FS Series

Electronic Components KEMET CHARGED®

Overview

FS Series Supercapacitors, also known as Electric Double-Layer Capacitors (EDLCs), are intended for high energy storage applications.

Applications

Supercapacitors have characteristics ranging from traditional capacitors and batteries. As a result, supercapacitors can be used like a secondary battery when applied in a DC circuit. These devices are best suited for use in low voltage DC hold-up applications such as embedded microprocessor systems with flash memory.

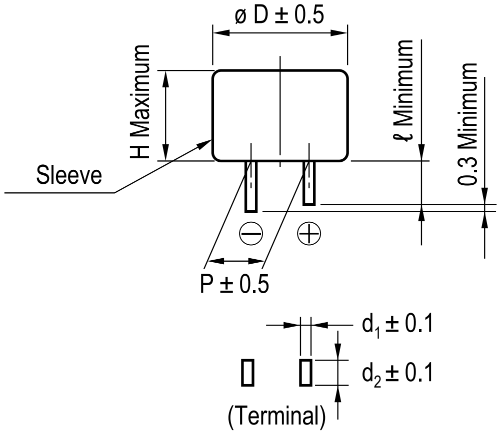
Benefits

- Wide range of temperature from -25°C to +70°C
- Maintenance free
- 5.5 VDC, 11.0 VDC, and 12.0 VDC
- Highly reliable against liquid leakage
- Lead-free and RoHS Compliant

Part Number System

FS	0H	104	Z	F
Series	Maximum Operating Voltage	Capacitance Code (F)	Capacitance Tolerance	Environmental
FS	0H = 5.5 VDC 1A = 11.0 VDC 1B = 12.0 VDC	First two digits represent significant figures. Third digit specifies number of zeros.	Z = -20/+80%	F = Lead-free

Dimensions – Millimeters



Part Number	ø D	H	P	ℓ	d_1	d_2
FS0H223ZF	11.5	8.5	5.08	2.7	0.4	1.2
FS0H473ZF	13.0	8.5	5.08	2.2	0.4	1.2
FS0H104ZF	16.5	8.5	5.08	2.7	0.4	1.2
FS0H224ZF	16.5	13.0	5.08	2.7	0.4	1.2
FS0H474ZF	21.5	13.0	7.62	3.0	0.6	1.2
FS0H105ZF	28.5	14.0	10.16	6.1	0.6	1.4
FS1A474ZF	28.5	25.5	10.16	6.1	0.6	1.4
FS1A105ZF	28.5	31.5	10.16	6.1	0.6	1.4
FS1B105ZF	28.5	38.0	10.16	6.1	0.6	1.4
FS1B505ZF	44.8	60.0	20.00	9.5	1.0	1.4

Performance Characteristics

Supercapacitors should not be used for applications such as ripple absorption because of their high internal resistance (several hundred mΩ to a hundred Ω) compared to aluminum electrolytic capacitors. Thus, its main use would be similar to that of secondary battery such as power back-up in DC circuit. The following list shows the characteristics of supercapacitors as compared to aluminum electrolytic capacitors for power back-up and secondary batteries.

	Secondary Battery		Capacitor	
	NiCd	Lithium Ion	Aluminum Electrolytic	Supercapacitor
Back-up ability	–	–	–	–
Eco-hazard	Cd	–	–	–
Operating Temperature Range	-20 to +60°C	-20 to +50°C	-55 to +105°C	-40 to +85°C (FR, FT)
Charge Time	few hours	few hours	few seconds	few seconds
Charge/Discharge Life Time	approximately 500 times	approximately 500 to 1,000 times	limitless (*1)	limitless (*1)
Restrictions on Charge/Discharge	yes	yes	none	none
Flow Soldering	not applicable	not applicable	applicable	applicable
Automatic Mounting	not applicable	not applicable	applicable	applicable (FM and FC series)
Safety Risks	leakage, explosion	leakage, combustion, explosion, ignition	heat-up, explosion	gas emission (*2)

*(*1) Aluminum electrolytic capacitors and supercapacitors have limited lifetime. However, when used under proper conditions, both can operate within a predetermined lifetime.*
*(*2) There is no harm as it is a mere leak of water vapor which transitioned from water contained in the electrolyte (diluted sulfuric acid). However, application of abnormal voltage surge exceeding maximum operating voltage may result in leakage and explosion.*

Typical Applications

Intended Use (Guideline)	Power Supply (Guideline)	Application	Examples of Equipment	Series
Back-up for 1 hour or less	50 mA and below	Embedded memory backup	DVD player, television, game console, set-top box	FS series
		Motor driver	DVD player, printer, projector, camera	

Environmental Compliance

All KEMET supercapacitors are RoHS Compliant.

RoHS Compliant

Table 1 – Ratings & Part Number Reference

Part Number	Maximum Operating Voltage (VDC)	Nominal Capacitance		Maximum ESR @ 1 kHz (Ω)	Maximum Current @ 30 Minutes (mA)	Weight (g)
		Charge System (F)	Discharge System (F)			
FS0H223ZF	5.5	0.022	0.033	60.0	0.033	1.6
FS0H473ZF	5.5	0.047	0.072	40.0	0.071	2.6
FS0H104ZF	5.5	0.10	0.15	25.0	0.15	4.1
FS0H224ZF	5.5	0.22	0.33	25.0	0.33	5.3
FS0H474ZF	5.5	0.47	0.75	13.0	0.71	10
FS0H105ZF	5.5	1.0	1.3	7.0	1.5	18
FS1A474ZF	11.0	0.47	0.60	7.0	1.41	32
FS1A105ZF	11.0	1.0	1.3	7.0	3.0	35
FS1B105ZF	12.0	1.0	1.3	7.5	3.6	40
FS1B505ZF	12.0	5.0	6.5	4.0	18.0	160

Part numbers in bold type represent popularly purchased components.

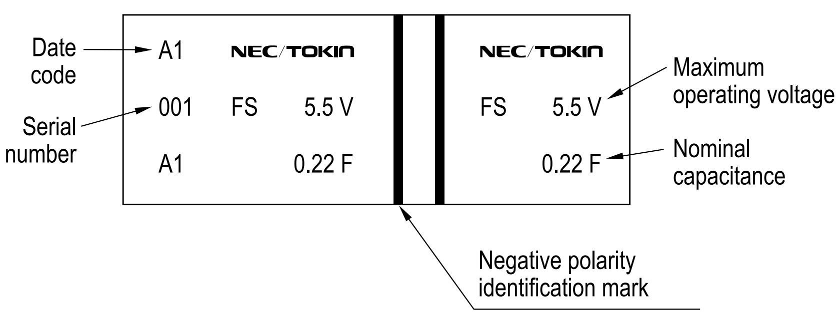
Specifications

Item			FS Type	Test Conditions (conforming to JIS C 5160-1)
Category Temperature Range			-25°C to +70°C	
Maximum Operating Voltage			5.5 VDC, 11 VDC, 12 VDC	
Capacitance			Refer to Table 1	Refer to "Measurement Conditions"
Capacitance Allowance			+80%, -20%	Refer to "Measurement Conditions"
ESR			Refer to Table 1	Measured at 1 kHz, 10 mA; See also "Measurement Conditions"
Current (30 minutes value)			Refer to Table 1	Refer to "Measurement Conditions"
Surge	Capacitance		> 90% of initial ratings	Surge voltage: 6.3 V (5.5 V type), 12.6 V (11 V type), 13.6 V (12 V type) Charge: 30 seconds Discharge: 9 minutes 30 seconds Number of cycles: 1,000 Series resistance: 0.022 F 560 Ω; 0.047 F 300 Ω; 0.10 F 150 Ω; 0.22 F 56 Ω; 0.47 F 30 Ω; 1.0 F 15 Ω; 5.0 F 10 Ω Discharge resistance: 0 Ω Temperature: 70 ±2°C
	ESR		≤ 120% of initial ratings	
	Current (30 minutes value)		≤ 120% of initial ratings	
	Appearance		No obvious abnormality	
Characteristics in Different Temperature	Capacitance	Phase 2	≥ 50% of initial value	Conforms to 4.17 Phase 1: +25 ±2°C Phase 2: -25 ±2°C Phase 4: +25 ±2°C Phase 5: +70 ±2°C Phase 6: +25 ±2°C
	ESR	Phase 2	≤ 400% of initial value	
	Capacitance	Phase 3		
	ESR	Phase 3		
	Capacitance	Phase 5	≤ 150% of initial value	
	ESR	Phase 5	Satisfy initial ratings	
	Current (30 minutes value)	Phase 5	≤ 1.5 CV (mA)	
	Capacitance	Phase 6	Within ±20% of initial value	
	ESR	Phase 6	Satisfy initial ratings	
	Current (30 minutes value)	Phase 6	Satisfy initial ratings	
Lead Strength (tensile)			No terminal damage	Conforms to 4.9
Vibration Resistance	Capacitance		Satisfy initial ratings	Conforms to 4.13 Frequency: 10 to 55 Hz Testing Time: 6 hours
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		Satisfy initial ratings	
	Appearance		No obvious abnormality	
Solderability			Over 3/4 of the terminal should be covered by the new solder	Conforms to 4.11 Solder temp: +245 ±5°C Dipping time: 5 ±0.5 seconds 1.6 mm from the bottom should be dipped.
Solder Heat Resistance	Capacitance		Satisfy initial ratings	Conforms to 4.10 Solder temp: +260 ±10°C Dipping time: 10 ±1 seconds 1.6 mm from the bottom should be dipped.
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		Satisfy initial ratings	
	Appearance		No obvious abnormality	

Specifications cont'd

Item		FS Type	Test Conditions (conforming to JIS C 5160-1)
Temperature Cycle	Capacitance	Satisfy initial ratings	Conforms to 4.12 Temperature Condition: -25°C→ Room temperature→ +70°C→ Room temperature Number of cycles: 5 cycles
	ESR		
	Current (30 minutes value)		
	Appearance	No obvious abnormality	
High Temperature and High Humidity Resistance	Capacitance	Within ±20% of initial value	Conforms to 4.14 Temperature: +40 ±2°C Relative humidity: 90 to 95% RH Testing time: 240 ±8 hours
	ESR	≤ 120% of initial ratings	
	Current (30 minutes value)	≤ 120% of initial ratings	
	Appearance	No obvious abnormality	
High Temperature Load	Capacitance	Within ±30% of initial value	Conforms to 4.15 Temperature: +70 ±2°C Voltage applied: Maximum operating voltage Series protection resistance: 0 Ω Testing time: 1,000 +48 (+48/-0) hours
	ESR	< 200% of initial ratings	
	Current (30 minutes value)	< 200% of initial ratings	
	Appearance	No obvious abnormality	

Marking



Packaging Quantities

Part Number	Bulk Quantity per Box
FS0H223ZF	1,000 pieces
FS0H473ZF	800 pieces
FS0H104ZF	600 pieces
FS0H224ZF	400 pieces
FS0H474ZF	90 pieces
FS0H105ZF	50 pieces
FS1A474ZF	50 pieces
FS1A105ZF	50 pieces
FS1B105ZF	50 pieces
FS1B505ZF	20 pieces

List of Plating & Sleeve Type

By changing the solder plating from leaded solder to lead-free solder and the outer tube material of can-cased conventional supercapacitor from polyvinyl chloride to polyethylene terephthalate (PET), our supercapacitor is now even friendlier to the environment.

a. Iron + copper base + lead-free solder plating (Sn-1Cu)
b. SUS nickel base + copper base + reflow lead-free solder plating (100% Sn, reflow processed)

Series	Part Number	Plating	Sleeve
FS	All FS Types	a	PET (Blue)

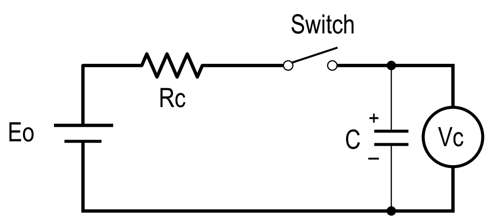
Recommended Pb-free solder : Sn / 3.5Ag / 0.75Cu
Sn / 3.0Ag / 0.5Cu
Sn / 0.7Cu
Sn / 2.5Ag / 1.0Bi / 0.5Cu

Measurement Conditions

Capacitance (Charge System)

Capacitance is calculated from expression (9) by measuring the charge time constant (τ) of the capacitor (C). Prior to measurement, the capacitor is discharged by shorting both pins of the device for at least 30 minutes. In addition, use the polarity indicator on the device to determine correct orientation of capacitor for charging.

$$\text{Capacitance: } C = \frac{\tau}{Rc} \text{ (F)} \quad (9)$$



Eo: 3.0 (V) Product with maximum operating voltage of 3.5 V
5.0 (V) Product with maximum operating voltage of 5.5 V
6.0 (V) Product with maximum operating voltage of 6.5 V
10.0 (V) Product with maximum operating voltage of 11 V
12.0 (V) Product with maximum operating voltage of 12 V

τ: Time from start of charging until Vc becomes 0.632 Eo (V) (seconds)

Rc: See table below (Ω).

Charge Resistor Selection Guide

Cap	FA	FE	FS	FY			FR	FM, FME FMR, FML	FMC	FG FGR	FGH	FT	FC, FCS	HV
				FYD	FYH	FYL								
0.010 F	–	–	–	–	–	5000 Ω	–	5000 Ω	–	5000 Ω	–	–	–	–
0.022 F	1000 Ω	–	1000 Ω	2000 Ω	2000 Ω	2000 Ω	2000 Ω	2000 Ω	–	2000 Ω	–	–	Discharge	–
0.033 F	–	–	–	–	–	–	–	Discharge	–	–	–	–	–	–
0.047 F	1000 Ω	1000 Ω	1000 Ω	2000 Ω	1000 Ω	2000 Ω	1000 Ω	2000 Ω	1000 Ω	2000 Ω	–	–	–	–
0.10 F	510 Ω	510 Ω	510 Ω	1000 Ω	510 Ω	–	1000 Ω	1000 Ω	1000 Ω	1000 Ω	Discharge	510 Ω	Discharge	–
0.22 F	200 Ω	200 Ω	200 Ω	510 Ω	510 Ω	–	510 Ω	0H: Discharge 0V: 1000 Ω	–	1000 Ω	Discharge	200 Ω	Discharge	–
0.33 F	–	–	–	–	–	–	–	–	Discharge	–	–	–	–	–
0.47 F	100 Ω	100 Ω	100 Ω	200 Ω	200 Ω	–	200 Ω	–	–	1000 Ω	Discharge	100 Ω	Discharge	–
1.0 F	51 Ω	51 Ω	100 Ω	100 Ω	100 Ω	–	100 Ω	–	–	510 Ω	Discharge	100 Ω	Discharge	Discharge
1.4 F	–	–	–	200 Ω	–	–	–	–	–	–	–	–	–	–
1.5 F	–	51 Ω	–	–	–	–	–	–	–	510 Ω	–	–	–	–
2.2 F	–	–	–	100 Ω	–	–	–	–	–	200 Ω	–	51 Ω	–	–
2.7 F	–	–	–	–	–	–	–	–	–	–	–	–	–	Discharge
3.3 F	–	–	–	–	–	–	–	–	–	–	–	51 Ω	–	–
4.7 F	–	–	–	–	–	–	–	–	–	100 Ω	–	–	–	Discharge
5.0 F	–	–	100 Ω	–	–	–	–	–	–	–	–	–	–	–
5.6 F	–	–	–	–	–	–	–	–	–	–	–	20 Ω	–	–
10.0 F	–	–	–	–	–	–	–	–	–	–	–	–	–	Discharge
22.0 F	–	–	–	–	–	–	–	–	–	–	–	–	–	Discharge
50.0 F	–	–	–	–	–	–	–	–	–	–	–	–	–	Discharge
100.0 F	–	–	–	–	–	–	–	–	–	–	–	–	–	Discharge
200.0 F	–	–	–	–	–	–	–	–	–	–	–	–	–	Discharge

*Capacitance values according to the constant current discharge method.

*HV Series capacitance is measured by discharge system

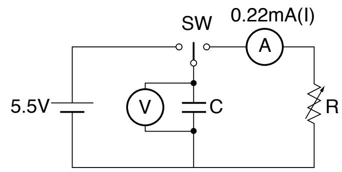
Measurement Conditions cont'd

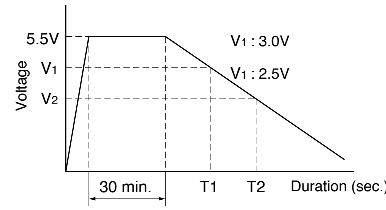
Capacitance (Discharge System)

As shown in the diagram below, charging is performed for a duration of 30 minutes once the voltage of the capacitor terminal reaches 5.5 V. Then, use a constant current load device and measure the time for the terminal voltage to drop from 3.0 to 2.5 V upon discharge at 0.22 mA per 0.22 F, for example, and calculate the static capacitance according to the equation shown below.

Note: The current value is 1 mA discharged per 1 F.

$$C = \frac{I \times (T_2 - T_1)}{V_1 - V_2} \quad (F)$$

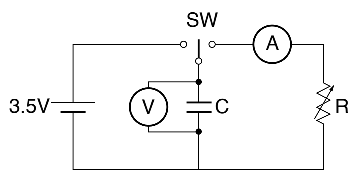


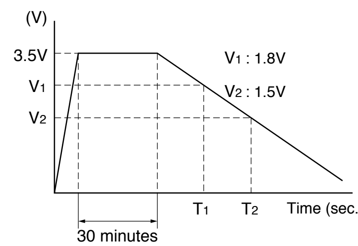


Capacitance (Discharge System – 3.5 V)

As shown in the diagram below, charging is performed for a duration of 30 minutes once the voltage of the capacitor terminal reaches 3.5 V. Then, use a constant current load device and measure the time for the terminal voltage to drop from 1.8 to 1.5 V upon discharge at 1.0 mA per 1.0 F, for example, and calculate the static capacitance according to the equation shown below.

$$C = \frac{I \times (T_2 - T_1)}{V_1 - V_2} \quad (F)$$

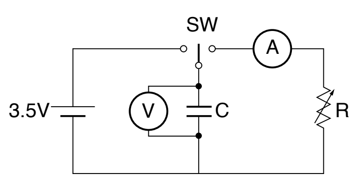


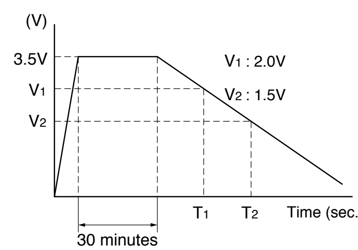


Capacitance (Discharge System – HV Series)

As shown in the diagram below, charging is performed for a duration of 30 minutes once the voltage of the capacitor terminal reaches maximum operating voltage. Then, use a constant current load device and measure the time for the terminal voltage to drop from 2.0 to 1.5 V upon discharge at 1.0 mA per 1.0 F, and calculate the static capacitance according to the equation shown below.

$$C = \frac{I \times (T_2 - T_1)}{V_1 - V_2} \quad (F)$$

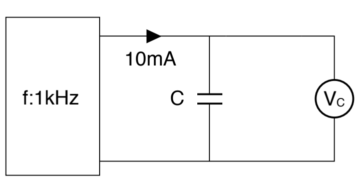




Equivalent Series Resistance (ESR)

ESR shall be calculated from the equation below.

$$ESR = \frac{V_C}{0.01} \quad (\Omega)$$



Measurement Conditions cont'd

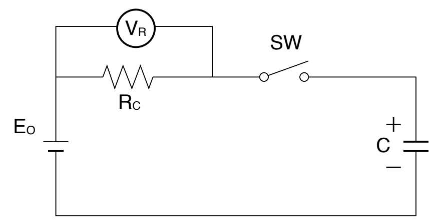
Current (at 30 minutes after charging)

Current shall be calculated from the equation below. Prior to measurement, both lead terminals must be short-circuited for a minimum of 30 minutes. The lead terminal connected to the metal can case is connected to the negative side of the power supply.

Eo: 2.5 VDC (HV Series 50 F)
2.7 VDC (HV Series except 50 F)
3.0 VDC (3.5 V type)
5.0 VDC (5.5 V type)

Rc: 1000 Ω (0.010 F, 0.022 F, 0.047 F)
100 Ω (0.10 F, 0.22 F, 0.47 F)
10 Ω (1.0 F, 1.5 F, 2.2 F, 4.7 F)
2.2 Ω (HV Series)

$$\text{Current} = \frac{V_R}{R_C}\ (\text{A})$$



Self-Discharge Characteristic (0H – 5.5 V Products)

The self-discharge characteristic is measured by charging a voltage of 5.0 VDC (charge protection resistance: 0 Ω) according to the capacitor polarity for 24 hours, then releasing between the pins for 24 hours and measuring the pin-to-pin voltage. The test should be carried out in an environment with an ambient temperature of 25° C or below and relative humidity of 70% RH or below.

the soldering is checked.

4. Dismantling

There is a small amount of electrolyte stored within the capacitor. Do not attempt to dismantle as direct skin contact with the electrolyte will cause burning. This product should be treated as industrial waste and not is not to be disposed of by fire.

Notes on Using Supercapacitors or Electric Double-Layer Capacitors (EDLCs)

1. Circuitry Design

1.1 Useful life

The FC Series Supercapacitor (EDLC) uses an electrolyte in a sealed container. Water in the electrolyte can evaporate while in use over long periods of time at high temperatures, thus reducing electrostatic capacity which in turn will create greater internal resistance. The characteristics of the supercapacitor can vary greatly depending on the environment in which it is used. Basic breakdown mode is an open mode due to increased internal resistance.

1.2 Fail rate in the field

Based on field data, the fail rate is calculated at approximately 0.006 Fit. We estimate that unreported failures are ten times this amount. Therefore, we assume that the fail rate is below 0.06 Fit.

1.3 Exceeding maximum usable voltage

Performance may be compromised and in some cases leakage or damage may occur if applied voltage exceeds maximum working voltage.

1.4 Use of capacitor as a smoothing capacitor (ripple absorption)

As supercapacitors contain a high level of internal resistance, they are not recommended for use as smoothing capacitors in electrical circuits. Performance may be compromised and, in some cases, leakage or damage may occur if a supercapacitor is used in ripple absorption.

1.5 Series connections

As applied voltage balance to each supercapacitor is lost when used in series connection, excess voltage may be applied to some supercapacitors, which will not only negatively affect its performance but may also cause leakage and/or damage. Allow ample margin for maximum voltage or attach a circuit for applying equal voltage to each supercapacitor (partial pressure resistor/voltage divider) when using supercapacitors in series connection. Also, arrange supercapacitors so that the temperature between each capacitor will not vary.

1.6 Case Polarity

The supercapacitor is manufactured so that the terminal on the outer case is negative (-). Align the (-) symbol during use. Even though discharging has been carried out prior to shipping, any residual electrical charge may negatively affect other parts.

1.7 Use next to heat emitters

Useful life of the supercapacitor will be significantly affected if used near heat emitting items (coils, power transistors and posistors, etc.) where the supercapacitor itself may become heated.

1.8 Usage environment

This device cannot be used in any acidic, alkaline or similar type of environment.

Notes on Using Supercapacitors or Electric Double-Layer Capacitors (EDLCs) cont'd

2. Mounting

2.1 Mounting onto a reflow furnace
Except for the FC series, it is not possible to mount this capacitor onto an IR / VPS reflow furnace. Do not immerse the capacitor into a soldering dip tank.

2.2 Flow soldering conditions
See Recommended Reflow Curves in Section – Precautions for Use

2.3 Installation using a soldering iron
Care must be taken to prevent the soldering iron from touching other parts when soldering. Keep the tip of the soldering iron under 400ºC and soldering time to within 3 seconds. Always make sure that the temperature of the tip is controlled. Internal capacitor resistance is likely to increase if the terminals are overheated.

2.4 Lead terminal processing
Do not attempt to bend or polish the capacitor terminals with sand paper, etc. Soldering may not be possible if the metallic plating is removed from the top of the terminals.

2.5 Cleaning, Coating, and Potting
Except for the FM series, cleaning, coating and potting must not be carried out. Consult KEMET if this type of procedure is necessary. Terminals should be dried at less than the maximum operating temperature after cleaning.

3. Storage

3.1 Temperature and humidity
Make sure that the supercapacitor is stored according to the following conditions: Temperature: 5 – 35ºC (Standard 25ºC), Humidity: 20 – 70% (Standard: 50%). Do not allow the build up of condensation through sudden temperature change.

3.2 Environment conditions
Make sure there are no corrosive gasses such as sulfur dioxide, as penetration of the lead terminals is possible. Always store this item in an area with low dust and dirt levels. Make sure that the packaging will not be deformed through heavy loading, movement and/or knocks. Keep out of direct sunlight and away from radiation, static electricity and magnetic fields.

3.3 Maximum storage period
This item may be stored up to one year from the date of delivery if stored at the conditions stated above.

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