Powering next generation products

DATASHEET

GY13R0/GY26R0 SERIES RADIAL LEADS SUPERCAPACITOR

Revision 4.4, Feb 2024

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
- Peak power support for 3V primary cells and last gasp transmission or activation of a unit into a safe state at end of battery life. These supercapacitors may be placed directly across a 3V battery with no voltage regulation required.
- Peak power support for low power batteries such as Lithium Thionyl Chloride batteries during automatic meter reading data transmission and last gasp transmission at end of battery life
- 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

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 22 = 22	012 = 12 068 = 68 120 = 120	M ± 20% S +50% /-20% V +30% / -10% N +20%/-0% T +25% / -5%	Two digits + number of zeros. 155 = 1500000µF = 1.5F	R = radial

Rated Voltage: 3.0V (Surge 3.2V)
Temperature Range: -40°C to +65°C (+85°C @ 2.5V)
Parameters measured at 25°C
Radial leads

CAP-XX Part no.	Cap (F)	DC ESR Max (mΩ)	AC ESR Max @ 1KHz (mΩ)	IL max @ 72 Hrs (µA)	Diameter (mm)	Length (mm)	Mass (gm)
GY13R06C012V105R	1	650	500	2	6.3	12	0.7
GY13R008014V105R	1	520	400	3	8	14	0.9
GY13R008014V205R	2	210	160	6	8	14	1
GY13R008020V305R	3	105	80	9	8	20	1.4
GY13R008020V335R	3.3	150	100	10	8	20	1.4
GY13R008025V505R	5	135	95	15	8	25	1.7
GY13R010020V505R	5	113	80	15	10	20	2.2
GY13R010025V705R	7	90	60	21	10	25	2.7
GY13R010030V106R	10	68	50	30	10	30	3.2
GY13R01B025V156R	15	45	35	45	12.5	25	4.3
GY13R01B030V206R	20	35	28	60	12.5	30	5.2
GY13R016025V256R	25	38	25	75	16	25	7.4
GY13R018040V506R	50	25	20	150	18	40	13.8
GY13R022045V107R	100	25	18	300	22	45	22.5

Note: Series modules using above single cell can be made to order. Please contact CAP-XX.

Dual Cell Modules

Part numbering code

G	Y	N	vvv	tt	ll	S	ccc	R	B
Model	**Cylindrical**	**# of cells**	**Voltage**	**Module thickness (mm)**	**Length (mm)**	**Tolerance**	**Cap. (µF)**	**Lead format**	**Balancing**
		2	6R0 = 6V	6E = 6.5 8E = 8.5 11 = 11 13 = 13 17 = 17	17 = 17 44 = 44	M ± 20% S +50% /-20% V +30% / -10% P +80% / -20% N +20%/-0% T +25% / -5%	Two digits + number of zeros.	R= radial leads T= Wire & connector B= Bent radial lead	R = Resistor[1] N = No balancing

[1]R = A pair of balancing 0402 resistors are used. CAP-XX strongly recommends balancing when operating above 5.5V to ensure longevity. Please contact CAP-XX for more information.

Rated Voltage: 6V (Surge 6.4V)

Temperature Range: -40°C to +65°C (-40 ~ +85°C @ 5V)

Parameters measured at 25°C

CAP-XX Part no.	Cap (F)	DC ESR Max (mΩ)	AC ESR Max (mΩ)	IL max @ 72 Hrs (µA)	Thick x Width (mm)	Length (mm)
GY26R06E14M504RN	0.5	1300	1000	2	6.5x13	14
GY26R08E16V105RN	1	660	340	3	8.5x17	16
GY26R08E22V155RN	1.5	340	180	5	8.5x17	22
GY26R08E27V255RN	2.5	780	400	8	8.5x17	27
GY26R01122V255RN	2.5	340	180	8	11 x 21	22
GY26R08E32V355RN	3.5	420	220	11	8.5x17	32
GY26R01122V355RN	3.5	340	180	11	11 x 21	22
GY26R01127V505RN	5	380	200	15	11 x 21	27
GY26R01323V505RN	5	220	120	15	13 x 26	23
GY26R01327V755RN	7.5	160	90	23	13 x 26	27
GY26R01333V755RN	7.5	160	90	23	13 x 26	33
GY26R01724V106RN	10	132	76	30	17 x 33	24
GY26R01327V106RN	10	132	76	30	13 x 26	27
GY26R01729V126RN	12.5	120	70	38	17 x 33	29
GY26R01735V156RN	15	120	70	45	17 x 33	35
GY26R01735V176RN	17.5	104	62	53	17 x 33	35
GY26R01739V206RN	20	104	62	60	17 x 33	39
GY26R01843V256RN	25	100	60	75	18 x 37	43
GY26R01853V356RN	35	100	60	105	18 x 37	53
GY26R01863V506RN	50	92	56	150	18 x 37	63

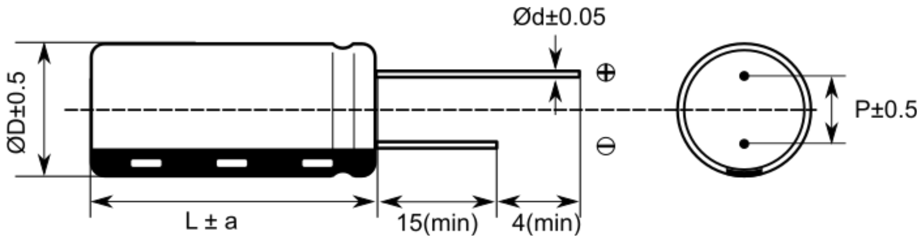
Notes:

1. Module consisting of 2 single cells listed on page 2, but not shown in the table above, can be made to order. Please contact CAP-XX.
2. Parts pass IEC62391 Endurance test at rated voltage & temperature.

Dimensions (all units in mm)

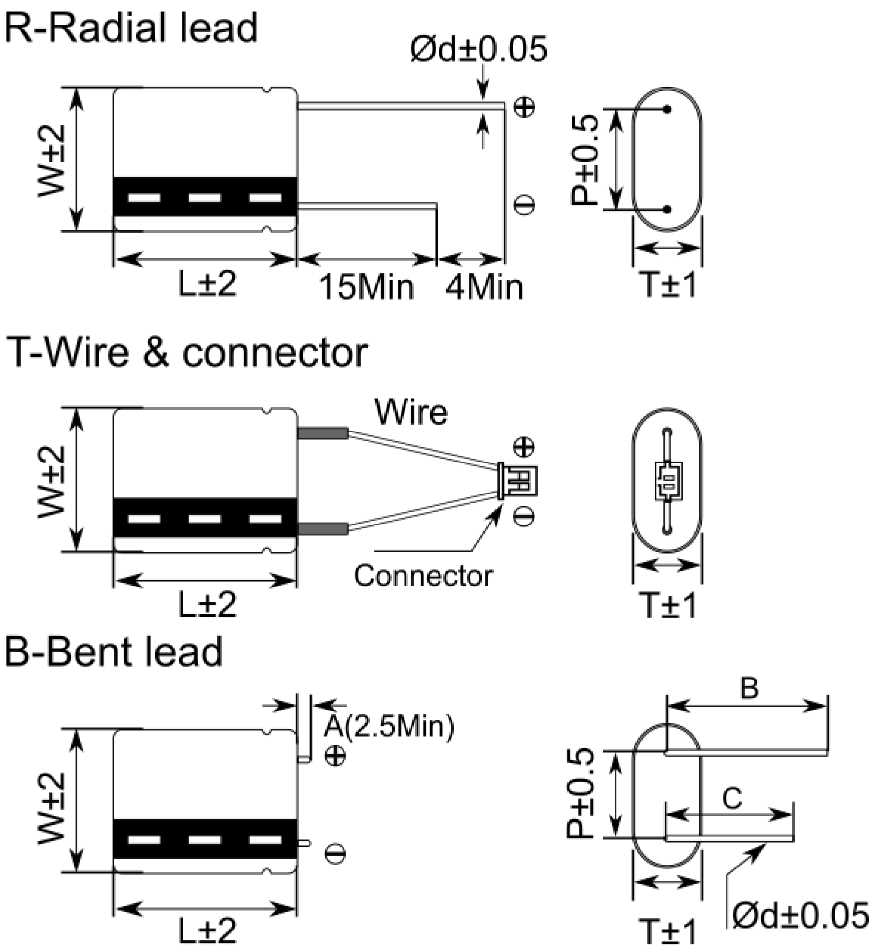
GY1 Series Radial Lead 0.5F – 100F

ΦD	P	a	Φd
5	2.0	1.5	0.5
6.3	2.5	1.5	0.5
8	3.5	1.5	0.6
10	5	2	0.6
12.5	5	2	0.6
16	7.5	2	0.8
18	7.5	2	0.8
22	10	3.5	1



GY2 Series, 0.22F – 50F

T	P	Φd
5.5	7.5	0.5
6.5	8.8	0.5
8.5	12	0.6
11	15.5	0.6
13	18	0.6
17	24	0.8
18	26	0.8



Note: the colour of the shrink wrap on GY product may be either Blue or Black.

Limited customisations on choice of connector (default 1.25mm pitch, PN A1251), wire and lead length (A, B & C) are possible. Please contact CAP-XX.

Typical long-term performance

Item		Details
Cycle Life	Test condition	Charge and discharge between V_R and $V_R/2$ at constant current for 500,000 cycles. 25˚C
	$\Delta C / C_{initial}$	≤ 30%
	Final ESR	≤ 2 times of initial value
Lifespan	High temperature storage	After 1000 hours storage, without charge at 65˚C.
		$\Delta C / C_{initial} \leq 30\%$, $ESR_{Final} \leq 2x\ ESR_{initial}$
	Endurance	After 1000 hours at V_R, 65˚C.
		$\Delta C / C_{initial} \leq 30\%$, $ESR_{Final} \leq 4x\ ESR_{initial}$
	Projected RT life	10 years ($\Delta C / C_{initial} \leq 30\%$, $ESR_{Final} \leq 4x\ ESR_{initial}$)

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 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 x V_R to 0.4 x V_R is measured to calculate capacitance as:

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

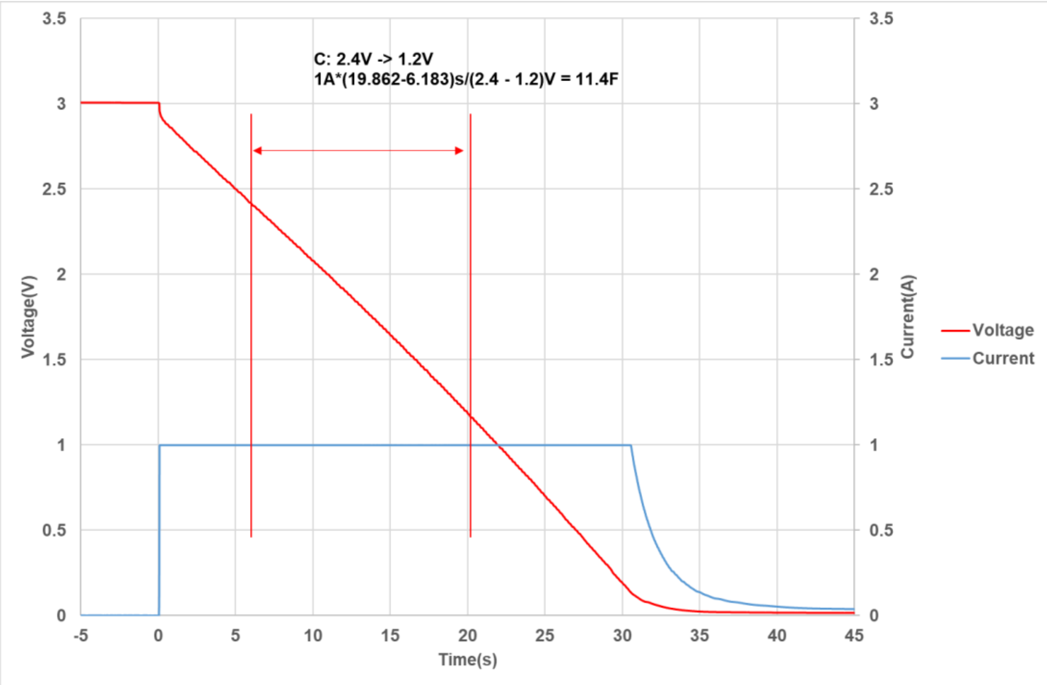


Fig 1: Capacitance measurement

In this case, C = 1A*(19.862-6.183)s/(2.4 - 1.2)V = 11.4F, which is well within the 10F +30% / -10% tolerance for a GY13R010024V106R cell.

Measurement of DC 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 GY13R010024V106R the ESR is measured as 29mV/1.05A = 27.6mΩ, well below the specified maximum of 40mΩ.

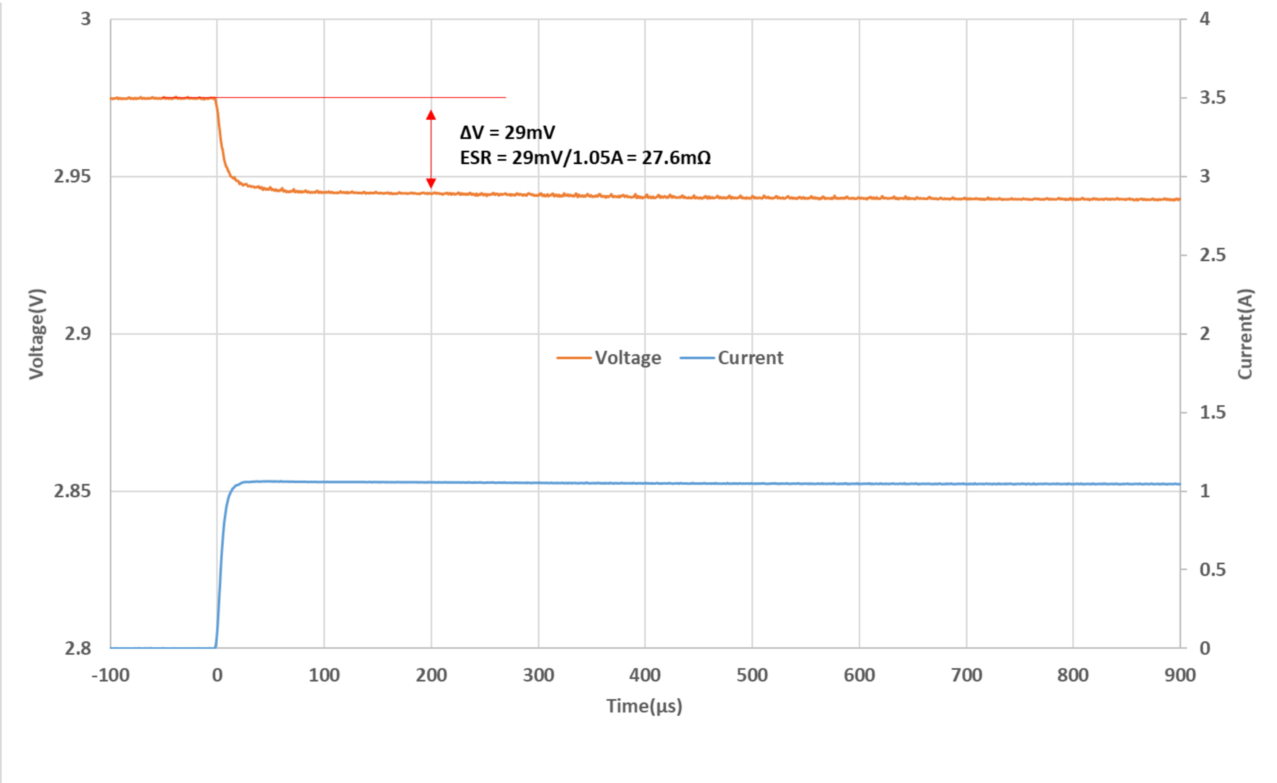


Fig 2: ESR Measurement

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 settles to its minimum value after ~120hrs and is typically 2µA/F however the datasheet quotes the maximum values after 72hrs at rated voltage.

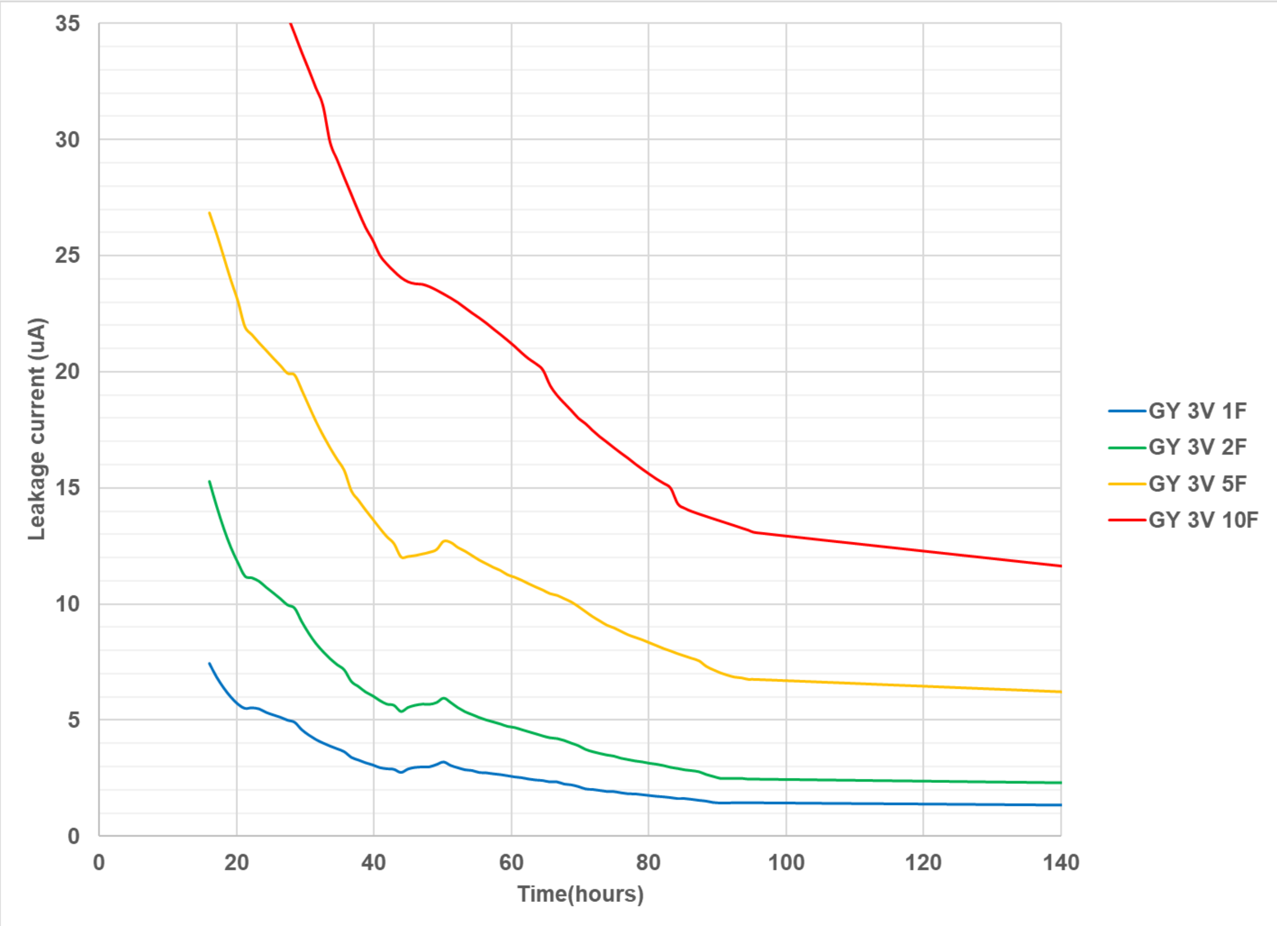


Fig 3: Leakage current measurement

Variation in DC Capacitance and ESR with temperature

Figure 4 shows that DC capacitance does not vary significantly over the operating temperature range of -40°C to +65°C.

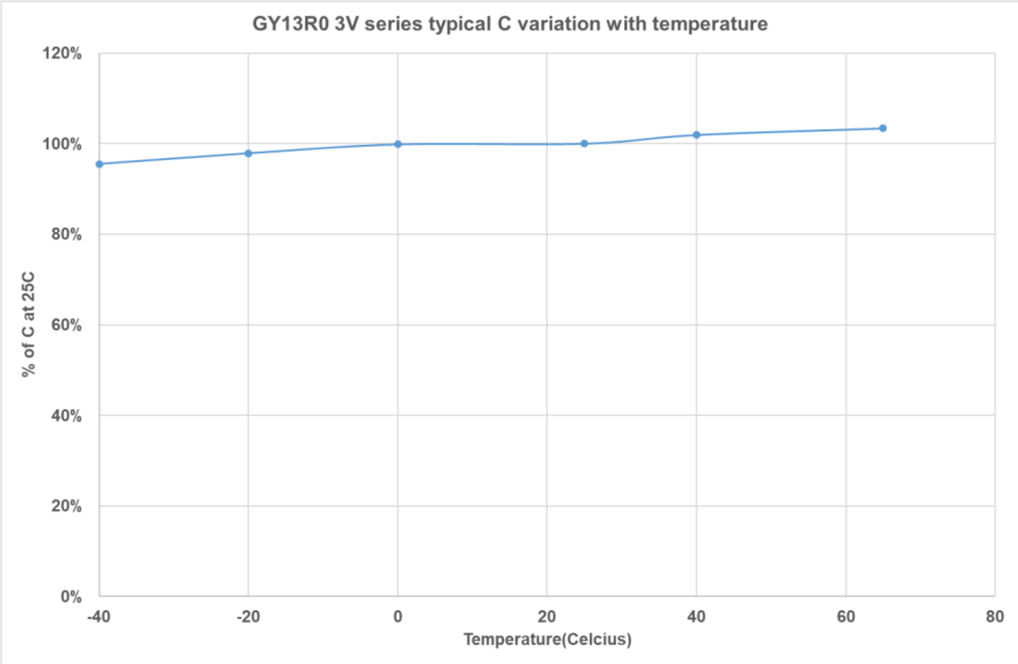


Fig 4: Variation in DC Capacitance over the operating temperature range

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

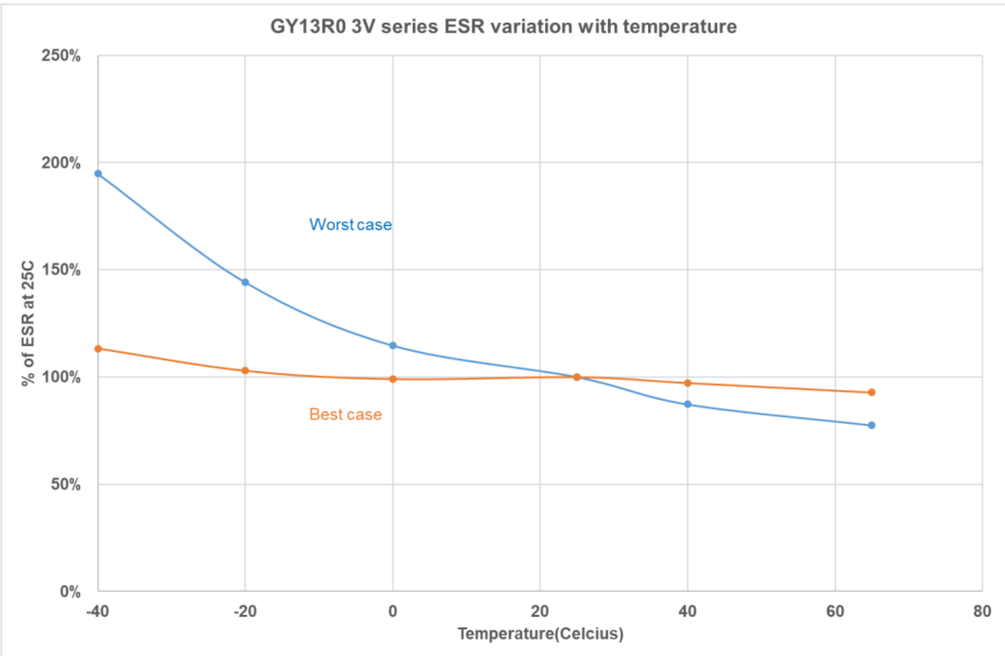


Fig 5: Variation in DC ESR over the operating temperature range

From Figure 5, ESR_{DC} at -40°C is between ~1.1x to 1.8x the ESR_{DC} at room temperature. ESR_{DC} at 65°C is 70% to 90% 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 Vrated/(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:

[Vrated/(ESR_{DC} + R_L)].$e^{-t/[(ESR_{DC}+RL).C]}$

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 (°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} + Load resistance, not by any thermal limitations.

The voltage drop when a constant current pulse of duration τ is applied =

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

Where:

I = constant current

τ = duration of constant current

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

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

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

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

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 GY13R0 series supercapacitors.

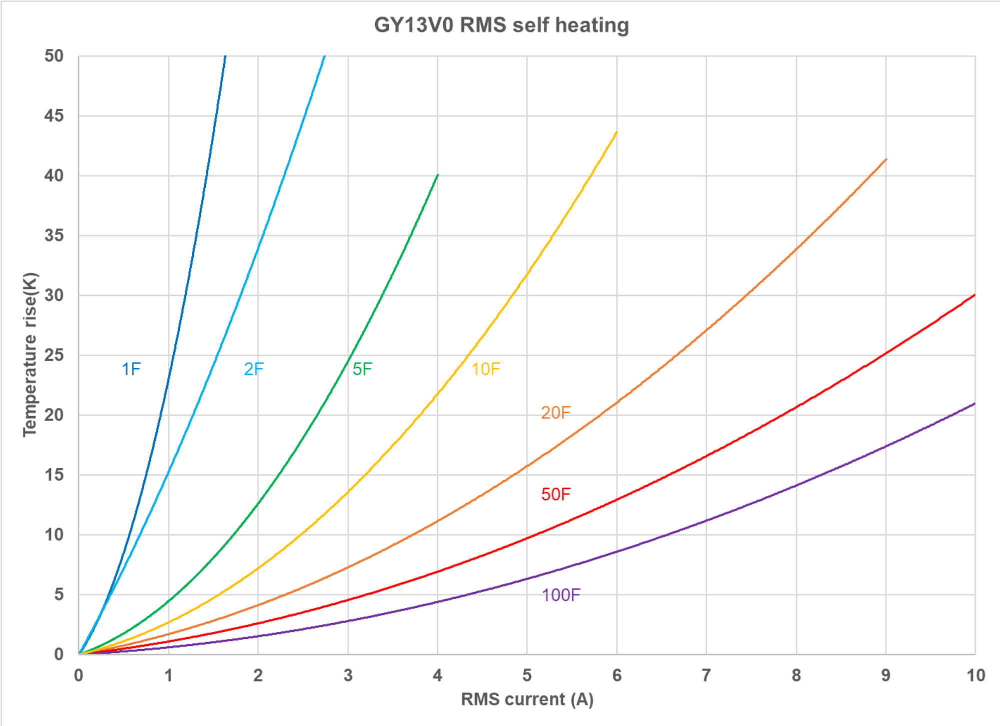


Fig 6: Self heating with RMS current for various supercapacitors

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 4.4A, which causes a 25°C temperature increase.

Effective capacitance (Ceff)

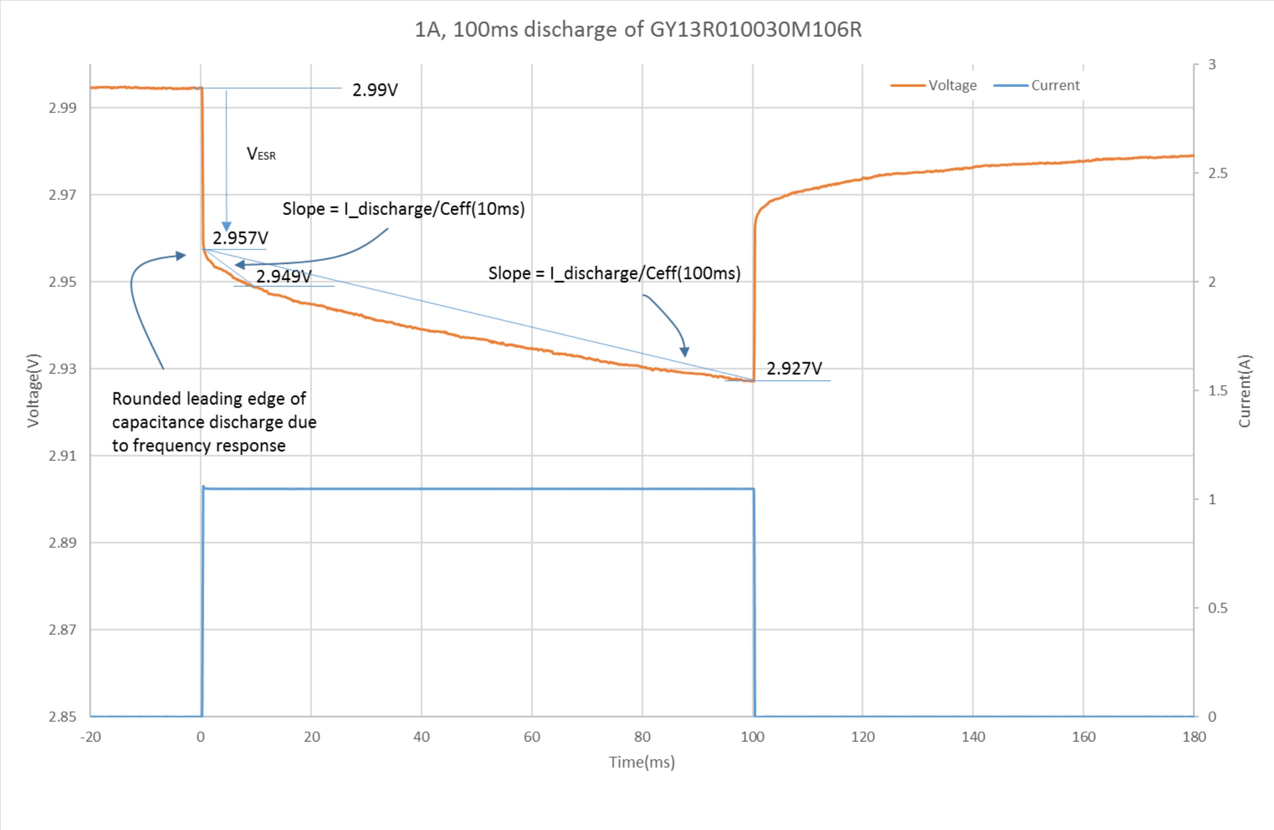


Fig 7: Discharge pulse illustrating the concept of Ceff

In Fig 7, consider the voltage drop due to capacitance for the 10F GY13R010030M106R after 10ms = 2.957– 2.949V = 8mV. Therefore Ceff(10ms) = Discharge_Current x 10ms/Voltage drop(10ms) = 1.05A x 0.01s/0.008V = 1.3F or 13% of DC Capacitance. The voltage drop due to capacitance after 100ms = 2.957V – 2.927V = 30mV. Ceff(100ms) = 1.05A x 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.

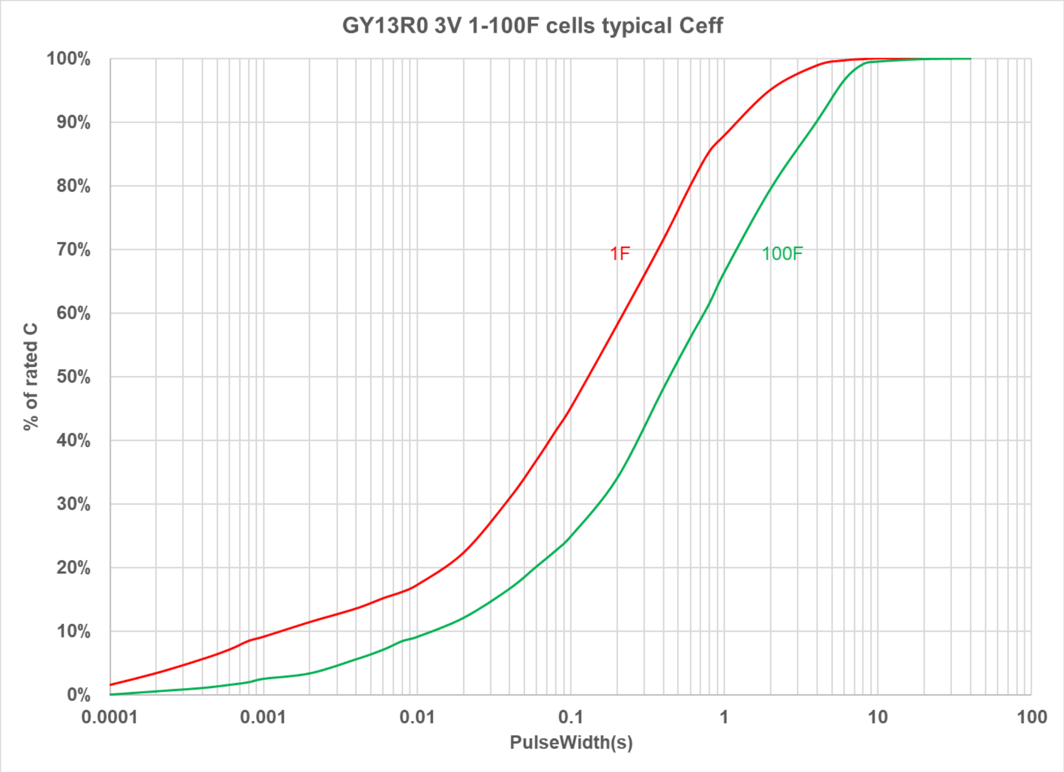


Fig 8: Typical range of effective capacitance for GY13R0 series supercapacitors

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

Vdrop = I_{DISCH} x 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 frequency response.

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: ½ x Capacitance x V_{rated}^2/3600. The largest cell in this range is 180F, so stored energy = ½ x 180 x 3^2 /3600 = 0.225Wh. Under regulation UN3499 there is no restriction on shipping these supercapacitors. Their shipping description is “Electrical Capacitors” with harmonized shipping code 8532.29.0040.