

## DATASHEET

# GY13R0 SERIES SUPERCAPACITOR

Revision 3.0, Apr 2021

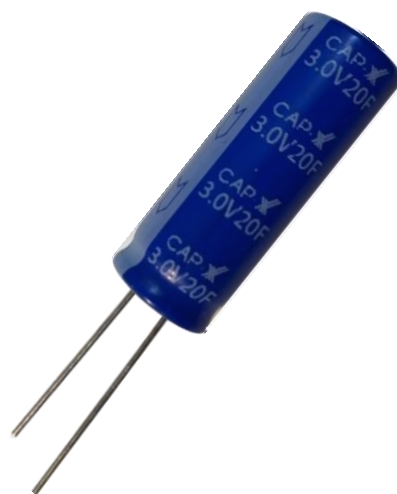
The GY13R0 series of supercapacitors are 3V cylindrical cells offering excellent value with high C and low ESR. They can be placed across a 3V primary battery to provide peak power support without any need for any voltage regulation or cell balancing which lower voltage cells require.

**Features:**

- High power output to support peak current loads
- On-board energy storage to handle power surges (high capacitance and energy density)
- Long cycle life

**Applications:**

- Energy Harvesting for wireless sensors
- Peak power support for GSM/GPRS transmission
- Last gasp power for remote meter status transmission
- Peak power support for locks & actuators
- Peak power support for portable drug delivery systems
- Short term bridging power for battery hot swap
- Peak power support for 3V primary cells



## GY13R0 SERIES DATASHEET

## 1. Electrical Specifications

## Part numbering code

G	Y	N	vvv	dd	mmm	S	ccc	R
Model	Cylindrical	# of cells	Voltage	Diameter (mm)	Length (mm)	Tolerance	Capacitance (μF)	Lead format
		1	3R0 = 3.0V	6C = 6.3 08 = 8.0 10 = 10 1B = 12.5 16 = 16 18 = 18	012 = 12 068 = 68 120 = 120	M ± 20% S +50% /-20% V +30% /-10%	Two digits + number of zeros. 155 = 1500000μF = 1.5F	R = radial S = 2 solder pins W = 4 Cu tabs

Rated Voltage: 3.0V

Temperature Range: -40°C to +65°C

Parameters measured at 25°C

Radial leads

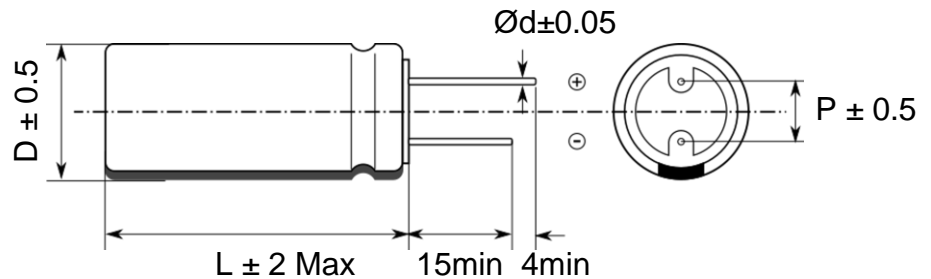
CAP-XX Part no.	Cap (F)	ESR Max @ 1KHz (mΩ)	Diameter (mm)	Length (mm)	IL max @ 72 Hrs (μA)
GY13R008012V105R	1	150	8	12	6
GY13R008014V105R	1	260	8	14	10
GY13R008014V205R	2	130	8	14	12
GY13R008016V205R	2	80	8	16	10
GY13R008020V335R	3.3	60	8	20	11
GY13R010020V505R	5	70	10	20	18
GY13R010025V705R	7	55	10	25	25
GY13R010030V106R	10	40	10	30	40
GY13R01B020V106R	10	50	12.5	20	30
GY13R01B035V206R	20	30	12.5	35	60
GY13R016026V256R	25	25	16	26	80
GY13R018042V506R	50	16	18	42	150
GY13R016062V107R	100	16	16	62	300

## GY13R0 SERIES DATASHEET

## 2. Dimensions (mm)

## GY1 Series Shrink Wrap Radial Lead 1F – 100F

ΦD	P	Φd
8	3.5	0.6
10	5.5	0.6
12.5	5.5	0.6
16	8	0.8
18	8	0.8



## Measurement of capacitance

Capacitance is measured at 25°C using the method specified by IEC62391 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  $0.8 \times V_R$  to  $0.4 \times V_R$  is measured to calculate capacitance as:

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

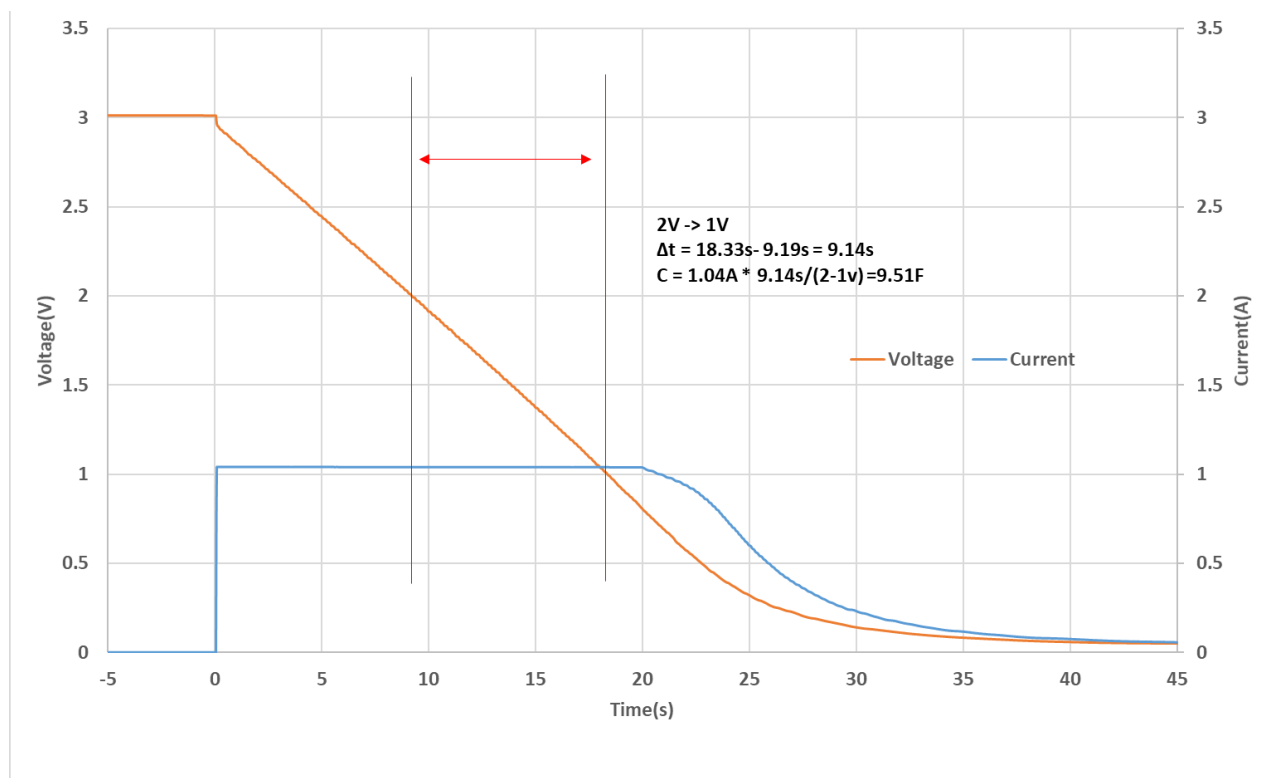


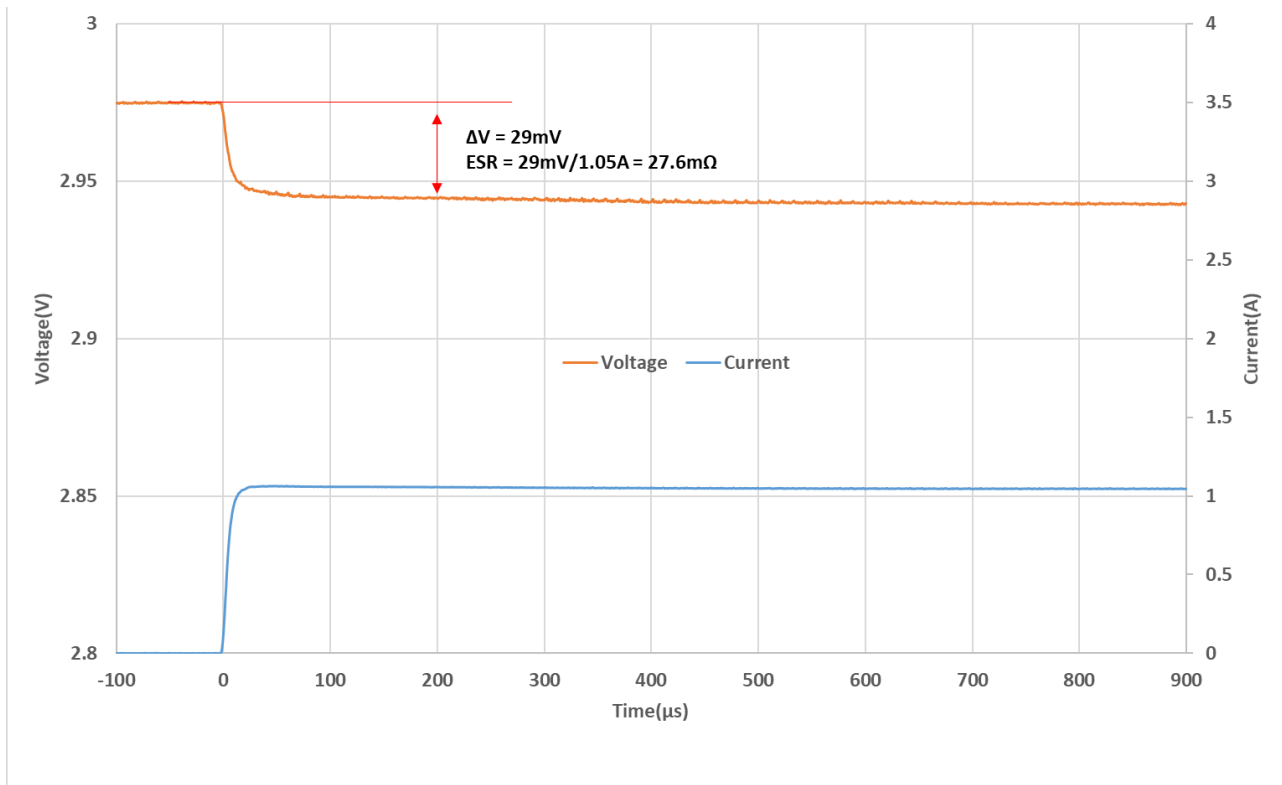
Fig 1: Capacitance measurement

In this case,  $C = 1.04A \times 9.14s / 1V = 9.51F$ , which is well within the 10F +50% / - 20% tolerance for a GY13R010030V106R cell.

## GY13R0 SERIES DATASHEET

## Measurement of ESR

Equivalent Series Resistance (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 200µs after the step current is applied to ensure the voltage and current have settled. In this case, for a GY13R010030V106R the ESR is measured as  $29\text{mV}/1.05\text{A} = 27.6\text{m}\Omega$ .

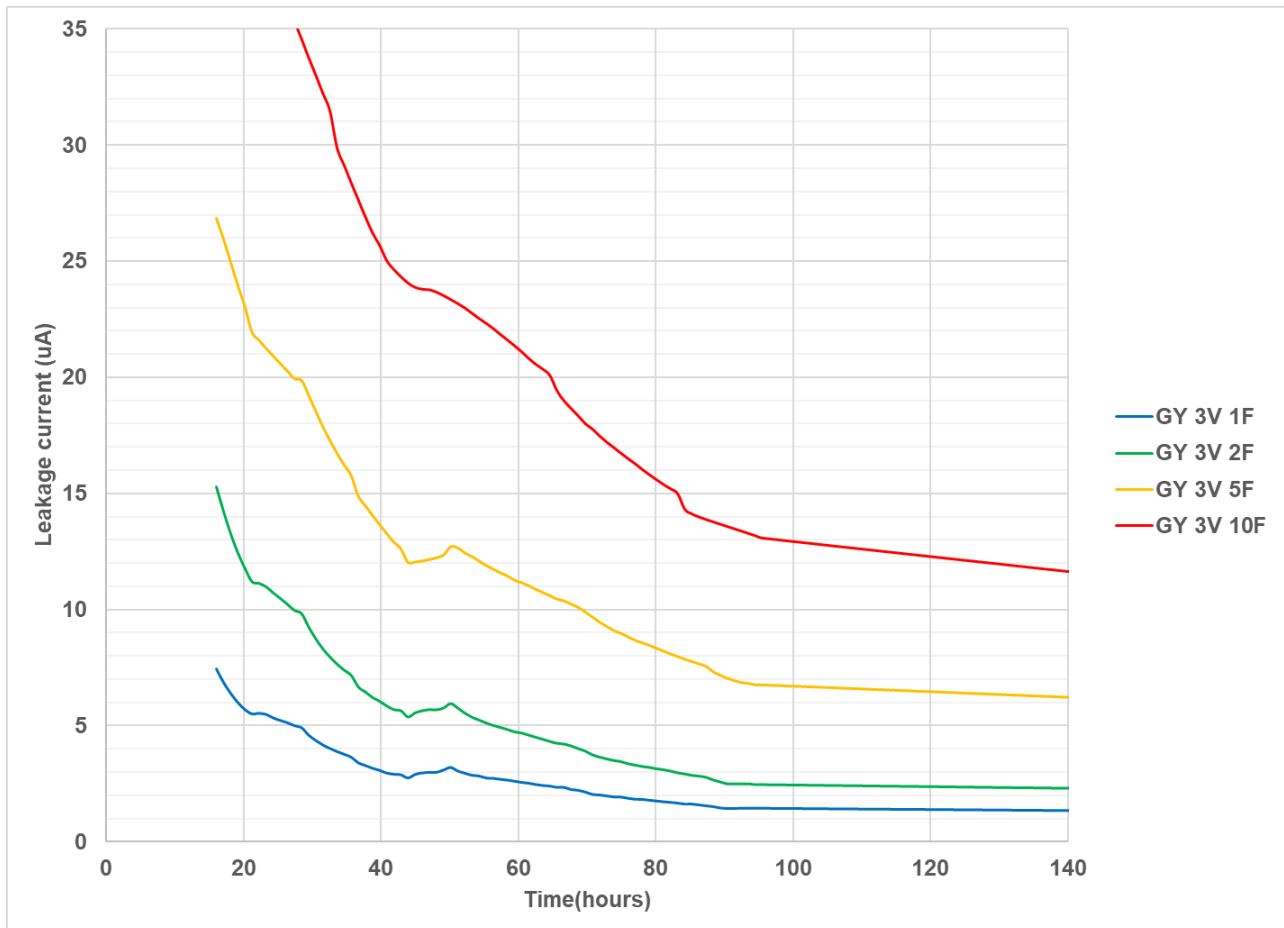


**Fig 2: ESR Measurement**

## GY13R0 SERIES DATASHEET

## Measurement of Leakage Current

Leakage current is measured by holding the supercapacitor at rated voltage at 25°C and measuring the current drawn through a high value resistor, typically 1KΩ or 2.2KΩ. The leakage current decays over time as shown in Fig 3 which shows the leakage current for multiple samples of 1F, 2F, 5F and 10F supercapacitors. Leakage current is typically 2μA/F but the datasheet quotes the maximum values after 72hrs at rated voltage.

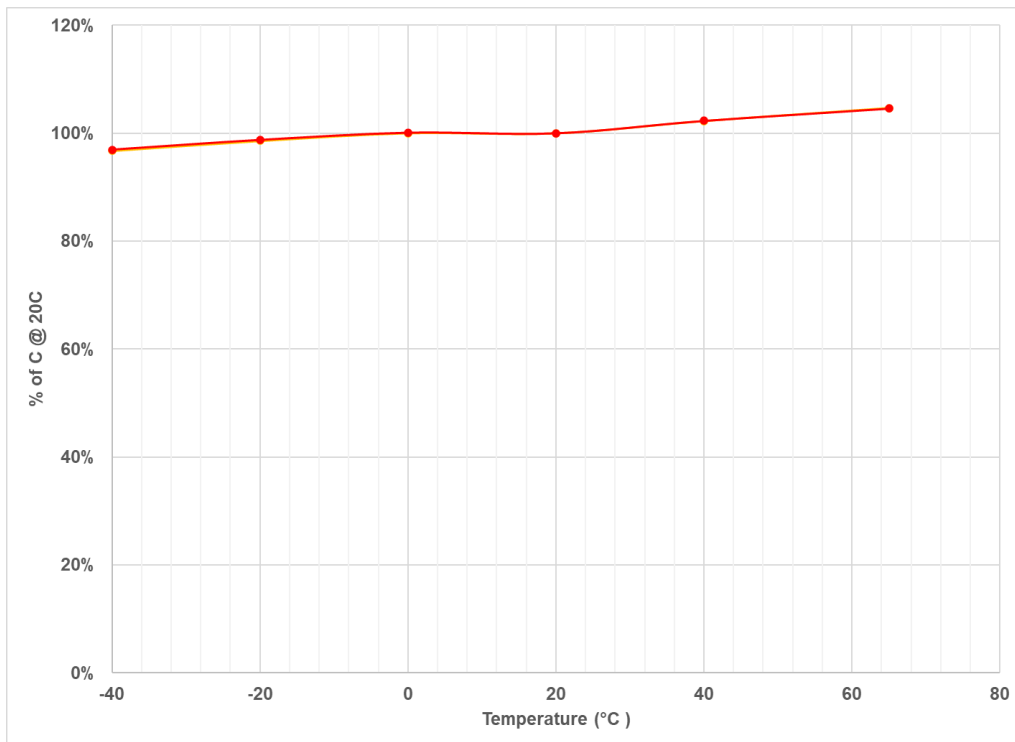


**Fig 3: Leakage current measurement**

## GY13R0 SERIES DATASHEET

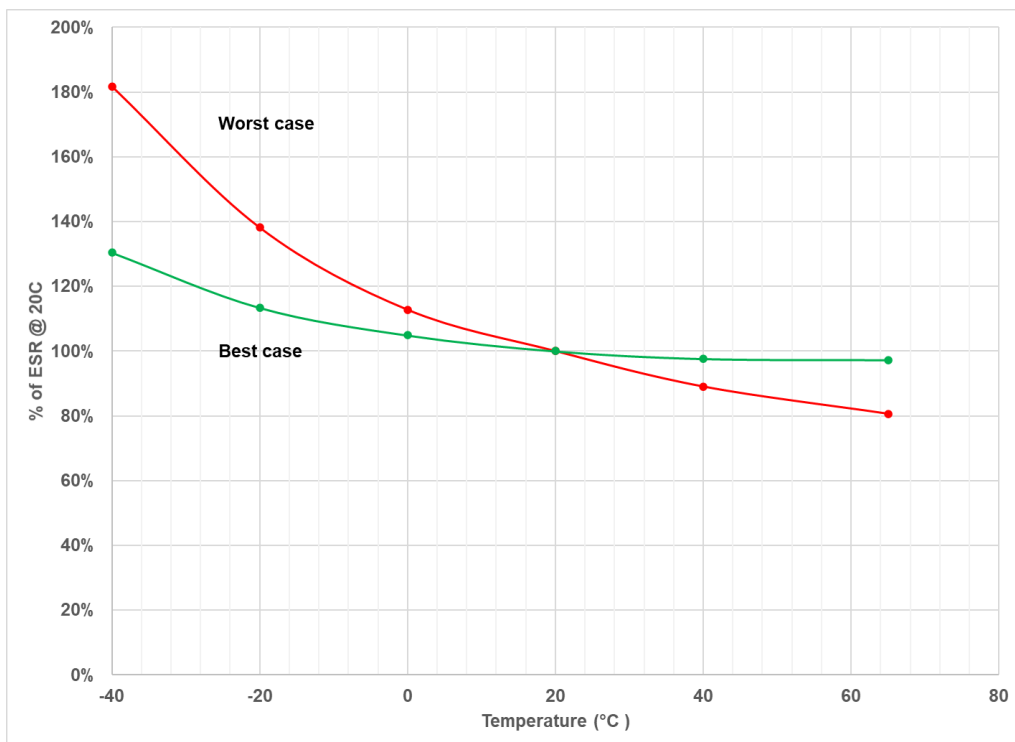
**Variation in DC Capacitance and ESR with temperature**

Figure 4 shows that DC capacitance does not vary with significantly over the operating temperature range of -40°C to +60°C.



**Fig 4: Variation in DC Capacitance over the operating temperature range**

Figure 5 shows variation in DC ESR over the operating temperature range.



**Fig 5: Variation in DC ESR over the operating temperature range**

## GY13R0 SERIES DATASHEET

From Figure 5,  $ESR_{DC}$  at  $-40^{\circ}\text{C}$  is between  $\sim 1.3x$  to  $1.8x$  the  $ESR_{DC}$  at room temperature.  $ESR_{DC}$  at  $65^{\circ}\text{C}$  is 80% to 100% of  $ESR_{DC}$  at room temperature. The variation in ESR with temperature is due to the change in the mobility of ions in solution in the electrolyte.

## Peak Current

Peak current is limited by  $V_{\text{rated}}/(ESR_{DC} + R_L)$  where  $R_L$  is the load resistance including parasitic resistance such as PCB traces. The current then decays and is given by:

$$[V_{\text{rated}}/(ESR_{DC} + R_L)] \cdot e^{-t/[(ESR_{DC} + R_L) \cdot C]}$$

where  $t$  = time in seconds. At high peak current, the supercapacitor discharges rapidly so that self heating due to the high current is negligible. Table 1 Shows short circuit current for a range of supercapacitors initially charged to 3V at the instant the short circuit is applied and after 100ms. It also shows the temperature increase recorded due to the short circuit.

**Table 1:**

Capacitance (F)	Instantaneous peak current (A)	Current after 100ms (A)	Temperature rise ( $^{\circ}\text{C}$ )
10	92	56	3.2
5	78	41	2.9
2	33	15	2
1	30	10	1.1

In all cases the temperature rise is not significant. A one-time peak current pulse is only limited by the  $ESR_{DC} + \text{Load resistance}$ , not by any thermal limitations.

The voltage drop when a constant current pulse of duration  $\tau$  is applied =

$$V_{\text{INIT}} - V_{\text{FINAL}} = I \cdot ESR_{DC} + I \cdot \tau / C$$

Where:

$I$  = constant current

$\tau$  = duration of constant current

$V_{\text{INIT}}$  = the initial voltage when the current pulse is first applied

$V_{\text{FINAL}}$  = the supercap voltage at the end of the pulse

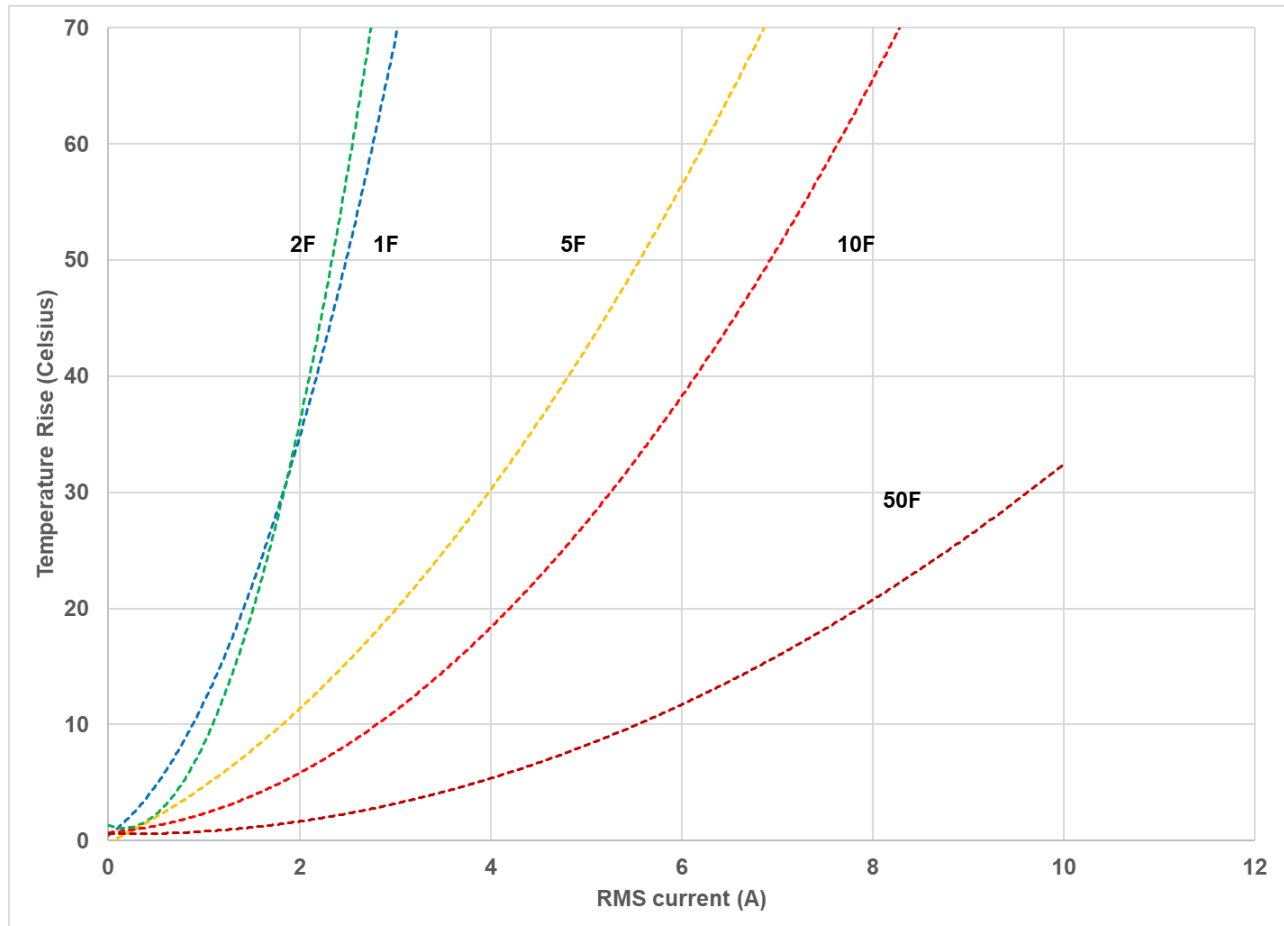
Re-arranging terms, the maximum current that can be sustained for a time  $\tau$ , when the supercapacitor is initially charged to rated voltage,  $V_R$ , and discharged to  $V_{\text{MIN}}$ , the minimum voltage that supports the given application =

$$I_{\text{MAX}} = \frac{V_R - V_{\text{MIN}}}{ESR_{DC} + \frac{\tau}{C}}$$

## GY13R0 SERIES DATASHEET

## Maximum Continuous Current

Continuous current flow into/out of the supercapacitor will cause self-heating, which limits the maximum continuous current the supercapacitor can withstand. This is measured by a current square wave with 50% duty cycle, charging the supercapacitor to rated voltage,  $V_R$ , at a constant current, and then discharging the supercapacitor to a half rated voltage  $V_R/2$  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 6 shows the increase in temperature as a function of RMS current for various GY1R30 series supercapacitors.



**Fig 6: Self heating with RMS current for various supercapacitors**

From Fig 6, the maximum RMS current in an application can be calculated. For example, if the ambient temperature is 40°C, and the maximum operating temperature for the supercapacitor is 65°C, then the maximum RMS current for a 10F supercapacitor should be limited to 4.6A, which causes a 25°C temperature increase.



## GY13R0 SERIES DATASHEET

## Effective capacitance (Ceff)

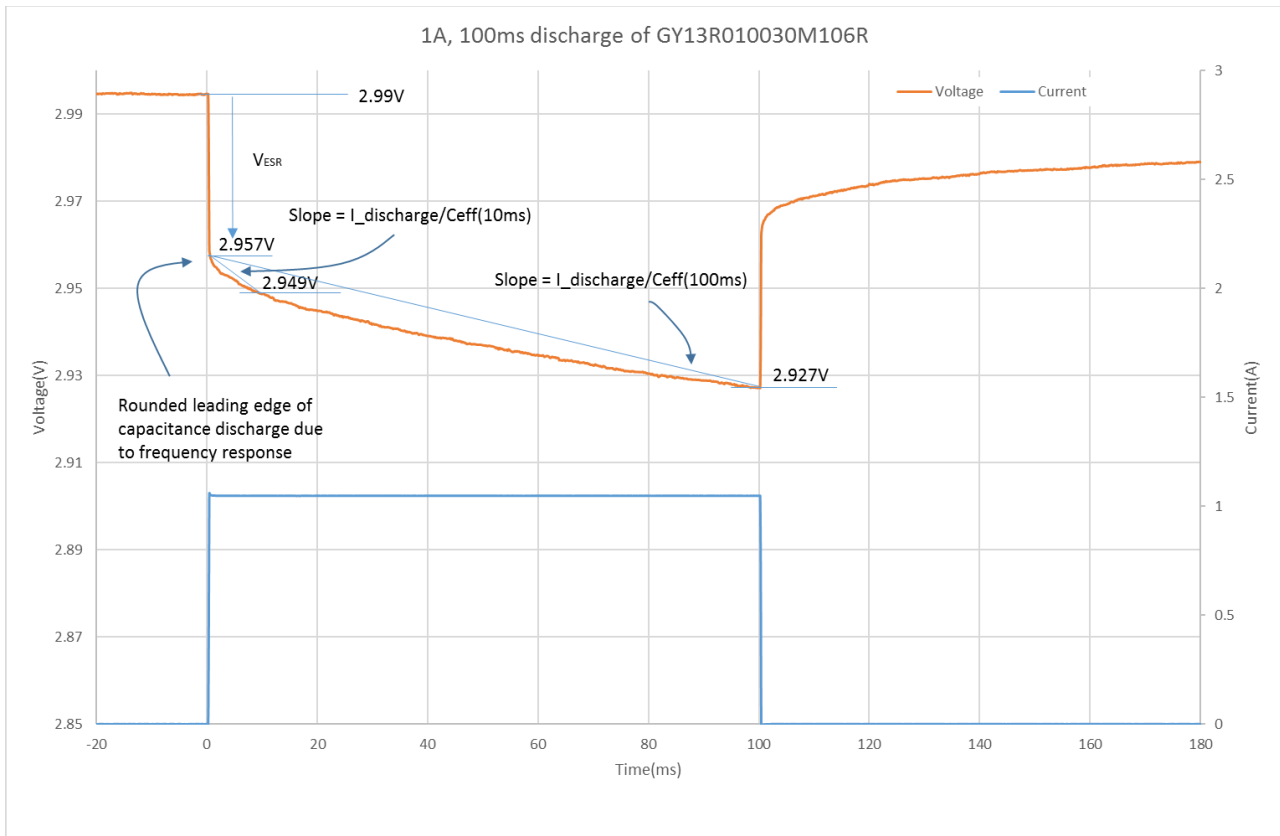
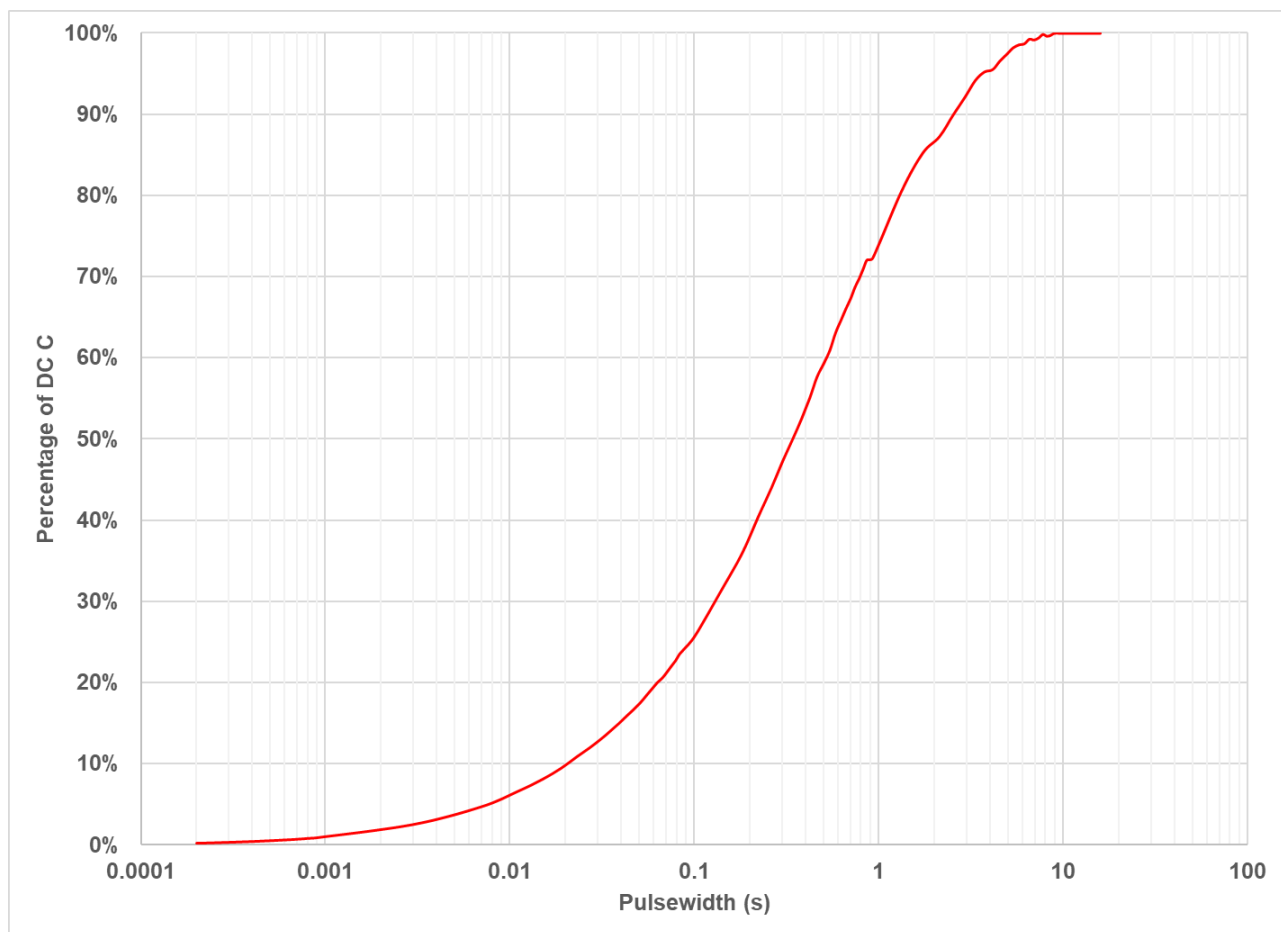


Fig 7: Discharge pulse illustrating the concept of Ceff

In Fig 7, consider the voltage drop due to capacitance for the 10F GY13R010030M106R after 10ms = 2.957V – 2.949V = 8mV. Therefore  $C_{eff}(10ms) = \text{Discharge\_Current} \times 10ms / \text{Voltage drop}(10ms) = 1.05A \times 0.01s / 0.008V = 1.3F$  or 13% of DC Capacitance. The voltage drop due to capacitance after 100ms = 2.957V – 2.927V = 30mV.  $C_{eff}(100ms) = 1.05A \times 0.1s / 0.03V = 3.5F$  or 35% of DC capacitance. Fig 10 shows Ceff as a % of DC capacitance for the GY13R0 series of supercapacitors.



**Fig 8: Typical effective capacitance for GY13R0 series supercapacitors**

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

$$V_{drop} = I_{DISCH} \times ESR + I_{DISCH} \times T / C_{eff}(T)$$

Where  $C_{eff}(T)$  = 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 frequency response.

## Balancing options

In many applications where voltage > 3V is required, 2 or more supercapacitor cells need to be connected in series into modules. These cells should have a balancing circuit to ensure that the cell voltages remain approximately equal, or the cell with the lower  $C$  will have a higher voltage across it, causing it to age faster than its companion cell, hence losing even more  $C$  until it goes over voltage. This is a reason why a balancing circuit should aim to maintain the voltage across each cell equal, rather than just prevent over-voltage. As an example, if the dual cell module was at 5.0V and there was over-voltage protection circuits that prevented each cell from exceeding 3V, then module could have one cell at 3V and the other at 2V. The cell at 3V will age faster than the cell at 2V and will age faster than if both cells were held at 2.5V shortening module life.

If the application uses a supercapacitor charging IC that has an integrated supercapacitor midpoint balancing circuit, or there is a balancing circuit on the PCB, then order 2 x GY13R0 cells and place them in series. This makes the midpoint available to your balancing circuit. Refer to the Application

## GY13R0 SERIES DATASHEET

Whitepaper on Supercapacitor Cell Balancing under the DESIGN AIDS section of the CAP-XX website, [www.cap-xx.com](http://www.cap-xx.com).

## Storage

CAP-XX recommends storing supercapacitors 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 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

## Soldering

When soldering it is important to not over-heat the 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 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

The PCB should be pre-heated only from the bottom and for < 60 secs with temperature ≤ 100°C on the top side of the board for PCBs ≥ 0.8mm thick. The table below lists suggested solder temperatures.

Solder temperature °C	Suggested solder time (s)
220	7
240	7
250	5
260	3

### Reflow Soldering

Infrared or conveyor oven soldering techniques can be used providing the supercapacitor body is not subject to temperatures > 65°C. Do not use a standard reflow oven.

## Transportation

All the supercapacitor cells in this datasheet store < 0.3Wh energy. The energy in watt-hours is calculated as:  $\frac{1}{2} \times \text{Capacitance} \times V_{\text{rated}}^2 / 3600$ . The largest cell in this range is 100F, so stored energy =  $\frac{1}{2} \times 100 \times 3^2 / 3600 = 0.125\text{Wh}$ . Under regulation UN3499 there is no restriction on shipping these supercapacitors. Their shipping description is “Electrical Capacitors” with harmonized shipping code 8532.29.0040.