Supercapacitors

FC Series

Overview

FC Series Supercapacitors, also known as Electric Double-Layer Capacitors (EDLCs), are surface mount type components intended for high energy storage applications. The FC Series is designed specifically for reflow soldering, allowing them to be attached to a printed circuit board (PCB) directly.

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.

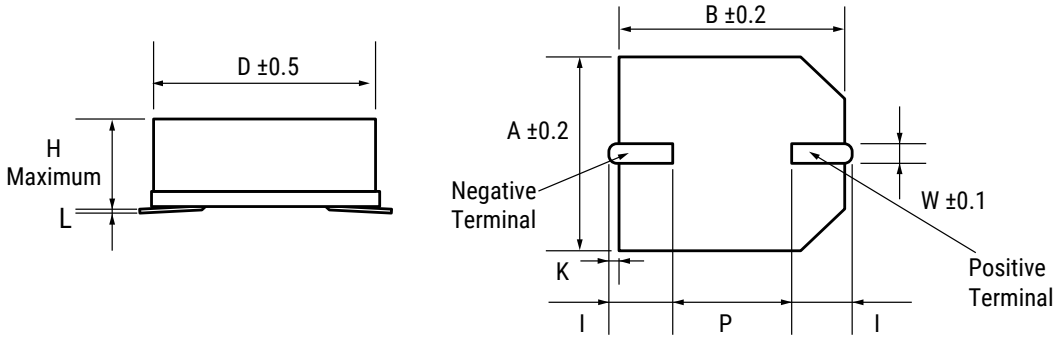
Benefits

- Surface mount without holder
- Wide range of temperature from −25°C to +70°C
- Maintenance free
- Maximum operating voltages of 3.5 and 5.5 VDC
- Highly reliable against liquid leakage
- Lead-free and RoHS Compliant

Part Number System

FC	0H	104	Z	F	TB	R	24	–SS
Series Surface Mount	Maximum Operating Voltage	Capacitance Code	Capacitance Tolerance	Environmental	Tape Type	Orientation	Tape Width	C-Spec
FCS FC	0V = 3.5 VDC 0H = 5.5 VDC	First two digits represent significant figures. Third digit specifies number of zeros to follow µF code.	Z = −20/+80%	F = Lead-free	TB = Embossed	R = Positive electrode forward	24 = 24 mm 32 = 32 mm 44 = 44 mm	–SS = 3 digit serial number marked on top Blank = No serial number marking

Dimensions – Millimeters



Part Number	D	H	A	B	I	W	P	K	L	Reflow Peak Temperature
FC0H473ZFTBR24	10.5	5.5	10.8	10.8	3.6±0.5	1.2	5.0	0.7±0.3	0 (+0.3/−0.1)	235°C
FC0H104ZFTBR24	10.5	5.5	10.8	10.8	3.6±0.5	1.2	5.0	0.7±0.3	0 (+0.3/−0.1)	235°C
FC0H224ZFTBR24	10.5	8.5	10.8	10.8	3.6±0.5	1.2	5.0	0.7±0.3	0 (+0.3/−0.1)	235°C
FC0H474ZFTBR32–SS	16.0	9.5	16.3	16.3	6.8±1.0	1.2	5.0	1.2±0.5	0 (+0.5/−0.1)	235°C
FC0H105ZFTBR44–SS	21.0	10.5	21.6	21.6	7.0±1.0	1.4	10.0	1.2±0.5	0 (+0.5/−0.1)	235°C
FC0V104ZFTBR24	10.5	5.5	10.8	10.8	3.6±0.5	1.2	5.0	0.7±0.3	0 (+0.3/−0.1)	235°C
FC0V224ZFTBR24	10.5	5.5	10.8	10.8	3.6±0.5	1.2	5.0	0.7±0.3	0 (+0.3/−0.1)	235°C
FC0V474ZFTBR24	10.5	8.5	10.8	10.8	3.6±0.5	1.2	5.0	0.7±0.3	0 (+0.3/−0.1)	235°C
FCS0H473ZFTBR24	10.7	5.5	10.8	10.8	3.9±0.5	1.2	5.0	0.9±0.3	0 (+0.3/−0.1)	260°C
FCS0H104ZFTBR24	10.7	5.5	10.8	10.8	3.9±0.5	1.2	5.0	0.9±0.3	0 (+0.3/−0.1)	260°C
FCS0H224ZFTBR24	10.7	8.5	10.8	10.8	3.9±0.5	1.2	5.0	0.9±0.3	0 (+0.3/−0.1)	260°C
FCS0V104ZFTBR24	10.7	5.5	10.8	10.8	3.9±0.5	1.2	5.0	0.9±0.3	0 (+0.3/−0.1)	260°C
FCS0V224ZFTBR24	10.7	5.5	10.8	10.8	3.9±0.5	1.2	5.0	0.9±0.3	0 (+0.3/−0.1)	260°C
FCS0V474ZFTBR24	10.7	8.5	10.8	10.8	3.9±0.5	1.2	5.0	0.9±0.3	0 (+0.3/−0.1)	260°C

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, FMR type)
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
Long time back-up	500 µA and below	CMOS microcomputer, IC for clocks	CMOS microcomputer, static RAM/DTS (digital tuning system)	FC series

Environmental Compliance

All KEMET supercapacitors are RoHS Compliant.

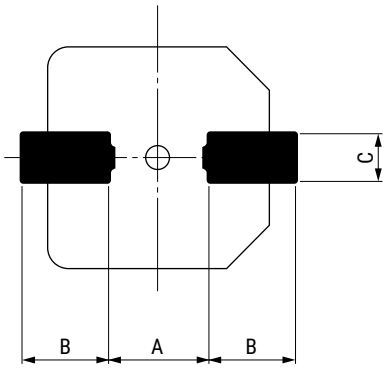
RoHS

Table 1 – Ratings & Part Number Reference

Part Number	Maximum Operating Voltage (VDC)	Nominal Capacitance Discharge System (F)	Maximum ESR at 1 kHz (Ω)	Maximum Current at 30 Minutes (mA)	Voltage Holding Characteristic Minimum (V)	Weight (g)
FC0V104ZFTBR24	3.5	0.10	50	0.09	–	1.0
FCS0V104ZFTBR24	3.5	0.10	100	0.09	–	1.0
FC0V224ZFTBR24	3.5	0.22	25	0.20	–	1.0
FCS0V224ZFTBR24	3.5	0.22	50	0.20	–	1.0
FC0V474ZFTBR24	3.5	0.47	25	0.42	–	1.4
FCS0V474ZFTBR24	3.5	0.47	50	0.42	–	1.4
FC0H473ZFTBR24	5.5	0.047	50	0.071	4.2	1.0
FCS0H473ZFTBR24	5.5	0.047	100	0.071	4.2	1.0
FC0H104ZFTBR24	5.5	0.10	25	0.15	4.2	1.0
FCS0H104ZFTBR24	5.5	0.10	50	0.15	4.2	1.0
FC0H224ZFTBR24	5.5	0.22	25	0.33	4.2	1.4
FCS0H224ZFTBR24	5.5	0.22	50	0.33	4.2	1.4
FC0H474ZFTBR32–SS	5.5	0.47	13	0.71	4.2	4.0
FC0H105ZFTBR44–SS	5.5	1.0	7	1.50	4.2	6.7

Part numbers in bold type represent popularly purchased components.

Land Pattern



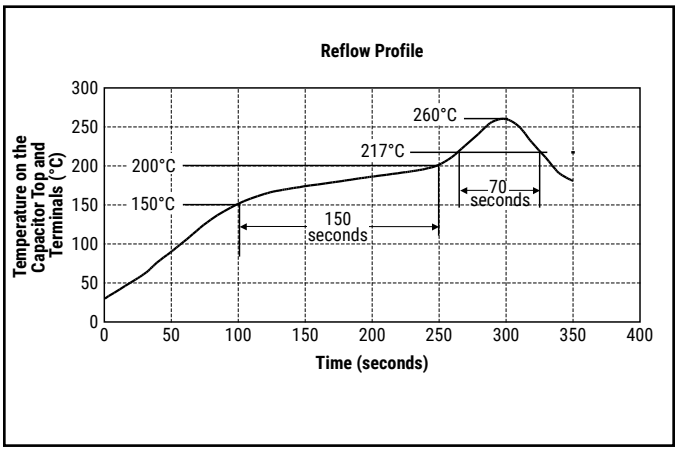
	Land Pattern			Lead Terminal		
Diameter (mm)	A	B	C	A	B	C
10.5	5.0	4.9	2.5	5.0	3.6	1.2
10.7	5.0	4.9	2.5	5.0	3.9	1.2
16	5.0	10.0	2.5	5.0	6.8	1.2
21	10.0	10.5	3.5	10.0	7.0	1.4

Precautions for Use

- This series is exclusively for reflow soldering. It is designed for thermal conduction system such as combination use of infrared ray and heat blow. Consult with KEMET before applying other methods.
- The reflow condition must be kept within reflow profile graphs shown below.
- Applying reflow soldering is limited to 2 times. After the first reflow, cool down the capacitor thoroughly to 5 – 35°C before the second reflow.

Always consult with KEMET when applying reflow soldering in a more severe condition than the condition described here.

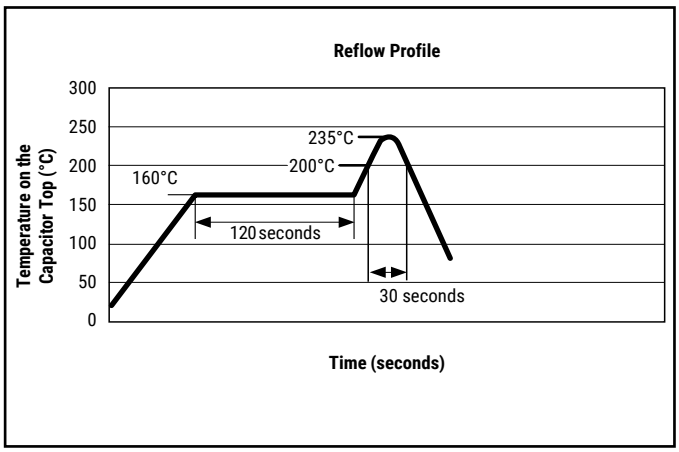
FCS Type



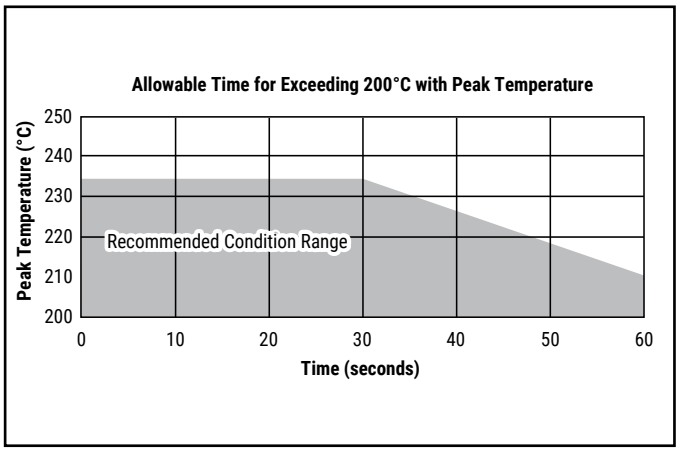
Above "Reflow Profile" graph indicates temperature at the terminals and capacitor top.

Peak Temperature	Below +260°C
Over +255°C	Within 10 seconds
Over +230°C	Within 45 seconds
Over +220°C	Within 60 seconds
Over +217°C	Within 70 seconds
Time between +150°C to +200°C (temperature zone over +170°C within 50 seconds)	150 seconds

FC Type



Above "Reflow Profile" graph indicates temperature at capacitor top.



Specifications

Item		FC 5.5 V Type, 3.5 V Type		Test Conditions (conforming to JIS C 5160-1)
Category Temperature Range		−25°C to +70°C		
Maximum Operating Voltage		5.5 VDC, 3.5 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: 4.0 V (3.5 V type,3.6 V type) Charge: 6.3 V (5.5 V type) Discharge: 30 seconds Number of cycles: 9 minutes 30 seconds Series resistance: 1,000 0.043 F, 0.047 F 300 Ω 0.068 F 240 Ω 0.10 F 150 Ω 0.22 F 56 Ω 0.47 F 30 Ω 1.0 F 15 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		≤ 400% of initial value	
	Capacitance	Phase 3		
	ESR			
	Capacitance	Phase 5	≤ 200% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		1.5 CV (mA) or below	
	Capacitance	Phase 6	Within ±20% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		Satisfy initial ratings	
* Vibration Resistance	Capacitance	Satisfy initial ratings		Conforms to 4.13 Frequency: 10 to 55 Hz Testing Time: 6 hours
	ESR			
	Current (30 minutes value)			
	Appearance	No obvious abnormality		
* Solder Heat Resistance	Capacitance	Satisfy initial ratings		Cooled down to ambient temperature after reflow soldering, then the product must fulfill the condition stated left. (See Precautions for Use)
	ESR			
	Current (30 minutes value)			
	Appearance	No obvious abnormality		
* 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		

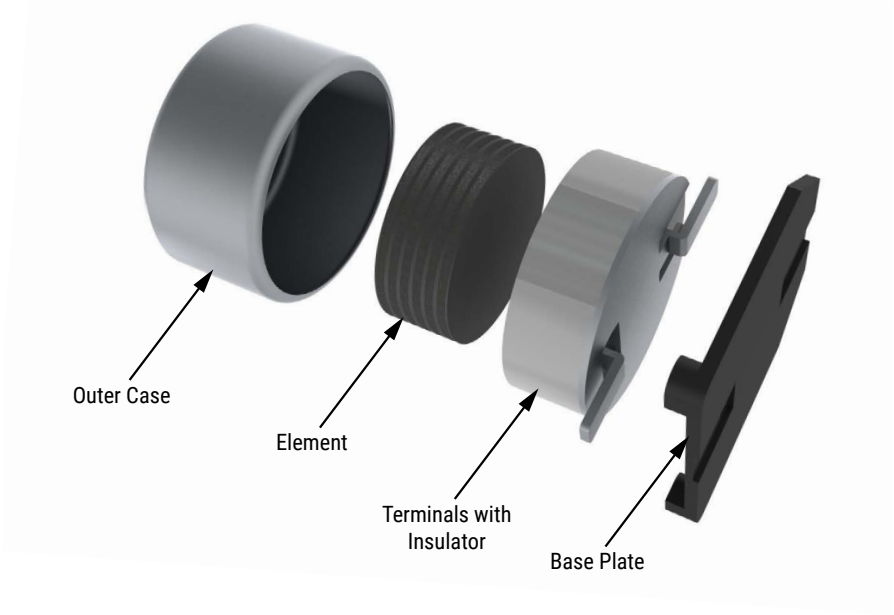
** Must fulfill the above condition after reflow soldering.*

Specifications cont.

Item		FC 5.5 V Type, 3.5 V Type		Test Conditions (conforming to JIS C 5160-1)
* 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 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		
* Self Discharge Characteristics (Voltage Holding Characteristics)		5.5 V type:	Voltage between terminal leads > 4.2 V	Charging condition Voltage applied: 5.0 VDC (Terminal at the case side must be negative) Series resistance: 0 Ω Charging time: 24 hours
		3.5 V type:	Not specified	Storage Let stand for 24 hours in condition described below with terminals opened. Ambient temperature: < 25°C Relative humidity: < 70% RH

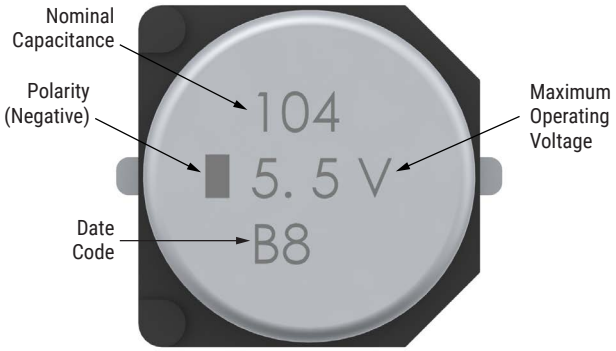
** Must fulfill the above condition after reflow soldering.*

Construction

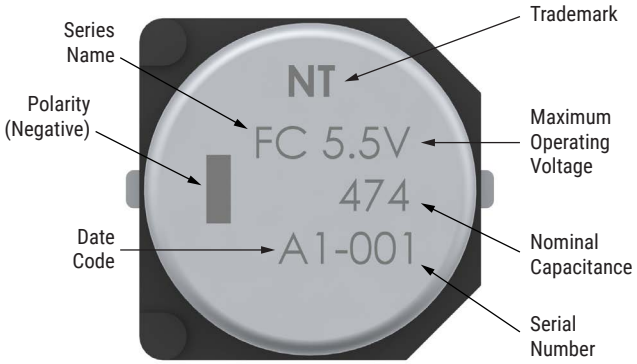


Marking

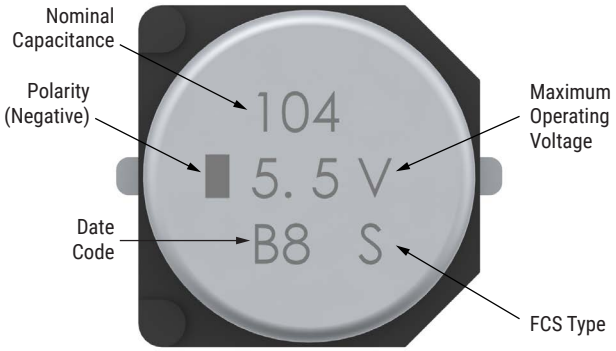
D = 10.5 mm



D = 16 & 21 mm

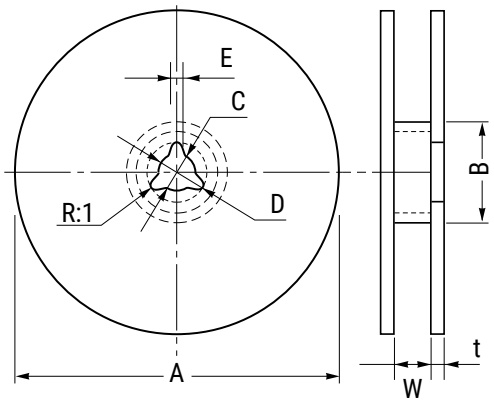


D = 10.7 mm



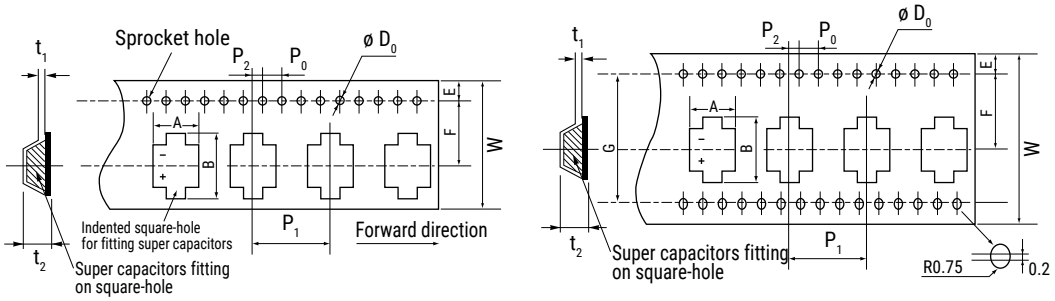
Displays nominal capacitance, maximum operating voltage serial number, polarity, etc.

Tape & Reel Packaging Information – Millimeters



Mark	TBR24		TBR32	TBR44
A	380±2		330±2	380±2
B	Product height 5.5 mm	80±1	100±1	100±1
	Product height 8.5 mm	100±1		
C	13±0.5		13±0.5	13±0.5
D	21±0.8		21±0.8	21±0.8
E	2±0.5		2±0.5	2±0.5
W	Product height 5.5 mm	25.5±0.5	33.5±1.0	45.5±1.0
	Product height 8.5 mm	25.5±1.0		
t	2.0		2.0	2.0

Tape & Reel Packaging Information – Millimeters cont.



Mark	TBR24		TBR32	TBR44
W	24.0		32.0	44.0
A	11.4		18.0	23.0
B	13.0		20.0	25.0
P_0	4.0		4.0	4.0
P_1	16.0		24.0	32.0
P_2	2.0		2.0	2.0
F	11.5		14.2	20.2
ø D_0	1.55		1.55	1.55
t_1	0.4		0.5	0.5
E	1.75		1.75	1.75
t_2	Product height 5.5 mm	6.0	10.0	12.0
	Product height 8.5 mm	8.4		
G	–		28.4	40.4

Ammo Pack Packaging Information

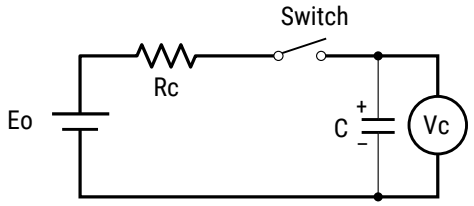
Part Number	Quantity per Reel
FC0H473ZFTBR24	1,000 pieces/reel
FC0H104ZFTBR24	1,000 pieces/reel
FC0H224ZFTBR24	500 pieces/reel
FC0H474ZFTBR32–SS	200 pieces/reel
FC0H105ZFTBR44–SS	150 pieces/reel
FC0V104ZFTBR24	1,000 pieces/reel
FC0V224ZFTBR24	1,000 pieces/reel
FC0V474ZFTBR24	500 pieces/reel
FCS0H473ZFTBR24	1,000 pieces/reel
FCS0H104ZFTBR24	1,000 pieces/reel
FCS0H224ZFTBR24	500 pieces/reel
FCS0V104ZFTBR24	1,000 pieces/reel
FCS0V224ZFTBR24	1,000 pieces/reel
FCS0V474ZFTBR24	500 pieces/reel

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	FMC	FG, FGR	FGH	FT	FC, FCS	HV
				FYD	FYH								
0.010 F	–	–	–	–	–	–	5,000 Ω	–	5,000 Ω	–	–	–	–
0.022 F	1,000 Ω	–	1,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	–	2,000 Ω	–	–	Discharge	–
0.033 F	–	–	–	–	–	–	Discharge	–	–	–	–	–	–
0.047 F	1,000 Ω	1,000 Ω	1,000 Ω	2,000 Ω	1,000 Ω	1,000 Ω	2000 Ω	1,000 Ω	2,000 Ω	–	–	–	–
0.10 F	510 Ω	510 Ω	510 Ω	1,000 Ω	510 Ω	1,000 Ω	1000 Ω	1,000 Ω	1,000 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	–	1,000 Ω	Discharge	200 Ω	Discharge	–
0.33 F	–	–	–	–	–	–	–	Discharge	–	–	–	–	–
0.47 F	100 Ω	100 Ω	100 Ω	200 Ω	200 Ω	200 Ω	–	–	1,000 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.*

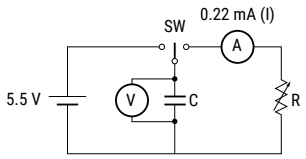
Measurement Conditions cont.

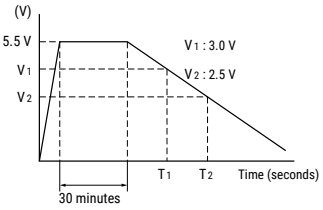
Capacitance (Discharge System)

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.

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

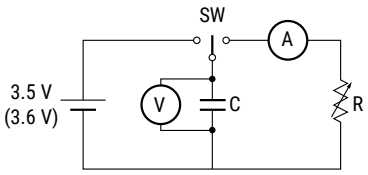


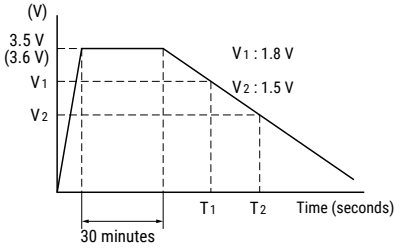


Capacitance (Discharge System – 3.5 V, 3.6 V)

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 (3.6 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.

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

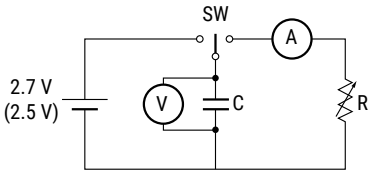


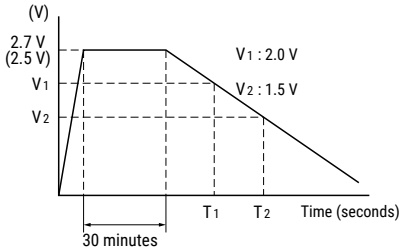


Capacitance (Discharge System – HV Series)

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.

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



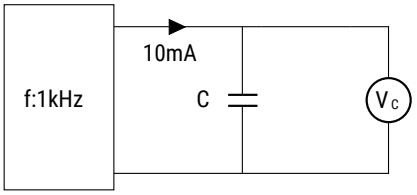


Measurement Conditions cont.

Equivalent Series Resistance (ESR)

ESR shall be calculated from the equation below.

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

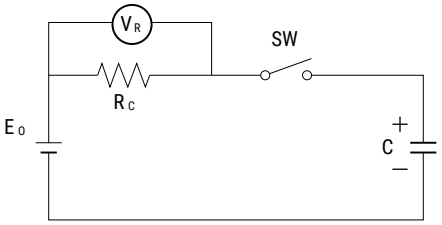


Current (at 30 minutes after charging)

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)
3.6 VDC (3.6 V type)
5.0 VDC (5.5 V type)
6.0 VDC (6.5 V type)
10.0 VDC (11 V type)
12.0 VDC (12 V type)

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



Rc: 1,000 Ω (0.01 F, 0.022 F, 0.047 F)
100 Ω (0.10 F, 0.22 F, 0.33 F, 0.47 F)
10 Ω (1.0 F, 1.4 F, 1.5 F, 2.2 F, 3.3 F, 4.7 F, 5.6 F)
2.2 Ω (HV Series)
However, FS Seres 11 V type and 12 V type
100 Ω 0.47 F, 1.0 F
10 Ω 5.0 F

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.

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

Keep solder under 260°C and soldering time to within 10 seconds when using the flow automatic soldering method. (Except for the FC and HV series)

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 400°C 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 – 35°C (Standard 25°C), 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.

Supercapacitors

FM Series

Overview

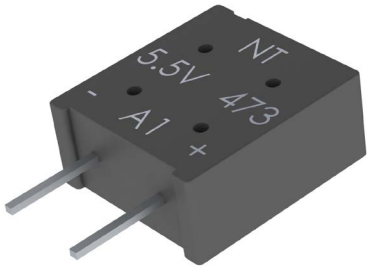
FM Series Supercapacitors, also known as Electric Double-Layer Capacitors (EDLCs), are intended for high energy storage applications.

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

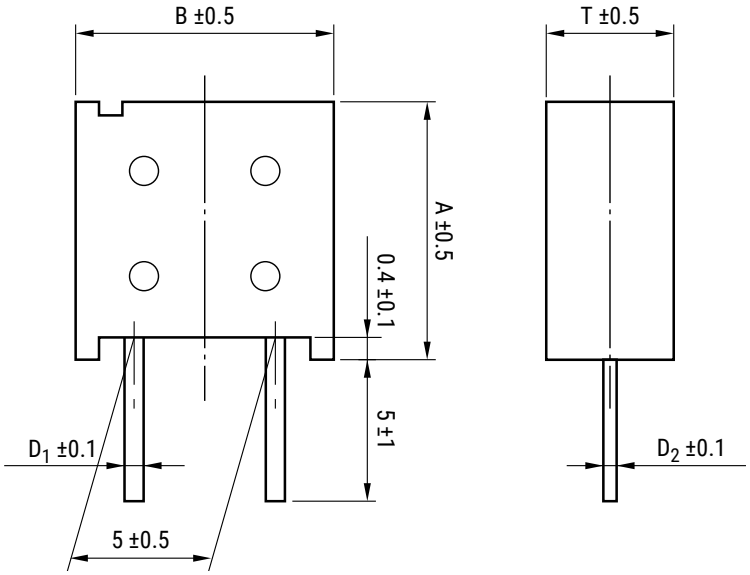
- Rectangular case
- Wide range of temperature from −25°C to +70°C (all types except FMR) and −40°C to +85°C (FMR type)
- Maintenance free
- Maximum operating voltages of 3.5, 3.6, 5.5, and 6.5 VDC
- Highly reliable against liquid leakage
- Lead-free and RoHS compliant
- Leads can be transverse mounted



Part Number System

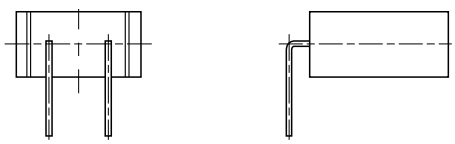
FM	0H	223	Z	F	TP	18
Series	Maximum Operating Voltage	Capacitance Code	Capacitance Tolerance	Environmental	Tape Type	Height (excluding lead)
FM FME FMR FMC	0V = 3.5 VDC 0H = 5.5 VDC 0J = 6.5 VDC	First two digits represent significant figures. Third digit specifies number of zeros to follow µF code.	Z = −20/+80%	F = Lead-free	TP = AMMO -L1 = Transverse mounting Blank = Bulk	18 = 18 mm Blank = Bulk

Dimensions – Millimeters



Part Number	A	B	T	D_1	D_2
FM0H103ZF	11.5	10.5	5.0	0.5	0.4
FM0H223ZF	11.5	10.5	5.0	0.5	0.4
FM0H473ZF	11.5	10.5	5.0	0.5	0.4
FM0H104ZF	11.5	10.5	6.5	0.5	0.4
FM0H224ZF	11.5	10.5	6.5	0.5	0.4
FM0V473ZF	11.5	10.5	5.0	0.5	0.4
FM0V104ZF	11.5	10.5	5.0	0.5	0.4
FM0V224ZF	11.5	10.5	6.5	0.5	0.4
FM0J473ZF	11.5	10.5	6.5	0.5	0.4
FME0H223ZF	11.5	10.5	5.0	0.5	0.4
FME0H473ZF	11.5	10.5	5.0	0.5	0.4
FMR0H473ZF	11.5	10.5	6.5	0.5	0.4
FMR0H104ZF	11.5	10.5	6.5	0.5	0.4
FMR0V104ZF	11.5	10.5	6.5	0.5	0.4
FMR0V334ZF	11.5	10.5	6.5	0.5	0.4
FMR0V474ZF	15.0	14.0	9.0	0.6	0.6
FMC0H473ZF	11.5	10.5	5.0	0.5	0.4
FMC0H104ZF	11.5	10.5	6.5	0.5	0.4
FMC0H334ZF	15.0	14.0	9.0	0.6	0.6

Lead Terminal Forming



Add "L1" to the end of bulk part number for transverse mounting option

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, FMR Type)
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
Long time back-up	500 µA and below	CMOS microcomputer, IC for clocks	CMOS microcomputer, static RAM/DTS (digital tuning system)	FM series

Environmental Compliance

All KEMET supercapacitors are RoHS compliant.

RoHS

Table 1 – Ratings & Part Number Reference

Part Number	Maximum Operating Voltage (VDC)	Nominal Capacitance		Maximum ESR at 1 kHz (Ω)	Maximum Current at 30 Minutes (mA)	Voltage Holding Characteristic Minimum (V)	Weight (g)
		Charge System (F)	Discharge System (F)				
FM0V473ZF	3.5	0.047	0.06	200	0.042	-	1.3
FMR0V104ZF	3.5	0.10	-	50	0.090	-	1.6
FM0V104ZF	3.5	0.10	0.13	100	0.090	-	1.3
FM0V224ZF	3.5	0.22	0.30	100	0.20	-	1.6
FM0H103ZF	5.5	0.01	0.014	300	0.015	4.2	1.3
FME0H223ZF	5.5	0.022	0.028	40	0.033	-	1.3
FM0H223ZF	5.5	0.022	0.028	200	0.033	4.2	1.3
FME0H473ZF	5.5	0.047	0.06	20	0.071	-	1.3
FMC0H473ZF	5.5	0.047	0.06	100	0.071	4.2	1.3
FM0H473ZF	5.5	0.047	0.06	200	0.071	4.2	1.3
FMR0H473ZF	5.5	0.047	0.062	200	0.071	4.2	1.6
FMR0H104ZF	5.5	0.10	-	50	0.15	4.2	1.6
FMR0V334ZF	3.6	-	0.33	50	0.3	-	1.6
FMR0V474ZF	3.6	-	0.47	25	0.42	-	3.5
FMC0H104ZF	5.5	0.10	0.13	50	0.15	4.2	1.6
FM0H104ZF	5.5	0.10	0.13	100	0.15	4.2	1.6
FM0H224ZF	5.5	-	0.22	100	0.33	4.2	1.6
FMC0H334ZF	5.5	-	0.33	25	0.50	4.2	3.5
FM0J473ZF	6.5	0.047	0.062	200	0.071	-	1.6

Specifications – All Types Except FMR

Item		FM 5.5 V Type, 3.5 V Type, 6.5 V Type, FMC Type	FME Type	Test Conditions (conforming to JIS C 5160-1)
Category Temperature Range		−25°C to +70°C	−25°C to +70°C	
Maximum Operating Voltage		5.5 VDC, 3.5 VDC, 6.5 VDC	5.5 VDC	
Capacitance		Refer to Table 1	Refer to Table 1	Refer to “Measurement Conditions”
Capacitance Allowance		+80%, −20%	+80%, −20%	Refer to “Measurement Conditions”
ESR		Refer to Table 1	Refer to Table 1	Measured at 1 kHz, 10 mA; See also “Measurement Conditions”
Current (30 minutes value)		Refer to Table 1	Refer to Table 1	Refer to “Measurement Conditions”
Surge	Capacitance	> 90% of initial ratings	> 90% of initial ratings	Surge voltage: 4.0 V (3.5 V type) 6.3 V (5.5 V type) 7.4 V (6.5 V type) Charge: 30 seconds Discharge: 9 minutes 30 seconds Number of cycles: 1,000 Series resistance: 0.010 F 1,500 Ω; 0.022 F 560 Ω; 0.047 F 300 Ω; 0.068 F 240 Ω; 0.10 F 150 Ω; 0.22 F 56 Ω; 0.33 F 51 Ω Discharge resistance: 0 Ω Temperature: 70±2°C
	ESR	≤ 120% of initial ratings	≤ 120% of initial ratings	
	Current (30 minutes value)	≤ 120% of initial ratings	≤ 120% of initial ratings	
	Appearance	No obvious abnormality	No obvious abnormality	
Characteristics in Different Temperature	Capacitance	Phase 2: ≥ 50% of initial value	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	Phase 2: ≤ 300% or less than initial value	
	Capacitance	Phase 3	Phase 3	
	ESR	Phase 3	Phase 3	
	Capacitance	Phase 5: ≤ 200% of initial value	Phase 5: ≤ 150% of initial value	
	ESR	Phase 5: Satisfy initial ratings	Phase 5: Satisfy initial ratings	
	Current (30 minutes value)	Phase 5: ≤ 1.5 CV (mA)	Phase 5: ≤ 1.5 CV (mA)	
	Capacitance	Phase 6: Within ±20% of initial value	Phase 6: Within ±20% of initial value	
	ESR	Phase 6: Satisfy initial ratings	Phase 6: Satisfy initial ratings	
	Current (30 minutes value)	Phase 6: Satisfy initial ratings	Phase 6: Satisfy initial ratings	
Vibration Resistance	Capacitance	Satisfy initial ratings	Satisfy initial ratings	Conforms to 4.13 Frequency: 10 to 55 Hz Testing Time: 6 hours
	ESR			
	Current (30 minutes value)			
	Appearance	No obvious abnormality	No obvious abnormality	
Solderability		Over 3/4 of the terminal should be covered by the new solder	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.

Specifications – All Types Except FMR cont.

Item		FM 5.5 V Type, 3.5 V Type, 6.5 V Type, FMC Type	FME Type	Test Conditions (conforming to JIS C 5160-1)
Solder Heat Resistance	Capacitance	Satisfy initial ratings	Satisfy initial ratings	Conforms to 4.10 Solder temp: +260±10°C Dipping time: 10±1 seconds
	ESR			
	Current (30 minutes value)			
	Appearance	No obvious abnormality	No obvious abnormality	1.6 mm from the bottom should be dipped.
Temperature Cycle	Capacitance	Satisfy initial ratings	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	No obvious abnormality	
High Temperature and High Humidity Resistance	Capacitance	Within ±20% of initial value	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	≤ 120% of initial ratings	
	Current (30 minutes value)	≤ 120% of initial ratings	≤ 120% of initial ratings	
	Appearance	No obvious abnormality	No obvious abnormality	
High Temperature Load	Capacitance	Within ±30% of initial value	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	< 200% of initial ratings	
	Current (30 minutes value)	< 200% of initial ratings	< 200% of initial ratings	
	Appearance	No obvious abnormality	No obvious abnormality	
Self Discharge Characteristics (Voltage Holding Characteristics)		5.5 V type: Voltage between terminal leads > 4.2 V 3.5 V type: Not specified 6.5 V type: Not specified		Charging condition Voltage applied: 5.0 VDC (Terminal at the case side must be negative) Series resistance: 0 Ω Charging time: 24 hours Storage Let stand for 24 hours in condition described below with terminals opened. Ambient temperature: < 25°C Relative humidity: < 70% RH

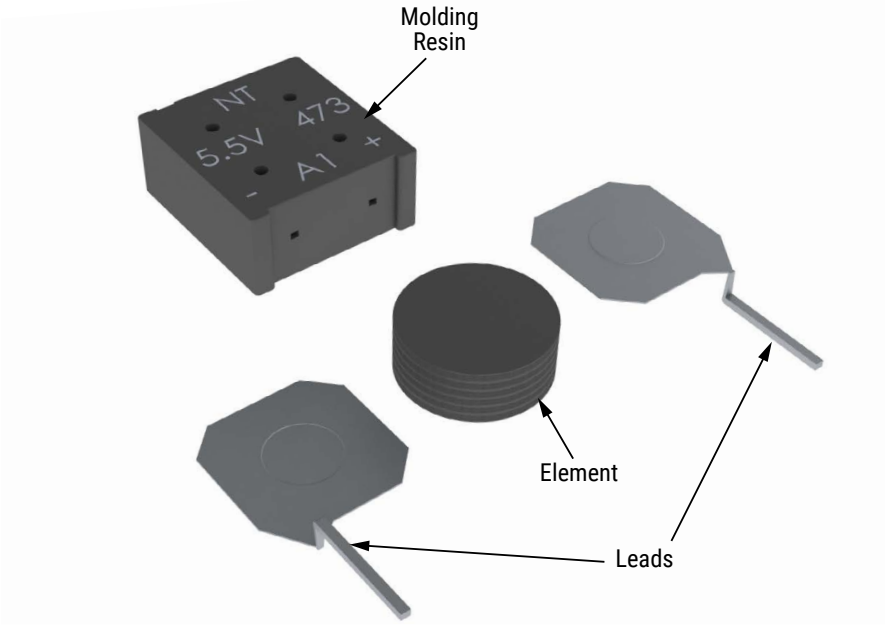
Specifications – FMR Type

Item		FMR Type		Test Conditions (conforming to JIS C 5160-1)
Category Temperature Range		−40°C to +85°C		
Maximum Operating Voltage		5.5 VDC, 3.5 VDC, 3.6 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	More than 90% of initial ratings		Surge voltage: 4.0 V (3.5 & 3.6 V type) 6.3 V (5.5 V type) Charge: 30 seconds Discharge: 9 minutes 30 seconds Number of cycles: 1,000 Series resistance: 0.047 F 300 Ω; 0.10 F 150 Ω; 0.33 F 56 Ω; 0.47 F 30 Ω Discharge resistance: 0 Ω Temperature: 85±2°C
	ESR	Not to exceed 120% of initial ratings		
	Current (30 minutes value)	Not to exceed 120% of initial ratings		
	Appearance	No obvious abnormality		
Characteristics in Different Temperature	Capacitance	Phase 2	50% higher than initial value	Conforms to 4.17 Phase 1: +25±2°C Phase 2: −25 ±2°C Phase 3: −40 ±2°C Phase 4: +25 ±2°C Phase 5: +85 ±2°C Phase 6: +25 ±2°C
	ESR		400% or less than initial value	
	Capacitance	Phase 3	30% or higher than initial value	
	ESR		700% or less than initial value	
	Capacitance	Phase 5	200% or less than initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		1.5 CV (mA) or below	
	Capacitance	Phase 6	Within ±20% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		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			
	Current (30 minutes value)			
	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			
	Current (30 minutes value)			
	Appearance	No obvious abnormality		
Temperature Cycle	Capacitance	Satisfy initial ratings		Conforms to 4.12 Temperature Condition: −40°C » Room temperature » +85°C » Room temperature Number of cycles: 5 cycles
	ESR			
	Current (30 minutes value)			
	Appearance	No obvious abnormality		

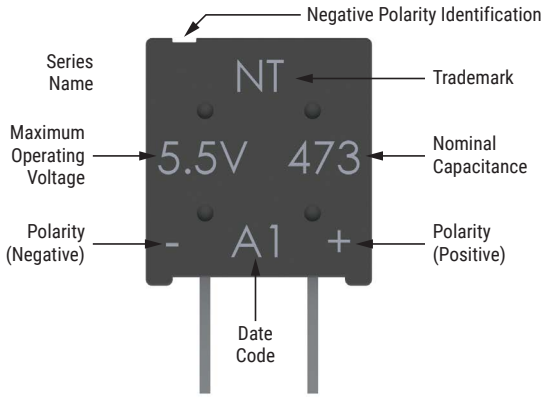
Specifications – FMR Type cont.

Item		FMR Type		Test Conditions (conforming to JIS C 5160-1)
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	Not to exceed 120% of initial ratings		
	Current (30 minutes value)	Not to exceed 120% of initial ratings		
	Appearance	No obvious abnormality		
High Temperature Load	Capacitance	Within ±30% of initial value		Conforms to 4.15 Temperature: +85 ±2°C Voltage applied: Maximum operating voltage Series protection resistance: 0 Ω Testing time: 1,000 +48 (+48/−0) hours
	ESR	Below 200% of initial ratings		
	Current (30 minutes value)	Below 200% of initial ratings		
	Appearance	No obvious abnormality		
Self Discharge Characteristics (Voltage Holding Characteristics)		5.5 V type:	Voltage between terminal leads higher than 4.2 V	Charging condition Voltage applied: 5.0 VDC (Terminal at the case side must be negative) Series resistance: 0 Ω Charging time: 24 hours
		3.5 V type: 3.6 V type:	Not specified	Storage Let stand for 24 hours in condition described below with terminals opened. Ambient temperature: Lower than 25°C Relative humidity: Lower than 70% RH

Construction



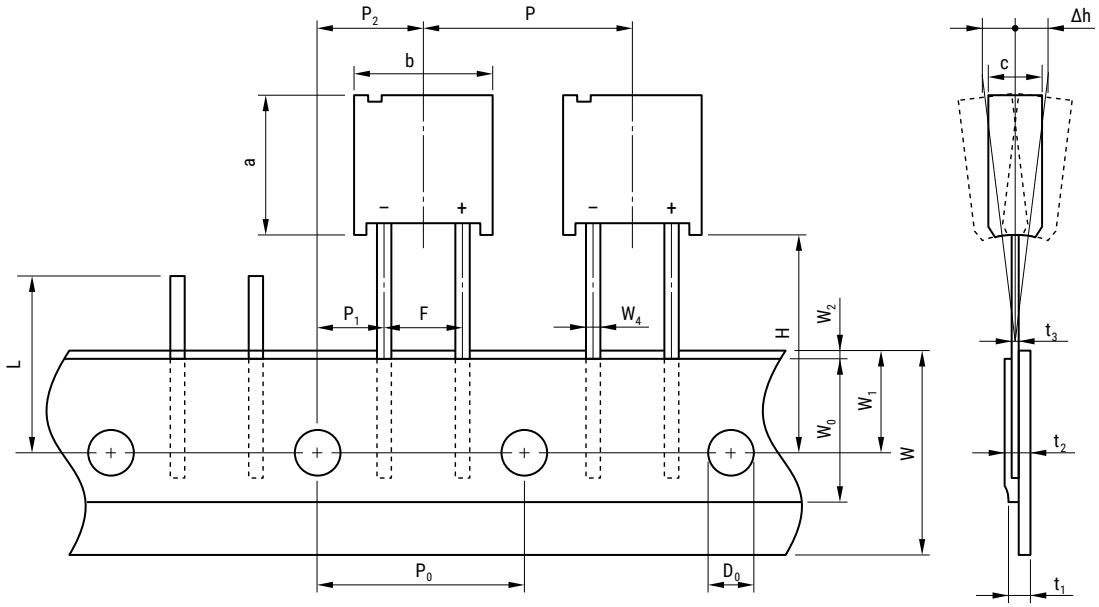
Marking



Packaging Quantities

Part Number	Bulk Quantity per Box Straight Lead	Bulk Quantity per Box L1 Lead Option	Ammo Pack Quantity
FM0H103ZF	1,000 pieces	1,000 pieces	1,000 pieces
FM0H223ZF	1,000 pieces	1,000 pieces	1,000 pieces
FM0H473ZF	1,000 pieces	1,000 pieces	1,000 pieces
FM0H104ZF	1,000 pieces	800 pieces	1,000 pieces
FM0H224ZF	1,000 pieces	800 pieces	1,000 pieces
FM0V473ZF	1,000 pieces	1,000 pieces	1,000 pieces
FM0V104ZF	1,000 pieces	1,000 pieces	1,000 pieces
FM0V224ZF	1,000 pieces	800 pieces	1,000 pieces
FM0J473ZF	1,000 pieces	800 pieces	1,000 pieces
FME0H223ZF	1,000 pieces	1,000 pieces	1,000 pieces
FME0H473ZF	1,000 pieces	1,000 pieces	1,000 pieces
FMR0H473ZF	1,000 pieces	1,000 pieces	1,000 pieces
FMR0H104ZF	1,000 pieces	1,000 pieces	1,000 pieces
FMR0V104ZF	1,000 pieces	800 pieces	1,000 pieces
FMR0V334ZF	1,000 pieces	800 pieces	1,000 pieces
FMR0V474ZF	400 pieces	300 pieces	400 pieces
FMC0H473ZF	1,000 pieces	1,000 pieces	1,000 pieces
FMC0H104ZF	1,000 pieces	1,000 pieces	1,000 pieces
FMC0H334ZF	400 pieces	300 pieces	400 pieces

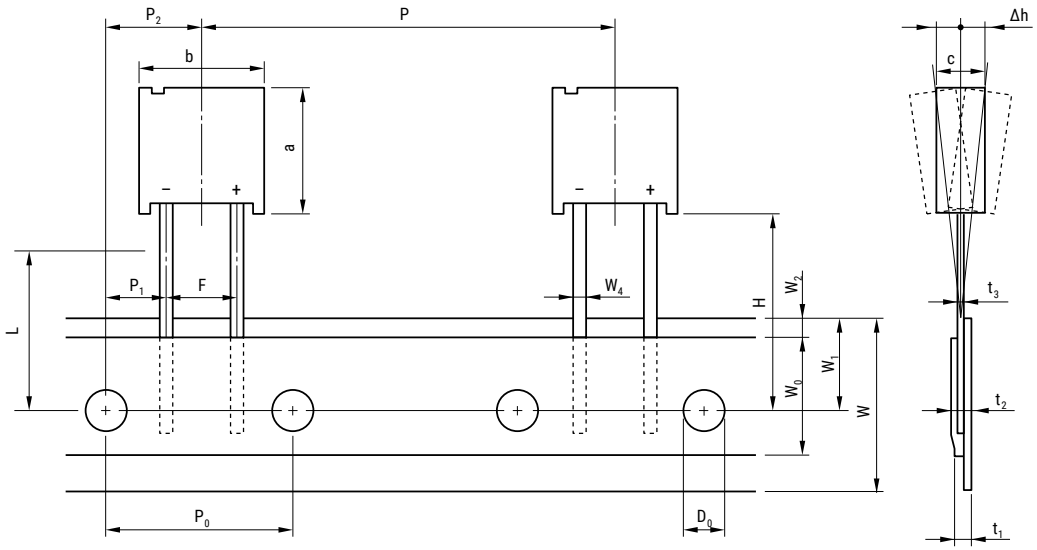
Ammo Pack Taping Format (Except FMC0H334ZFTP, FMR0V474ZFTP)



Ammo Pack Taping Specifications (Except FMC0H334ZFTP, FMR0V474ZFTP)

Item	Symbol	Dimensions (mm)
Component Height	a	11.5±0.5
Component Width	b	10.5±0.5
Component Thickness	c	Refer to “Dimensions” table
Lead-Wire Width	W_4	0.5±0.1
Lead-Wire Thickness	t_3	0.4±0.1
Component Pitch	P	12.7±1.0
Sprocket Hole Pitch	P_0	12.7±0.3
Sprocket Hole Center to Lead Center	P_1	3.85±0.7
Sprocket Hole Center to Component Center	P_2	6.35±0.7
Lead Spacing	F	5.0±0.5
Component Alignment (side/side)	Δh	2.0 Maximum
Carrier Tape Width	W	18.0+1.0/−0.5
Hold-Down Tape Width	W_0	12.5 Minimum
Sprocket Hole Position	W_1	9.0±0.5
Hold-Down Tape Position	W_2	3.0 Maximum
Height to Seating Plane (lead length)	H	16.0±0.5/18.0±0.5
Sprocket Hole Diameter	D_0	ø 4.0±0.2
Carrier Tape Thickness	t_1	0.7±0.2
Total Thickness (Carrier Tape, Hold-Down Tape and Lead)	t_2	1.5 Maximum
Cut Out Length	L	11.0 Maximum

Ammo Pack Taping Format (FMC0H334ZFTP, FMR0V474ZFTP)



Ammo Pack Taping Specifications (FMC0H334ZFTP, FMR0V474ZFTP)

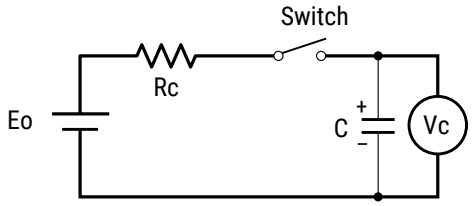
Item	Symbol	Dimensions (mm)
Component Height	a	15.0±0.5
Component Width	b	14.0±0.5
Component Thickness	c	9.0±0.5
Lead-Wire Width	W_4	0.6±0.1
Lead-Wire Thickness	t_3	0.6±0.1
Component Pitch	P	25.4±1.0
Sprocket Hole Pitch	P_0	12.7±0.3
Sprocket Hole Center to Lead Center	P_1	3.85±0.7
Sprocket Hole Center to Component Center	P_2	6.35±0.7
Lead Spacing	F	5.0±0.5
Component Alignment (side/side)	Δh	2.0 Maximum
Carrier Tape Width	W	18.0+1.0/−0.5
Hold-Down Tape Width	W_0	12.5 Minimum
Sprocket Hole Position	W_1	9.0±0.5
Hold-Down Tape Position	W_2	3.0 Maximum
Height to Seating Plane (lead length)	H	16.0±0.5/18.0±0.5
Sprocket Hole Diameter	D_0	ø 4.0±0.2
Carrier Tape Thickness	t_1	0.67±0.2
Total Thickness (Carrier Tape, Hold-Down Tape and Lead)	t_2	1.7 Maximum
Cut Out Length	L	11.0 Maximum

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	FMC	FG, FGR	FGH	FT	FC, FCS	HV
				FYD	FYH								
0.010 F	–	–	–	–	–	–	5,000 Ω	–	5,000 Ω	–	–	–	–
0.022 F	1,000 Ω	–	1,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	–	2,000 Ω	–	–	Discharge	–
0.033 F	–	–	–	–	–	–	Discharge	–	–	–	–	–	–
0.047 F	1,000 Ω	1,000 Ω	1,000 Ω	2,000 Ω	1,000 Ω	1,000 Ω	2000 Ω	1,000 Ω	2,000 Ω	–	–	–	–
0.10 F	510 Ω	510 Ω	510 Ω	1,000 Ω	510 Ω	1,000 Ω	1000 Ω	1,000 Ω	1,000 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	–	1,000 Ω	Discharge	200 Ω	Discharge	–
0.33 F	–	–	–	–	–	–	–	Discharge	–	–	–	–	–
0.47 F	100 Ω	100 Ω	100 Ω	200 Ω	200 Ω	200 Ω	–	–	1,000 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.*

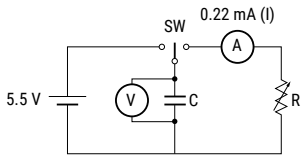
Measurement Conditions cont.

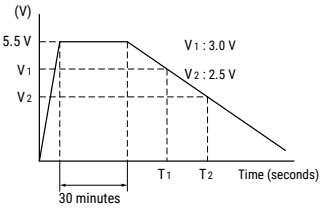
Capacitance (Discharge System)

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.

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

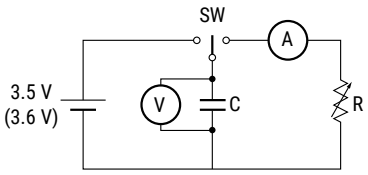


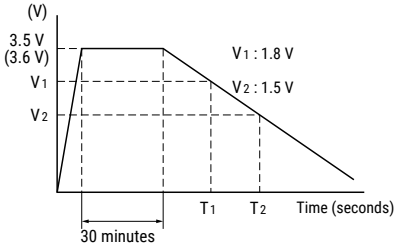


Capacitance (Discharge System – 3.5 V, 3.6 V)

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 (3.6 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.

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

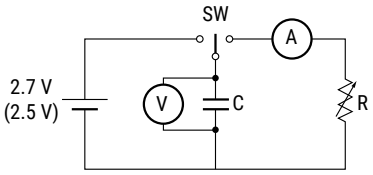


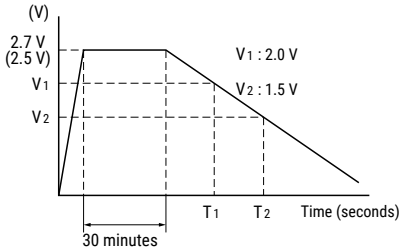


Capacitance (Discharge System – HV Series)

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.

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

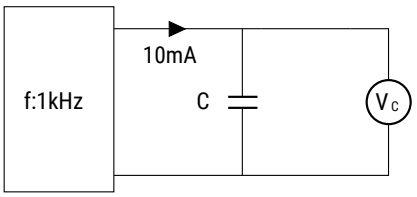




Measurement Conditions cont.

Equivalent Series Resistance (ESR)
ESR shall be calculated from the equation below.

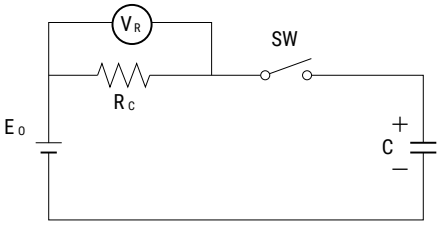
$$ESR = \frac{V_C}{0.01} (\Omega)$$



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)
3.6 VDC (3.6 V type)
5.0 VDC (5.5 V type)
6.0 VDC (6.5 V type)
10.0 VDC (11 V type)
12.0 VDC (12 V type)

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



Rc: 1,000 Ω (0.01 F, 0.022 F, 0.047 F)
100 Ω (0.10 F, 0.22 F, 0.33 F, 0.47 F)
10 Ω (1.0 F, 1.4 F, 1.5 F, 2.2 F, 3.3 F, 4.7 F, 5.6 F)
2.2 Ω (HV Series)
However, FS Seres 11 V type and 12 V type
100 Ω 0.47 F, 1.0 F
10 Ω 5.0 F

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.

FG Series

Overview

FG 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.

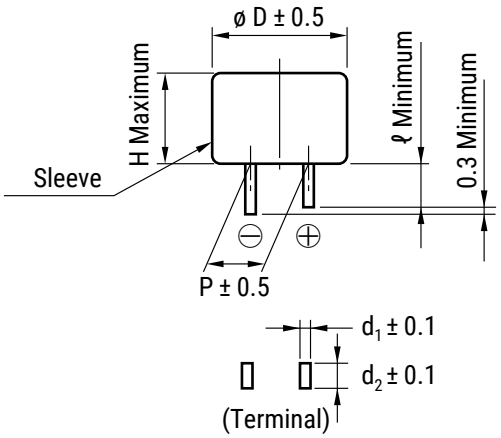
Benefits

- Wide range of temperature from −25°C to +70°C (FG and FGH types) and −40°C to +85°C (FGR type)
- Maintenance free
- Maximum operating voltages of 3.5 VDC and 5.5 VDC
- Highly reliable against liquid leakage
- Lead-free and RoHS compliant

Part Number System

FG	0H	104	Z	F
Series	Maximum Operating Voltage	Capacitance Code	Capacitance Tolerance	Environmental
FG FGH FGR	0V = 3.5 VDC 0H = 5.5 VDC	First two digits represent significant figures. Third digit specifies number of zeros to follow µF code.	Z = −20/+80%	F = Lead-free

Dimensions – Millimeters



Part Number	ø D	H	P	ℓ	d_1	d_2
FG0H103ZF	11.0	5.5	5.08	2.7	0.2	1.2
FG0H223ZF	11.0	5.5	5.08	2.7	0.2	1.2
FG0H473ZF	11.0	5.5	5.08	2.7	0.2	1.2
FG0H104ZF	11.0	6.5	5.08	2.7	0.2	1.2
FG0H224ZF	13.0	9.0	5.08	2.2	0.4	1.2
FG0H474ZF	14.5	18.0	5.08	2.4	0.4	1.2
FG0H105ZF	16.5	19.0	5.08	2.7	0.4	1.2
FG0H225ZF	21.5	19.0	7.62	3.0	0.6	1.2
FG0H475ZF	28.5	22.0	10.16	6.1	0.6	1.4
FG0V155ZF	16.5	14.0	5.08	3.1	0.4	1.2
FGH0H104ZF	11.0	5.5	5.08	2.7	0.2	1.2
FGH0H224ZF	11.0	7.0	5.08	2.7	0.2	1.2
FGH0H474ZF	16.5	8.0	5.08	2.7	0.4	1.2
FGH0H105ZF	21.5	9.5	7.62	3.0	0.6	1.2
FGH0V474ZF	13.0	7.5	5.08	2.7	0.4	1.2
FGR0H474ZF	14.5	18.0	5.08	2.4	0.4	1.2
FGR0H105ZF	16.5	19.0	5.08	2.7	0.4	1.2
FGR0H225ZF	21.5	19.0	7.62	3.0	0.6	1.2

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, FMR type)
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
Long time back-up	500 µA and below	CMOS microcomputer, IC for clocks	CMOS microcomputer, static RAM/DTS (digital tuning system)	FG series

Environmental Compliance

All KEMET supercapacitors are RoHS compliant.

Table 1 – Ratings & Part Number Reference

Part Number	Maximum Operating Voltage (VDC)	Nominal Capacitance		Maximum ESR at 1 kHz (Ω)	Maximum Current at 30 Minutes (mA)	Voltage Holding Characteristic Minimum (V)	Weight (g)
		Charge System (F)	Discharge System (F)				
FG0V155ZF	3.5	1.5	2.2	65	1.5	–	5.2
FG0H103ZF	5.5	0.010	0.013	300	0.015	4.2	0.9
FG0H223ZF	5.5	0.022	0.028	200	0.033	4.2	1.0
FG0H473ZF	5.5	0.047	0.060	200	0.071	4.2	1.0
FG0H104ZF	5.5	0.10	0.13	100	0.15	4.2	1.3
FGH0H104ZF	5.5	–	0.10	100	0.15	4.2	1.0
FG0H224ZF	5.5	0.22	0.28	100	0.33	4.2	2.5
FGH0H224ZF	5.5	–	0.22	100	0.33	4.2	1.3
FGH0H105ZF	5.5	–	1.0	35	1.5	4.2	7.2
FGH0H474ZF	5.5	–	0.47	65	0.71	4.2	4.1
FGH0V474ZF	3.5	–	0.47	25	0.42	–	2.6
FG0H474ZF	5.5	0.47	0.60	120	0.71	4.2	5.1
FGR0H474ZF	5.5	0.47	0.60	120	0.71	4.2	5.1
FG0H105ZF	5.5	1.0	1.3	65	1.5	4.2	7.0
FGR0H105ZF	5.5	1.0	1.3	65	1.5	4.2	7.0
FG0H225ZF	5.5	2.2	2.8	35	3.3	4.2	12.1
FGR0H225ZF	5.5	2.2	2.8	35	3.3	4.2	12.1
FG0H475ZF	5.5	4.7	6.0	35	7.1	4.2	27.3

Part numbers in bold type represent popularly purchased components.

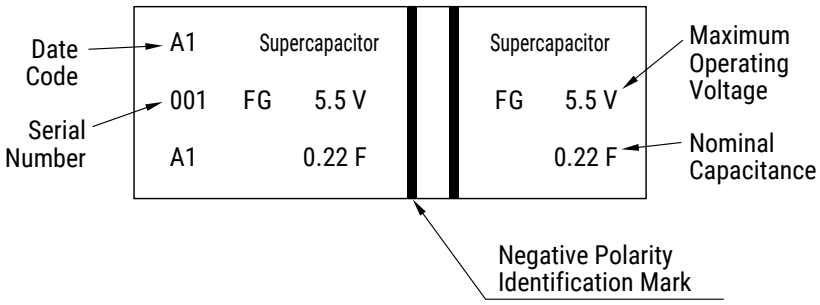
Specifications

Item		FG, FGH Type		FGR Type		Test Conditions (conforming to JIS C 5160-1)
Category Temperature Range		−25°C to +70°C		−40°C to +85°C		
Maximum Operating Voltage		5.5 VDC, 3.5 VDC		5.5 VDC		
Capacitance		Refer to Table 1		Refer to Table 1		Refer to "Measurement Conditions"
Capacitance Allowance		+80%,−20%		+80%,−20%		Refer to "Measurement Conditions"
ESR		Refer to Table 1		Refer to Table 1		Measured at 1 kHz, 10 mA; See also "Measurement Conditions"
Current (30 minutes value)		Refer to Table 1		Refer to Table 1		Refer to "Measurement Conditions"
Surge	Capacitance	> 90% of initial ratings		> 90% of initial ratings		Surge voltage: 6.3 V (5.5 V type) 4.0 V (3.5 V type) Charge: 30 seconds Discharge: 9 minutes 30 seconds Number of cycles: 1,000 Series resistance: 0.010 F 1,500 Ω 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, 1.5 F 15 Ω 2.2 F, 4.7 F 10 Ω Discharge resistance: 0 Ω Temperature: 70±2°C (FG, FGH) 85±2°C (FGR)
	ESR	≤ 120% of initial ratings		≤ 120% of initial ratings		
	Current (30 minutes value)	≤ 120% of initial ratings		≤ 120% of initial ratings		
	Appearance	No obvious abnormality		No obvious abnormality		
Characteristics in Different Temperature	Capacitance	Phase 2	≥ 50% of initial value	Phase 2	≥ 50% of initial value	Conforms to 4.17 Phase 1: +25±2°C Phase 2: −25±2°C Phase 3: −40±2°C (FGR) Phase 4: +25±2°C Phase 5: +70±2°C (FG, FGH) +85±2°C (FGR) Phase 6: +25±2°C
	ESR		≤ 400% of initial value		≤ 400% of initial value	
	Capacitance	Phase 3		Phase 3	≥ 30% of initial value	
	ESR				≤ 700% of initial value	
	Capacitance	Phase 5	≤ 200% of initial value	Phase 5	≤ 200% of initial value	
	ESR		Satisfy initial ratings		Satisfy initial ratings	
	Current (30 minutes value)		≤ 1.5 CV (mA)		≤ 1.5 CV (mA)	
	Capacitance	Phase 6	Within ±20% of initial value	Phase 6	Within ±20% of initial value	
	ESR		Satisfy initial ratings		Satisfy initial ratings	
	Current (30 minutes value)		Satisfy initial ratings		Satisfy initial ratings	
Vibration Resistance	Capacitance	Satisfy initial ratings		Satisfy initial ratings		Conforms to 4.13 Frequency: 10 to 55 Hz Testing Time: 6 hours
	ESR					
	Current (30 minutes value)					
	Appearance	No obvious abnormality		No obvious abnormality		
Solderability		Over 3/4 of the terminal should be covered by the new solder		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.

Specifications cont.

Item		FG, FGH Type	FGR Type	Test Conditions (conforming to JIS C 5160-1)
Solder Heat Resistance	Capacitance	Satisfy initial ratings	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			
	Current (30 minutes value)			
	Appearance	No obvious abnormality	No obvious abnormality	
Temperature Cycle	Capacitance	Satisfy initial ratings	Satisfy initial ratings	Conforms to 4.12 Temperature Condition: Minimum temperature » Room temperature » Category maximum temperature » Room temperature Number of cycles: 5 cycles
	ESR			
	Current (30 minutes value)			
	Appearance	No obvious abnormality	No obvious abnormality	
High Temperature and High Humidity Resistance	Capacitance	Within ±20% of initial value	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	≤ 120% of initial ratings	
	Current (30 minutes value)	≤ 120% of initial ratings	≤ 120% of initial ratings	
	Appearance	No obvious abnormality	No obvious abnormality	
High Temperature Load	Capacitance	Within ±30% of initial value	Within ±30% of initial value	Conforms to 4.15 Temperature: Category maximum temperature ±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	< 200% of initial ratings	
	Current (30 minutes value)	< 200% of initial ratings	< 200% of initial ratings	
	Appearance	No obvious abnormality	No obvious abnormality	
Self Discharge Characteristics (Voltage Holding Characteristics)		5.5 V type: Voltage between terminal leads > 4.2 V 3.5 V type: Not specified	Voltage between terminal leads > 4.2 V	Charging condition Voltage applied: 5.0 VDC (Terminal at the case side must be negative) Series resistance: 0 Ω Charging time: 24 hours Storage Let stand for 24 hours in condition described below with terminals opened. Ambient temperature: < 25°C Relative humidity: < 70% RH

Marking



Packaging Quantities

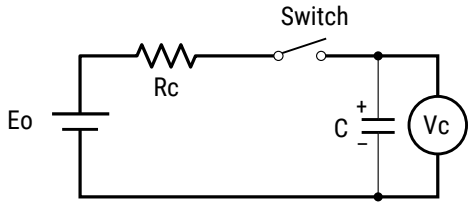
Part Number	Bulk Quantity per Box
FG0H103ZF	2,000 pieces
FG0H223ZF	2,000 pieces
FG0H473ZF	2,000 pieces
FG0H104ZF	1,600 pieces
FG0H224ZF	800 pieces
FG0H474ZF	300 pieces
FG0H105ZF	240 pieces
FG0H225ZF	90 pieces
FG0H475ZF	50 pieces
FG0V155ZF	160 pieces
FGH0H104ZF	2,000 pieces
FGH0H224ZF	1,600 pieces
FGH0H474ZF	600 pieces
FGH0H105ZF	90 pieces
FGH0V474ZF	800 pieces
FGR0H474ZF	300 pieces
FGR0H105ZF	240 pieces
FGR0H225ZF	90 pieces

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	FMC	FG, FGR	FGH	FT	FC, FCS	HV
				FYD	FYH								
0.010 F	–	–	–	–	–	–	5,000 Ω	–	5,000 Ω	–	–	–	–
0.022 F	1,000 Ω	–	1,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	–	2,000 Ω	–	–	Discharge	–
0.033 F	–	–	–	–	–	–	Discharge	–	–	–	–	–	–
0.047 F	1,000 Ω	1,000 Ω	1,000 Ω	2,000 Ω	1,000 Ω	1,000 Ω	2000 Ω	1,000 Ω	2,000 Ω	–	–	–	–
0.10 F	510 Ω	510 Ω	510 Ω	1,000 Ω	510 Ω	1,000 Ω	1000 Ω	1,000 Ω	1,000 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	–	1,000 Ω	Discharge	200 Ω	Discharge	–
0.33 F	–	–	–	–	–	–	–	Discharge	–	–	–	–	–
0.47 F	100 Ω	100 Ω	100 Ω	200 Ω	200 Ω	200 Ω	–	–	1,000 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.*

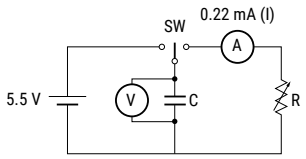
Measurement Conditions cont.

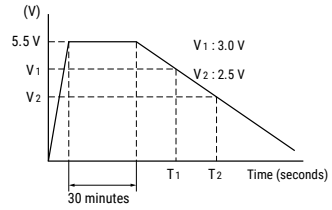
Capacitance (Discharge System)

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.

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

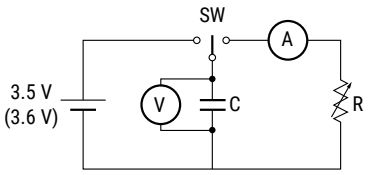


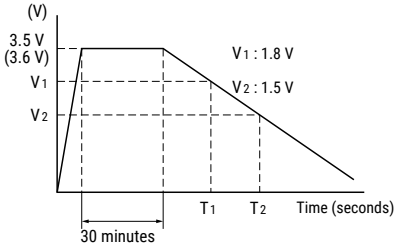


Capacitance (Discharge System – 3.5 V, 3.6 V)

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 (3.6 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.

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

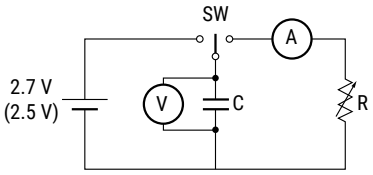


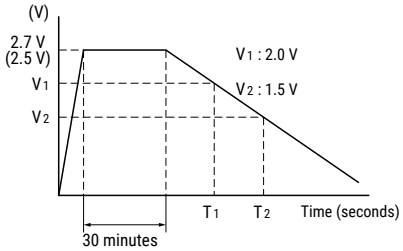


Capacitance (Discharge System – HV Series)

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.

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

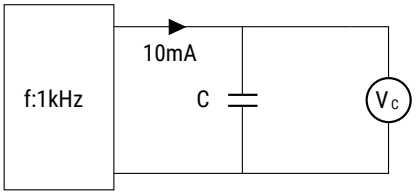




Measurement Conditions cont.

Equivalent Series Resistance (ESR)
ESR shall be calculated from the equation below.

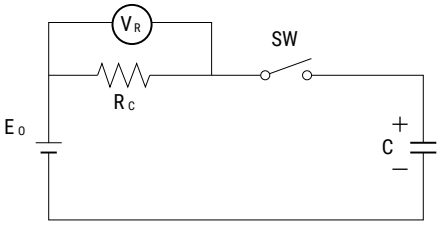
$$ESR = \frac{V_C}{0.01} (\Omega)$$



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)
3.6 VDC (3.6 V type)
5.0 VDC (5.5 V type)
6.0 VDC (6.5 V type)
10.0 VDC (11 V type)
12.0 VDC (12 V type)

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



Rc: 1,000 Ω (0.01 F, 0.022 F, 0.047 F)
100 Ω (0.10 F, 0.22 F, 0.33 F, 0.47 F)
10 Ω (1.0 F, 1.4 F, 1.5 F, 2.2 F, 3.3 F, 4.7 F, 5.6 F)
2.2 Ω (HV Series)
However, FS Seres 11 V type and 12 V type
100 Ω 0.47 F, 1.0 F
10 Ω 5.0 F

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.

Supercapacitors

FT Series

Overview

FT 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.

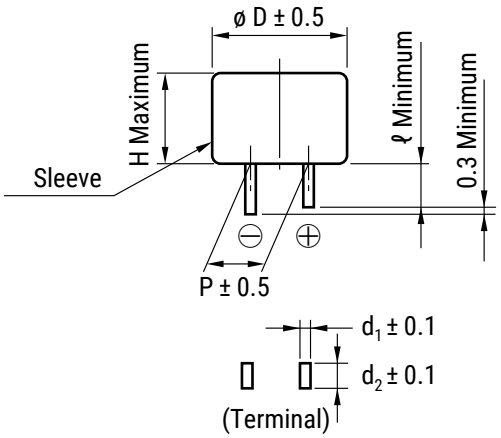
Benefits

- Wide range of temperature from −40°C to +85°C
- Maintenance free
- Maximum operating voltage of 5.5 VDC
- Highly reliable against liquid leakage
- Lead-free and RoHS compliant

Part Number System

FT	0H	104	Z	F
Series	Maximum Operating Voltage	Capacitance Code	Capacitance Tolerance	Environmental
FT FTW	0H = 5.5 VDC	First two digits represent significant figures. Third digit specifies number of zeros to follow µF code.	Z = −20/+80%	F = Lead-free

Dimensions – Millimeters



Part Number	ø D	H	P	ℓ	d_1	d_2
FT0H104ZF	11.5	8.5	5.08	2.7	0.4	1.2
FT0H224ZF	14.5	12.0	5.08	2.2	0.4	1.2
FT0H474ZF	16.5	13.0	5.08	2.7	0.4	1.2
FT0H105ZF	21.5	13.0	7.62	3.0	0.6	1.2
FT0H225ZF	28.5	14.0	10.16	6.1	0.6	1.4
FT0H335ZF	36.5	15.0	15.00	6.1	0.6	1.7
FT0H565ZF	44.5	17.0	20.00	6.1	1.0	1.4
FTW0H104ZF	11.5	8.5	5.08	2.7	0.4	1.2

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, FMR Type)
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	FT series
		Motor driver	DVD player, printer, projector, camera	

Environmental Compliance

All KEMET supercapacitors are RoHS compliant.

Table 1 – Ratings & Part Number Reference

Part Number	Maximum Operating Voltage (VDC)	Nominal Capacitance		Maximum ESR at 1 kHz (Ω)	Maximum Current at 30 Minutes (mA)	Weight (g)
		Charge System (F)	Discharge System (F)			
FT0H104ZF	5.5	0.10	0.14	16	0.15	1.6
FT0H224ZF	5.5	0.22	0.28	10	0.33	4.1
FT0H474ZF	5.5	0.47	0.60	6.5	0.71	5.3
FT0H105ZF	5.5	1.0	1.3	3.5	1.5	10.0
FT0H225ZF	5.5	2.2	2.8	1.8	3.3	18.0
FT0H335ZF	5.5	3.3	4.2	1.0	5.0	38.0
FT0H565ZF	5.5	5.6	7.2	0.6	8.4	72.0
FTW0H104ZF	5.5	0.10	0.14	16	0.15	2.0

Part numbers in bold type represent popularly purchased components.

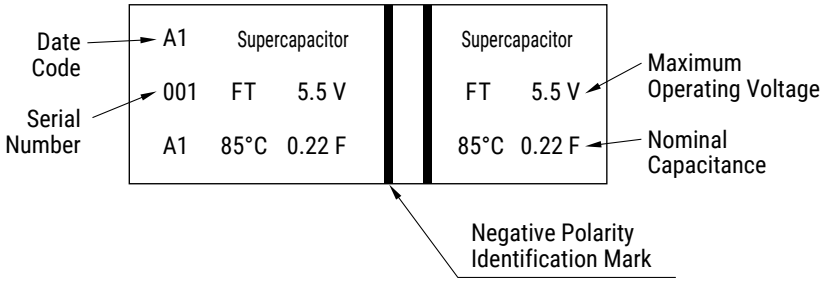
Specifications

Item		FT Type		Test Conditions (conforming to JIS C 5160-1)
Category Temperature Range		−40°C to +85°C		
Maximum Operating Voltage		5.5 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 Charge: 30 seconds Discharge: 9 minutes 30 seconds Number of cycles: 1,000 Series resistance: 0.10 F 150 Ω 0.22 F 56 Ω 0.47 F 30 Ω 1.0 F 15 Ω 2.2 F 10 Ω 3.3 F 10 Ω 5.6 F 10 Ω Discharge resistance: 0 Ω Temperature: 85±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 3: −40 ±2°C Phase 4: +25 ±2°C Phase 5: +85 ±2°C Phase 6: +25 ±2°C
	ESR		≤ 300% of initial value	
	Capacitance	Phase 3	≥ 30% of initial value	
	ESR		≤ 700% of initial value	
	Capacitance	Phase 5	≤ 150% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		≤ 1.5 CV (mA)	
	Capacitance	Phase 6	Within ±20% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		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			
	Current (30 minutes value)			
	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
	ESR			
	Current (30 minutes value)			
	Appearance	No obvious abnormality		1.6 mm from the bottom should be dipped.
Temperature Cycle	Capacitance	Satisfy initial ratings		Conforms to 4.12 Temperature Condition: −40°C » Room temperature » +85°C » Room temperature Number of cycles: 5 cycles
	ESR			
	Current (30 minutes value)			

Specifications cont.

Item		FT Type	Test Conditions (conforming to JIS C 5160-1)
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: +85±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

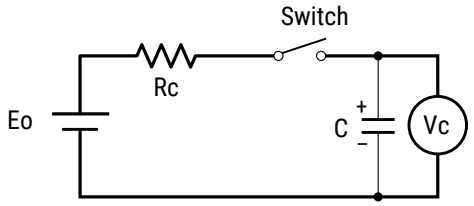
Part Number	Bulk Quantity per Box
FT0H104ZF	1,000 pieces
FT0H224ZF	400 pieces
FT0H474ZF	400 pieces
FT0H105ZF	90 pieces
FT0H225ZF	50 pieces
FT0H335ZF	30 pieces
FT0H565ZF	20 pieces
FTW0H104ZF	1,000 pieces

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	FMC	FG, FGR	FGH	FT	FC, FCS	HV
				FYD	FYH								
0.010 F	–	–	–	–	–	–	5,000 Ω	–	5,000 Ω	–	–	–	–
0.022 F	1,000 Ω	–	1,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	–	2,000 Ω	–	–	Discharge	–
0.033 F	–	–	–	–	–	–	Discharge	–	–	–	–	–	–
0.047 F	1,000 Ω	1,000 Ω	1,000 Ω	2,000 Ω	1,000 Ω	1,000 Ω	2000 Ω	1,000 Ω	2,000 Ω	–	–	–	–
0.10 F	510 Ω	510 Ω	510 Ω	1,000 Ω	510 Ω	1,000 Ω	1000 Ω	1,000 Ω	1,000 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	–	1,000 Ω	Discharge	200 Ω	Discharge	–
0.33 F	–	–	–	–	–	–	–	Discharge	–	–	–	–	–
0.47 F	100 Ω	100 Ω	100 Ω	200 Ω	200 Ω	200 Ω	–	–	1,000 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.*

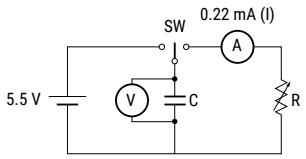
Measurement Conditions cont.

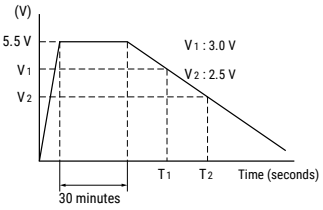
Capacitance (Discharge System)

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.

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

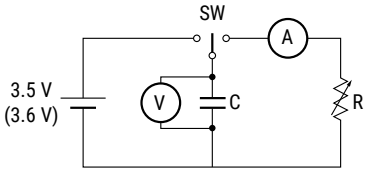


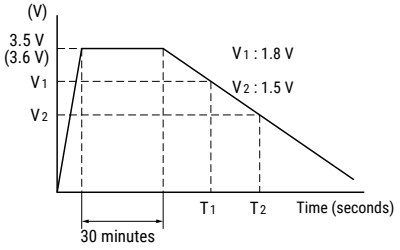


Capacitance (Discharge System – 3.5 V, 3.6 V)

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 (3.6 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.

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

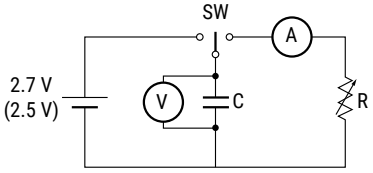


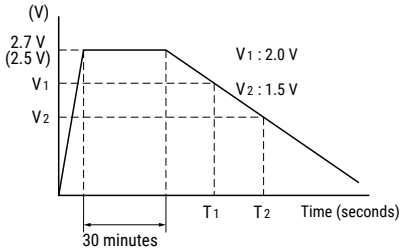


Capacitance (Discharge System – HV Series)

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.

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

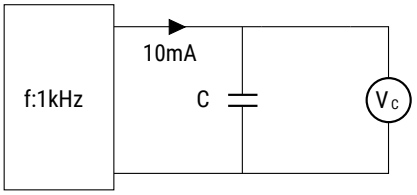




Measurement Conditions cont.

Equivalent Series Resistance (ESR)
ESR shall be calculated from the equation below.

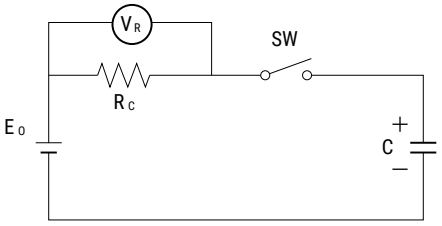
$$ESR = \frac{V_C}{0.01} (\Omega)$$



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)
3.6 VDC (3.6 V type)
5.0 VDC (5.5 V type)
6.0 VDC (6.5 V type)
10.0 VDC (11 V type)
12.0 VDC (12 V type)

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



Rc: 1,000 Ω (0.01 F, 0.022 F, 0.047 F)
100 Ω (0.10 F, 0.22 F, 0.33 F, 0.47 F)
10 Ω (1.0 F, 1.4 F, 1.5 F, 2.2 F, 3.3 F, 4.7 F, 5.6 F)
2.2 Ω (HV Series)
However, FS Seres 11 V type and 12 V type
100 Ω 0.47 F, 1.0 F
10 Ω 5.0 F

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.

Supercapacitors

FY Series

Overview

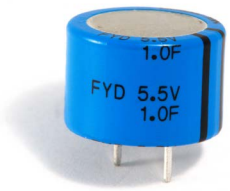
FY Series Supercapacitors, also known as Electric Double-Layer Capacitors (EDLCs), are intended for high energy storage applications.

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

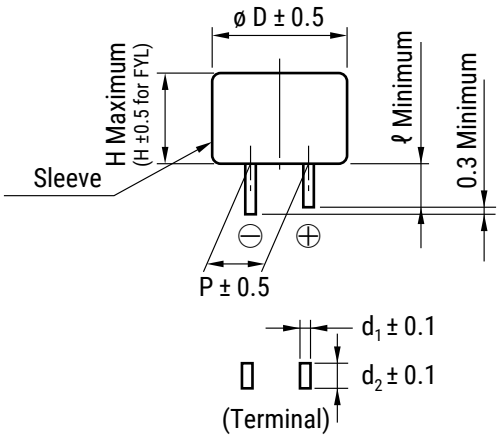
- Wide range of temperature from −25°C to +70°C
- Maintenance free
- Maximum operating voltage of 5.5 VDC
- Highly reliable against liquid leakage
- Lead-free and RoHS compliant



Part Number System

FY	0H	104	Z	F
Series	Maximum Operating Voltage	Capacitance Code	Capacitance Tolerance	Environmental
FYD FYH	0H = 5.5 VDC	First two digits represent significant figures. Third digit specifies number of zeros to follow µF code.	Z = −20/+80%	F = Lead-free

Dimensions – Millimeters



Part Number	ø D	H	P	ℓ	d_1	d_2
FYD0H223ZF	11.5	8.5	5.08	2.7	0.4	1.2
FYD0H473ZF	11.5	8.5	5.08	2.7	0.4	1.2
FYD0H104ZF	13.0	8.5	5.08	2.2	0.4	1.2
FYD0H224ZF	14.5	15.0	5.08	2.4	0.4	1.2
FYD0H474ZF	16.5	15.0	5.08	2.7	0.4	1.2
FYD0H105ZF	21.5	16.0	7.62	3.0	0.6	1.2
FYD0H145ZF	21.5	19.0	7.62	3.0	0.6	1.2
FYD0H225ZF	28.5	22.0	10.16	6.1	0.6	1.4
FYH0H223ZF	11.5	7.0	5.08	2.7	0.4	1.2
FYH0H473ZF	13.0	7.0	5.08	2.2	0.4	1.2
FYH0H104ZF	16.5	7.5	5.08	2.7	0.4	1.2
FYH0H224ZF	16.5	9.5	5.08	2.7	0.4	1.2
FYH0H474ZF	21.5	10.0	7.62	3.0	0.6	1.2
FYH0H105ZF	28.5	11.0	10.16	6.1	0.6	1.4
FYL0H103ZF	11.0	5.0	5.08	2.7	0.2	1.2
FYL0H223ZF	11.0	5.0	5.08	2.7	0.2	1.2
FYL0H473ZF	12.0	5.0	5.08	2.7	0.2	1.2

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, FMR Type)
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
Long time back-up	500 µA and below	Embedded memory backup	DVD player, television, game console, set-top box	FY series
		Motor driver	DVD player, printer, projector, camera	

Environmental Compliance

All KEMET supercapacitors are RoHS compliant.

Table 1 – Ratings & Part Number Reference

Part Number	Maximum Operating Voltage (VDC)	Nominal Capacitance		Maximum ESR at 1 kHz (Ω)	Maximum Current at 30 Minutes (mA)	Voltage Holding Characteristic Minimum (V)	Weight (g)
		Charge System (F)	Discharge System (F)				
FYL0H103ZF	5.5	0.01	0.013	300	0.015	4.2	0.9
FYL0H223ZF	5.5	0.022	0.028	200	0.033	4.2	1.0
FYH0H223ZF	5.5	0.022	0.033	200	0.033	4.2	1.5
FYD0H223ZF	5.5	0.022	0.033	220	0.033	4.2	1.6
FYH0H473ZF	5.5	0.047	0.075	100	0.071	4.2	2.2
FYL0H473ZF	5.5	0.047	0.061	200	0.071	4.2	1.2
FYD0H473ZF	5.5	0.047	0.070	220	0.071	4.2	1.7
FYH0H104ZF	5.5	0.10	0.16	50	0.15	4.2	3.4
FYD0H104ZF	5.5	0.10	0.14	100	0.15	4.2	2.4
FYH0H224ZF	5.5	0.22	0.30	60	0.33	4.2	3.6
FYD0H224ZF	5.5	0.22	0.35	120	0.33	4.2	4.3
FYH0H474ZF	5.5	0.47	0.70	35	0.71	4.2	7.2
FYD0H474ZF	5.5	0.47	0.75	65	0.71	4.2	6.0
FYH0H105ZF	5.5	1.0	1.5	20	1.5	4.2	13.9
FYD0H105ZF	5.5	1.0	1.6	35	1.5	4.2	11.0
FYD0H145ZF	5.5	1.4	2.1	45	2.1	4.2	12.0
FYD0H225ZF	5.5	2.2	3.3	35	3.3	4.2	22.9

Part numbers in bold type represent popularly purchased components.

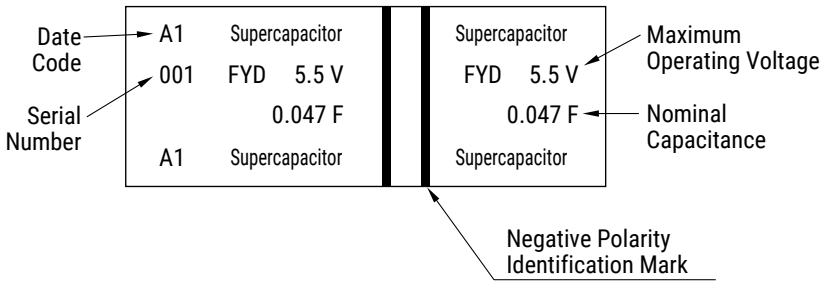
Specifications

Item		FY Type (FYD, FYH)		Test Conditions (conforming to JIS C 5160-1)
Category Temperature Range		−25°C to +70°C		
Maximum Operating Voltage		5.5 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 Charge: 30 seconds Discharge: 9 minutes 30 seconds Number of cycles: 1,000 Series resistance: 0.010 F 1,500 Ω 0.022 F 560 Ω 0.047 F 300 Ω 0.068 F 240 Ω 0.10 F 150 Ω 0.22 F 56 Ω 0.47 F 30 Ω 1.0 F, 1.4 F 15 Ω 2.2 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		≤ 400% of initial value	
	Capacitance	Phase 3		
	ESR			
	Capacitance	Phase 5	≤ 200% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		≤ 1.5 CV (mA)	
	Capacitance	Phase 6	Within ±20% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		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			
	Current (30 minutes value)			
	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
	ESR			
	Current (30 minutes value)			
	Appearance	No obvious abnormality		1.6 mm from the bottom should be dipped.

Specifications cont.

Item		FY Type (FYD, FYH)	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	
Self Discharge Characteristics (Voltage Holding Characteristics)		Voltage between terminal leads > 4.2 V	Charging condition Voltage applied: 5.0 VDC (Terminal at the case side must be negative) Series resistance: 0 Ω Charging time: 24 hours
			Storage Let stand for 24 hours in condition described below with terminals opened. Ambient temperature: < 25°C Relative humidity: < 70% RH

Marking



Packaging Quantities

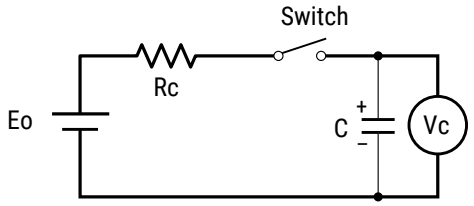
Part Number	Bulk Quantity per Box
FYD0H223ZF	1,000 pieces
FYD0H473ZF	1,000 pieces
FYD0H104ZF	800 pieces
FYD0H224ZF	400 pieces
FYD0H474ZF	240 pieces
FYD0H105ZF	90 pieces
FYD0H145ZF	90 pieces
FYD0H225ZF	50 pieces
FYH0H223ZF	1,600 pieces
FYH0H473ZF	800 pieces
FYH0H104ZF	600 pieces
FYH0H224ZF	500 pieces
FYH0H474ZF	90 pieces
FYH0H105ZF	50 pieces
FYL0H103ZF	2,000 pieces
FYL0H223ZF	2,000 pieces
FYL0H473ZF	1,600 pieces

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	FMC	FG, FGR	FGH	FT	FC, FCS	HV
				FYD	FYH								
0.010 F	–	–	–	–	–	–	5,000 Ω	–	5,000 Ω	–	–	–	–
0.022 F	1,000 Ω	–	1,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	–	2,000 Ω	–	–	Discharge	–
0.033 F	–	–	–	–	–	–	Discharge	–	–	–	–	–	–
0.047 F	1,000 Ω	1,000 Ω	1,000 Ω	2,000 Ω	1,000 Ω	1,000 Ω	2000 Ω	1,000 Ω	2,000 Ω	–	–	–	–
0.10 F	510 Ω	510 Ω	510 Ω	1,000 Ω	510 Ω	1,000 Ω	1000 Ω	1,000 Ω	1,000 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	–	1,000 Ω	Discharge	200 Ω	Discharge	–
0.33 F	–	–	–	–	–	–	–	Discharge	–	–	–	–	–
0.47 F	100 Ω	100 Ω	100 Ω	200 Ω	200 Ω	200 Ω	–	–	1,000 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.*

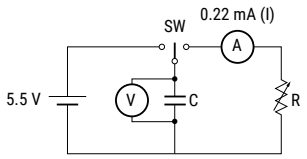
Measurement Conditions cont.

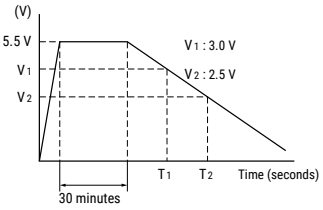
Capacitance (Discharge System)

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.

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

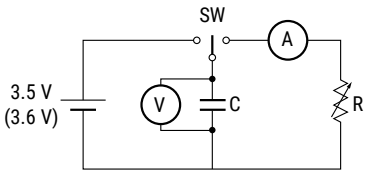


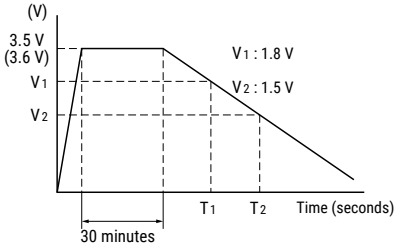


Capacitance (Discharge System – 3.5 V, 3.6 V)

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 (3.6 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.

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

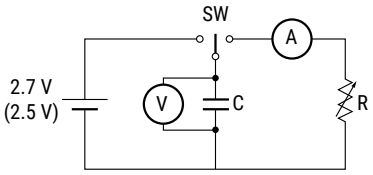


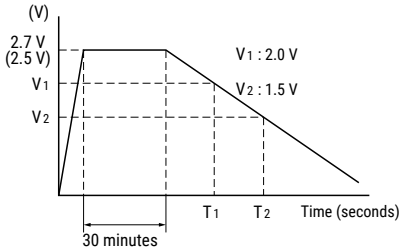


Capacitance (Discharge System – HV Series)

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.

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



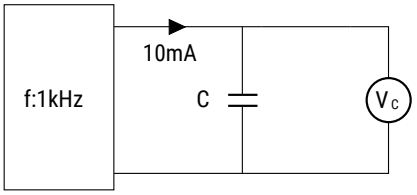


Measurement Conditions cont.

Equivalent Series Resistance (ESR)

ESR shall be calculated from the equation below.

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

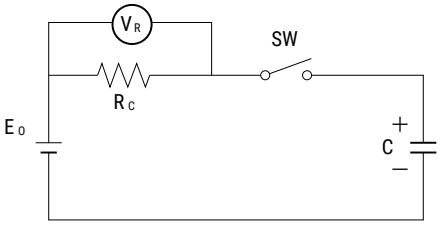


Current (at 30 minutes after charging)

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)
3.6 VDC (3.6 V type)
5.0 VDC (5.5 V type)
6.0 VDC (6.5 V type)
10.0 VDC (11 V type)
12.0 VDC (12 V type)

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



Rc: 1,000 Ω (0.01 F, 0.022 F, 0.047 F)
100 Ω (0.10 F, 0.22 F, 0.33 F, 0.47 F)
10 Ω (1.0 F, 1.4 F, 1.5 F, 2.2 F, 3.3 F, 4.7 F, 5.6 F)
2.2 Ω (HV Series)
However, FS Seres 11 V type and 12 V type
100 Ω 0.47 F, 1.0 F
10 Ω 5.0 F

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.

Supercapacitors

FR Series

Overview

FR 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.

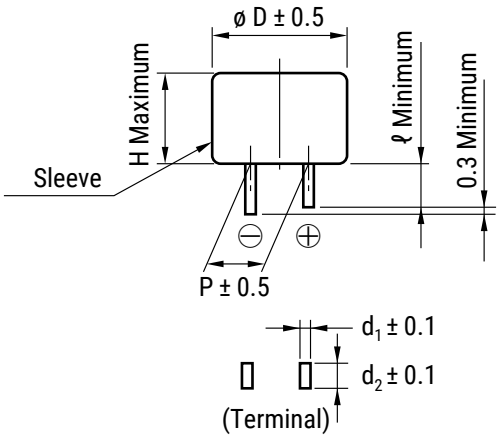
Benefits

- Wide range of temperature from −40°C to +85°C
- Maintenance free
- Maximum operating voltage of 5.5 VDC
- Highly reliable against liquid leakage
- Lead-free and RoHS compliant

Part Number System

FR	0H	104	Z	F
Series	Maximum Operating Voltage	Capacitance Code	Capacitance Tolerance	Environmental
FR	0H = 5.5 VDC	First two digits represent significant figures. Third digit specifies number of zeros to follow µF code.	Z = −20/+80%	F = Lead-free

Dimensions – Millimeters



Part Number	ø D	H	P	ℓ	d_1	d_2
FR0H223ZF	11.5	14.0	5.08	2.7	0.4	1.2
FR0H473ZF	14.5	14.0	5.08	2.4	0.4	1.2
FR0H104ZF	14.5	15.5	5.08	2.4	0.4	1.2
FR0H224ZF	14.5	21.0	5.08	2.4	0.4	1.2
FR0H474ZF	16.5	21.5	5.08	2.7	0.4	1.2
FR0H105ZF	21.5	22.0	7.62	3.0	0.6	1.2

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, FMR Type)
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
Long time back-up	500 µA and below	Embedded memory backup	DVD player, television, game console, set-top box	FR series
		Motor driver	DVD player, printer, projector, camera	

Environmental Compliance

All KEMET supercapacitors are RoHS compliant.

Table 1 – Ratings & Part Number Reference

Part Number	Maximum Operating Voltage (VDC)	Nominal Capacitance		Maximum ESR at 1 kHz (Ω)	Maximum Current at 30 Minutes (mA)	Voltage Holding Characteristic Minimum (V)	Weight (g)
		Charge System (F)	Discharge System (F)				
FR0H223ZF	5.5	0.022	0.028	220	0.033	4.2	2.3
FR0H473ZF	5.5	0.047	0.060	110	0.071	4.2	3.9
FR0H104ZF	5.5	0.10	0.15	150	0.15	4.2	4.3
FR0H224ZF	5.5	0.22	0.33	180	0.33	4.2	5.3
FR0H474ZF	5.5	0.47	0.75	100	0.71	4.2	7.5
FR0H105ZF	5.5	1.0	1.6	60	1.5	4.2	13.3

Part numbers in bold type represent popularly purchased components.

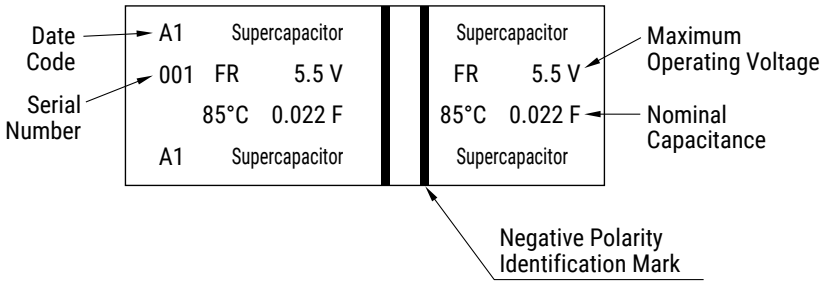
Specifications

Item		FR Type		Test Conditions (conforming to JIS C 5160-1)
Category Temperature Range		−40°C to +85°C		
Maximum Operating Voltage		5.5 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 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 0.068 F 240 Ω 0.10 F 150 Ω 0.22 F 56 Ω 0.47 F 30 Ω 1.0 F 15 Ω Discharge resistance: 0 Ω Temperature: 85 ±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 3: −40 ±2°C Phase 4: +25 ±2°C Phase 5: +85 ±2°C Phase 6: +25 ±2°C
	ESR		≤ 400% of initial value	
	Capacitance	Phase 3	≥ 30% of initial value	
	ESR		≤ 700% of initial value	
	Capacitance	Phase 5	≤ 200% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		≤ 1.5 CV (mA)	
	Capacitance	Phase 6	Within ±20% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		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			
	Current (30 minutes value)			
	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
	ESR			
	Current (30 minutes value)			
	Appearance	No obvious abnormality		1.6 mm from the bottom should be dipped.

Specifications cont.

Item		FR Type	Test Conditions (conforming to JIS C 5160-1)
Temperature Cycle	Capacitance	Satisfy initial ratings	Conforms to 4.12 Temperature Condition: −40°C » Room temperature » +85°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: +85 ±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	
Self Discharge Characteristics (Voltage Holding Characteristics)		Voltage between terminal leads > 4.2 V	Charging condition Voltage applied: 5.0 VDC (Terminal at the case side must be negative) Series resistance: 0 Ω Charging time: 24 hours
			Storage Let stand for 24 hours in condition described below with terminals opened. Ambient temperature: < 25°C Relative humidity: < 70% RH

Marking



Packaging Quantities

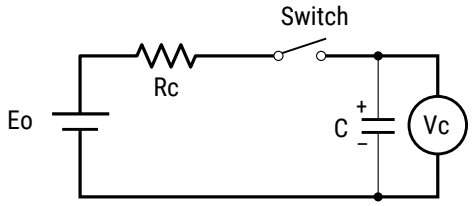
Part Number	Bulk Quantity per Box
FR0H223ZF	800 pieces
FR0H473ZF	400 pieces
FR0H104ZF	400 pieces
FR0H224ZF	300 pieces
FR0H474ZF	240 pieces
FR0H105ZF	90 pieces

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	FMC	FG, FGR	FGH	FT	FC, FCS	HV
				FYD	FYH								
0.010 F	–	–	–	–	–	–	5,000 Ω	–	5,000 Ω	–	–	–	–
0.022 F	1,000 Ω	–	1,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	–	2,000 Ω	–	–	Discharge	–
0.033 F	–	–	–	–	–	–	Discharge	–	–	–	–	–	–
0.047 F	1,000 Ω	1,000 Ω	1,000 Ω	2,000 Ω	1,000 Ω	1,000 Ω	2000 Ω	1,000 Ω	2,000 Ω	–	–	–	–
0.10 F	510 Ω	510 Ω	510 Ω	1,000 Ω	510 Ω	1,000 Ω	1000 Ω	1,000 Ω	1,000 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	–	1,000 Ω	Discharge	200 Ω	Discharge	–
0.33 F	–	–	–	–	–	–	–	Discharge	–	–	–	–	–
0.47 F	100 Ω	100 Ω	100 Ω	200 Ω	200 Ω	200 Ω	–	–	1,000 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.*

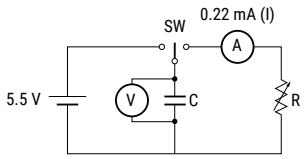
Measurement Conditions cont.

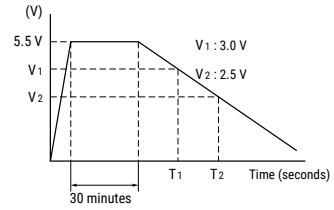
Capacitance (Discharge System)

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.

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

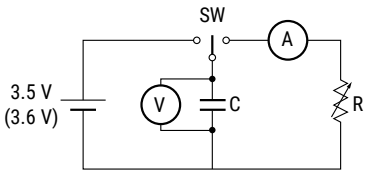


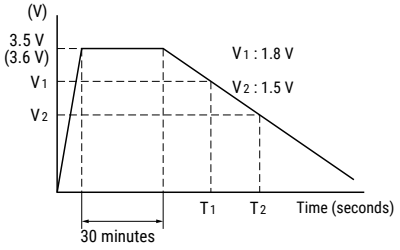


Capacitance (Discharge System – 3.5 V, 3.6 V)

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 (3.6 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.

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

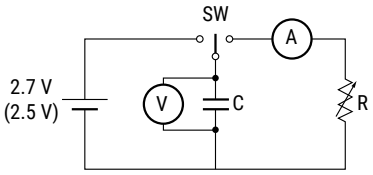


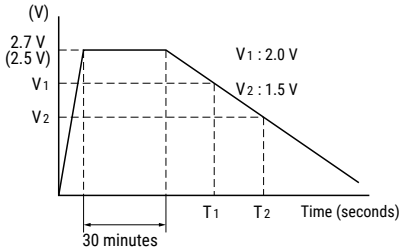


Capacitance (Discharge System – HV Series)

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.

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

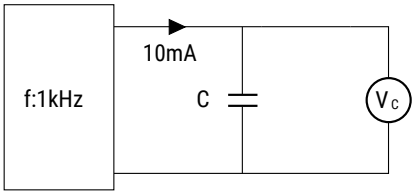




Measurement Conditions cont.

Equivalent Series Resistance (ESR)
ESR shall be calculated from the equation below.

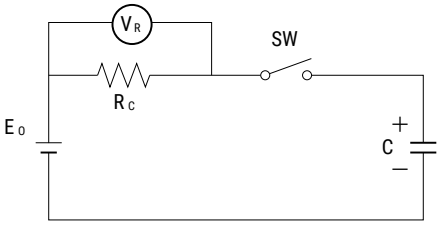
$$ESR = \frac{V_C}{0.01} (\Omega)$$



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)
3.6 VDC (3.6 V type)
5.0 VDC (5.5 V type)
6.0 VDC (6.5 V type)
10.0 VDC (11 V type)
12.0 VDC (12 V type)

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



Rc: 1,000 Ω (0.01 F, 0.022 F, 0.047 F)
100 Ω (0.10 F, 0.22 F, 0.33 F, 0.47 F)
10 Ω (1.0 F, 1.4 F, 1.5 F, 2.2 F, 3.3 F, 4.7 F, 5.6 F)
2.2 Ω (HV Series)
However, FS Seres 11 V type and 12 V type
100 Ω 0.47 F, 1.0 F
10 Ω 5.0 F

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.

Supercapacitors

FS Series

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.

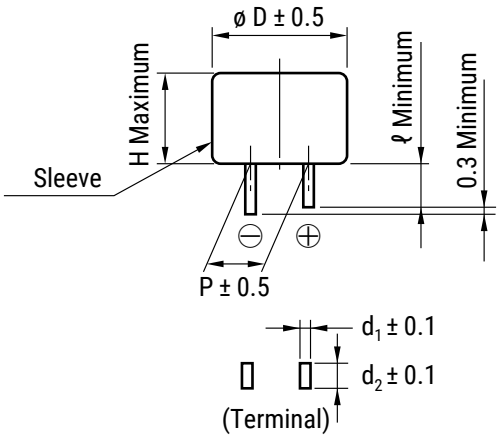
Benefits

- Wide range of temperature from −25°C to +70°C
- Maintenance free
- Maximum operating voltages of 5.5, 11.0, 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	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 to follow µF code.	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, FMR type)
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.

Table 1 – Ratings & Part Number Reference

Part Number	Maximum Operating Voltage (VDC)	Nominal Capacitance		Maximum ESR at 1 kHz (Ω)	Maximum Current at 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.

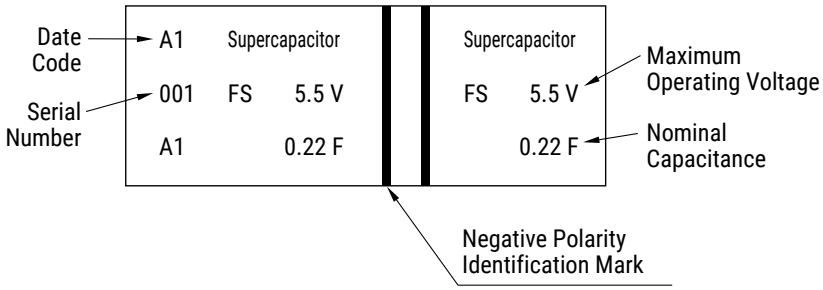
Specifications

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		≤ 300% of initial value	
	Capacitance	Phase 3		
	ESR			
	Capacitance	Phase 5	≤ 150% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		≤ 1.5 CV (mA)	
	Capacitance	Phase 6	Within ±20% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		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			
	Current (30 minutes value)			
	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			
	Current (30 minutes value)			
	Appearance	No obvious abnormality		

Specifications cont.

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	More than 90% of initial specified value (5.5V type) Within ±20% of initial measured value (11V type, 12V type)	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

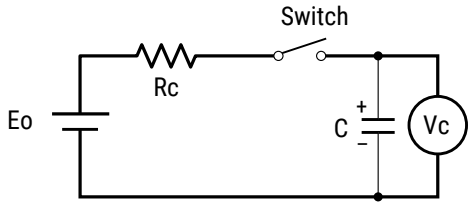
Part Number	Bulk Quantity per Box
FS0H223ZF	1,000 pieces
FS0H473ZF	800 pieces
FS0H104ZF	600 pieces
FS0H224ZF	400 pieces
FS0H474ZF	90 pieces
FS0H105ZF	50 pieces
FS1A474ZF	50 pieces
FS1A105ZF	50 pieces
FS1B105ZF	50 pieces
FS1B505ZF	20 pieces

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	FMC	FG, FGR	FGH	FT	FC, FCS	HV
				FYD	FYH								
0.010 F	–	–	–	–	–	–	5,000 Ω	–	5,000 Ω	–	–	–	–
0.022 F	1,000 Ω	–	1,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	–	2,000 Ω	–	–	Discharge	–
0.033 F	–	–	–	–	–	–	Discharge	–	–	–	–	–	–
0.047 F	1,000 Ω	1,000 Ω	1,000 Ω	2,000 Ω	1,000 Ω	1,000 Ω	2000 Ω	1,000 Ω	2,000 Ω	–	–	–	–
0.10 F	510 Ω	510 Ω	510 Ω	1,000 Ω	510 Ω	1,000 Ω	1000 Ω	1,000 Ω	1,000 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	–	1,000 Ω	Discharge	200 Ω	Discharge	–
0.33 F	–	–	–	–	–	–	–	Discharge	–	–	–	–	–
0.47 F	100 Ω	100 Ω	100 Ω	200 Ω	200 Ω	200 Ω	–	–	1,000 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.*

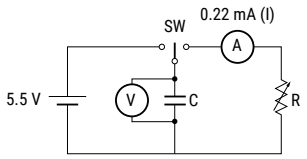
Measurement Conditions cont.

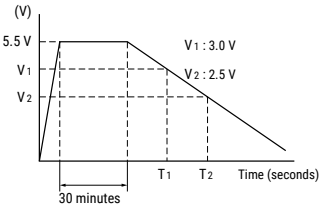
Capacitance (Discharge System)

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.

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

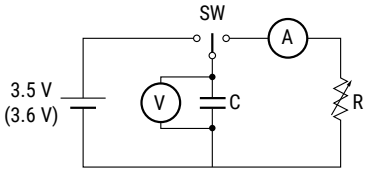


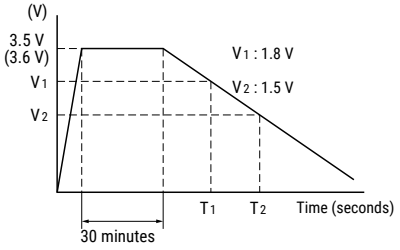


Capacitance (Discharge System – 3.5 V, 3.6 V)

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 (3.6 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.

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

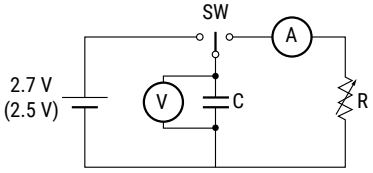


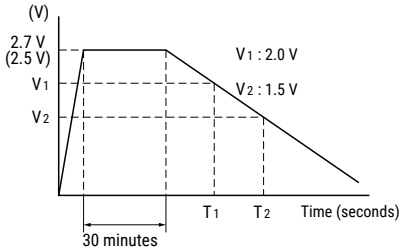


Capacitance (Discharge System – HV Series)

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.

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

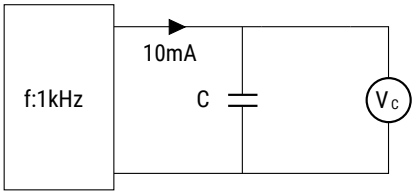




Measurement Conditions cont.

Equivalent Series Resistance (ESR)
ESR shall be calculated from the equation below.

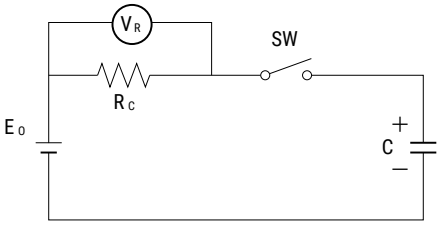
$$ESR = \frac{V_C}{0.01} (\Omega)$$



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)
3.6 VDC (3.6 V type)
5.0 VDC (5.5 V type)
6.0 VDC (6.5 V type)
10.0 VDC (11 V type)
12.0 VDC (12 V type)

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



Rc: 1,000 Ω (0.01 F, 0.022 F, 0.047 F)
100 Ω (0.10 F, 0.22 F, 0.33 F, 0.47 F)
10 Ω (1.0 F, 1.4 F, 1.5 F, 2.2 F, 3.3 F, 4.7 F, 5.6 F)
2.2 Ω (HV Series)
However, FS Seres 11 V type and 12 V type
100 Ω 0.47 F, 1.0 F
10 Ω 5.0 F

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.

Supercapacitors

FA Series

Overview

FA 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.

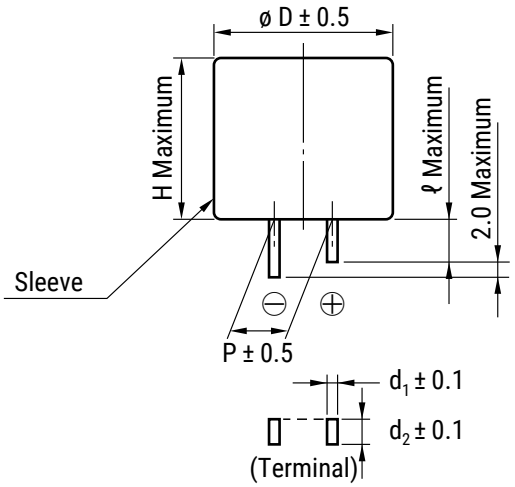
Benefits

- Wide range of temperature from −25°C to +70°C
- Maintenance free
- Maximum operating voltages of 5.5 and 11 VDC
- Highly reliable against liquid leakage
- Lead-free and RoHS compliant

Part Number System

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

Dimensions – Millimeters



Part Number	ø D	H	P	ℓ	d_1	d_2
FA0H473ZF	16.0	15.5	5.1	5.0	0.4	1.2
FA0H104ZF	21.5	15.5	7.6	5.5	0.6	1.2
FA0H224ZF	28.5	16.5	10.2	9.5	0.6	1.4
FA0H474ZF	36.5	16.5	15.0	9.5	0.6	1.7
FA0H105ZF	44.5	18.5	20.0	9.5	1.0	1.4
FA1A223ZF	16.0	25.0	5.1	5.0	0.4	1.2
FA1A104ZF	28.5	25.5	10.2	9.5	0.6	1.4
FA1A224ZF	36.5	27.5	15.0	9.5	1.0	1.4
FA1A474ZF	44.5	28.5	20.0	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, FMR type)
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 10 seconds or less	1 A and below	Power source of toys, LED, buzzer	Toys, display device, alarm device	FA series
		High current supply for a short amount of time	Actuator, relay solenoid, gas igniter	

Environmental Compliance

All KEMET supercapacitors are RoHS compliant.

Table 1 – Ratings & Part Number Reference

Part Number	Maximum Operating Voltage (VDC)	Nominal Capacitance		Maximum ESR at 1 kHz (Ω)	Maximum Current at 30 Minutes (mA)	Weight (g)
		Charge System (F)	Discharge System (F)			
FA0H473ZF	5.5	0.047	0.075	20.0	0.071	6.2
FA0H104ZF	5.5	0.10	0.16	8.0	0.15	12
FA0H224ZF	5.5	0.22	0.35	5.0	0.33	25
FA0H474ZF	5.5	0.47	0.75	3.5	0.71	42
FA0H105ZF	5.5	1.0	1.6	2.5	1.5	65
FA1A223ZF	11.0	0.022	0.035	20.0	0.066	7.5
FA1A104ZF	11.0	0.10	0.16	8.0	0.30	32
FA1A224ZF	11.0	0.22	0.35	6.0	0.66	55
FA1A474ZF	11.0	0.47	0.75	4.0	1.41	83

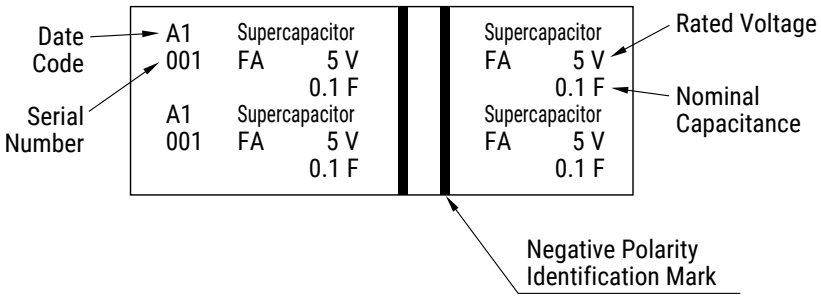
Specifications

Item		FA 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		
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			Surge voltage: 6.3 V (5.5 V type) 12.6 V (11 V type) Charge: 30 seconds Discharge: 9 minutes 30 seconds Number of cycles: 1,000 Series resistance: 0.047 F 300 Ω 0.10 F 150 Ω 0.22 F 56 Ω 0.47 F 30 Ω 1.0 F, 1.5 F 15 Ω Discharge resistance: 0 Ω Temperature: 70 ±2°C
	ESR			
	Current (30 minutes value)			
	Appearance			
Characteristics in Different Temperature	Capacitance	Phase 2	≥ 70% 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		≤ 300% of initial value	
	Capacitance	Phase 3		
	ESR			
	Capacitance	Phase 5	≤ 150% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		≤ 1.5 CV (mA)	
	Capacitance	Phase 6	Within ±20% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		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			
	Current (30 minutes value)			
	Appearance	No obvious abnormality		

Specifications cont.

Item		FA Type	Test Conditions (conforming to JIS C 5160-1)
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		
	Current (30 minutes value)		
	Appearance	No obvious abnormality	
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	> 90% 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	> 80% 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	< 120% of initial ratings	
	Current (30 minutes value)	< 200% of initial ratings	
	Appearance	No obvious abnormality	

Marking



Packaging Quantities

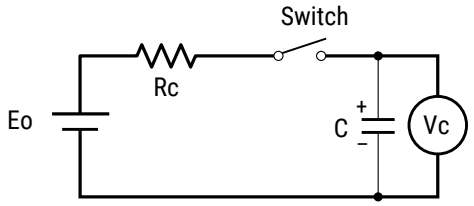
Part Number	Bulk Quantity per Box
FA0H473ZF	400 pieces
FA0H104ZF	90 pieces
FA0H224ZF	50 pieces
FA0H474ZF	30 pieces
FA0H105ZF	20 pieces
FA1A223ZF	240 pieces
FA1A104ZF	50 pieces
FA1A224ZF	30 pieces
FA1A474ZF	20 pieces

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	FMC	FG, FGR	FGH	FT	FC, FCS	HV
				FYD	FYH								
0.010 F	–	–	–	–	–	–	5,000 Ω	–	5,000 Ω	–	–	–	–
0.022 F	1,000 Ω	–	1,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	–	2,000 Ω	–	–	Discharge	–
0.033 F	–	–	–	–	–	–	Discharge	–	–	–	–	–	–
0.047 F	1,000 Ω	1,000 Ω	1,000 Ω	2,000 Ω	1,000 Ω	1,000 Ω	2000 Ω	1,000 Ω	2,000 Ω	–	–	–	–
0.10 F	510 Ω	510 Ω	510 Ω	1,000 Ω	510 Ω	1,000 Ω	1000 Ω	1,000 Ω	1,000 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	–	1,000 Ω	Discharge	200 Ω	Discharge	–
0.33 F	–	–	–	–	–	–	–	Discharge	–	–	–	–	–
0.47 F	100 Ω	100 Ω	100 Ω	200 Ω	200 Ω	200 Ω	–	–	1,000 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.*

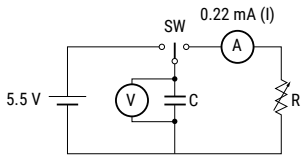
Measurement Conditions cont.

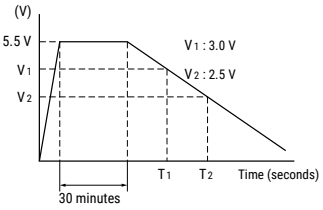
Capacitance (Discharge System)

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.

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

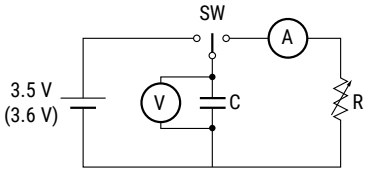


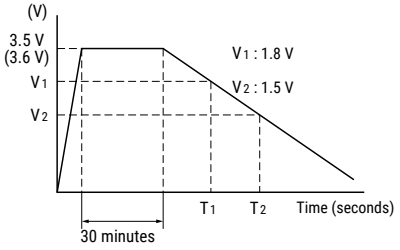


Capacitance (Discharge System – 3.5 V, 3.6 V)

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 (3.6 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.

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

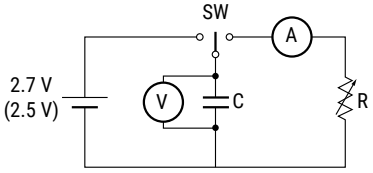


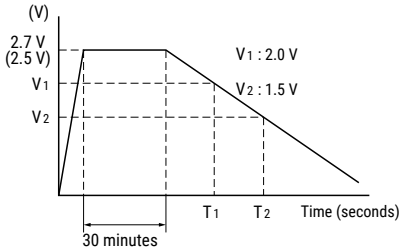


Capacitance (Discharge System – HV Series)

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.

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

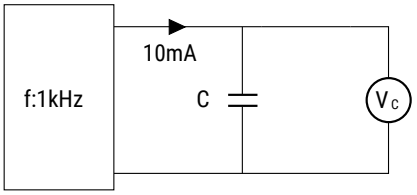




Measurement Conditions cont.

Equivalent Series Resistance (ESR)
ESR shall be calculated from the equation below.

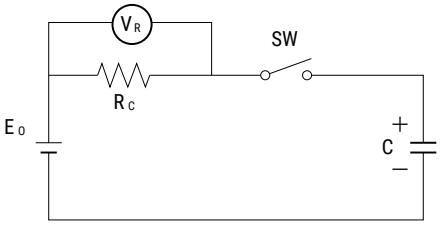
$$ESR = \frac{V_C}{0.01} (\Omega)$$



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)
3.6 VDC (3.6 V type)
5.0 VDC (5.5 V type)
6.0 VDC (6.5 V type)
10.0 VDC (11 V type)
12.0 VDC (12 V type)

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



Rc: 1,000 Ω (0.01 F, 0.022 F, 0.047 F)
100 Ω (0.10 F, 0.22 F, 0.33 F, 0.47 F)
10 Ω (1.0 F, 1.4 F, 1.5 F, 2.2 F, 3.3 F, 4.7 F, 5.6 F)
2.2 Ω (HV Series)
However, FS Seres 11 V type and 12 V type
100 Ω 0.47 F, 1.0 F
10 Ω 5.0 F

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.

Supercapacitors

FE Series

Overview

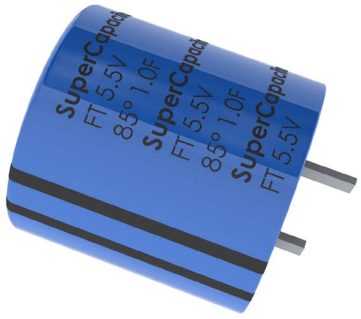
FE Series Supercapacitors, also known as Electric Double-Layer Capacitors (EDLCs), are intended for high energy storage applications.

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

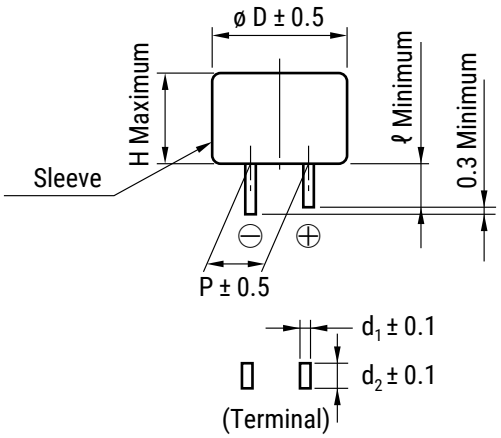
- Wide range of temperature from −40°C to +70°C
- Maintenance free
- Maximum operating voltage of 5.5 VDC
- Highly reliable against liquid leakage
- Lead-free and RoHS compliant



Part Number System

FE	0H	104	Z	F
Series	Maximum Operating Voltage	Capacitance Code	Capacitance Tolerance	Environmental
FE	0H = 5.5 VDC	First two digits represent significant figures. Third digit specifies number of zeros to follow µF code.	Z = −20/+80%	F = Lead-free

Dimensions – Millimeters



Part Number	ø D	H	P	ℓ	d_1	d_2
FE0H473ZF	14.5	14.0	5.1	2.2	0.4	1.2
FE0H104ZF	16.5	14.0	5.1	2.7	0.4	1.2
FE0H224ZF	21.5	15.5	7.6	3.0	0.6	1.2
FE0H474ZF	28.5	16.5	10.2	6.1	0.6	1.4
FE0H105ZF	36.5	18.5	15.0	6.1	0.6	1.7
FE0H155ZF	44.5	18.5	20.0	6.1	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, FMR type)
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 10 seconds or less	1 A and below	Power source of toys, LED, buzzer	Toys, display device, alarm device	FE series
		High current supply for a short amount of time	Actuator, relay solenoid, gas igniter	

Environmental Compliance

All KEMET supercapacitors are RoHS compliant.

Table 1 – Ratings & Part Number Reference

Part Number	Maximum Operating Voltage (VDC)	Nominal Capacitance		Maximum ESR at 1 kHz (Ω)	Maximum Current at 30 Minutes (mA)	Weight (g)
		Charge System (F)	Discharge System (F)			
FE0H473ZF	5.5	0.047	0.075	14.0	0.071	3.9
FE0H104ZF	5.5	0.10	0.16	6.5	0.15	5
FE0H224ZF	5.5	0.22	0.35	3.5	0.33	9.5
FE0H474ZF	5.5	0.47	0.75	1.8	0.71	16
FE0H105ZF	5.5	1.0	1.4	1.0	1.5	38
FE0H155ZF	5.5	1.5	2.1	0.6	2.3	72

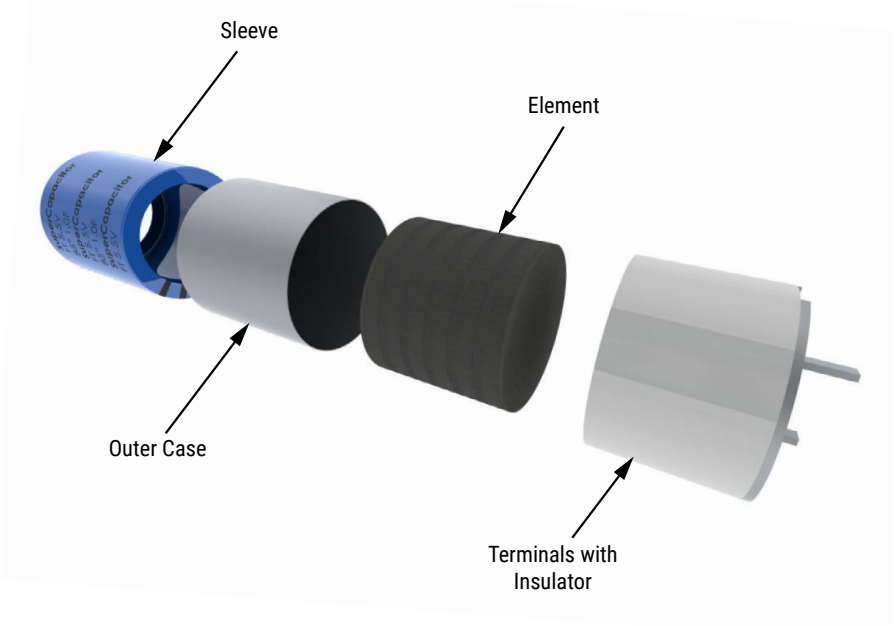
Specifications

Item		FE Type		Test Conditions (conforming to JIS C 5160-1)
Category Temperature Range		−40°C to +70°C		
Maximum Operating Voltage		5.5 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 Charge: 30 seconds Discharge: 9 minutes 30 seconds Number of cycles: 1,000 Series resistance: 0.047 F 300 Ω; 0.10 F 150 Ω; 0.22 F 56 Ω; 0.47 F 30 Ω; 1.0 F, 1.5 F 15 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	≥ 70% of initial value	Conforms to 4.17 Phase 1: +25 ±2°C Phase 2: −25 ±2°C Phase 3: −40 ±2°C Phase 4: +25 ±2°C Phase 5: +70 ±2°C Phase 6: +25 ±2°C
	ESR		≤ 300% of initial value	
	Capacitance	Phase 3	≥ 40% of initial value	
	ESR		≤ 400% of initial value	
	Capacitance	Phase 5	≤ 200% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		≤ 1.5 CV (mA)	
	Capacitance	Phase 6	Within ±20% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		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			
	Current (30 minutes value)			
	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			
	Current (30 minutes value)			
	Appearance	No obvious abnormality		
Temperature Cycle	Capacitance	Satisfy initial ratings		Conforms to 4.12 Temperature Condition: −40°C » Room temperature » +70°C » Room temperature Number of cycles: 5 cycles
	ESR			
	Current (30 minutes value)			
	Appearance	No obvious abnormality		

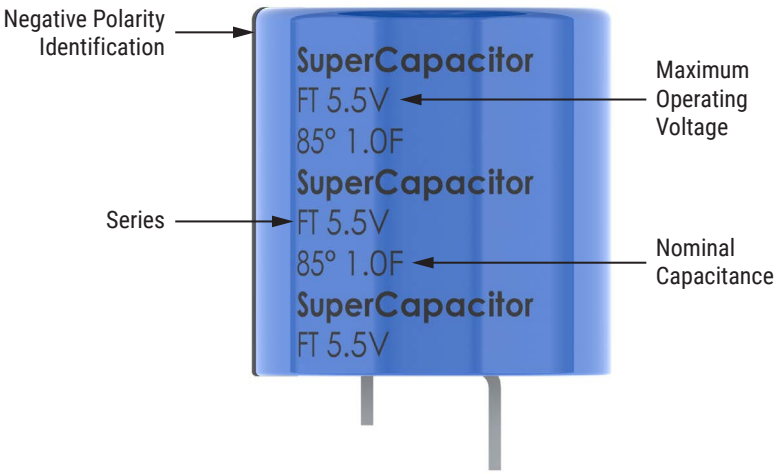
Specifications cont.

Item		FE Type	Test Conditions (conforming to JIS C 5160-1)
High Temperature and High Humidity Resistance	Capacitance	Within ±30% 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	

Construction



Marking



Packaging Quantities

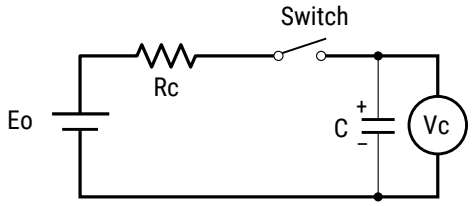
Part Number	Bulk Quantity per Box
FE0H473ZF	400 pieces
FE0H104ZF	400 pieces
FE0H224ZF	90 pieces
FE0H474ZF	50 pieces
FE0H105ZF	30 pieces
FE0H155ZF	20 pieces

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	FMC	FG, FGR	FGH	FT	FC, FCS	HV
				FYD	FYH								
0.010 F	–	–	–	–	–	–	5,000 Ω	–	5,000 Ω	–	–	–	–
0.022 F	1,000 Ω	–	1,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	–	2,000 Ω	–	–	Discharge	–
0.033 F	–	–	–	–	–	–	Discharge	–	–	–	–	–	–
0.047 F	1,000 Ω	1,000 Ω	1,000 Ω	2,000 Ω	1,000 Ω	1,000 Ω	2000 Ω	1,000 Ω	2,000 Ω	–	–	–	–
0.10 F	510 Ω	510 Ω	510 Ω	1,000 Ω	510 Ω	1,000 Ω	1000 Ω	1,000 Ω	1,000 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	–	1,000 Ω	Discharge	200 Ω	Discharge	–
0.33 F	–	–	–	–	–	–	–	Discharge	–	–	–	–	–
0.47 F	100 Ω	100 Ω	100 Ω	200 Ω	200 Ω	200 Ω	–	–	1,000 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.*

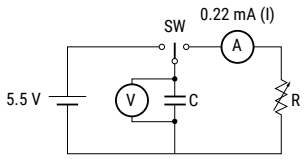
Measurement Conditions cont.

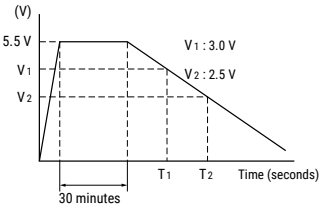
Capacitance (Discharge System)

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.

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

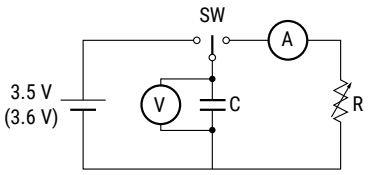


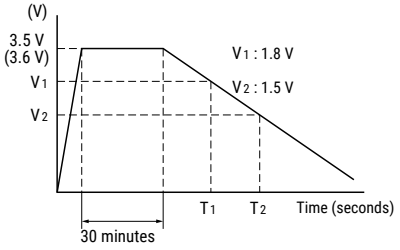


Capacitance (Discharge System – 3.5 V, 3.6 V)

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 (3.6 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.

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

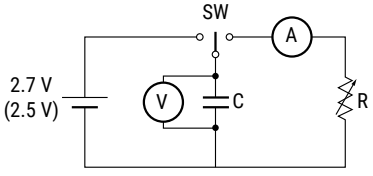


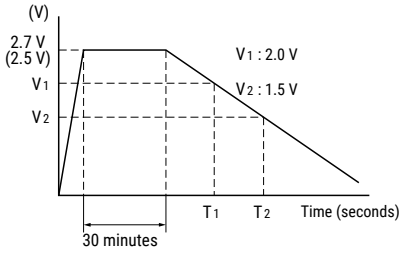


Capacitance (Discharge System – HV Series)

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.

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



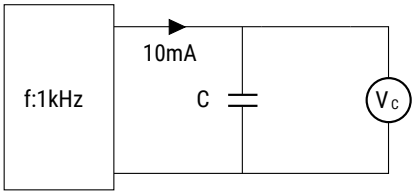


Measurement Conditions cont.

Equivalent Series Resistance (ESR)

ESR shall be calculated from the equation below.

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

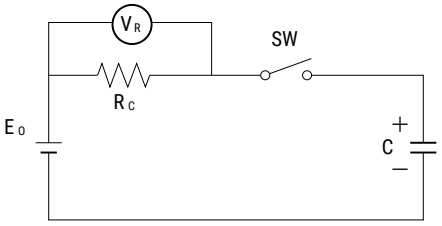


Current (at 30 minutes after charging)

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)
3.6 VDC (3.6 V type)
5.0 VDC (5.5 V type)
6.0 VDC (6.5 V type)
10.0 VDC (11 V type)
12.0 VDC (12 V type)

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



Rc: 1,000 Ω (0.01 F, 0.022 F, 0.047 F)
100 Ω (0.10 F, 0.22 F, 0.33 F, 0.47 F)
10 Ω (1.0 F, 1.4 F, 1.5 F, 2.2 F, 3.3 F, 4.7 F, 5.6 F)
2.2 Ω (HV Series)
However, FS Seres 11 V type and 12 V type
100 Ω 0.47 F, 1.0 F
10 Ω 5.0 F

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.

Supercapacitors

HV Series

Overview

HV 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

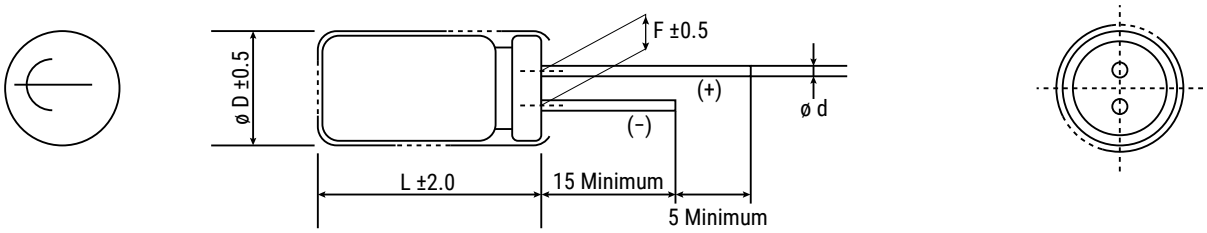
- Wide range of temperature from −25°C to +60°C and −25°C to +70°C
- Maintenance free
- Maximum operating voltages of 2.5 and 2.7 VDC
- Highly reliable against liquid leakage
- Lead-free and RoHS compliant

Part Number System

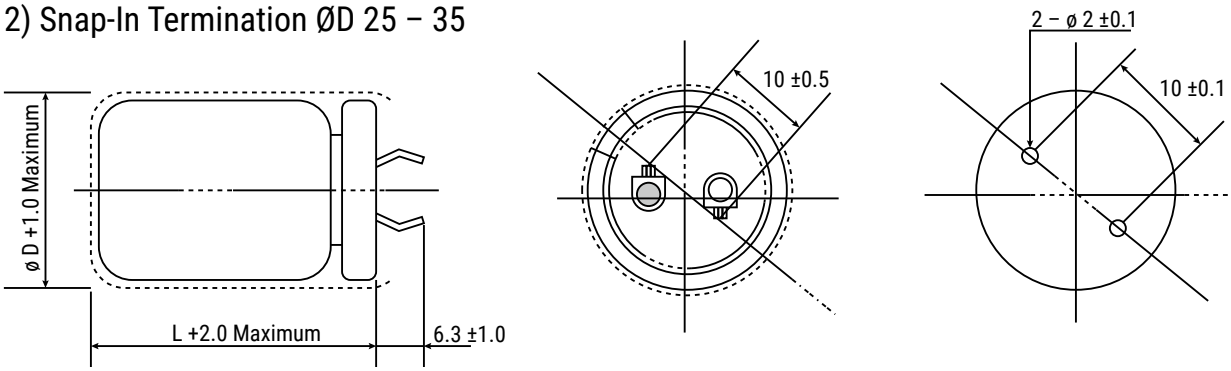
HVZ	0H	104	Z	F	-LT
Series	Maximum Operating Voltage	Capacitance Code	Capacitance Tolerance	Environmental	Terminal
HVZ	0E = 2.7 VDC (50 F type has 2.5 VDC)	First two digits represent significant figures. Third digit specifies number of zeros to follow µF code.	N = ±30%	F = Lead-free	-LT = Snap-in Blank = Standard

Dimensions – Millimeters

1) Standard Termination ØD 8 – 18

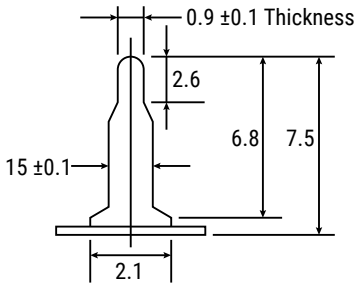


2) Snap-In Termination ØD 25 – 35



Part Number	ø D	L	F	d
HVZ0E105NF	8.0	12.0	3.5	0.6
HVZ0E275NF	8.0	22.0	3.5	0.6
HVZ0E475NF	10.0	20.0	5.0	0.6
HVZ0E106NF	10.0	35.0	5.0	0.6
HVZ0E226NF	12.5	35.0	5.0	0.6
HVZ0E506NF	18.0	40.0	7.5	0.8
HVZ0E107NF-LT	25.0	50.0	-	-
HVZ0E207NF-LT	35.0	50.0	-	-

Snap-In (-LT) Terminal Details



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, FMR Type)
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
Power Assist	Up to several A	Power supply, subsidiary power supply	Street sign, display light, UPS	HV series

Environmental Compliance

All KEMET supercapacitors are RoHS compliant.

Table 1 – Ratings & Part Number Reference

Part Number	Maximum Operating Voltage (VDC)	Nominal Capacitance (F)	Maximum ESR at 1 kHz (Ω)	Maximum Current at 30 Minutes (mA)	Weight (g)
HVZ0E506NF	2.5	50.0	50	40.0	14.0
HVZ0E105NF	2.7	1.0	300	0.8	1.0
HVZ0E275NF	2.7	2.7	300	2.2	1.9
HVZ0E475NF	2.7	4.7	100	3.8	2.5
HVZ0E106NF	2.7	10.0	100	8.0	4.0
HVZ0E226NF	2.7	22.0	100	18.0	10.0
HVZ0E107NF-LT	2.7	100.0	30	81.0	28.0
HVZ0E207NF-LT	2.7	200.0	30	162.0	61.5

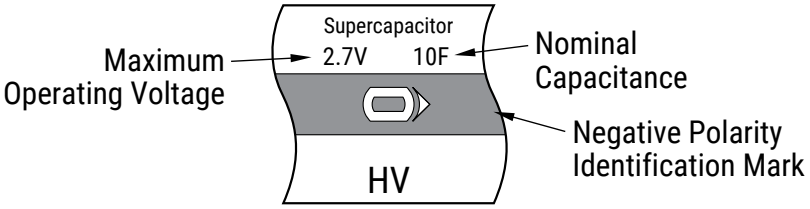
Specifications

Item		FT Type		Test Conditions (conforming to JIS C 5160-1)
Category Temperature Range		-25°C to +60°C (22 F, 50 F, 100 F, 200 F) -25°C to +70°C (1.0 F, 2.7 F, 4.7 F, 10 F)		
Maximum Operating Voltage		2.7 VDC (50 F type has 2.5 VDC)		
Capacitance		Refer to Table 1		Refer to "Measurement Conditions"
Capacitance Allowance		±30%		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"
Characteristics in Different Temperature	Capacitance	Phase 2	≥ 70% of initial value	Conforms to 4.13 Phase 2: −25 ±2°C Phase 4: Category maximum tenperature ±2°C Phase 5: +25 ±2°C
	ESR		≤ 500% of initial value	
	Capacitance	Phase 4	≤ 150% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		≤ 1.5 CV (mA)	
	Capacitance	Phase 5	Within ±20% of initial value	
	ESR		Satisfy initial ratings	
	Current (30 minutes value)		Satisfy initial ratings	
Lead Strength		No pin disconnection		Conforms to 4.5
Vibration Resistance	Capacitance	Satisfy initial ratings		Conforms to 4.9 Frequency: 10 to 55 Hz Testing Time: 6 hours
	ESR			
	Current (30 minutes value)			
	Appearance	No obvious abnormality		
Solderability		Over 3/4 of the terminal should be covered by the new solder		Conforms to 4.7 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 4.6 Solder temp: +245 ±5°C Dipping time: 5 ±0.5 seconds 1.6 mm from the bottom should be dipped.
	ESR			
	Current (30 minutes value)			
	Appearance	No obvious abnormality		
Temperature Cycle	Capacitance	Satisfy initial ratings		Conforms to 4.8 Temperature Condition: −25°C » Room temperature » Category Maximum temperature » Room temperature Number of cycles: 5 cycles
	ESR			
	Current (30 minutes value)			
	Appearance	No obvious abnormality		
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	≤ 150% of initial ratings		
	Current (30 minutes value)	≤ 150% of initial ratings		
	Appearance	No obvious abnormality		

Specifications cont.

Item		FT Type	Test Conditions (conforming to JIS C 5160-1)
High Temperature Load	Capacitance	Within ±30% of initial value	Conforms to 4.10 Temperature: Category Maximum temperature ±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

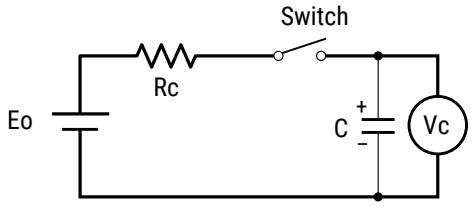
Part Number	Bulk Quantity per Box
HVZ0E105NF	4,000 pieces
HVZ0E275NF	2,000 pieces
HVZ0E475NF	2,000 pieces
HVZ0E106NF	2,000 pieces
HVZ0E226NF	1,000 pieces
HVZ0E506NF	250 pieces
HVZ0E107NF-LT	100 pieces
HVZ0E207NF-LT	100 pieces

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	FMC	FG, FGR	FGH	FT	FC, FCS	HV
				FYD	FYH								
0.010 F	–	–	–	–	–	–	5,000 Ω	–	5,000 Ω	–	–	–	–
0.022 F	1,000 Ω	–	1,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	2,000 Ω	–	2,000 Ω	–	–	Discharge	–
0.033 F	–	–	–	–	–	–	Discharge	–	–	–	–	–	–
0.047 F	1,000 Ω	1,000 Ω	1,000 Ω	2,000 Ω	1,000 Ω	1,000 Ω	2000 Ω	1,000 Ω	2,000 Ω	–	–	–	–
0.10 F	510 Ω	510 Ω	510 Ω	1,000 Ω	510 Ω	1,000 Ω	1000 Ω	1,000 Ω	1,000 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	–	1,000 Ω	Discharge	200 Ω	Discharge	–
0.33 F	–	–	–	–	–	–	–	Discharge	–	–	–	–	–
0.47 F	100 Ω	100 Ω	100 Ω	200 Ω	200 Ω	200 Ω	–	–	1,000 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.*

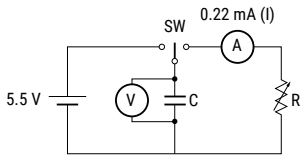
Measurement Conditions cont.

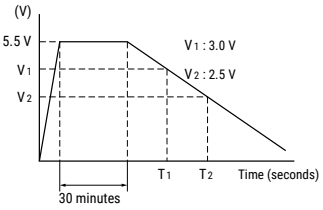
Capacitance (Discharge System)

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.

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

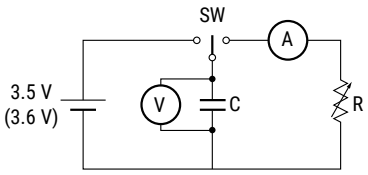


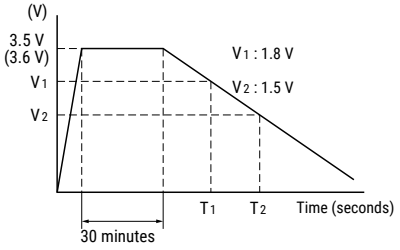


Capacitance (Discharge System – 3.5 V, 3.6 V)

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 (3.6 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.

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

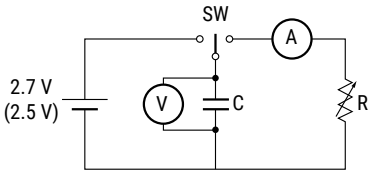


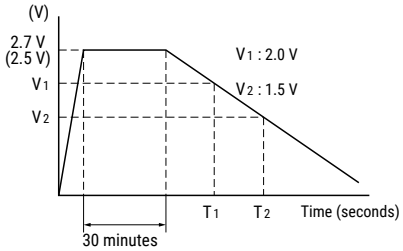


Capacitance (Discharge System – HV Series)

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.

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



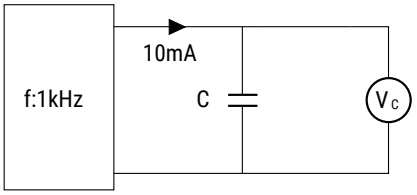


Measurement Conditions cont.

Equivalent Series Resistance (ESR)

ESR shall be calculated from the equation below.

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

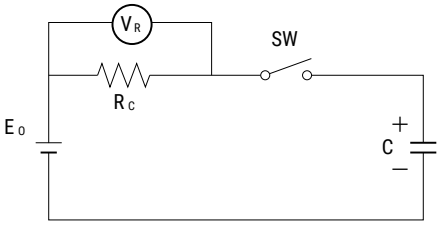


Current (at 30 minutes after charging)

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)
3.6 VDC (3.6 V type)
5.0 VDC (5.5 V type)
6.0 VDC (6.5 V type)
10.0 VDC (11 V type)
12.0 VDC (12 V type)

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



Rc: 1,000 Ω (0.01 F, 0.022 F, 0.047 F)
100 Ω (0.10 F, 0.22 F, 0.33 F, 0.47 F)
10 Ω (1.0 F, 1.4 F, 1.5 F, 2.2 F, 3.3 F, 4.7 F, 5.6 F)
2.2 Ω (HV Series)
However, FS Seres 11 V type and 12 V type
100 Ω 0.47 F, 1.0 F
10 Ω 5.0 F

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.

Supercapacitors - Automotive Grade

FMD Series, 5.5 V, 85°C

Overview

FMD Series Supercapacitors, also known as Electric Double-Layer Capacitors (EDLCs), are intended for power back up in the automotive applications.

Enhancements to the design and selected material upgrades were introduced to deliver 1,000 hours at 85°C/85% RH rated voltage and Automotive Testing Protocol with extended maximum operational temperature life up to 85°C. These capacitors are manufactured in an ISO TS 16949 certified plant and are subjected to PPAP/PSW, as well as change control.

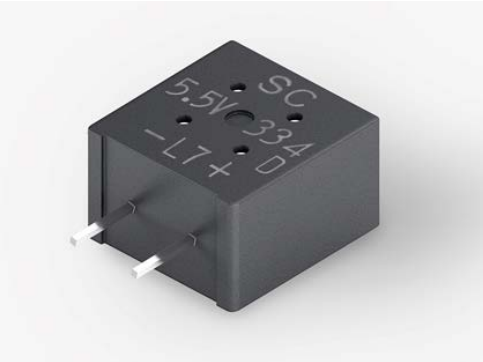
Applications

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.

FMD type Automotive grade Supercapacitor can be stable under harsh environmental conditions such as high humidity and high temperture.

Benefits

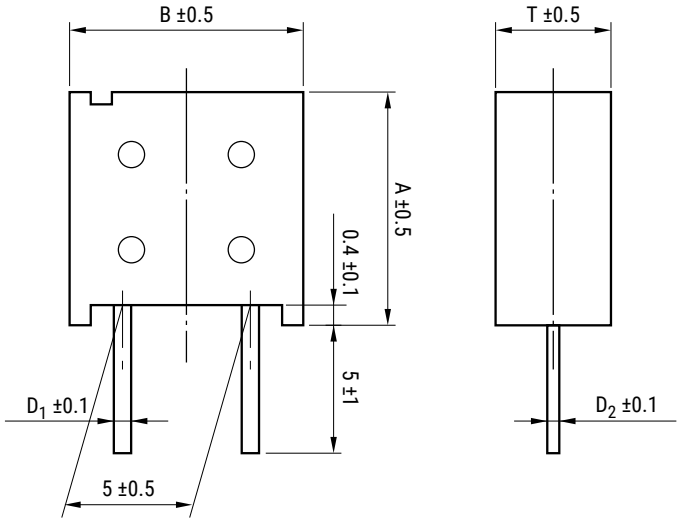
- AEC-Q200 rev E compliant
- TS 16949 certified plant
- Subject to PPAP/PSW and change control
- Wide range of temperature from -40°C to +85°C
- Maintenance free
- Maximum operating voltage of 5.5 VDC
- Highly reliable against liquid leakage
- Lead-free and RoHS compliant



Part Number System

FMD	0H	334	Z	F	TP	18
Series	Maximum Operating Voltage	Capacitance Code	Capacitance Tolerance	Environmental	Tape Type	Height (excluding lead)
FMD	0H = 5.5 VDC	First two digits represent significant figures. Third digit specifies number of zeros to follow µF code.	Z = -20/+80%	F = Lead-free	TP = Ammo Blank = Bulk	18 = 18 mm Blank = Bulk

Dimensions – Millimeters



Part Number	A	B	T	D_1	D_2
FMD0H334ZF	15	14	9	0.6	0.6

Environmental Compliance

All KEMET supercapacitors are RoHS compliant.

Table 1 – Ratings & Part Number Reference

Part Number	Maximum Operating Voltage (VDC)	Nominal Capacitance		Maximum ESR at 1 kHz (Ω)	Maximum Current at 30 Minutes (mA)	Voltage Holding Characteristic Minimum (V)	Reference Weight (g)
		Charge System (F)	Discharge System (F)				
FMD0H334ZF	5.5	-	0.33	25	0.50	4.2	3.8

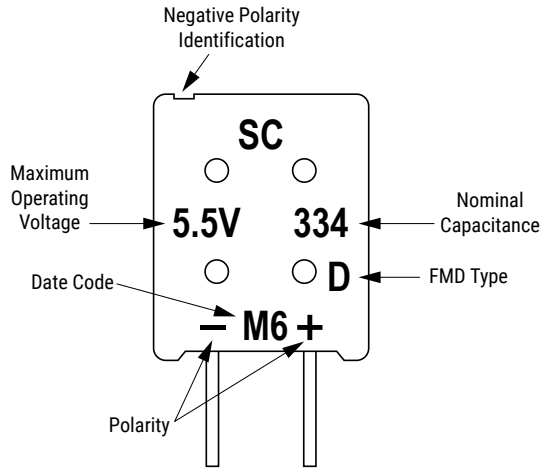
Specifications

Item			Specifications	Test Conditions	
Category temperature range			−40°C to +85°C		
MAX operating voltage			Refer to standard ratings		
Capacitance			Refer to standard ratings	Refer to “Measurement Conditions”	
Capacitance allowance			+80%, −20%	Refer to “Measurement Conditions”	
ESR			Refer to standard ratings	Measured at 1 kHz, 10 mA, See also “Measurement Conditions	
Current (30 minute value)			Refer to standard ratings	Refer to “Measurement Conditions”	
Self discharge characteristics (voltage holding characteristics)			Voltage between terminal leads higher than 4.2 V	Charging	Voltage applied: 5.0 VDC Series resistance: 0 Ω Let stand for 24 hours
				Storage	Let stand for 24 hours in described below with terminals opened Ambient temperature: Lower than 25°C Relative humidity: Lower than 70°C
High Temperature Exposure (Storage)	MIL-STD-202 Method 108	Capacitance	Within ±30% of initial measured value	Temperature: 85 ±2°C	
		ESR	Less than 200% of initial limit	Testing time: $1{,}000^{+48}_{-0}$ hours	
		Current	Less than 200% of initial limit		
Temperature Cycling	JESD22 Method JA-104	Capacitance	Within ±30% of initial measured value	Temperature condition: Lower −40°C » Upper +85°C	
				Dwell Time: 30 minutes	
		ESR	Less than 200% of initial limit	Transition time: Maximum 1 minute	
		Current	Less than 200% of initial limit	Number of cycles: 1,000 Cycles	
Biased humidity	MIL-STD- 202 Method 103	Capacitance	Within ±30% of initial measured value	Temperature: 85±2°C	
				Relative humidity: 80 to 85%RH	
				Voltage applied: MAX operating voltage	
		ESR	Less than 200% of initial limit	Series protection resistance: 0 Ω	
		Current	Less than 200% of initial limit	Testing time: $1{,}000^{+48}_{-0}$ hours	
Operational life	MIL-STD- 202 Method 108	Capacitance	Within ±30% of initial measured value	Temperature: 85±2°C	
		ESR	Less than 200% of initial limit	Voltage applied: MAX operating voltage	
		Current	Less than 200% of initial limit	Series protection resistance: 0 Ω	
				Testing time: $1{,}000^{+48}_{-0}$ hours	
Lead strength (Tensile)	MIL-STD-202 Method 211		No terminal damage	Test leaded device lead integrity only.	
				A (454 g), C (227 g)	
Mechanical shock	MIL-STD-202 Method 213	Capacitance	Satisfy initial limit	Figure 1 of Method 213 Condition C	
		ESR			
		Current			
Solderability	J-STD-002			Conforms to Method A1 (Through Hole Technology) Solder temp: 245±5°C	
				Dipping time: 5 +0/−0.5 second	
		Appearance	Minimum 95% of the terminal should be covered by the new solder	1.6mm from the bottom should be dipped.	
Vibration	MIL-STD-202 Method 204	Capacitance	Satisfy initial limit	Frequency: 10 to 2,000 Hz (5 g’s)	
		ESR		Testing time: 12 hours	
		Current			

Specifications cont.

Item			Specifications		Test Conditions
Resistance to Soldering Heat	MIL-STD- 202 Method 210	Capacitance	Satisfy initial limit		Solder temp: 260±10°C Dipping time: 3 seconds 2.0 mm from the bottom should be dipped. Condition B no pre-heat of samples. Note: Single Wave Solder. Procedure 1 with solder within 1.5 mm of device body for Leaded.
		ESR			
		Current			
Temperature Stability	IEC-62391-1	Capacitance	Phase2	More than 50% of initial measured	Phase1: +25±2°C Phase2: −25±2°C Phase3: −40±2°C Phase4: +25±2°C Phase5: +85±2°C Phase6: +25±2°C
		ESR		Less than 400% of initial measured	
		Capacitance	Phase3	More than 30% of initial measured	
		ESR		Less than 700% of initial measured	
		Capacitance	Phase5	Less than 200% of initial measured	
		ESR		Satisfy initial specified value	
		Current		1.5 CV (mA) or below	
		Capacitance	Phase6	Within ±20% of initial measured value	
		ESR		Satisfy initial specified value	
		Current		Satisfy initial specified value	

Marking

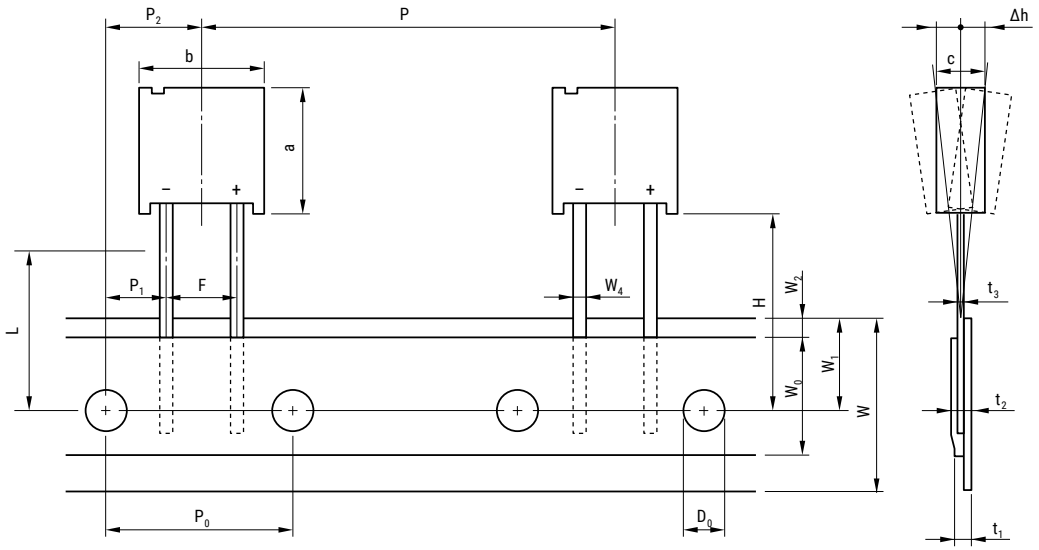


Example: FMD0H334ZF

Packaging Quantities

Part Number	Bulk Quantity per Box Straight Lead	Ammo Pack Quantity
FMD0H334ZF	400 pieces	400 pieces

Ammo Pack Taping Format



Ammo Pack Taping Specifications

Item	Symbol	Dimensions (mm)
Component Height	a	15.0±0.5
Component Width	b	14.0±0.5
Component Thickness	c	9.0±0.5
Lead-Wire Width	W_4	0.6±0.1
Lead-Wire Thickness	t_3	0.6±0.1
Component Pitch	P	25.4±1.0
Sprocket Hole Pitch	P_0	12.7±0.3
Sprocket Hole Center to Lead Center	P_1	3.85±0.7
Sprocket Hole Center to Component Center	P_2	6.35±0.7
Lead Spacing	F	5.0±0.5
Component Alignment (side/side)	Δh	2.0 Maximum
Carrier Tape Width	W	18.0+1.0/−0.5
Hold-Down Tape Width	W_0	12.5 Minimum
Sprocket Hole Position	W_1	9.0±0.5
Hold-Down Tape Position	W_2	3.0 Maximum
Height to Seating Plane (lead length)	H	16.0±0.5/18.0±0.5
Sprocket Hole Diameter	D_0	ø 4.0±0.2
Carrier Tape Thickness	t_1	0.67±0.2
Total Thickness (Carrier Tape, Hold-Down Tape and Lead)	t_2	1.7 Maximum
Cut Out Length	L	11.0 Maximum

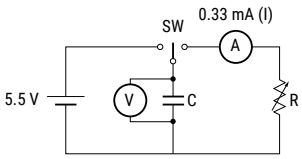
Measurement Conditions

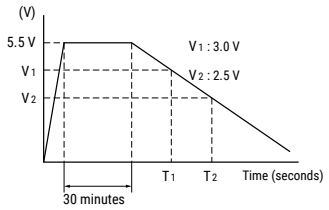
Capacitance (Discharge System)

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 0.33 mA per 0.33 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.

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

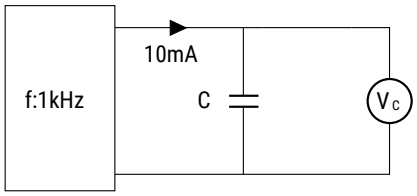




Equivalent Series Resistance (ESR)

ESR shall be calculated from the equation below.

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



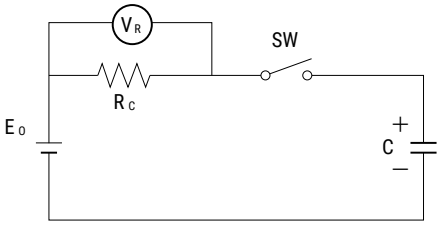
Current (at 30 minutes after charging)

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.

E_0: 5.0 VDC

R_C: 100 Ω

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



Self-Discharge Characteristic

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.

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.

Supercapacitors - Automotive Grade

FU0H Series, 5.5 V, 85°C

Overview

FU0H Series Supercapacitors, also known as Electric Double-Layer Capacitors (EDLCs), are intended for power back up in the automotive applications.

Enhancements to the design and selected material upgrades were introduced to deliver 1,000 hours at 85°C/85% RH rated voltage and up to 4,000 hours at 85°C operational life.

These capacitors are manufactured in an ISO TS 16949 certified plant and are subjected to PPAP/PSW, as well as change control.

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.

FU0H series Automotive grade Supercapacitor can be stable under harsh environmental conditions such as high humidity and high temperture.

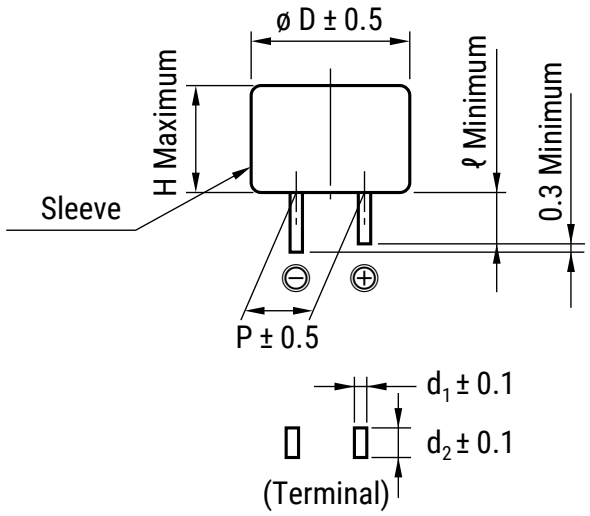
Benefits

- AEC-Q200 rev E compliant
- TS 16949 certified plant
- Subject to PPAP/PSW and change control
- Wide range of temperature from −40°C to +85°C
- Maintenance free
- Maximum operating voltage of 5.5 VDC
- Highly reliable against liquid leakage
- Lead-free and RoHS compliant

Part Number System

FU0H	105	Z	F
Series/Maximum Operating Voltage	Capacitance Code (µF)	Capacitance Tolerance	Environmental
FU0H = FU / Series 0H / 5.5 VDC	First two digits represent significant figures. Third digit specifies number of zeroes.	Z = -20/+80%	F = Lead-free

Dimensions – Millimeters



Part Number	ØD	H	P	ℓ	d_1	d_2
FU0H105ZF	21.5	15.0	7.62	3.0	0.6	1.2

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 (FMD, FU0H, FR, FT, FMR Type)
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
Long time back-up	500 µA and below	Memory, RTC backup for automotive	CMOS microcomputer, static RAM/DTS (digital tuning system)	FMD, FU0H series

Environmental Compliance

All KEMET supercapacitors are RoHS compliant.

Table 1 – Ratings & Part Number Reference

Part Number	Electrical				Physical
	Maximum Operating Voltage (VDC)	Nominal Capacitance Discharge System (F)	Maximum ESR at 1 kHz (Ω)	Maximum Current at 30 Minutes (mA)	Weight (g)
FU0H105ZF	5.5	1.0	10	1.5	10.0

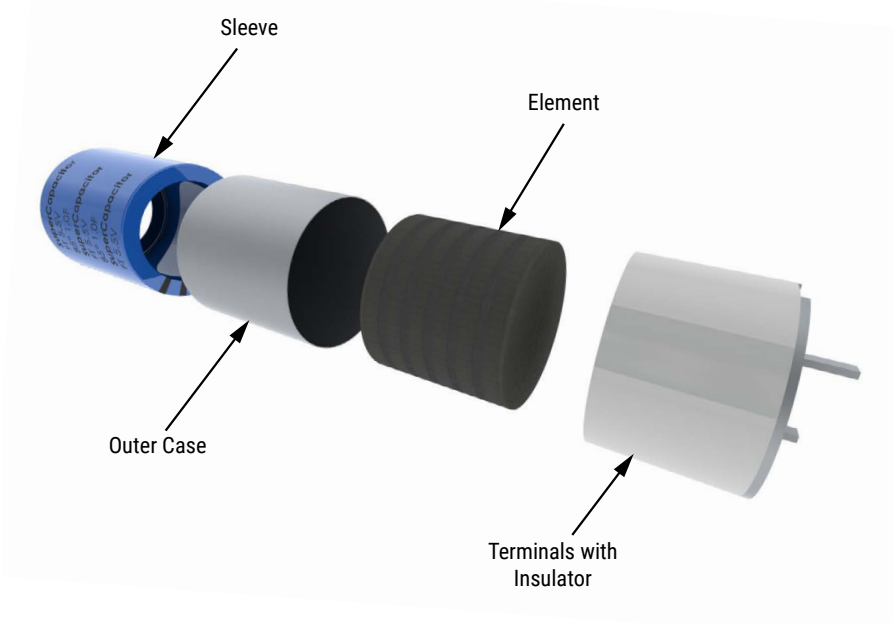
Specifications

Item			Specifications	Test Conditions
Category temperature range			−40°C to +85°C	
MAX operating voltage			Refer to standard ratings	
Capacitance			Refer to standard ratings	Refer to “Measurement Conditions”
Capacitance allowance			+80%, −20%	Refer to “Measurement Conditions”
ESR			Refer to standard ratings	Measured at 1 kHz, 10 mA, See also “Measurement Conditions
Current (30 minute value)			Refer to standard ratings	Refer to “Measurement Conditions”
High Temperature Exposure (Storage)	MIL-STD-202 Method 108	Capacitance	Within ±30% of initial measured value	Temperature: 85 ±2°C Testing time: $1{,}000^{+48}_{-0}$ hours
		ESR	Less than 200% of initial limit	
		Current	Less than 200% of initial limit	
Temperature Cycling	JESD22 Method JA-104	Capacitance	Within ±30% of initial measured value	Temperature condition: Lower −40°C » Upper +85°C Dwell Time: 30 minutes Transition time: Maximum 1 minute Number of cycles: 1,000 Cycles
		ESR	Less than 200% of initial limit	
		Current	Less than 200% of initial limit	
Biased humidity	MIL-STD- 202 Method 103	Capacitance	Within ±30% of initial measured value	Temperature: 85±2°C Relative humidity: 80 to 85%RH Voltage applied: MAX operating voltage Series protection resistance: 0 Ω Testing time: $1{,}000^{+48}_{-0}$ hours
		ESR	Less than 200% of initial limit	
		Current	Less than 200% of initial limit	
Operational life	MIL-STD- 202 Method 108	Capacitance	Within ±30% of initial measured value	Temperature: 85±2°C Voltage applied: MAX operating voltage Series protection resistance: 0 Ω Testing time: $4{,}000^{+48}_{-0}$ hours
		ESR	Less than 200% of initial limit	
		Current	Less than 200% of initial limit	
Lead strength (Tensile)	MIL-STD-202 Method 211		No terminal damage	Test leaded device lead integrity only. A (454 g), C (227 g)
Mechanical shock	MIL-STD-202 Method 213	Capacitance	Satisfy initial limit	Figure 1 of Method 213 Condition C
		ESR		
		Current		
Solderability	J-STD-002	Appearance	Minimum 95% of the terminal should be covered by the new solder	Conforms to Method A1 (Through-hole Technology) Solder temp: 245±5°C Dipping time: 5 +0/−0.5 second 1.27 mm from the bottom of the body should be dipped.
Vibration	MIL-STD-202 Method 204	Capacitance	Satisfy initial limit	Frequency: 10 to 2,000 Hz (5 g’s) Testing time: 12 hours
		ESR		
		Current		

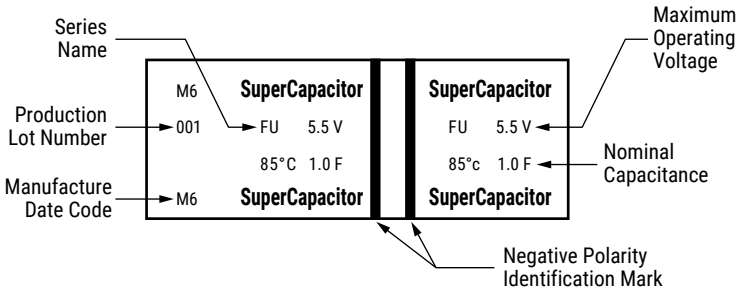
Specifications cont.

Item			Specifications		Test Conditions
Resistance to Soldering Heat	MIL-STD- 202 Method 210	Capacitance	Satisfy initial limit		Solder temp: 260±10°C Dipping time: 3 seconds 2.0 mm from the bottom should be dipped. Condition B no pre-heat of samples. Note: Single Wave Solder. Procedure 1 with solder within 1.5 mm of device body for Leaded.
		ESR			
		Current			
Temperature Stability	IEC-62391-1	Capacitance	Phase2	More than 50% of initial measured	Phase1: +25±2°C Phase2: −25±2°C Phase3: −40±2°C Phase4: +25±2°C Phase5: +85±2°C Phase6: +25±2°C
		ESR		Less than 400% of initial measured	
		Capacitance	Phase3	More than 30% of initial measured	
		ESR		Less than 700% of initial measured	
		Capacitance	Phase5	Less than 200% of initial measured	
		ESR		Satisfy initial specified value	
		Current		1.5 CV (mA) or below	
		Capacitance	Phase6	Within ±20% of initial measured value	
		ESR		Satisfy initial specified value	
		Current		Satisfy initial specified value	

Construction



Marking



Packaging Quantities

Part Number	Bulk Quantity per Box
FU0H105ZF	90 pieces

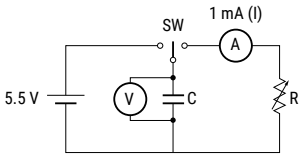
Measurement Conditions

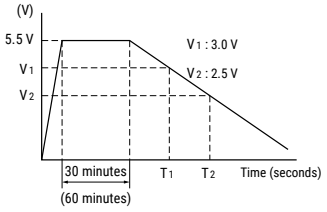
Capacitance (Discharge System)

As shown in the diagram below, charging is performed for a duration of 30 minutes[*1] 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 1mA per 1F[*2], for example, and calculate the static capacitance according to the equation shown below.

Note: *[*1]: Products with 1.0F or more capacitance should be charged for 60 minutes.*
*[*2]: The current value is 1mA discharged per 1F*

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

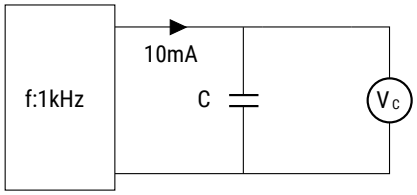




Measurement Conditions cont.

Equivalent Series Resistance (ESR)
ESR shall be calculated from the equation below.

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

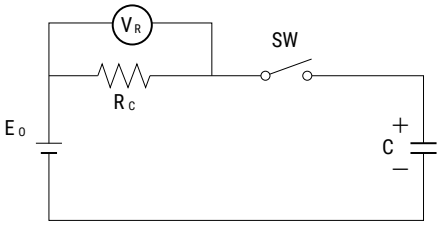


Current (at 30 minutes after charging)
Current shall be calculated from the equation below. Prior to measurement, both lead terminals must be short-circuited for a minimum of 30 minutes. The lead terminal connected to the metal can case is connected to the negative side of the power supply.

E_0: 5.0 VDC

R_C: 10 Ω

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



Supercapacitors - Automotive Grade

FMU Series, 5.5 V, 105°C

Overview

FMU Series Supercapacitors, also known as Electric Double-Layer Capacitors (EDLCs), are intended for high temperature automotive applications.

Enhancements to the design and selected material upgrades were introduced to deliver 1,000 hours at 85°C/85% RH rated voltage and and to AEC-Q200 compliance with maximum operational temperature life up to 105°C.

These capacitors are manufactured in an ISO TS 16949 certified plant and are subjected to PPAP/PSW, as well as change control.

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.

FMU type Automotive grade Supercapacitor can be stable under harsh envermental conditions such as high humidity and high temperture.

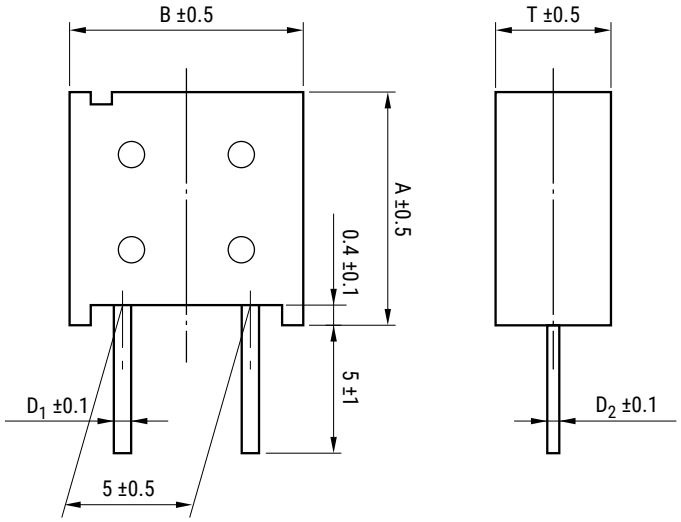
Benefits

- AEC-Q200 rev E compliant
- TS 16949 certified plant
- Subject to PPAP/PSW and change control
- Wide range of temperature from -40°C to +105°C
- Maintenance free
- Maximum operating voltage of 5.5 VDC
- Highly reliable against liquid leakage
- Lead-free and RoHS compliant

Part Number System

FMU	0H	334	Z	F	TP	18
Series	Maximum Operating Voltage	Capacitance Code	Capacitance Tolerance	Environmental	Tape Type	Height (excluding lead)
FMU	0H = 5.5 VDC	First two digits represent significant figures. Third digit specifies number of zeros to follow µF code.	Z = –20/+80%	F = Lead-free	TP = Ammo Blank = Bulk	18 = 18 mm Blank = Bulk

Dimensions – Millimeters



Part Number	A	B	T	D_1	D_2
FMU0H334ZF	15.0	14.0	9.0	0.6	0.6

Environmental Compliance

All KEMET supercapacitors are RoHS compliant.

Table 1 – Ratings & Part Number Reference

Part Number	Maximum Operating Voltage (VDC)	Nominal Capacitance		Maximum ESR at 1 kHz (Ω)	Maximum Current at 30 Minutes (mA)	Reference Weight (g)
		Charge System (F)	Discharge System (F)			
FMU0H334ZF	5.5	-	0.33	25	0.50	3.8

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 +105°C (FMU Type)
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
Long time back-up	500 µA and below	Memory, RTC backup for automotive	Automotive applications, medical, measurement and infrastructure, telecommunications equipment, medical equipment	FMU Series

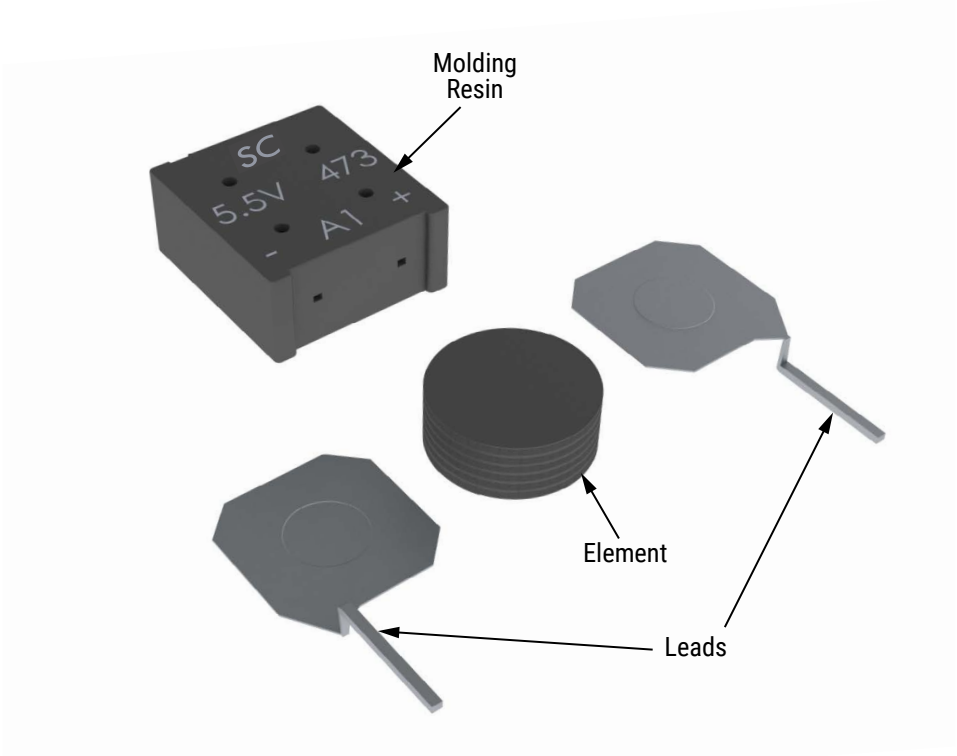
Specifications

Item			Specifications	Test Conditions
Category temperature range			−40°C to +105°C	
MAX operating voltage			Refer to standard ratings	
Capacitance			Refer to standard ratings	Refer to “Measurement Conditions”
Capacitance allowance			+80%, −20%	Refer to “Measurement Conditions”
ESR			Refer to standard ratings	Measured at 1 kHz, 10 mA, See also “Measurement Conditions
Current (30 minute value)			Refer to standard ratings	Refer to “Measurement Conditions”
High Temperature Exposure (Storage)	MIL-STD-202 Method 108	Capacitance	Within ±30% of initial measured value	Temperature: 105 ±2°C
		ESR	Less than 200% of initial limit	Testing time: $1{,}000^{+48}_{-0}$ hours
		Current	Less than 200% of initial limit	
Temperature Cycling	JESD22 Method JA-104	Capacitance	Within ±30% of initial measured value	Temperature condition: Lower −40°C » Upper +105°C
				Dwell Time: 30 minutes
		ESR	Less than 200% of initial limit	Transition time: Maximum 1 minute
		Current	Less than 200% of initial limit	Number of cycles: 1,000 Cycles
Biased Humidity	MIL-STD- 202 Method 103	Capacitance	Within ±30% of initial measured value	Temperature: 85 ±2°C
				Relative humidity: 80 to 85%RH
				Voltage applied: MAX operating voltage
		ESR	Less than 200% of initial limit	Series protection resistance: 0 Ω
		Current	Less than 200% of initial limit	Testing time: $1{,}000^{+48}_{-0}$ hours
Operational Life	MIL-STD- 202 Method 108	Capacitance	Within ±30% of initial measured value	Temperature: 105 ±2°C
		ESR	Less than 200% of initial limit	Voltage applied: MAX operating voltage
		Current	Less than 200% of initial limit	Series protection resistance: 0 Ω
				Testing time: $1{,}000^{+48}_{-0}$ hours
Lead Strength (Tensile)	MIL-STD-202 Method 211		No terminal damage	Test leaded device lead integrity only.
				A (454 g), C (227 g)
Mechanical Shock	MIL-STD-202 Method 213	Capacitance	Satisfy initial limit	Figure 1 of Method 213 Condition C
		ESR		
		Current		
Solderability	J-STD-002	Appearance	Minimum 95% of the terminal should be covered by the new solder	Conforms to Method A1 (Through Hole Technology) Solder temp: 245±5°C Dipping time: 5 +0/−0.5 second
Vibration	MIL-STD-202 Method 204	Capacitance	Satisfy initial limit	Frequency: 10 to 2,000 Hz (5 g’s) Testing time: 12 hours
		ESR		
		Current		

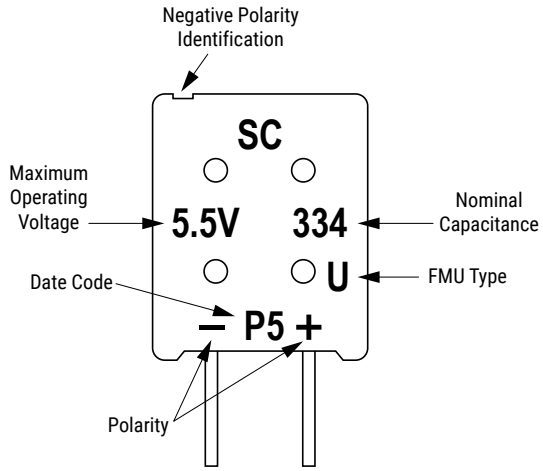
Specifications cont.

Item			Specifications		Test Conditions
Resistance to Soldering Heat	MIL-STD- 202 Method 210	Capacitance	Satisfy initial limit		Solder temp: 260 ±10°C Dipping time: 3 seconds 2.0 mm from the bottom should be dipped. Condition B no pre-heat of samples. Note: Single Wave Solder. Procedure 1 with solder within 1.5 mm of device body for Leaded.
		ESR			
		Current			
Temperature Stability	IEC-62391-1	Capacitance	Phase 2	More than 50% of initial measured	Phase 1: +25±2°C Phase 2: −25±2°C Phase 3: −40±2°C Phase 4: +25±2°C Phase 5: +105±2°C Phase 6: +25±2°C
		ESR		Less than 400% of initial measured	
		Capacitance	Phase 3	More than 30% of initial measured	
		ESR		Less than 700% of initial measured	
		Capacitance	Phase 5	Less than 200% of initial measured	
		ESR		Satisfy initial specified value	
		Current		1.5 CV (mA) or below	
		Capacitance	Phase 6	Within ±20% of initial measured value	
		ESR		Satisfy initial specified value	
		Current		Satisfy initial specified value	

Construction



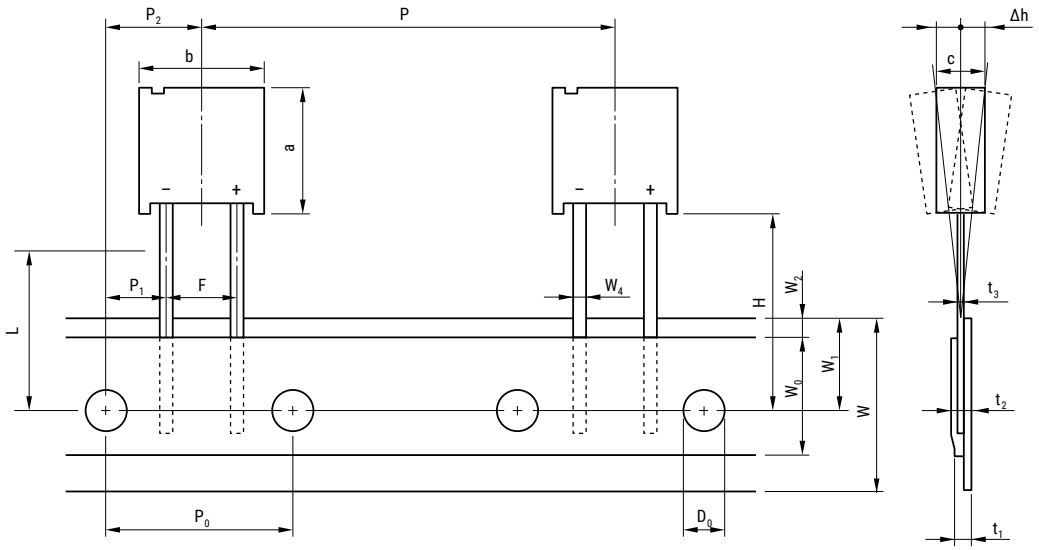
Marking



Packaging Quantities

Part Number	Bulk Quantity per Box Straight Lead	Ammo Pack Quantity
FMUD0H334ZF	400 pieces	400 pieces

Ammo Pack Taping Format



Ammo Pack Taping Specifications

Item	Symbol	Dimensions (mm)
Component Height	a	15.0±0.5
Component Width	b	14.0±0.5
Component Thickness	c	9.0±0.5
Lead-Wire Width	W_4	0.6±0.1
Lead-Wire Thickness	t_3	0.6±0.1
Component Pitch	P	25.4±1.0
Sprocket Hole Pitch	P_0	12.7±0.3
Sprocket Hole Center to Lead Center	P_1	3.85±0.7
Sprocket Hole Center to Component Center	P_2	6.35±0.7
Lead Spacing	F	5.0±0.5
Component Alignment (side/side)	Δh	2.0 Maximum
Carrier Tape Width	W	18.0+1.0/−0.5
Hold-Down Tape Width	W_0	12.5 Minimum
Sprocket Hole Position	W_1	9.0±0.5
Hold-Down Tape Position	W_2	3.0 Maximum
Height to Seating Plane (lead length)	H	16.0±0.5/18.0±0.5
Sprocket Hole Diameter	D_0	ø 4.0±0.2
Carrier Tape Thickness	t_1	0.67±0.2
Total Thickness (Carrier Tape, Hold-Down Tape and Lead)	t_2	1.7 Maximum
Cut Out Length	L	11.0 Maximum

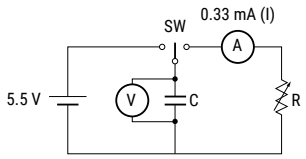
Measurement Conditions

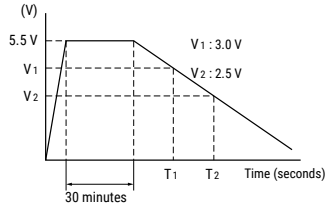
Capacitance (Discharge System)

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 0.33 mA per 0.33 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.

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

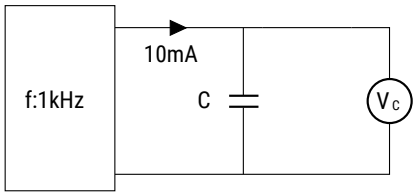




Equivalent Series Resistance (ESR)

ESR shall be calculated from the equation below.

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



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.

E_0: 5.0 VDC

R_C: 100 Ω

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