

DATASHEET

GY SERIES RADIAL LEAD SUPERCAPACITOR

Revision 4.5, Feb 2024

The GY series of supercapacitors are cylindrical cells offering excellent value. They are available as single cells, or dual cell modules with a choice of cell balancing options.

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 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 to ride through power interruptions or for battery hot swap



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Electrical Specifications

Single cells

Part numbering code

G	Y	N	vvv	dd	lll	S	ccc	R
Model	Cylindrical	# of cells	Voltage	Diameter (mm)	Length (mm)	Tolerance	Capacitance (μF)	Lead format
		1	2R7 = 2.7V	05 = 5 6C = 6.3 08 = 8.0 10 = 10 1B = 12.5 18 = 18 22 = 22	012 = 12 068 = 68 120 = 120	M ± 20% S +50% / -20% V +30% / -10% P +80% / -20% N +20%/-0% T +25% / -5%	Two digits + number of zeros. e.g. 155 = 1.5F	R = radial

Rated Voltage: 2.7V (Surge 2.85V)

Temperature Range: -40°C to +70°C (-40C ~ +85°C @ 2.3V)

Parameters measured at 25°C

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)
GY12R705012V504R	0.5	570	450	1	5	12	0.4
GY12R76C012V804R	0.8	440	350	2	6.3	12	0.66
GY12R76C012M105R	1	300	240	2	6.3	12	0.65
GY12R708012V105R	1	250	200	2	8	12	0.85
GY12R708014V205R	2	150	120	4	8	14	1
GY12R708020V305R	3	95	75	6	8	20	1.4
GY12R708020V335R	3.3	150	100	7	8	20	1.43
GY12R708025V505R	5	135	90	10	8	25	1.7
GY12R710020V505R	5	113	75	10	10	20	2.1
GY12R710020V705R	7	85	65	14	10	20	2.2
GY12R710025V106R	10	60	45	20	10	25	2.8
GY12R71B020V106R	10	68	45	20	12.5	20	3.4
GY12R710030V126R	12	50	40	24	10	30	3.2
GY12R71B025V156R	15	40	30	30	12.5	25	4.3
GY12R716020V206R	20	35	25	40	16	20	5.9
GY12R716025V256R	25	38	25	50	16	25	7.4
GY12R716030V356R	35	25	18	70	16	30	8.4
GY12R718040V506R	50	24	16	100	18	40	13.6
GY12R718060V107R	100	25	18	200	18	60	20.3
GY12R722045V107R	100	20	16	200	22	45	22.5
GY12R722045V127R	120	20	16	240	22	45	22.5
GY12R722055V187R	180	20	16	360	22	55	27

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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	5R5 = 5.5V	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

¹R = A pair of balancing 0402 resistors are used. CAP-XX strongly recommends balancing when operating above 5V to ensure longevity. Please contact CAP-XX for more information.

Rated Voltage: 5.5V (Surge 5.7V)

Temperature Range: -40°C to +70°C (-40 ~ +85°C @ 4.5V)

Parameters measured at 25°C

CAP-XX Part no.	Cap (F)	DC ESR Max (mΩ)	AC ESR Max @ 1KHz (mΩ)	IL max @ 72 Hrs (μA)	Thick x Width (mm)	Length (mm)
GY25R55E14V224RN	0.22	1130	900	1	5.5 x 11	14
GY25R56E14V334RN	0.33	880	700	2	6.5 x 13	14
GY25R56E14S474RN	0.47	900	720	2	6.5 x 13	14
GY25R58E16V504RN	0.5	530	420	2	8.5 x 17	16
GY25R58E16V105RN	1	330	260	4	8.5 x 17	16
GY25R58E22V155RN	1.5	220	170	6	8.5 x 17	22
GY25R58E27V255RN	2.5	250	200	10	8.5 x 17	27
GY25R51122V255RN	2.5	180	140	10	11 x 21	22
GY25R58E32V355RN	3.5	230	180	14	8.5 x 17	32
GY25R51122V355RN	3.5	190	150	14	11 x 21	22
GY25R51127V505RN	5	140	110	20	11 x 21	27
GY25R51323V505RN	5	130	100	20	13 x 26	23
GY25R51327V755RN	7.5	100	80	30	13 x 26	27
GY25R51724V106RN	10	90	70	40	17 x 33	24
GY25R51333V106RN	10	100	80	40	13 x 26	33
GY25R51729V126RN	12.5	80	64	50	17 x 33	29
GY25R51736V156RN	15	70	56	60	17 x 33	36
GY25R51739V206RN	20	70	56	80	17 x 33	39
GY25R51943V256RN	25	65	52	100	19 x 37	43
GY25R51953V356RN	35	70	56	140	19 x 37	53
GY25R51963V506RN	50	65	52	200	19 x 37	63

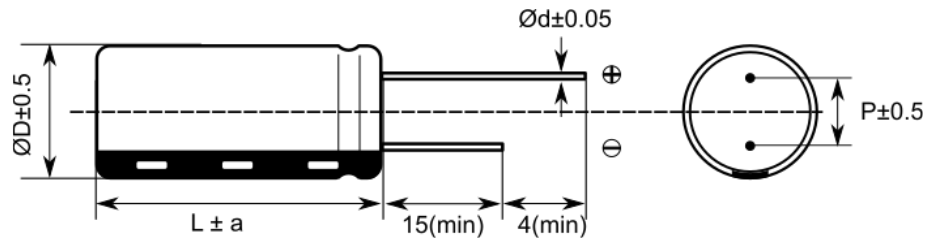
Notes:

- 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.
- Parts pass IEC62391 Endurance test at rated voltage & temperature.

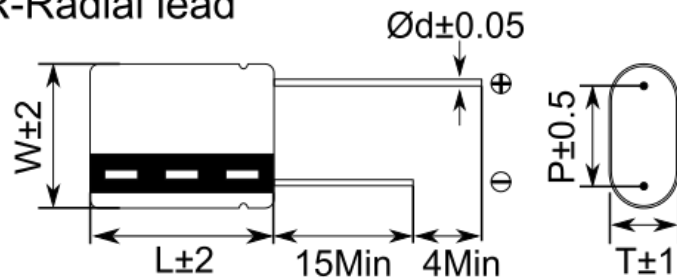
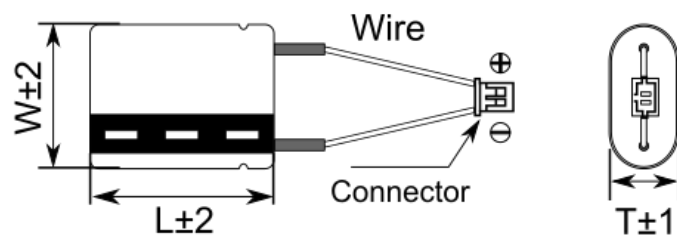
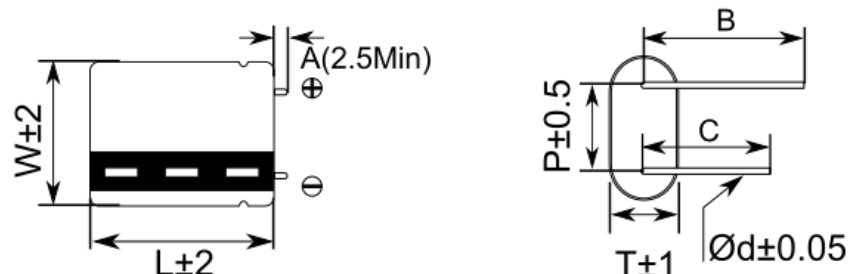
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Dimensions (all units in mm)**GY1 Series Radial Lead 0.5F – 180F**

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
19	26	0.8

R-Radial lead**T-Wire & connector****B-Bent lead**

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
	$\Delta C / C_{\text{initial}}$	$\leq 30\%$
	Final ESR	≤ 4 times of initial value
Lifespan	High temperature storage	After 1000 hours storage, without charge at 70°C.
		$\Delta C / C_{\text{initial}} \leq 30\%$, $\text{ESR}_{\text{Final}} \leq 2 \times \text{ESR}_{\text{initial}}$
	Endurance	After 1000 hours at V_R , 70°C.
		$\Delta C / C_{\text{initial}} \leq 30\%$, $\text{ESR}_{\text{Final}} \leq 4 \times \text{ESR}_{\text{initial}}$

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 $0.8 \times V_R$ to $0.4 \times V_R$ is measured to calculate capacitance as:

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

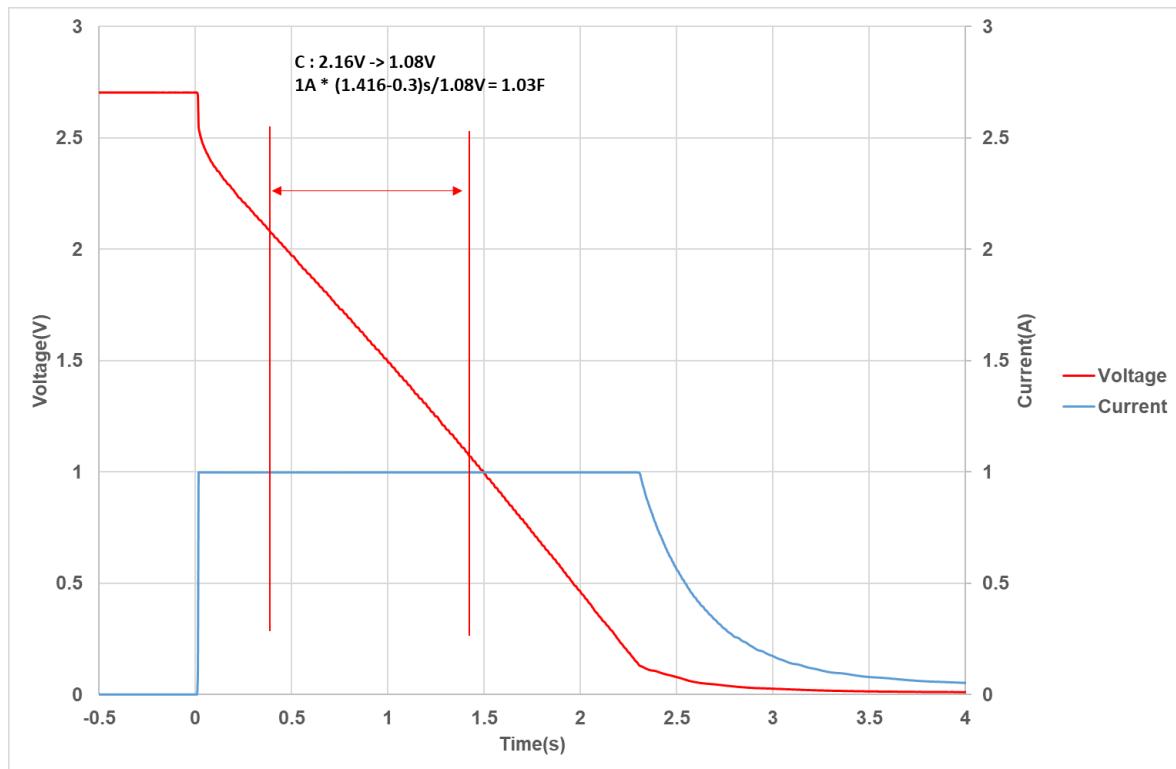


Fig 1: GY12R708012V105R Capacitance measurement

In this case, $C = 1A \times (1.416 - 0.3)s / (2.16 - 1.08)V = 1.03F$, which is well within the $1F +30\% / -10\%$ tolerance for a GY12R708012V105R 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 GY12R708012V105R the ESR is measured as $140\text{mV}/1\text{A} = 140\text{m}\Omega$ which is well below the specified maximum of 250mΩ.

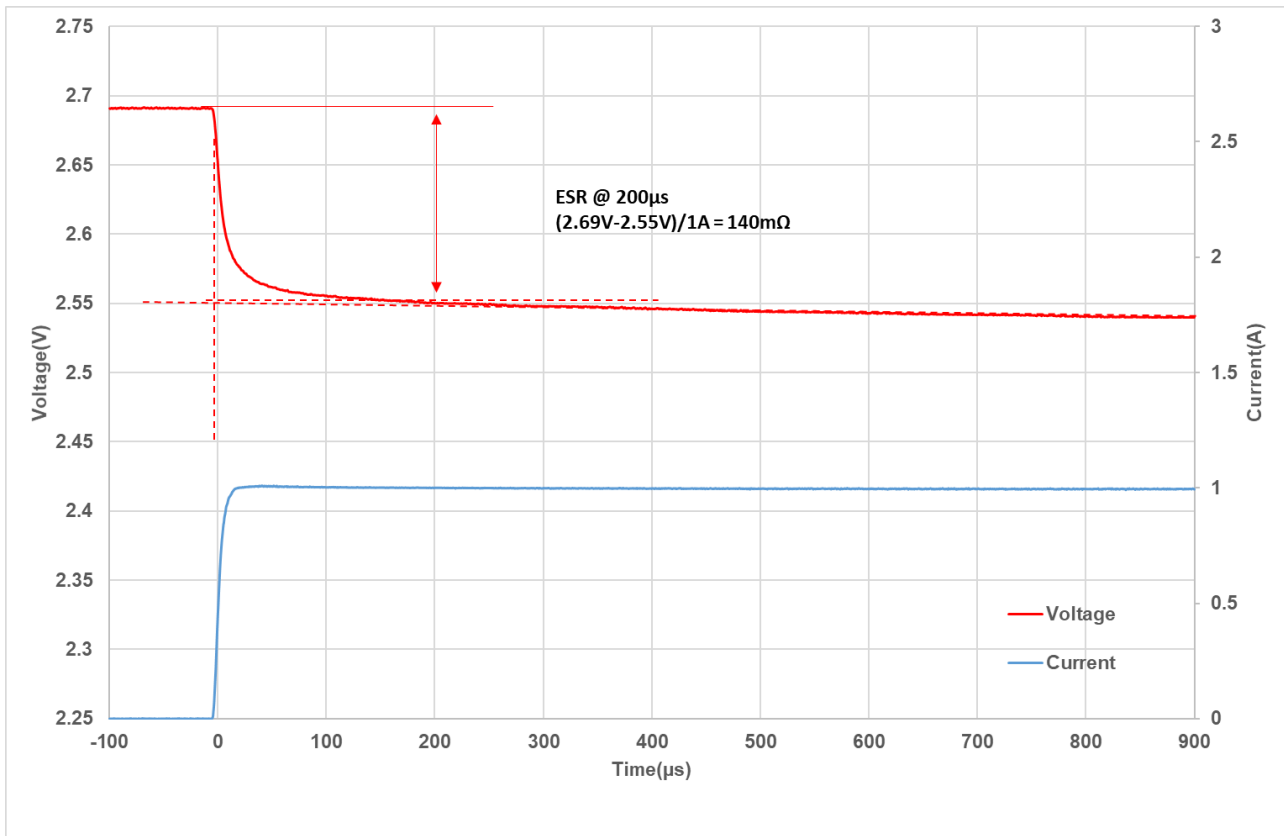


Fig 2: GY12R708012V105R ESR Measurement

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 the voltage is measured across this resistor to determine leakage current. The leakage current decays over time as shown in Fig 3 which shows the average leakage current for 4 samples each of 1F, 2F, 5F and 10F supercapacitors. The datasheet quotes the maximum values after 72hrs. Leakage current decays to its final equilibrium value after ~120hrs, typically ~1μA/F as shown in Fig 3.

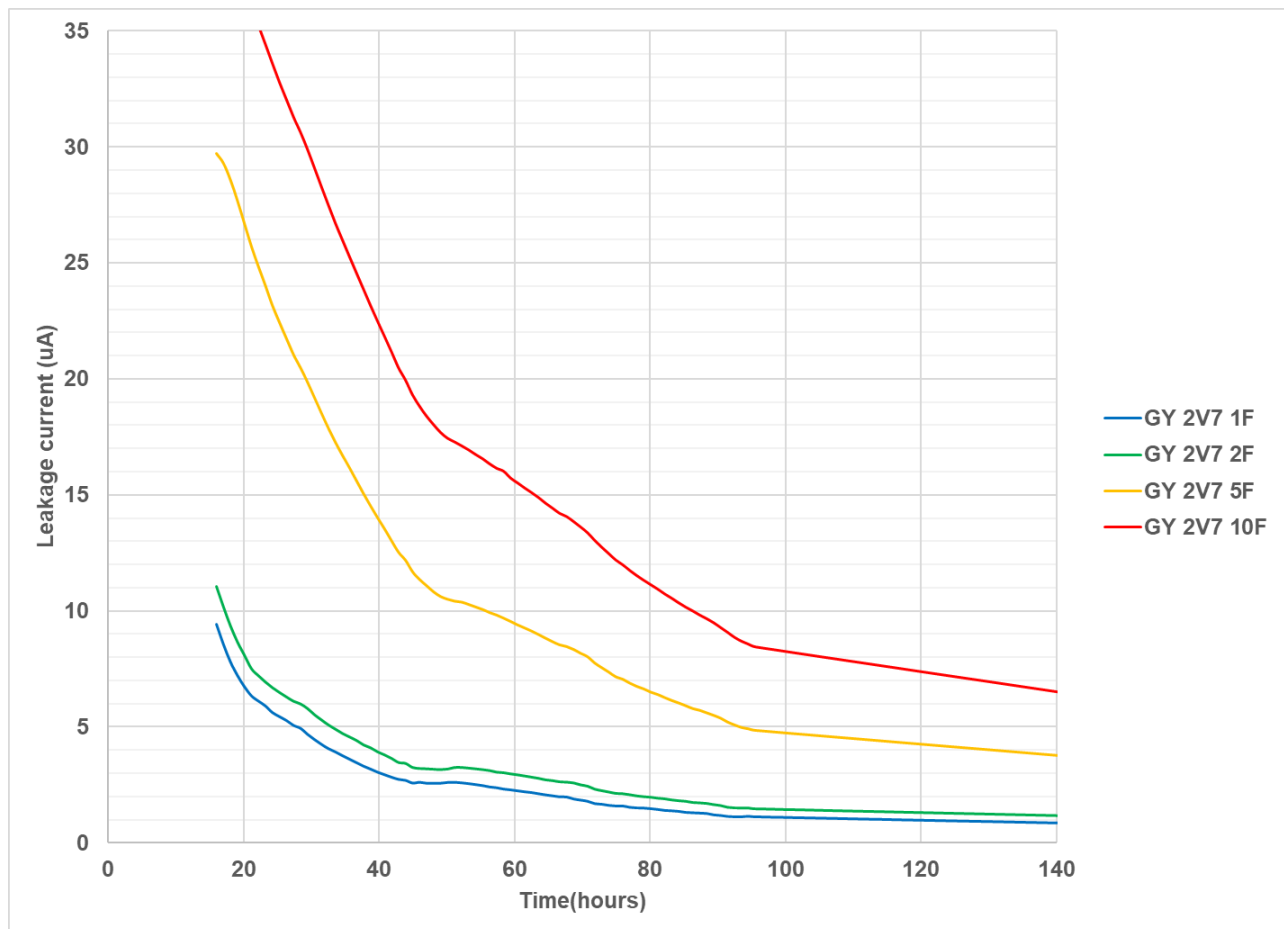


Fig 3: Leakage current measurement

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 +70°C.

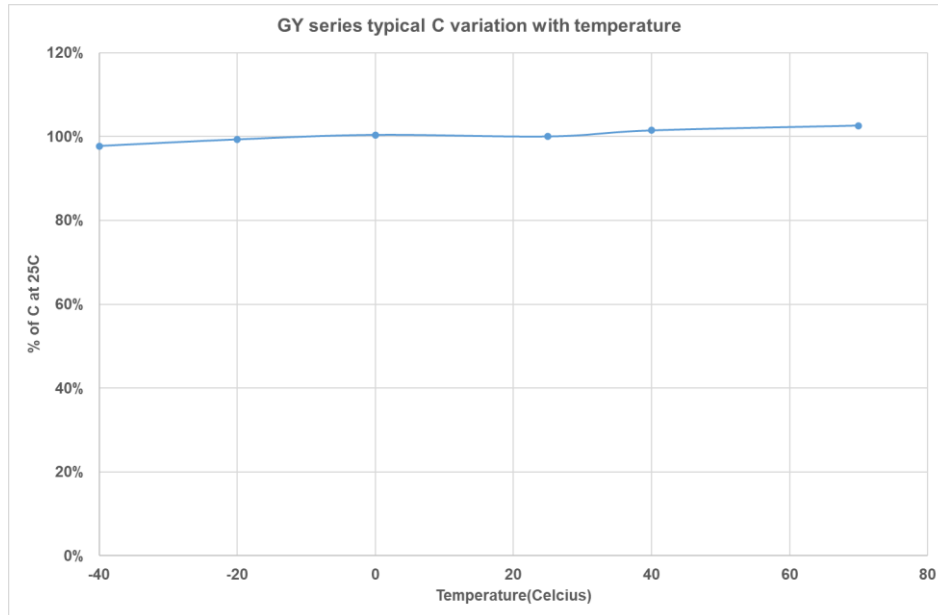


Fig 4: Typical variation in Capacitance over the operating temperature range

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

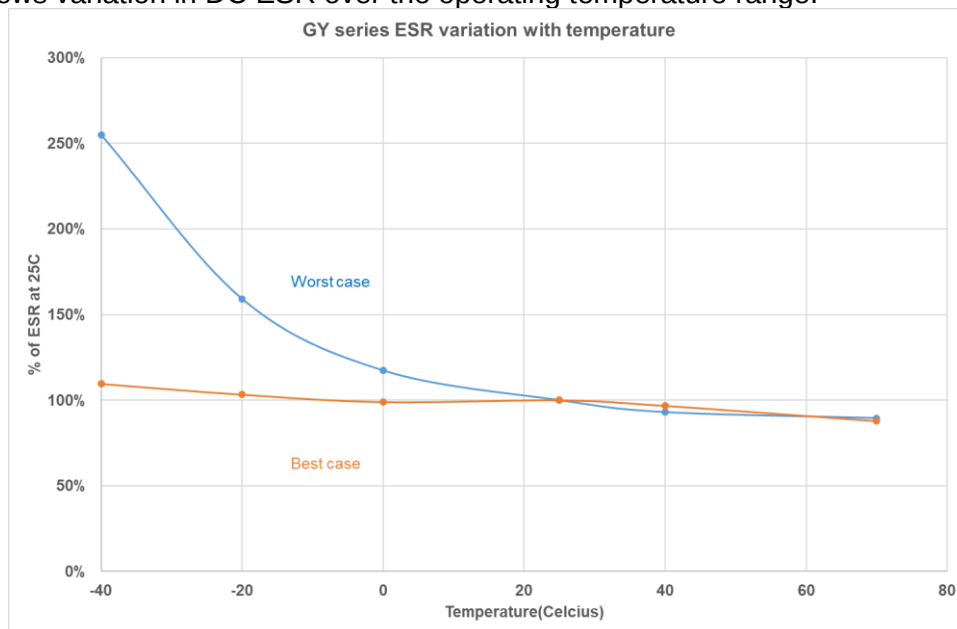


Fig 5: Typical variation in DC ESR over the operating temperature range

From Figure 5, ESR_{DC} at -40°C varies from ~2.6x to 1.1x ESR_{DC} at room temperature depending on the part. ESR_{DC} at 70°C is ~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 and the characteristics of the activated carbon used in that part.

Peak Current

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

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

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 2.7V 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	78	40	3.7
5	51	30	2.6
2	35	14	1.6
1	28	9	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 τ is applied =

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

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 =

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

Note that if the duration of the constant current, τ , is short then you will need to use $C_{eff}(\tau)$ accurately determine the voltage drop, or the max current for a given voltage drop over time τ . Please see the section on Effective Capacitance in this 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 handle. This is measured by a current square wave with 50% duty cycle, charging the supercapacitor to rated voltage at a constant current, and then discharging the supercapacitor to half rated voltage 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 GY12R7 series supercapacitors.

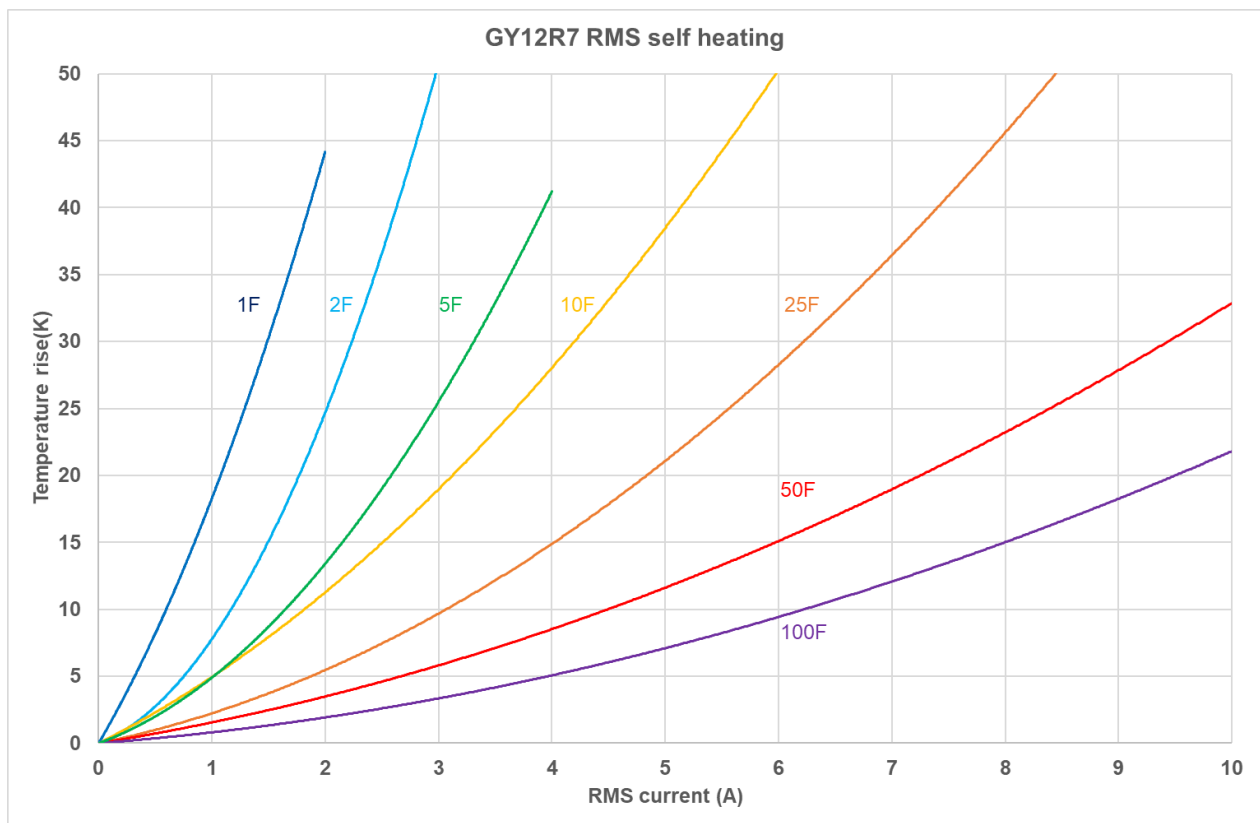


Fig 6: Self heating with RMS current for various supercapacitors

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 70°C, then the maximum RMS current for a 10F supercapacitor should be limited to 4.2A, which causes a 30°C temperature increase.

Effective capacitance (Ceff)

Effective capacitance is the capacitance seen for short pulse widths. Due to the supercapacitor's frequency response, for shorter pulse widths there will be less capacitance available than the DC capacitance. In Fig 7, consider the voltage drop due to capacitance after 10ms = 2.662V – 2.654V = 8mV. Therefore $C_{eff}(10ms) = \text{Discharge_Current} \times 10ms / \text{Voltage drop}(10ms) = 1.05A \times 0.01s / 0.008V = 1.3F$. The voltage drop due to capacitance after 100ms = 2.662V – 2.636V = 26mV, hence $C_{eff}(100ms) = 1.05A \times 0.1s / 0.026V = 4.0F$. Fig 8 shows Ceff as a % of DC capacitance for the GY series of supercapacitors.

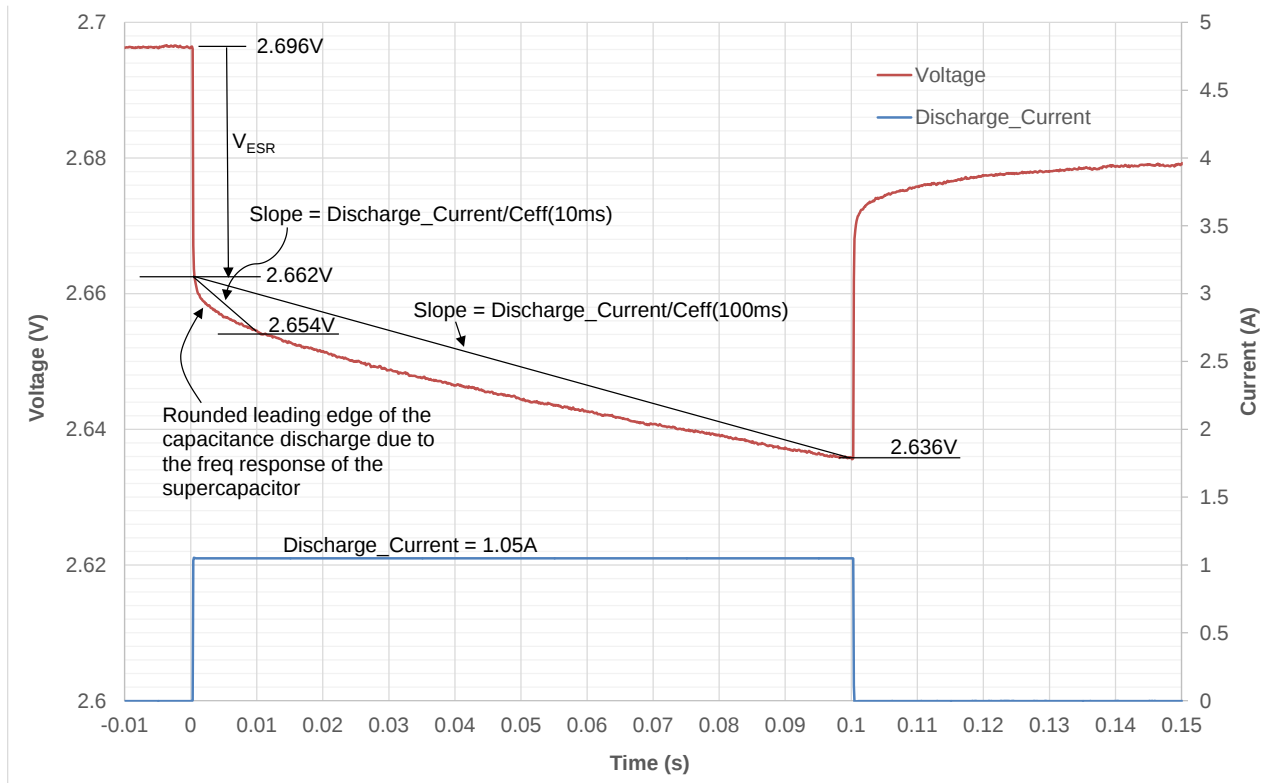


Fig 7: Discharge pulse illustrating the concept of Ceff

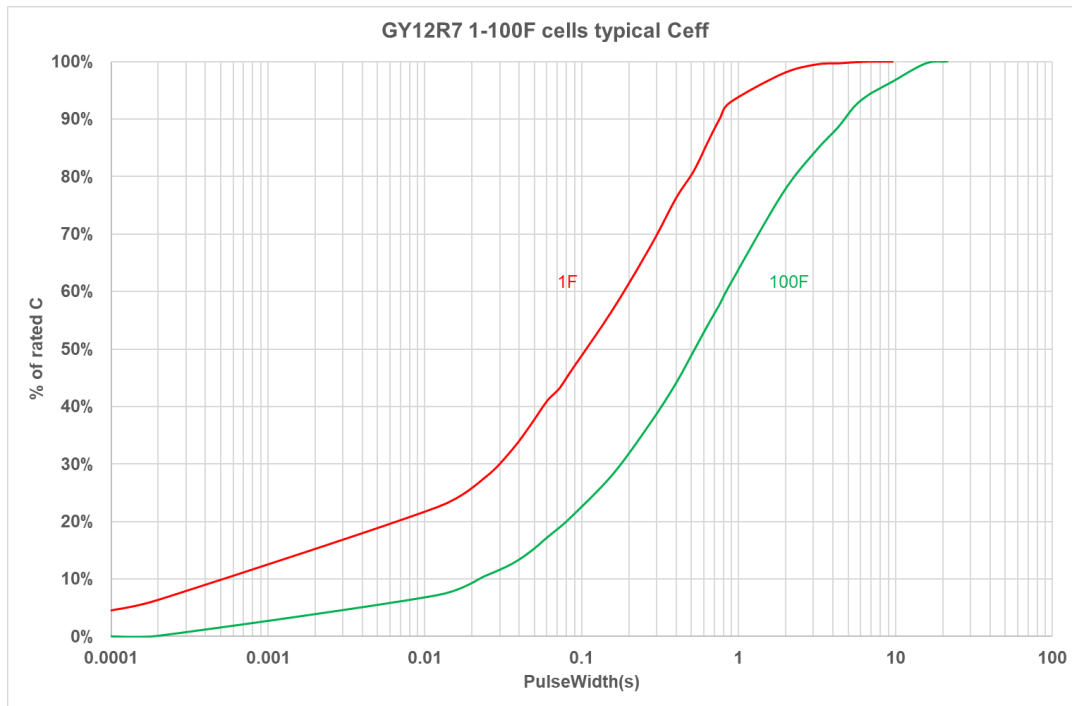


Fig 8: Typical effective capacitance range for GY 2.7V series supercapacitors

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 $\times$ % 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.

Balancing options

In many applications a voltage $> 2.7V$ but $\leq 5.5V$ is required. For these applications 2 supercapacitor cells are connected in series in dual cell modules such as the CAP-XX GY2 series which is rated to 5.5V.

Our experimental data shows in most cases these dual cylindrical cells modules self-balance sufficiently to ensure long life. However, under harsh operating condition, such as large temperature swing, high charge/discharge current, CAP-XX recommend the use of a balancing solution to ensure longevity.

In the GY2 series modules there is a PCB connecting the 2 cells. The voltage between the 2 cells must be balanced. This PCB can have one of two balancing options:

1. Option "R" as the last character in the GY2 series part number.
A pair of balancing resistors are fitted, one resistor across each cell. The balancing resistors increase leakage current drawn by the module. Thus the value of the resistor should be carefully chosen by the customer during ordering.
2. Option "N" as the last character in the GY2 series part number.
No balancing is included.

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 GY1 cells and place them in series. This makes the midpoint available to your balancing circuit. The dimensions of 2 GY1 cells placed next to each other are the same as a shrink wrapped GY2 series cell, refer to Dimensions on page 4 of this datasheet. Refer to the Application Whitepaper on Supercapacitor Cell Balancing under the DESIGN AIDS section of the CAP-XX website, www.cap-xx.com for more information on cell balancing.

Storage

CAP-XX recommends storing supercapacitors in their original packaging in an air conditioned room, preferably at $< 30^{\circ}\text{C}$ 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 $< 350^{\circ}\text{C}$ 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 $\leq 100^{\circ}\text{C}$ on the top side of the board for PCBs $\geq 0.8\text{mm}$ thick. The table below lists suggested solder temperatures.

Solder temperature $^{\circ}\text{C}$	Suggested solder time (s)
220	7
240	7
250	5
260	3

Reflow Soldering

Do not use reflow soldering on this family of EDLC.

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 = $\frac{1}{2} \times 100 \times 2.7^2 / 3600 = 0.101\text{Wh}$. Under regulation UN3499 there is no restriction on shipping these supercapacitors. Their shipping description is "Electrical Capacitors" with harmonized shipping code 8532.29.0040.