Product Bulletin

LY13R8 RADIAL LEAD LITHIUM-ION CAPACITOR datasheet

Revision 1.6, May 2024

Electrical Specifications

The LY13R8 radial lead Lithium-ion capacitors are 3.8V rated cylindrical cells offering excellent value, providing an order of magnitude higher capacitance for the same size compared to our standard GY/HY cells.

Part numbering code

L	Y	N	vvv	dd	mmm	S	ccc	R	-V
Model Li-ion Cap	**Cylind-rical**	**no of cells** 1	**Voltage** 3R8 = 3.8V	**Diameter** 08 = 8.0 10 = 10 1B = 12.5 16 = 16	**Length (mm)** 012 = 12	**Tolerance** M ± 20% S +30% /-10% V +25% / -5%	**µF** Two digits + number of zeros. 106 = 10000000µF = 10F	**Lead format** R = Radial lead	**Variant** -L = Low temperature variant -H = Standard variant -E = High energy variant

Low temperature variant:

Rated voltage range:	2.5V ~ 3.8V (DO NOT discharge below 2.5V)
Surge voltage:	4.2V
Temperature Range:	-25°C to +70°C
Cycle life:	250,000 cycles

CAP-XX Part no.	Cap (F)	AC ESR Max @1kHz (mΩ)	DC ESR (mΩ)	Diameter (mm)	Length (mm)	IL max @ 120Hrs (µA)	Test Current (A)* [1]	Pulse Current (A)* [2]	Mass (g)
LY13R808014M106R-L	10	270	800	8	14	3	0.05	1.4	1.3
LY13R808020M256R-L	25	175	370	8	20	3.3	0.125	3.2	1.9
LY13R808025M306R-L	30	125	350	8	25	4	0.15	3.4	2.3
LY13R810016M306R-L	30	125	280	10	16	4	0.15	4.1	2.4
LY13R810020M506R-L	50	95	220	10	20	6	0.25	5.4	3.1
LY13R810025M706R-L	70	65	165	10	25	8	0.35	7.3	3.7
LY13R810030M117R-L	110	50	125	10	30	10	0.55	9.7	4.7
LY13R81B025M127R-L	120	50	125	12.5	25	20	0.6	9.8	5.5
LY13R816025M227R-L	220	40	70	16	25	40	1.1	17.4	9.7

High temperature variant:

Rated voltage range: 2.5V ~ 3.8V (DO NOT discharge below 2.5V)
Surge voltage: 4.2V
Temperature Range: -15°C to +70°C (85°C @ 3.5V)
Cycle life: 500,000 cycles

CAP-XX Part no.	Cap (F)	AC ESR Max @1kHz (mΩ)	DC ESR (mΩ)	Diameter (mm)	Length (mm)	IL max @ 120Hrs (μA)	Test Current (A)* 1	Pulse Current (A)* 2	Mass (g)
LY13R808014M106R-H	10	500	1500	8	14	2	0.05	0.8	1.4
LY13R808020M256R-H	25	300	650	8	20	2.5	0.125	1.9	2
LY13R808025M306R-H	30	250	700	8	25	3	0.15	1.8	2.4
LY13R810016M306R-H	30	250	550	10	16	3	0.15	2.2	2.5
LY13R810020M506R-H	50	200	450	10	20	4.5	0.25	2.8	3.2
LY13R810025M706R-H	70	100	250	10	25	5	0.35	4.9	3.9
LY13R810030M117R-H	110	90	220	10	30	6.5	0.55	5.7	4.8
LY13R81B025M127R-H	120	80	200	12.5	25	20	0.6	6.2	5.7
LY13R816025M227R-H	220	60	100	16	25	40	1.1	12.4	9.7

High Energy variant:

Rated voltage range: 2.5V ~ 3.8V (DO NOT discharge below 2.5V)
Surge voltage: 4.2V
Temperature Range: -25°C to +70°C (85°C @ 3.5V)
Cycle life: 250,000 cycles

CAP-XX Part no.	Cap (F)	AC ESR Max @1kHz (mΩ)	DC ESR (mΩ)	Diameter (mm)	Length (mm)	IL max @ 120Hrs (μA)	Test Current (A)* 1	Pulse Current (A)* 2	Mass (g)
LY13R86C012M805R-E	8	1200	2600	6.3	12	2	0.04	0.5	0.8
LY13R86C022M226R-E	22	450	1000	6.3	22	3.5	0.11	1.2	1.2
LY13R808014M246R-E	24	400	900	8	14	2.5	0.125	1.4	1.4
LY13R808020M406R-E	40	250	550	8	20	3.2	0.2	2.3	2
LY13R808025M556R-E	55	200	450	8	25	5	0.275	2.8	2.4
LY13R810016M556R-E	55	200	450	10	16	5	0.275	2.8	2.4
LY13R810020M856R-E	85	120	250	10	20	8	0.425	5	3.2
LY13R810025M117R-E	110	90	220	10	25	9	0.55	5.7	3.9
LY13R810030M157R-E	150	70	140	10	30	15	0.75	8.9	7.8
LY13R81B025M207R-E	200	65	135	12.5	25	18	1	9.3	5.7
LY13R81B030M307R-E	300	50	100	12.5	30	30	1.5	12.6	5.7
LY13R81B040M357R-E	350	45	90	12.5	40	35	1.75	14	9.7
LY13R81B045M407R-E	400	45	80	12.5	45	70	2	15.8	12

Notes:

1. Current used to test DC ESR and Capacitance in production
2. 1 sec pulse current to discharge a LIC from 3.8V to 2.5V: $\frac{V_{rated} - V_{\min}}{1 + DC\ ESR \times C} \times C\ (Amp)$

Features:

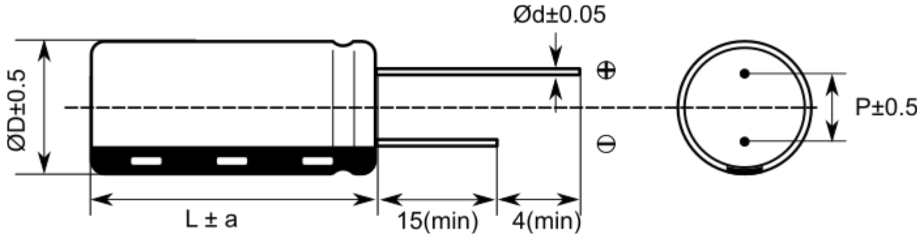
- Very high energy density
- Extremely long cycle life, up to 500,000 cycles
- Very low leakage current
- Very slow self-discharge
- Wide temperature range

Applications:

- Powering remote sensors with small energy harvesters
- Replacing small batteries
- Longer term power backup

Mechanical drawing:

ΦD	P	Φd	a
8	3.5	0.6	1.5
10	5	0.6	2.0
12.5	5	0.6	2.0
16	7.5	0.8	2.0



Typical long-term performance

Item		Details
Cycle Life	Test condition	Charge and discharge between 3.8V and 2.5V at Test Current for stated cycle count, 25˚C
	$\Delta C / C_{initial}$	≤ 30%
	Final ESR	≤ 2 times of initial value
Lifespan	High temperature storage	After 1000 hours at storage voltage ~ 3.3V at 70˚C.
		$\Delta C / C_{initial} \leq 30\%$, $ESR_{Final} \leq 2x\ ESR_{initial}$
	Endurance	After 1000 hours at 3.8V, 70˚C.
		$\Delta C / C_{initial} \leq 30\%$, $ESR_{Final} \leq 2x\ ESR_{initial}$

Note: The life performance of a supercapacitor is determined by the combination of voltage, temperature, and the duration at said condition. To get a more accurate estimate on ageing of a supercapacitor, please contact CAP-XX.

Measurement of capacitance

Capacitance is measured at 25°C using the method shown in Fig 1. This measures DC capacitance. The capacitor is charged to rated voltage, V_R, at constant current, held at rated voltage for at least 30 minutes and then discharged at constant current. The time taken to discharge from 3.5V to 2.5V is measured to calculate capacitance as:

$$C = I \times (T_1 - T_2)/(V_1 - V_2)$$

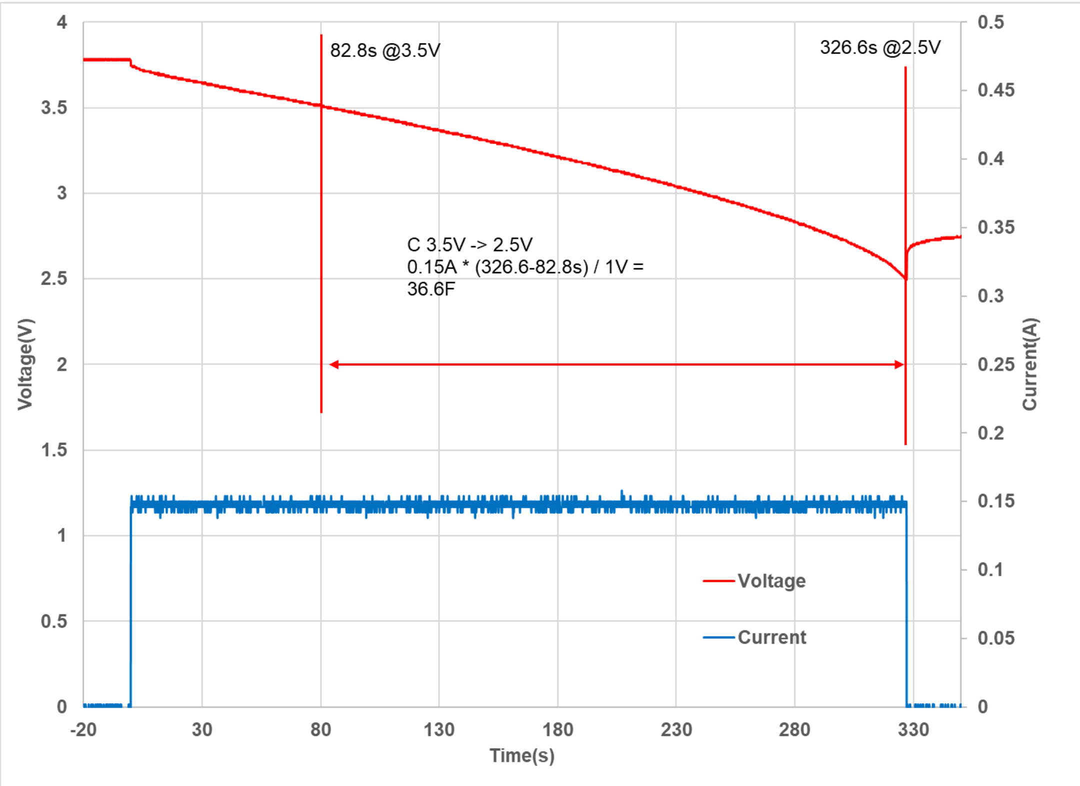


Fig 1: LY13R810016V306R-L Capacitance measurement

In this case, C = 0.15A x (326.6 - 82.8)s /(3.5 - 2.5)V = 36.6F, which is well within the 30F +30% / -10% tolerance for a LY13R810016V306R-L cell.

Measurement of ESR

DC Equivalent Series Resistance (DC ESR) is measured at 25°C by applying a step load current to the supercapacitor and measuring the resulting voltage drop. CAP-XX waits for a delay of 2ms after the step current is applied to ensure the voltage and current have settled. In this case, for a LY13R810016V306R-L the ESR is measured as 31mV/0.15A = 206.7mΩ.

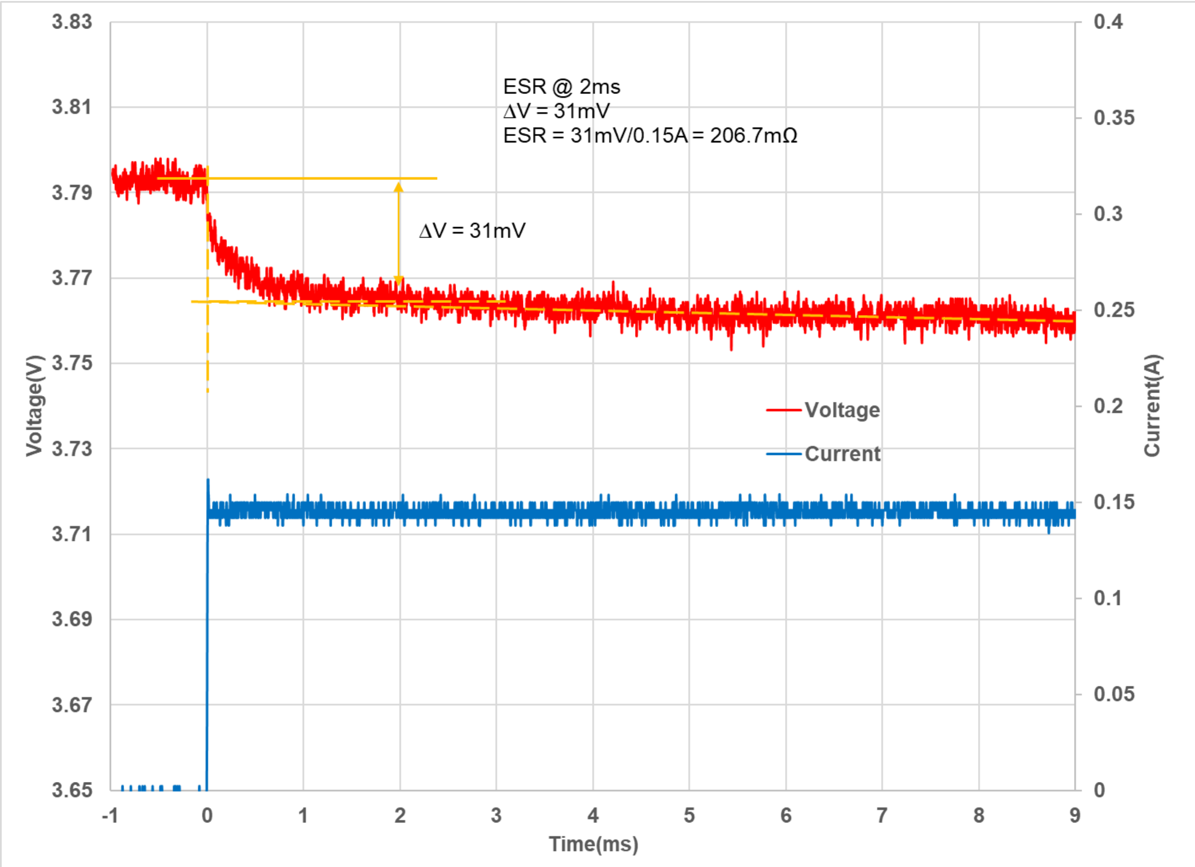


Fig 2: LY13R810016V306R-L ESR Measurement

Measurement of Leakage Current

Leakage current is measured by holding the supercapacitor at rated voltage at 25°C and charging it through a low value current limit resistor, in this case, 28Ω. After the current through the 28Ω resistor has decayed the supercapacitor is then held on charge with a higher value sense resistor, typically 1KΩ or 2.2KΩ, and measuring the voltage across this resistor to determine leakage current. The leakage current decays over time as shown in Fig 3. Leakage current at 120hrs for an LIC is less than 1/10th of an equivalent EDLC supercapacitor.

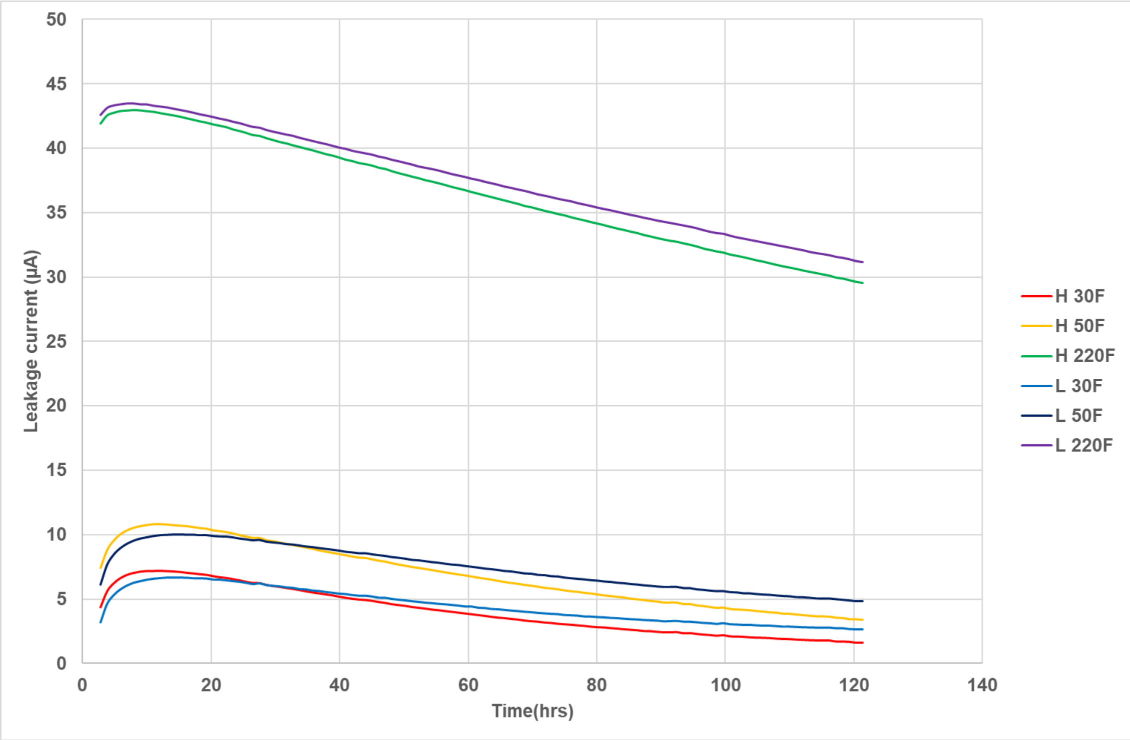


Fig 3: Leakage current measurement

Variation in DC Capacitance and ESR with temperature

Figure 4 shows the typical DC capacitance variation across the operating temperature range of -25°C to +70°C (low temp variant), -15°C to +85°C (high temp variant) or -25°C to +85°C (high energy variant). Discharge current used is set to the 5C rate = $5 * C * \frac{3.8-2.5}{3600}\ (Amp)$. **Cap > 50%** of the value at 20˚C over the temperature range.

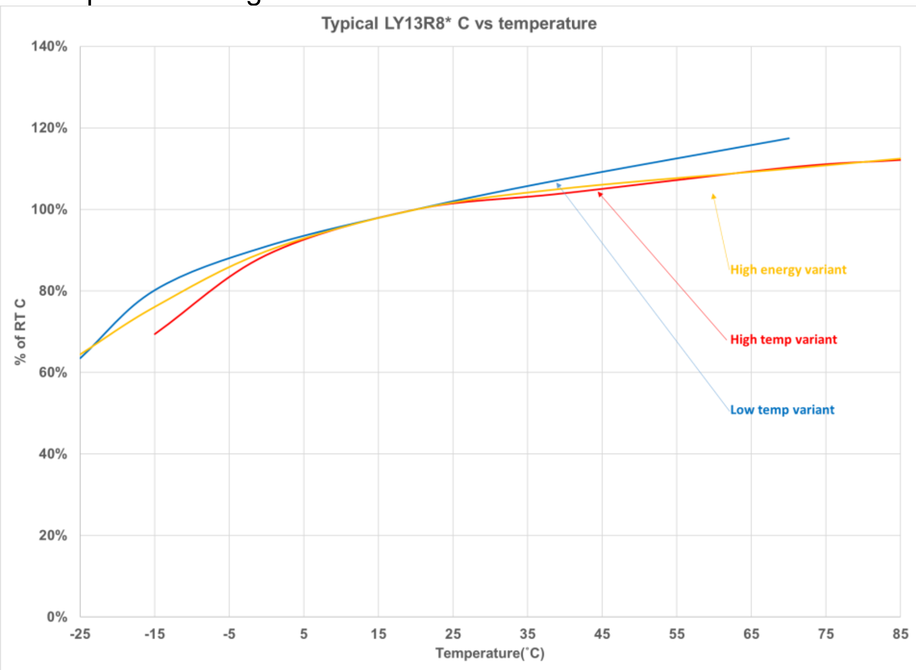


Fig 4: Typical variation in Capacitance over the operating temperature range

Figure 5 shows variation in ESR over the operating temperature range. **ESR < 1000%** of 20˚C value over the temperature range.

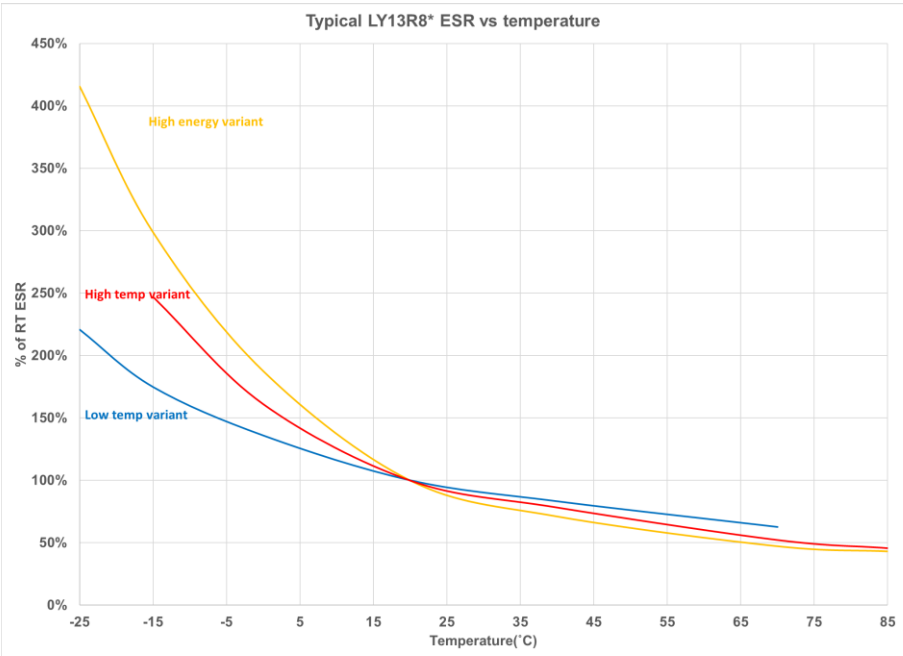


Fig 5: Typical variation in ESR over the operating temperature range

The variation in ESR with temperature is due to the change in the mobility of ions in solution in the electrolyte and the characteristics of the activated carbon used in that part.

Effective capacitance (Ceff)

Effective capacitance is the capacitance seen for short pulse widths. Due to the LiC's frequency response, for shorter pulse widths there will be less capacitance available than the DC capacitance. In Fig 6, consider the voltage drop due to capacitance after 100ms = 3.3V – 3.13V = 170mV. Therefore Ceff(100ms) = Discharge_Current x 100ms/Voltage drop(100ms) = 1.8A x 0.1s/0.17V = 1.06F. The voltage drop due to capacitance after 1s = 3.3V – 3.03V = 270mV, hence Ceff(1s) = 1.8A x 1s/0.27V = 6.7F. Fig 7 shows a typical Ceff as a % of DC capacitance for the LY13R8 series of Lithium-ion capacitors.

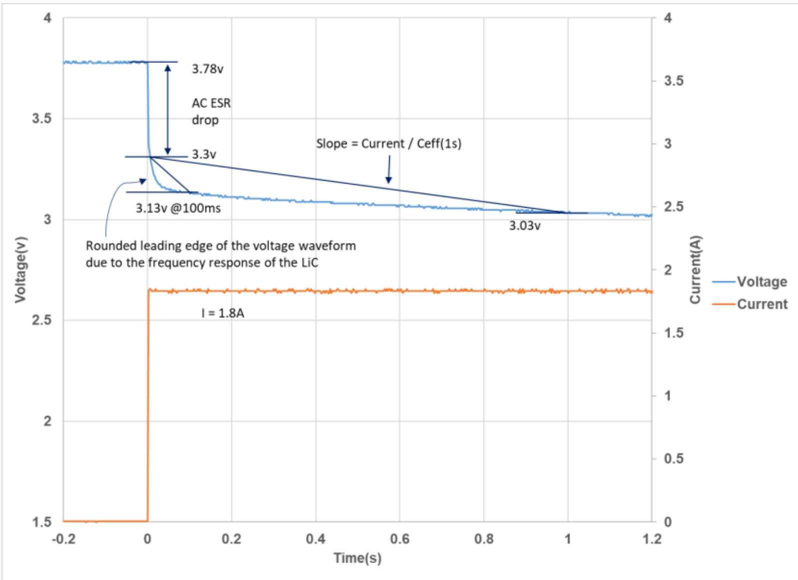


Fig 6: Discharge pulse illustrating the concept of Ceff

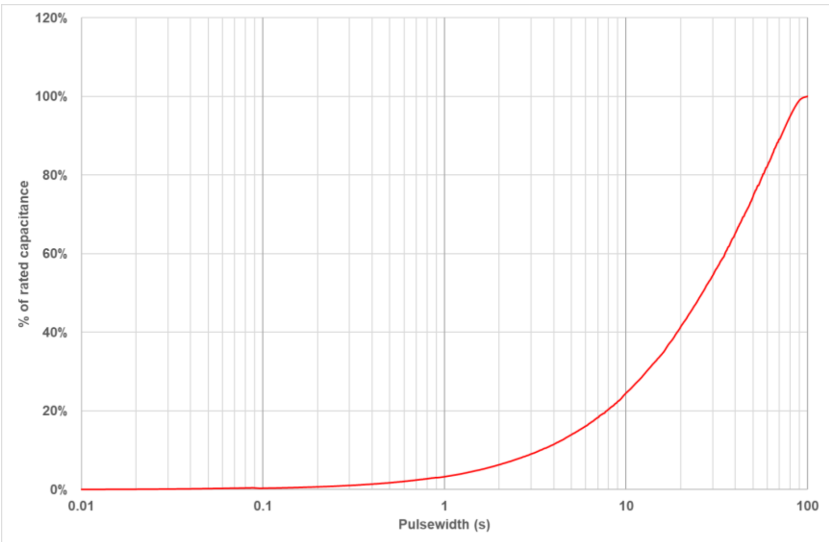


Fig 7: Typical effective capacitance range for LY13R8 series LiC

For any given pulse width, T, with a constant discharge current I_{DISCH}, the voltage drop is given by:

Vdrop = I_{DISCH} x AC ESR + I_{DISCH} x T/Ceff(T)

Where Ceff(T) = DC capacitance x % at time T read from Fig 8.

Shorter pulses need less capacitance to support them, so the supercapacitors can support short pulses despite their slow frequency response.

Self-discharge

Lithium-ion capacitor has very low self-discharge rate. Once a LIC is fully charged, it can hold a usable voltage for well over a year. Figure 8 below is the typical voltage decay over time in a self-discharge test done under room temperature. Data is extrapolated with an exponential curve fit.

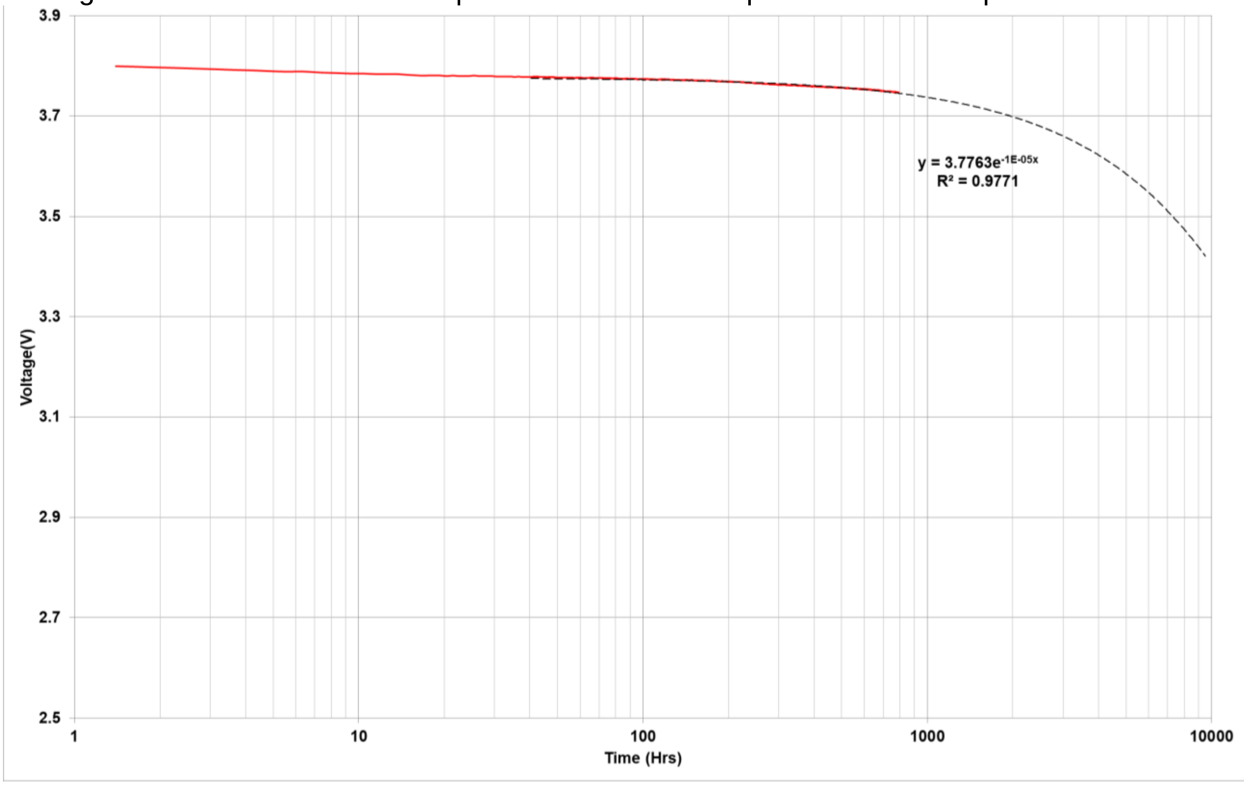


Figure 7, typical self-discharge on LY13R816025M227R-L, after 2 hours of charge

Such slow rate of self-discharge allows LIC to act as a long term energy source in certain applications.

Over discharge

Our LIC relies on similar electrochemical reactions to store the majority of its energy as a Lithium-ion battery, hence there is a minimum voltage rating. If an LIC is discharged below this point, there will be permanent damage done to the cell electrochemically. Fortunately there will not be a noticeable short term degradation if the time spent at below 2.5V is short. The only observable degradation seems to only be the reduction of long term life span for the product.

There is also very little additional energy can be released by discharging below 2.5V. See figure 8 below.

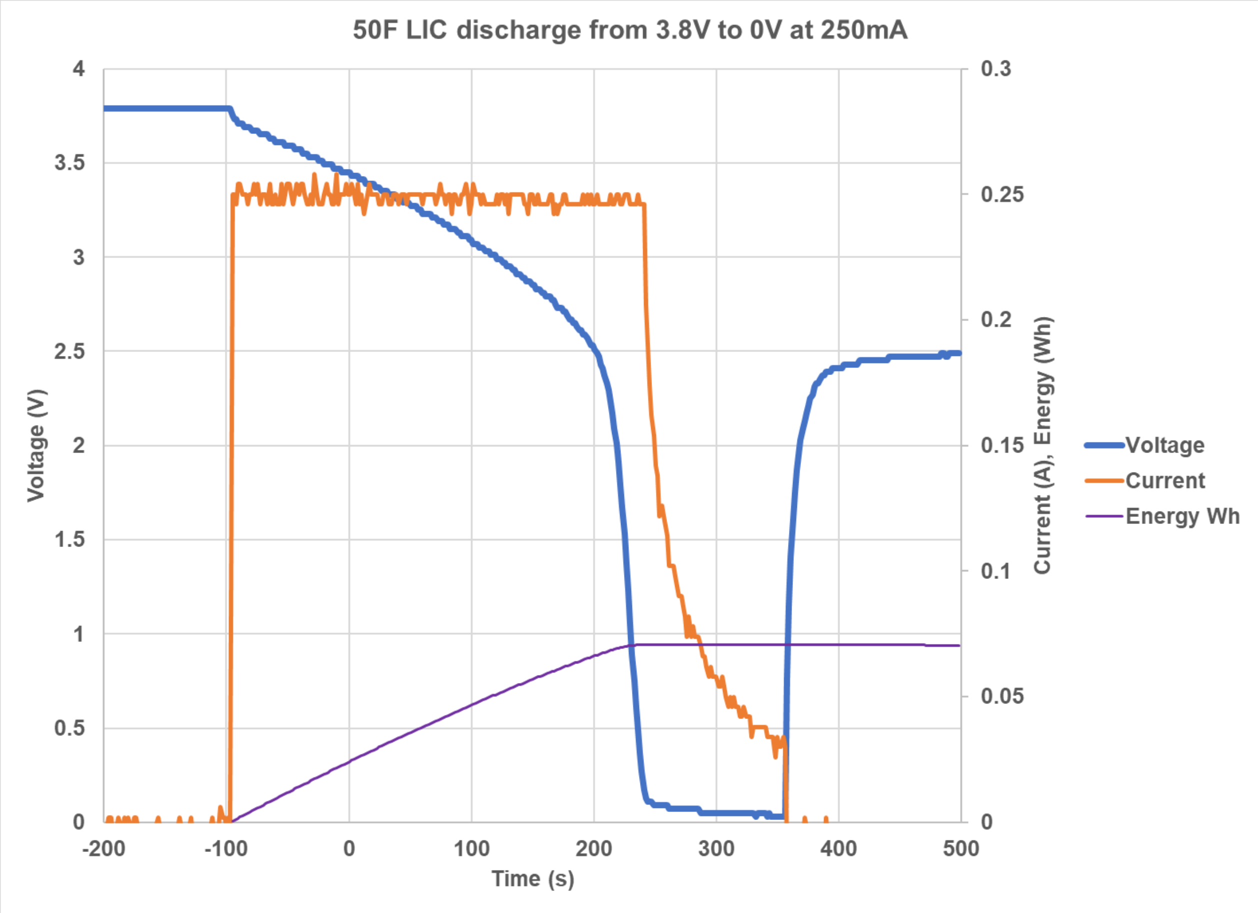


Figure 8, discharge curve when completely drain an LIC.

CAP-XX LIC products have also been tested destructively to determine their overall safety. A safety report will be provided when requested.

Storage

CAP-XX recommends storing supercapacitors and Lithium-Ion capacitors in their original packaging in an air conditioned room, preferably at < 30°C and < 50% relative humidity. CAP-XX supercapacitors can be stored at any temperature not exceeding their maximum operating temperature but storage at continuous high temperature and humidity is not recommended and will cause premature ageing.

DO NOT store Lithium-Ion capacitors or supercapacitors in the following environments:

- High temperature / high humidity
- Direct sunlight
- In direct contact with water, salt, oil or other chemicals
- In direct contact with corrosive materials, acids, alkalis or toxic gases
- Dusty environment
- In environments subjected to shock and vibration

LIC self-discharges overtime, after long term storage please check the cell voltage is >2.5V.

Soldering

When soldering it is important to not over-heat the Lithium-Ion capacitor or supercapacitor to not adversely affect its performance. CAP-XX recommends that only the leads come in contact with solder and not the supercapacitor body.

Hand, or robotic Soldering

Be sure the PCBA being soldered is electrically floating.

DO NOT short circuit the Lithium-Ion capacitor's pins when soldering.

Heat transfers from the leads into to the supercapacitor body, so the soldering iron temperature should be < 350°C soldering time should be kept to the minimum possible and be less than 4 seconds.

Wave Soldering

DO NOT wave solder. Wave soldering will short circuit the cell.

Reflow Soldering

DO NOT reflow solder.