5V 23°C 72hrs	GW209				
RMS Current[4]	I_{RMS}	23°C				6	A
Peak Current[5]	I_P	23°C				76	A

[3] After 72hrs rated voltage, 23°C. [4] Continuous charge and discharge for 2min operation, part mounted on FR4 circuit board.
[5] 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 1. In this figure the supercapacitor is pre-charged and then discharged with a constant current pulse (I). The ESR is found by dividing the instantaneous voltage step (ΔV after 50μsec from start of current pulse) 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 this is the voltage drop due to ESR. C_e shows the time response of the capacitor and it is useful for predicting circuit behaviour in pulsed applications.

In the example of Fig 1, using a GW209, ΔV = 4.49V – 4.42V = 0.07V, I = 1.0A, so ESR = 0.07V/1.0A = 70mΩ. Similarly for $C_{effective}$ at 15mS ΔV_n = 4.42V – 4.26V = 0.16V, Δt_n = 15mS, and I = 1.0A. Therefore, $C_{e(15mS)}$ = 1.0A X $15*10^{-3}$s/0.16V = 94mF.

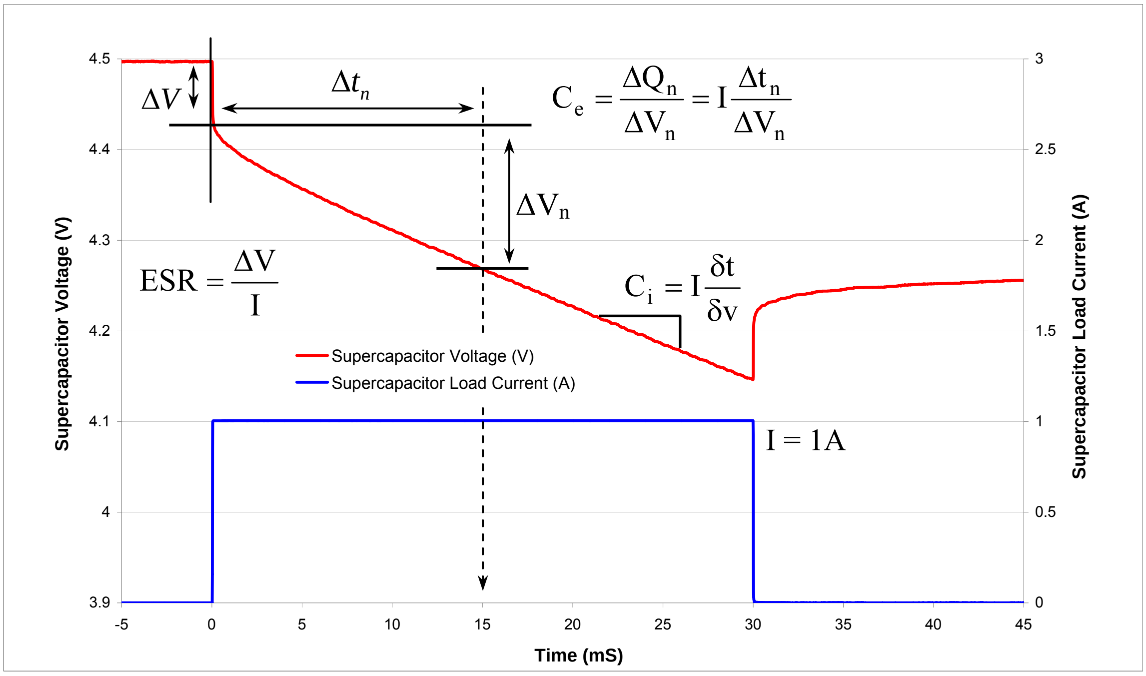


Figure 1: Definitions for Effective Capacitance, Instantaneous Capacitance and ESR

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. At Cap-XX, capacitance is measured using the time taken for the voltage to drop from 3V to 1V (1.5V to 0.5V for a single cell), 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_c = 5.19 – 2.13s = 3.06s.

C = I X $\Delta t_c/\Delta V_c$ where I = 0.1A, therefore C = 0.1x3.06s /2.0V = 153mF.

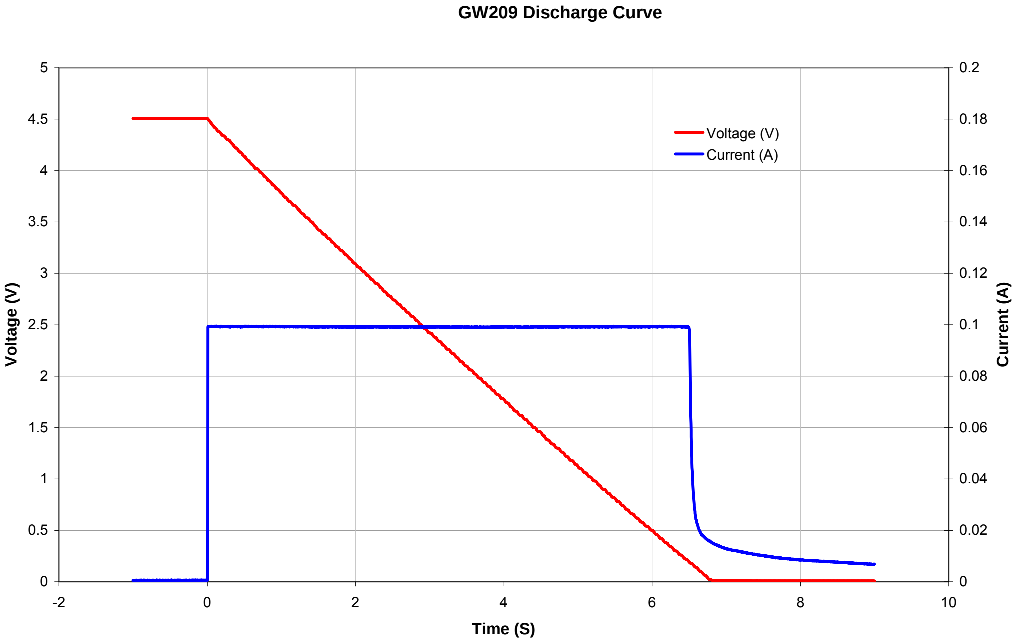


Figure 2: Measurement of DC Capacitance

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, a current step is then applied and the voltage drop after 50µsec is measured. The 50µsec delay allows time for the current pulse to settle before the measurement is made.

In the example shown in Fig 3 below a GW209 is measured where ΔV = 4.495V – 4.427V = 68mV and ΔI = 1.0A (load pulse), therefore ESR = ΔV/I = 68mΩ.

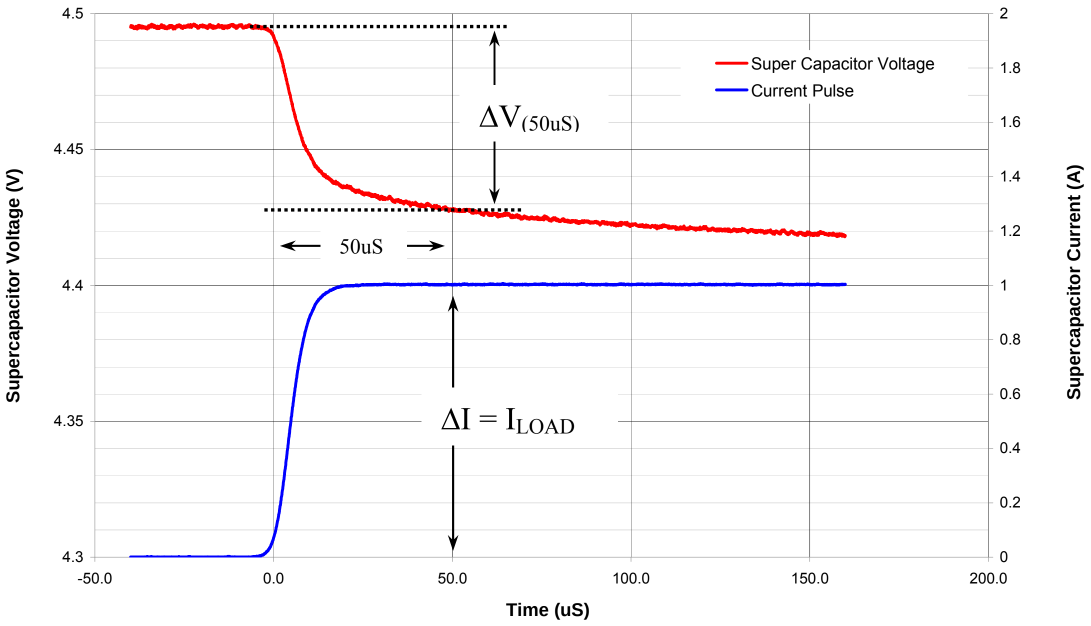


Figure 3: Measurement of ESR

Effective Capacitance

Figure 4 shows the Effective Capacitance for the GW209 @ 23°C. The supercapacitor was charged to and held at 4.5V until the current drawn by the supercapacitor dropped to less than 1mA. The supercapacitor was then disconnected from the source and a constant current discharge of 100mA was applied. The capacitance was measured at different times during the discharge.

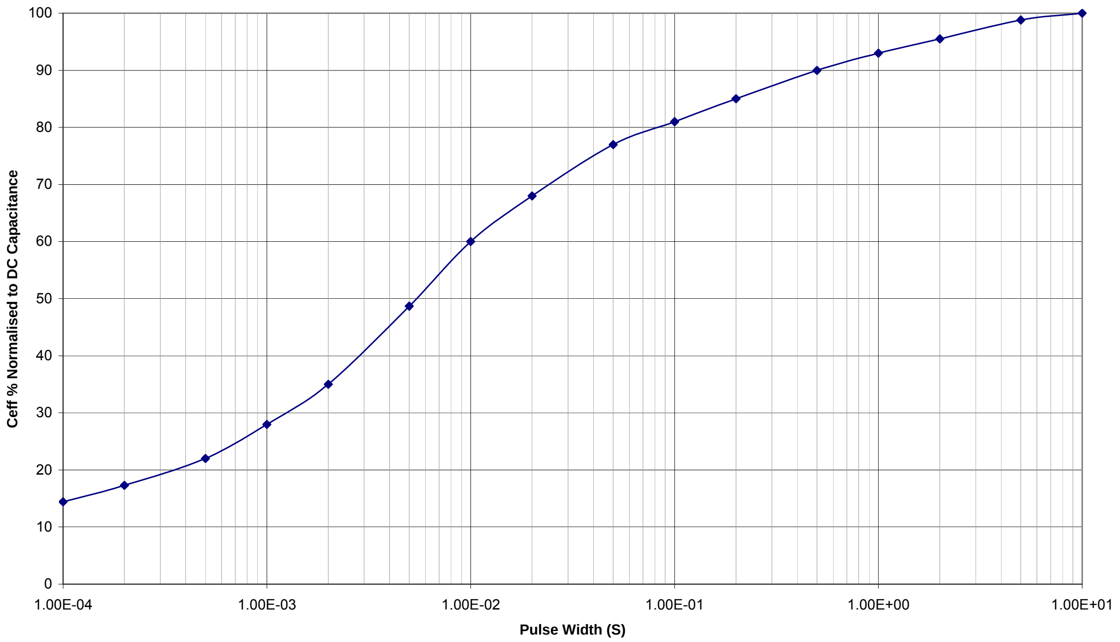


Figure 4: Effective capacitance at different times during the discharge.

Pulse Response

Figure 5 shows the voltage ripple for a class 10 GPRS pulse transmitter load. A GW209 provides a 1.8A load pulse of 1.15ms duration @ 25% duty cycle and the source current is limited to 600mA. The low supercapacitor ESR and high effective capacitance result in the load seeing a voltage ripple of only 180mV. The 1.8A load current would consist of 0.6A current from the supply and the remaining 1.2A from the supercapacitor.

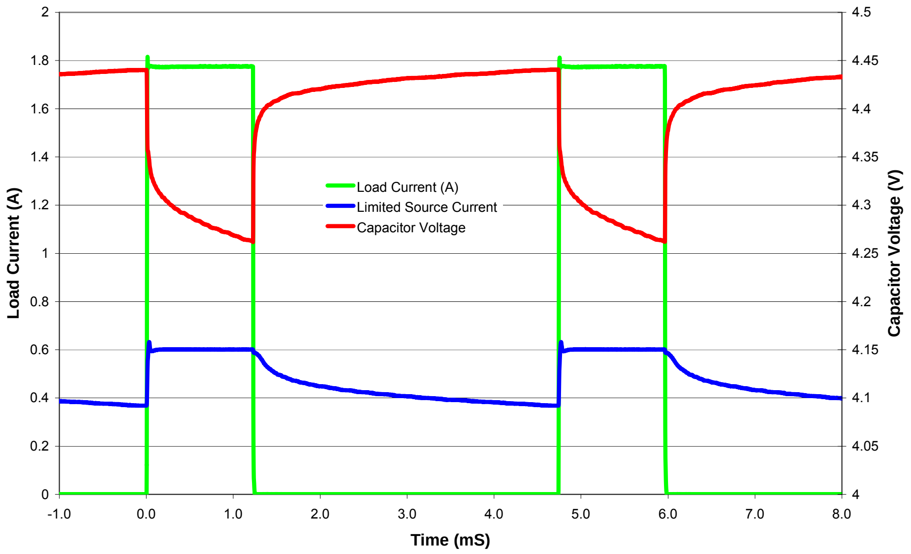


Figure 5: Class 10 GPRS pulse at 23C

Capacitance and ESR with temperature

Figure 6 and 7 below show normalized ESR and DC Capacitance respectively at different operating temperatures ranging from -40C to 70C. DC Capacitance is invariant with temp. At -30°C, ESR is only 1.7 x room temp ESR. ESR reduces with increased temperature since the viscosity of the electrolyte reduces with temperature.

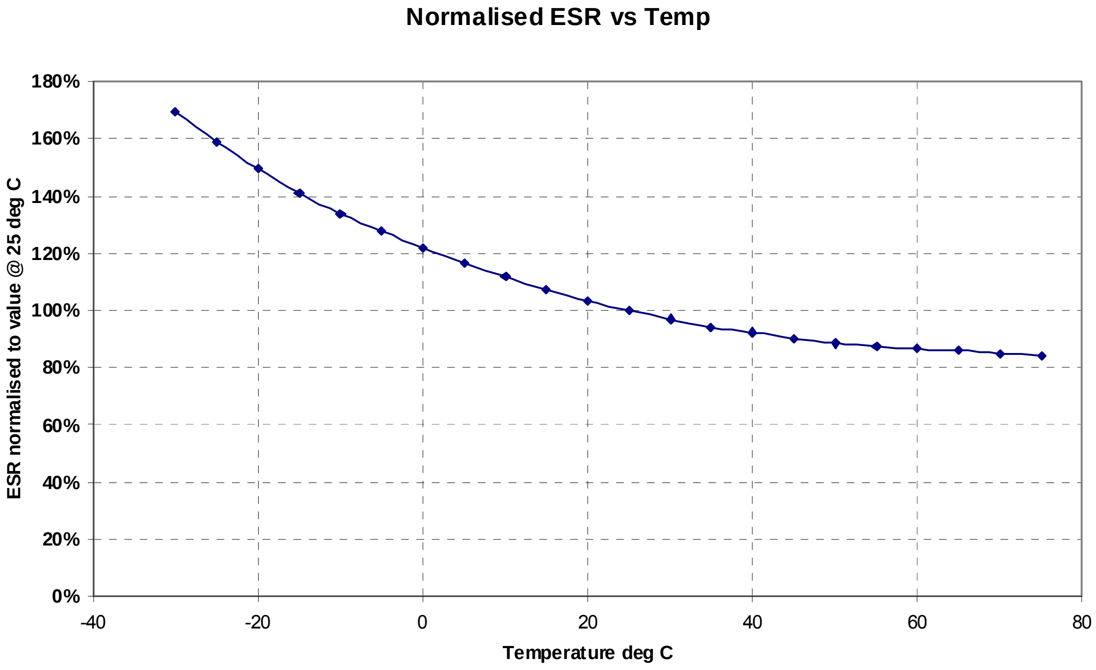


Figure 6: Normalised ESR at different temperatures

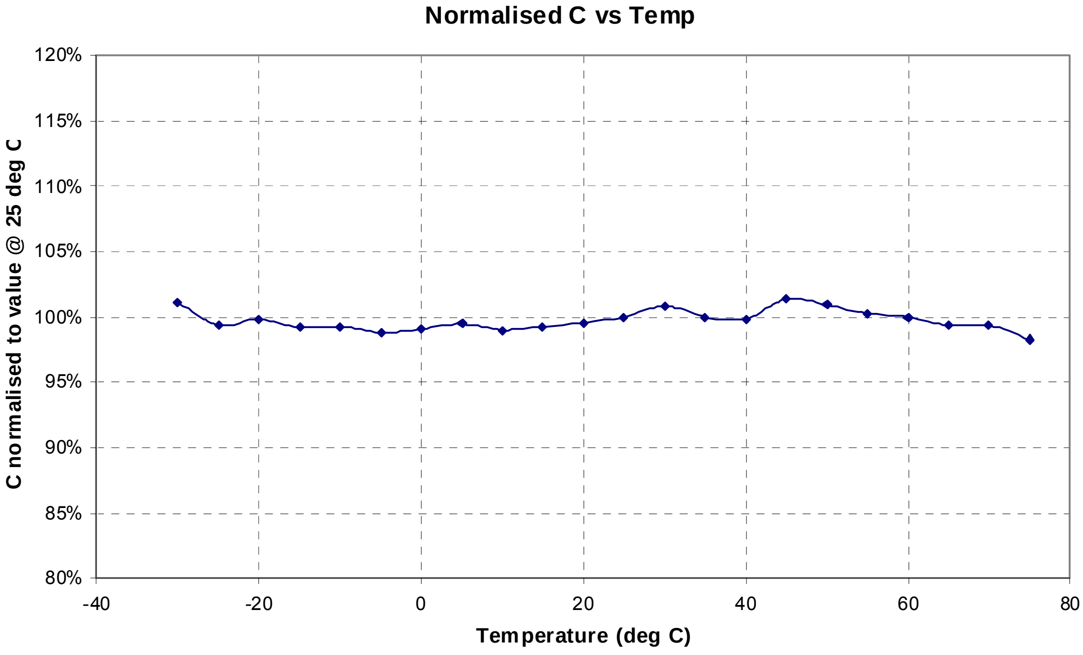


Figure 7: Normalised capacitance at different temperatures

Frequency Response

Figs 8 and 9 show the supercapacitor behaves as an ideal capacitor until approx 15Hz 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 10 kHz and is approx 100nH at 100 kHz and above.

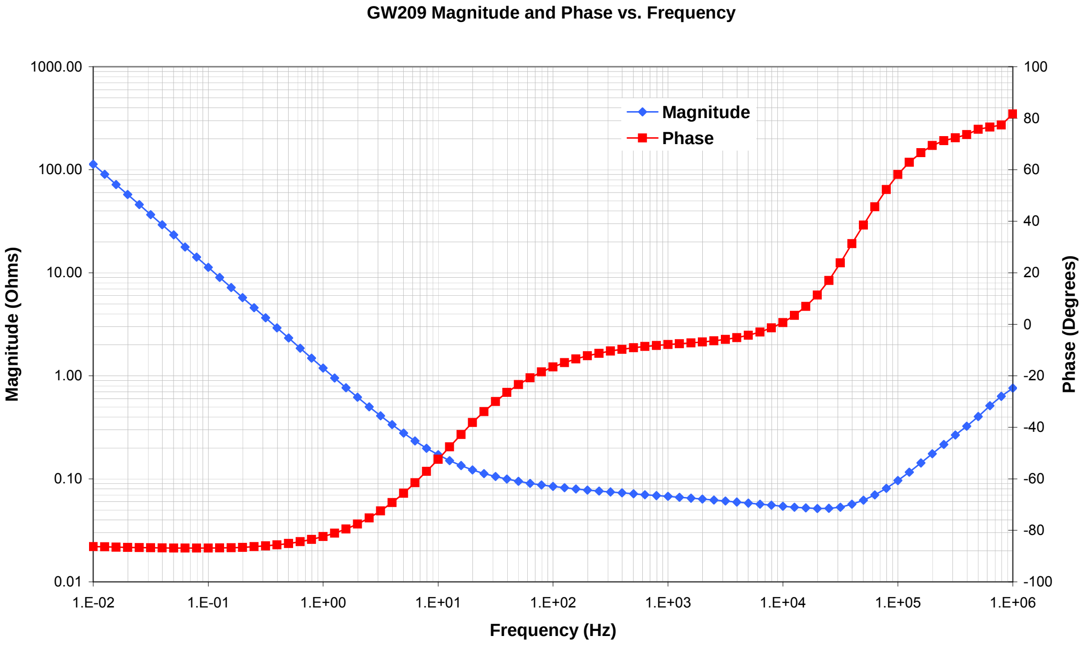


Figure 8: Frequency response of GW209 (biased at 4.5V with 50mV test signal)

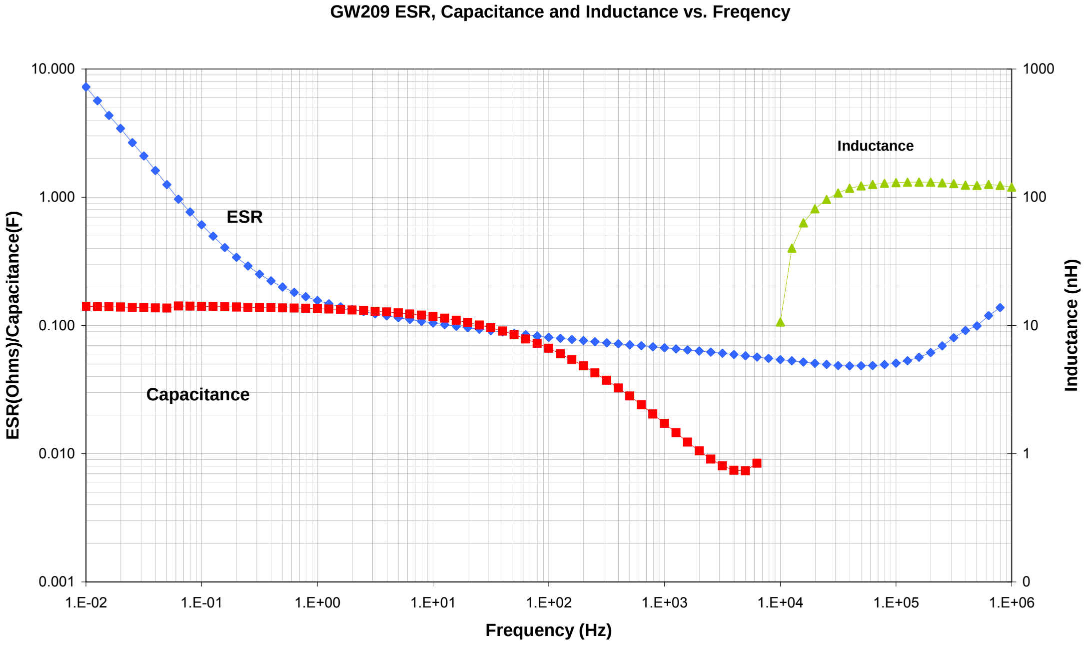


Figure 9: R, L and C components of GW209 vs frequency

Spice Model

SPICE model of our supercapacitors can be found on our web site, www.cap-xx.com. Note that the spice model predicts freq and pulse response, not leakage current over the first 120hrs, prior to equilibrium being reached.

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 magnitude. Fig 10 shows the increase in temperature as a function of RMS current. For example, if the ambient temperature is 40°C, and the maximum desired temperature for the supercapacitor is 70°C, then the allowable temperature increase is 30°C. Reading from Fig 10, the safe maximum RMS current is 4.6A.

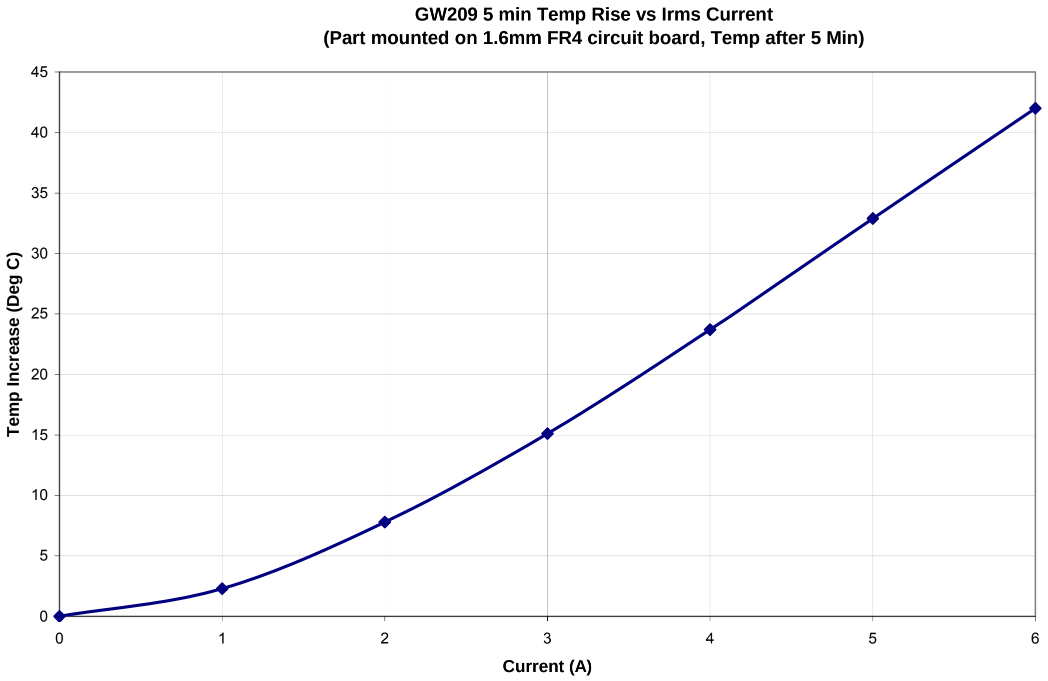


Fig 10: Temperature increase as a function of RMS current

Leakage Current

Figure 11 shows how average leakage current decays with time. After 24hrs @ 23°C, leakage current has decayed to under 3μA and after 72hrs it has decayed to less than 0.8μA. 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.

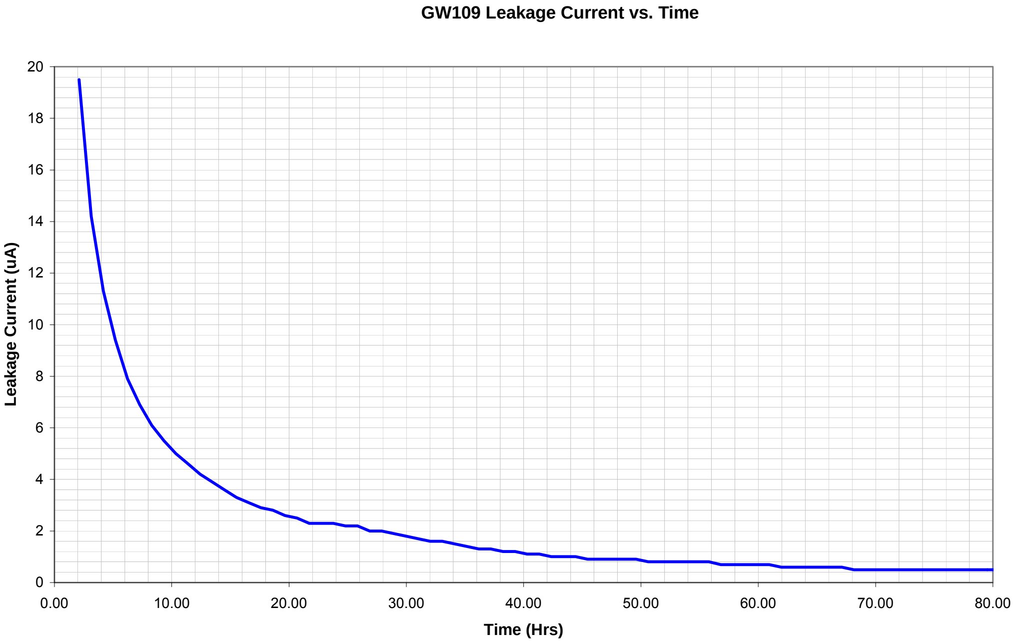


Figure 11: GW109 Leakage current vs. time

Charge Current

Supercapacitors require a minimum charge current before they behave as expected, i.e. before they begin to follow ΔV = I x Δt / C, for constant current charging from 0V. For a single cell (GW109) this minimum charge current is 20µA. Figure 12 illustrates the voltage over time for the GW109 using 20µA, 50µA, 100µA and 200µA to achieve a final voltage of 2.3V.

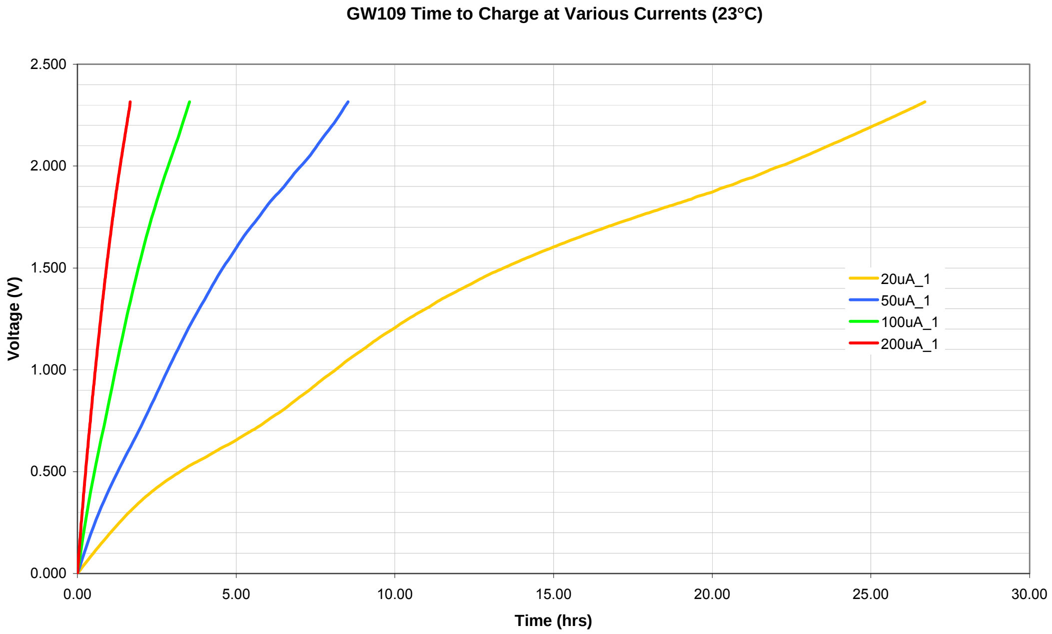


Figure 10: Typical Voltage vs. Time for 20µA, 50µA, 100µA, 200µA charging currents at 23C room temperature.

Soldering

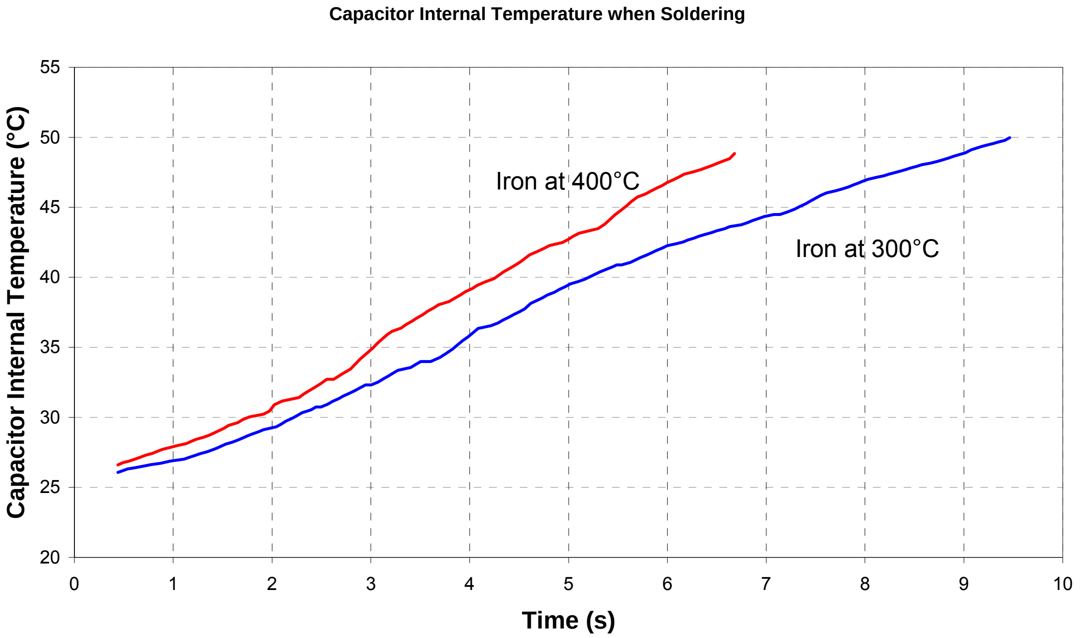


Figure 13: Capacitor temperature rise when soldering

The recommended maximum soldering time is 5 seconds when using an iron at 400°C in an ambient temperature of 23°C. Fig 13 shows the supercapacitor internal temperature increase over time as a soldering iron at 400°C is applied to one terminal.

Vibration

Tested to IEC68-2-6

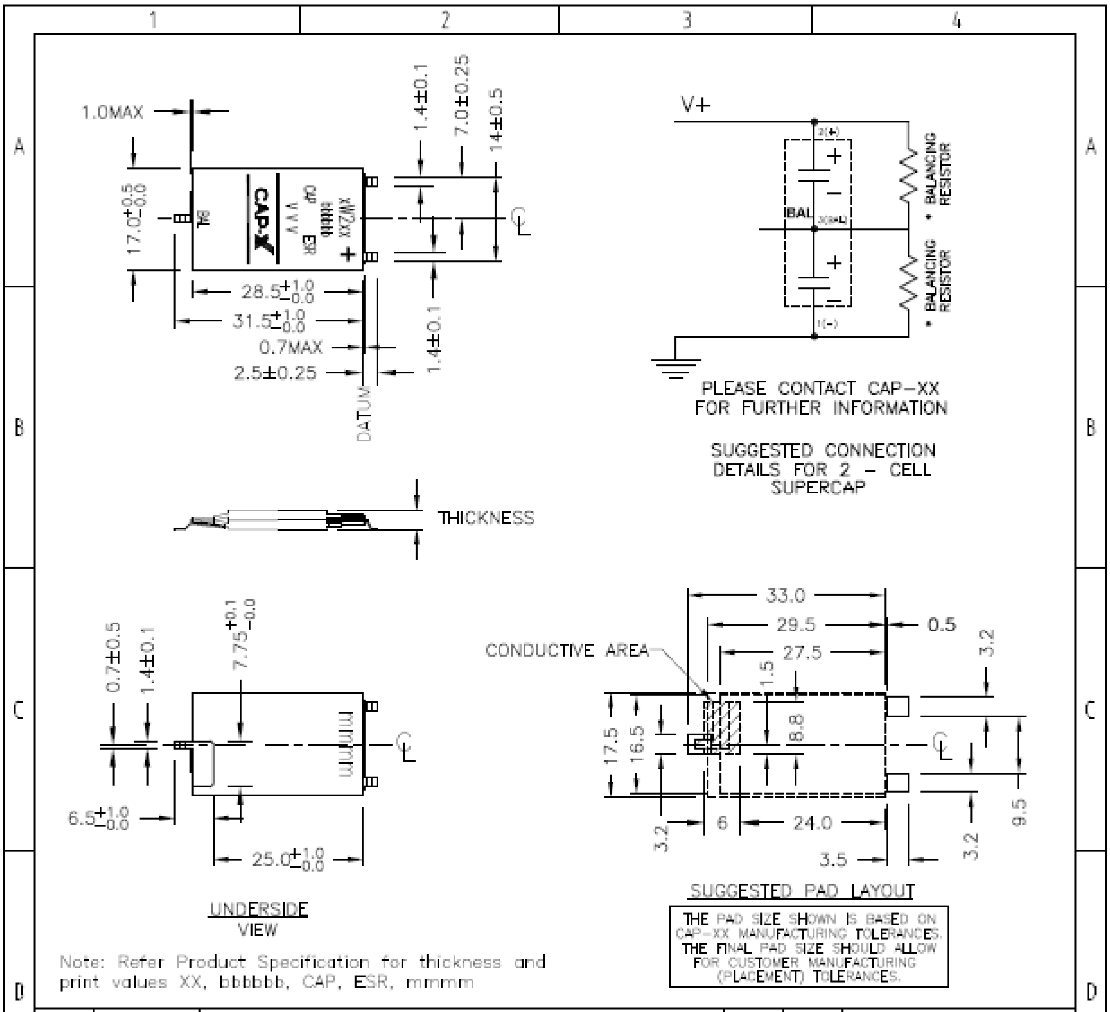
Type	Sinusoidal
Frequency	55Hz-500Hz
Amplitude	0.35mm±3dB (55Hz to 59.55Hz) 5g±3dB (59.55Hz to 500Hz)
Sweep Rate	1 Oct/min
No. of Cycles	10 (55Hz-500Hz-50Hz)
No. of Axis	3 orthogonal
Results	No electrical or mechanical degradation (adhesive not required)

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)

Mechanical Drawings



PLEASE CONTACT CAP−XX
FOR FURTHER INFORMATION

SUGGESTED CONNECTION
DETAILS FOR 2 − CELL
SUPERCAP

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

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

C	13/04/09	REVISED	MS	RS
B	05/12/08	UPDATED WIDTH LENGTH TOLERANCE (CR 324) & NAMED HW2XXF-P	JC	PK
A	26/09/08	ORIGINAL ISSUE	JC	PK
ISSUE NO.	DATE	DESCRIPTION OF CHANGE	DRN	APPR

DIMENSIONS IN
MILLIMETRES
DO NOT SCALE
DRAWN TO AS1100

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

CAP-XX

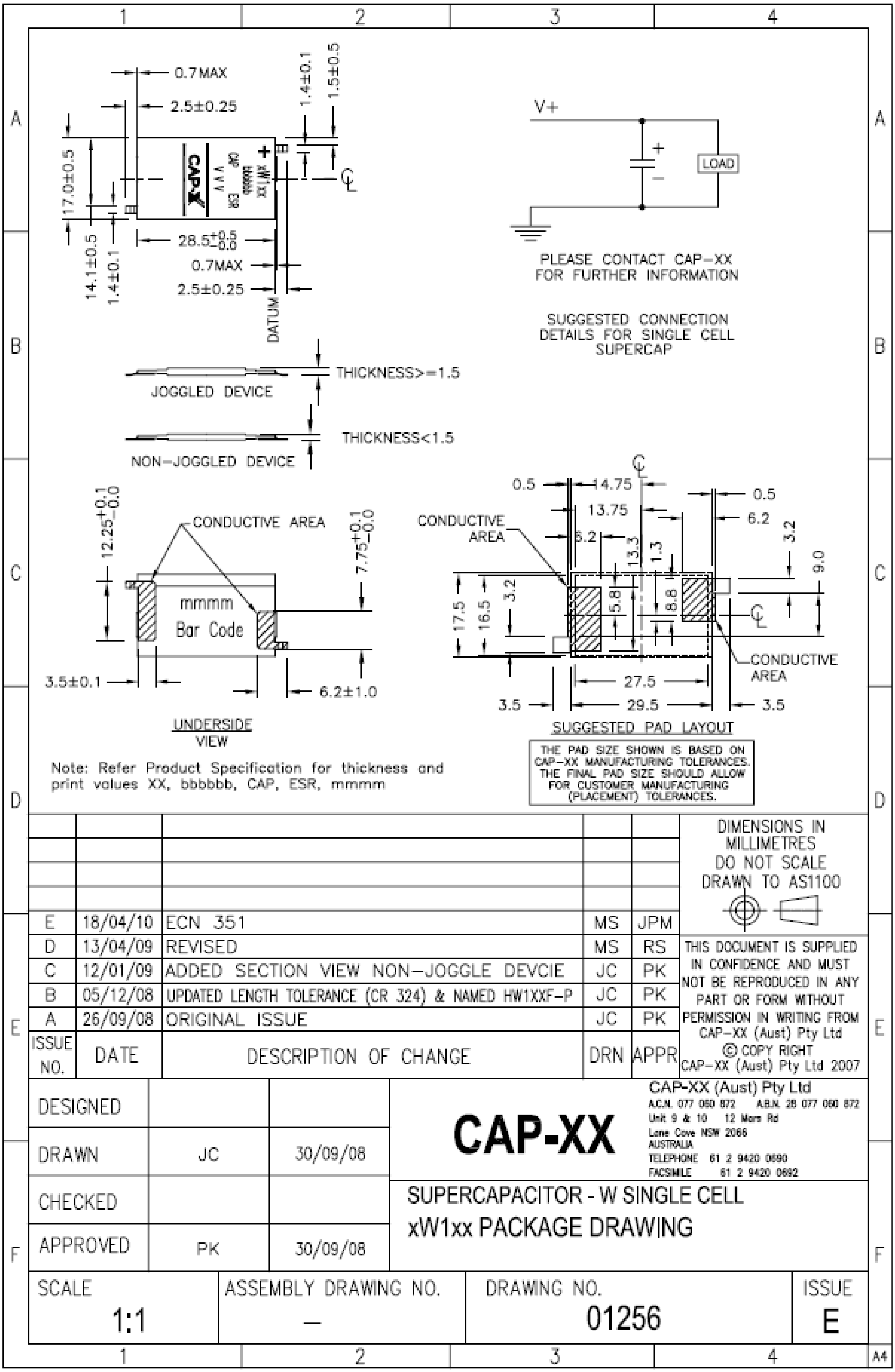
CAP-XX (Aust) Pty Ltd
A.C.N. 077 060 872 A.B.N. 28 077 060 872
Unit 9 & 10 12 Mars Rd
Lane Cove NSW 2066
AUSTRALIA
TELEPHONE 61 2 9420 0690
FACSIMILE 61 2 9420 0692

SUPERCAPACITOR - W DUAL CELL
xW2xx PACKAGE DRAWING

SCALE	ASSEMBLY DRAWING NO.	DRAWING NO.	ISSUE
1:1	–	01257	C

A4

Figure 14: GW209 Product drawing



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 DEVCIE	JC	PK
B	05/12/08	UPDATED LENGTH TOLERANCE (CR 324) & NAMED HW1XXF-P	JC	PK
A	26/09/08	ORIGINAL ISSUE	JC	PK

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

SCALE	ASSEMBLY DRAWING NO.	DRAWING NO.	ISSUE
1:1	–	01256	E

Figure 15: GW109 Product drawing

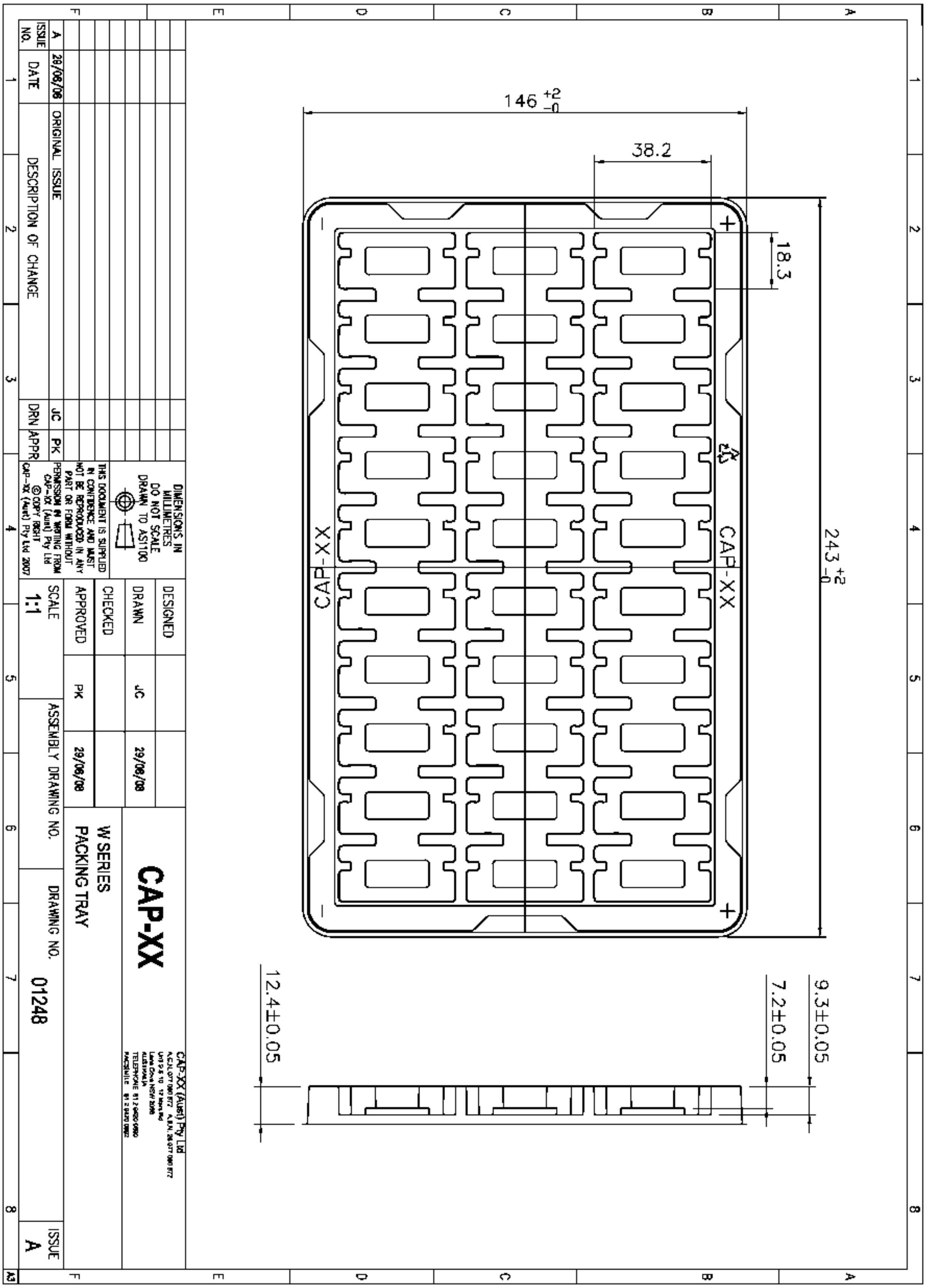


Figure 16: W Packaging tray