Panasonic

Technical Guide

Electric Double Layer Capacitors
(Gold Capacitor)

2016.01 http://industrial.panasonic.com/ww/products/capacitors/edlc

Contents

1. Introduction

Electric Double Layer Capacitors (Gold Capacitor) were developed by the Central Research Laboratory of MATSUSHITA ELECTRIC INDUSTRIAL COMPANY in 1972, then marketed and sold on a worldwide basis in 1978. Because these capacitors function as a battery, they are ideally suited for applications requiring a secondary power source such as a back-up energy source for microprocessors and solar battery.

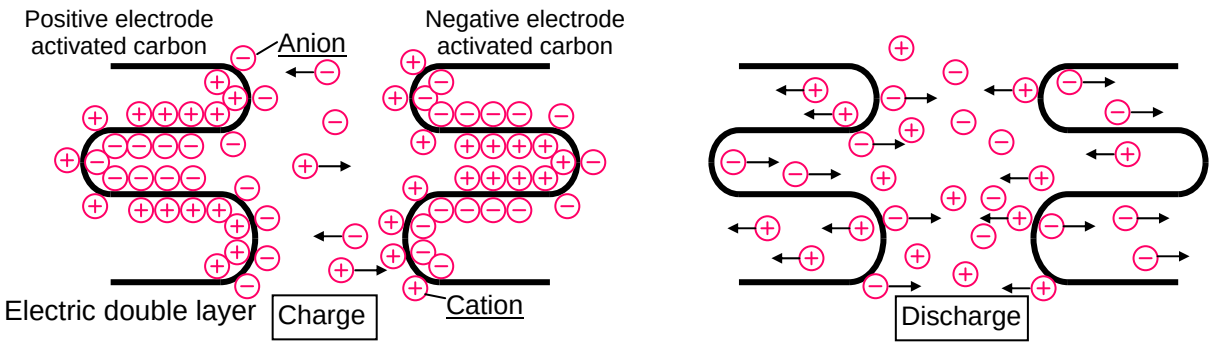
This product specification manual summarizes the technical characteristics of Gold Capacitors for use in electronic devices. Panasonic Gold Capacitor products meet our strict technological standards. Upon reviewing this manual, please feel free to contact us with your opinions or questions.

2. Principles and Features of Gold Capacitors

2-1 What are electric double layer capacitors?

Generally, capacitors have dielectric between two opposite electrodes. For example, Aluminum Electrolytic Capacitors use an aluminum oxide film, and Tantalum Capacitors use a tantalum oxide film as dielectric.

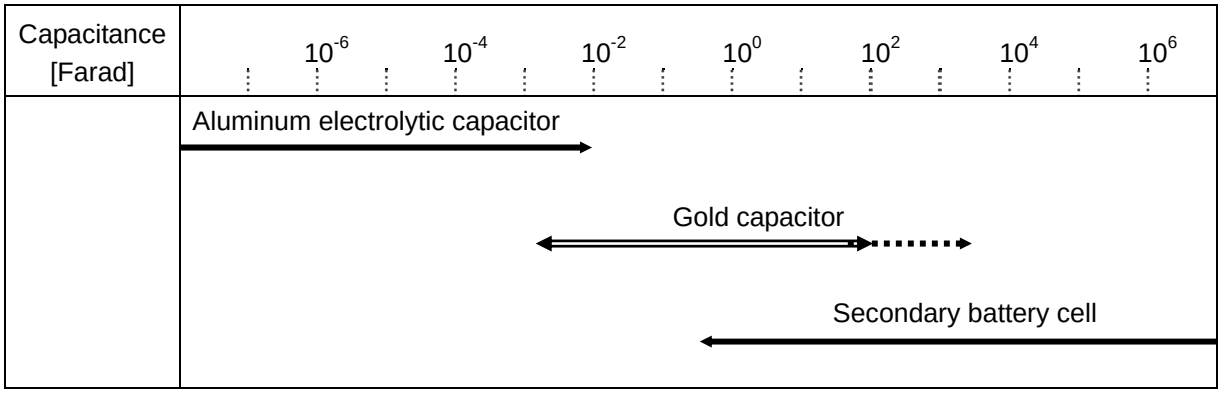
However, the electric double layer capacitor does not have dielectric but uses a physical mechanism that generates an electric double layer which performs the function of dielectric, hence, the name Electric Double Layer Capacitor. The charge-discharge factor in the element of electric double layer capacitors is an ion absorption layer which is formed on the surface of the positive and negative electrodes of activated carbon, to utilize absorption-desorption reactions.



(Fig.1)

In an electric double layer capacitor, there are two types of electrolyte systems used. One is water soluble and the other is non-water soluble. The non-water soluble electrolyte can increase the withstand voltage per one cell compared to water soluble electrolyte. Our Gold Capacitors are constructed with non-water soluble electrolyte, and feature small size and light weight.

The capacitance range of Gold Capacitors is mid-range between aluminum electrolytic capacitors and a secondary battery. For application, it is mainly used as a secondary battery.

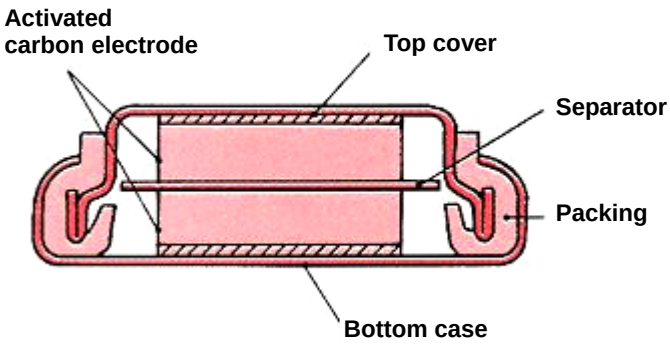


The benefits of Gold Capacitors are small size and high capacitance. Gold Capacitors are used to backup the real-time clock or memory as substitutions for secondary batteries. The examples are RTC backup of DVD, fax, telephone, DSC, mobile phone and stereo. Recently, Gold Capacitors are in the spotlight as a hybrid power supply system by the combination with the solar cell.

2-2 Construction and principle of electric double layer capacitors

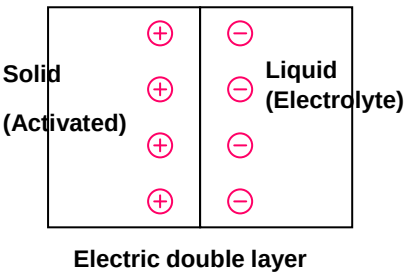
A cross-sectional drawing of a coin-shaped single cell Gold Capacitor is shown in Fig.2.

The electrode within the cell is made from activated carbon. The electrode is then impregnated with an electrolyte. A separator with high insulating properties against ion penetration is positioned between both electrodes to prevent short circuiting. Sealing is completed by adding packing between the top cover and bottom case.

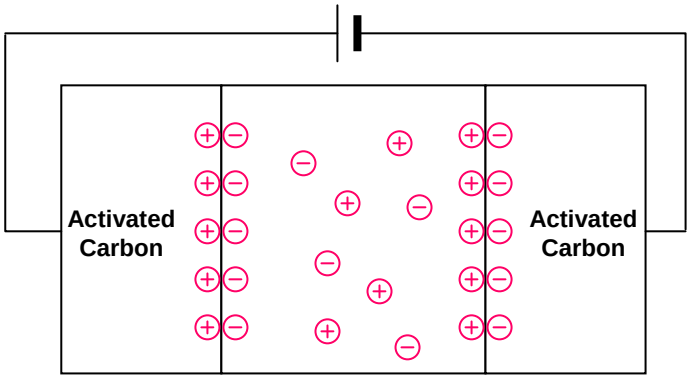


(Fig.2)

An electric double layer is a state where a very thin ionosphere is formed to the boundary of the electrolyte and the electrode (Shown in Fig.3.). Electric charge can be charged by applying the voltage (shown in Fig.4.)



(Fig.3)



(Fig.4)

The electric double layer acts as an insulator and does not allow current flow when an external DC voltage is applied. However, as the voltage is increased, an avalanche point is reached and current will begin to flow. The magnitude of this voltage is the “decomposition voltage”. Further increasing this voltage will cause the electrolyte to decompose causing additional current flow. The withstand voltage of Gold Capacitors is determined by the decomposition voltage. The decomposition voltage is decided with electrolyte and electrode material that composes Gold Capacitors.

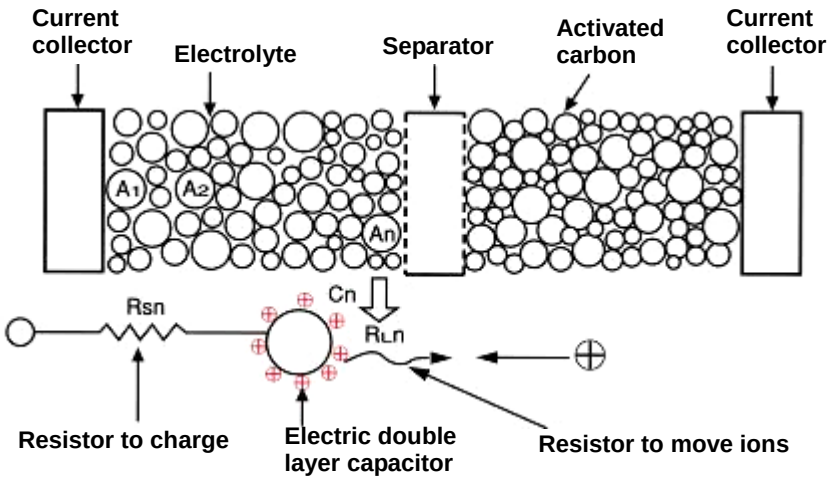
Gold capacitors use an activated carbon electrode (solid) and an organic electrolyte (liquid). Electric double layer formed to the interface of the electrode and electrolyte is very thin like a molecule. The activated carbon used for the electrode is a very large surface. Therefore, it becomes very high capacitance. Panasonic uses high withstand voltage organic electrolyte and products can be miniaturized.

2-3 Equivalent circuit

The same equivalent circuit used for conventional capacitors can also be applied to Gold Capacitors.

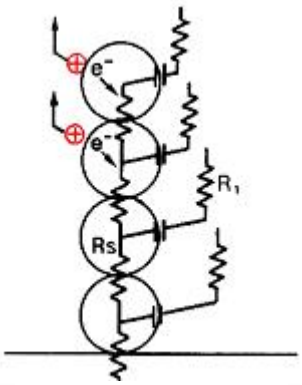
In an electric double layer capacitor, the electric double layer is formed on the surface of the activated carbon that is in contact with the liquid electrolyte. This is shown in Fig.5.

Because activated carbon particles are used as electrodes, each carbon layers as in Fig.5 functions as an electric double layer capacitor having a capacitance value of C_n. In order for the capacitance C_n to charge, two resistances are needed and are described in Fig.6.



(Fig.5)

As can be seen in Fig.6, resistance R_1 moves ions while resistance Rs is the charging resistance. The double layers formed on the activated carbon surfaces can be shown as parallel circuits.



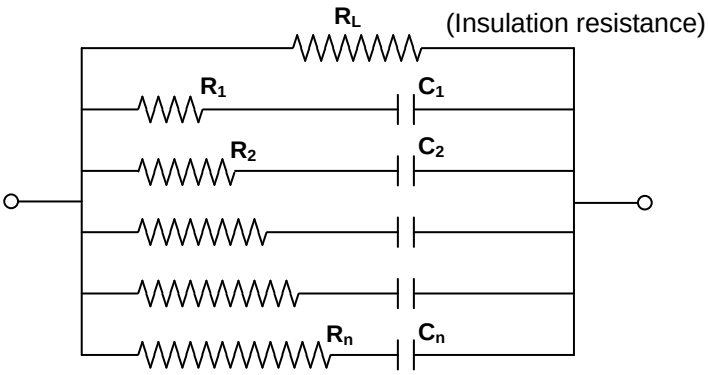
Particle type activated carbon

(Fig.6)

The resistances values can increase or decrease depending on the distance between the current collectors, speed of ions, contact resistance between the activated carbons, etc.

The equivalent circuit of an electric double layer capacitor is shown by the parallel R-C combinations shown in Fig.7.

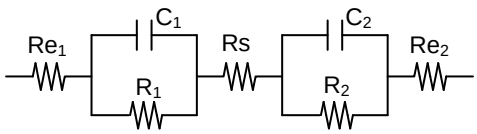
R_1, R_2 and R_n are the internal resistance of the activated carbons. C_1, C_2 and C_n are the capacitance of the activated carbons having resistances R_1, R_2 and R_n.



(Fig.7)

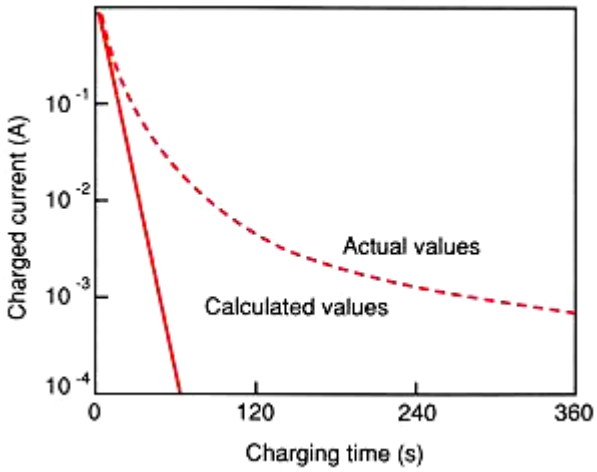
When applying a simple CR series circuit, the charging current (i) when the voltage (V) is applied decreases according to formula-(1). The value of the charging current decreases at charging time(t) . However, the actual charging current curve is exponential.

$$i = \frac{V}{R} \exp\left(\frac{-t}{C\,R}\right) \qquad (1)$$



C1, C2 : Electric double layer capacitance
Re_1,Re_2 : Electrode resistance
R_1,R_2 : Insulation resistance
Rs : Separator resistance

(Fig.8)



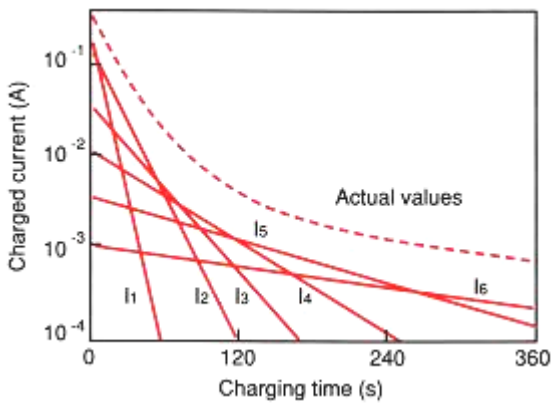
(Fig.9)

If one considers the equivalent circuit of the electric double layer capacitor shown in Fig.8 as having many small capacitors (C_n) with various internal resistances (R_n), then the current that flows through an individual capacitor can be represented by formula-(2).

$$i_n = \frac{V}{R_n} \exp\left(\frac{-t}{C_n R_n}\right) \qquad (2)$$

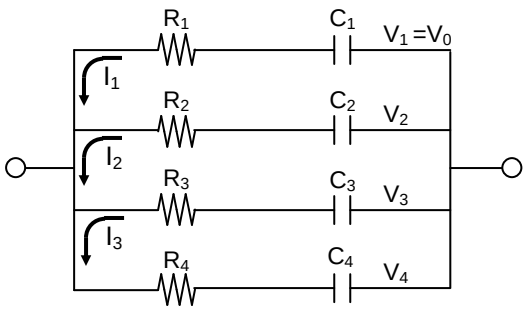
Therefore, the current(i) within the capacitor can be regarded as the sum(Σi_n) of the currents flowing through each of the small capacitors. It also can be seen that if the C×R value is small, the charging time will be short. Conversely, if the C×R value is large, the charging time will be long. The sum of the small capacitor charging currents is shown in Fig.10.

It should be noted that if the charging time is limited to only several minutes, or the charging source is current limited, the Electric double layer capacitor may not be sufficiently charged to provide the required backup energy for the time needed. If the capacitor is not sufficiently charged and is called upon to discharge its energy into a load, the discharge current will flow from a high voltage level to a low voltage level thereby causing a low terminal voltage.



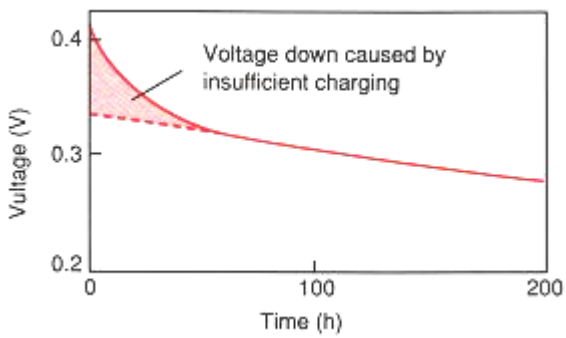
(Fig.10)

These conditions are shown in Fig.11, 12.



Just after charging $V_0 = V_1 > V_2 > V_3 > V_4$
After discharging $V_0 > V_1 = V_2 = V_3 = V_4$

(Fig.11)



(Fig.12)

2-4 Electrical characteristics of electric double layer capacitors

2-4-1 Capacitance

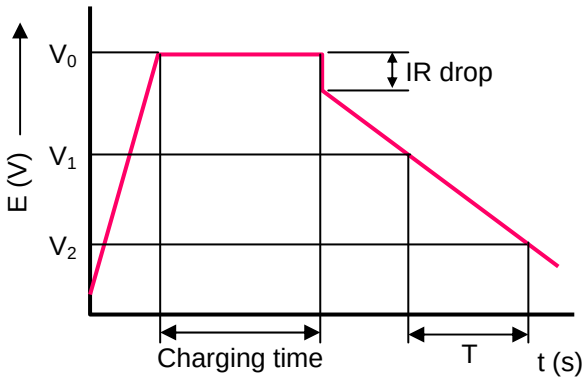
The capacitance of an electric double layer capacitor differs from the battery and is not influenced by the measurement condition in theory. However, it is influenced by internal resistance and leakage currents. Therefore, the electrical characteristics change depending on the measurement condition.

As previously stated, the electric double layer capacitor is comprised of many small capacitors having various values of resistance. Therefore, in order to measure the capacitance, measurement parameters such as charge voltage and charge time must be defined.

If the starting voltage is set slightly below the fully charged voltage value (V_0), then the voltage down condition shown in Fig.13 will occur at the start of measurement. This is due to the small capacitors that have large internal resistance not being fully charged which results in a large voltage drop at the start of measurement. With this condition, the measured capacitance value will be small.

However, by increasing the charging time, the small capacitors with high resistances will become charged and the voltage lost during the voltage down condition will be small resulting in a high measured value of capacitance. See Fig.13.

In addition, the capacitance is influenced also by the current. Therefore, we use 1mA/F as a standard of the measurement current. (It is discharged by the constant current for each 1F of 1mA.)



$$C = \frac{I \times T}{(V_1 - V_2)} \quad \text{(Farad)} \qquad (3)$$

C : Capacitance(F)
I : Test current(A)
T : Test time(s)
V1 – V2: Testing voltage range(V)

(Fig.13) Electrostatic capacitance test

2-4-2 Internal resistance

As previously described, the equivalent circuit of an electric double layer capacitor consists of many small capacitors having various internal resistance values. Normally, the values of these resistors would be expressed in DC values. However, so that a true picture may be established, we will use impedance (1kHz) as the parameter and being that the DC resistance and Z value are not equal, we must consider their relationship under current conditions.

2-4-3 Current

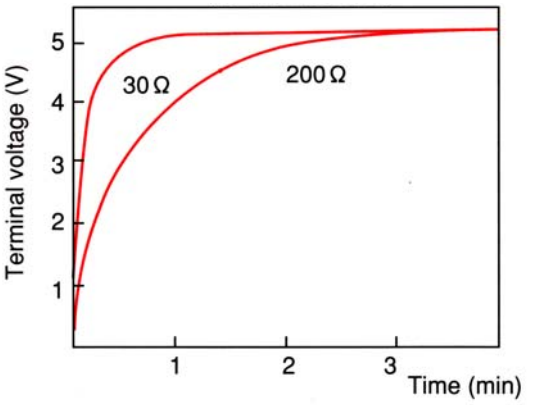
If current is measured 30 to 60 minutes after the application for rated voltage, quite a large current (several 10μA) will be present. This is due to the fact that the measured current is the sum of the charging currents that is flowing within the many small capacitors shown in the equivalent circuit. As it is extremely difficult to determine the leakage current of electric double layer capacitors, the current value specified as the leakage current is somewhat meaningless. It takes a minimum of 10 hours to fully charge the capacitor so that a meaningful leakage current value can be obtained.

2-4-4 Charging characteristics

The charging characteristics of an electric double layer capacitor can be represented by the equation(4) below:

$$V = V_0\{1 - \exp(\frac{-t}{CR})\} \qquad (4)$$

Because of the many internal resistances within the electric double layer capacitor, no external current limiting resistor is needed.



Relation between charging resistance and time

(Fig.14)

2-4-5 Discharging characteristics

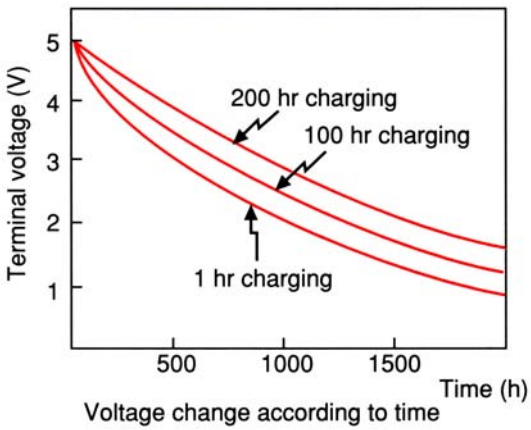
Self discharge characteristics

The self discharge characteristic of an electric double layer capacitor is shown in equation (5).

$$V = V_0 \exp(\frac{-t}{C R_L}) \qquad (5)$$

RL: Insulation resistance

This Fig.15 shows ideal self-discharge in the state that the product is completely charged. The self-discharge changes actually by the influence at charging time.



Voltage change according to time

(Fig.15)

Characteristics of constant current and constant resistance discharging

The time required for the constant current and constant resistance discharging are respectively presented by the equations (6) and (7) below

Discharging time (t) of constant current discharge

$$t = \frac{C(V_0 - V_1)}{I} \qquad (6)$$

Discharging time (t) of constant resistance discharge

$$t = -C\,R\,\ln\left(\frac{V_1}{V_0}\right) \qquad (7)$$

t : Charging time
C : Capacitance
V_0: Initial voltage
V_1: Terminal voltage after t(s)
I : Constant current load
R : Constant resistance load

The above equations may not always be accurate, as the terminal down voltage must be considered after the start of discharge if load resistance or load current is present.

Backup characteristics for IC

Also, if the capacitor is used to backup and IC, the V-I characteristics of the IC must also be considered. It can therefore be said that if the voltage is low, the current is also low and the actual backup time will be longer than that calculated. To be certain that the capacitor selected is of sufficient value to maintain the necessary energy and time, it should be checked and measured under actual operating conditions.

2-5 Features

The capacitance of an electric double layer capacitor can be expressed by equation (8)

$$C \propto \frac{S}{d} \qquad (8)$$

d = thickness of electric double layer

s = area of an activated carbon

It should be noted that the area of an activated carbon is approximately 2500 m^2/gram and the thickness of a double layer is less than a molecule. From this, it can be readily seen that the capacitance of an electric or double layer capacitor is several times greater than of an aluminum electrolytic capacitor.

The internal resistance of an electric double layer capacitor is quite high compared to an aluminum electrolytic capacitor and because of this it should not be used as a filter in an AC application. These devices are specifically designed for energy backup applications and secondary power sources.

Wide range for each application

These are wide range of Gold Capacitors from the coin type which is primarily used as RTC backup to the HW series which need large current.

Limited life

Gold Capacitors have a limited life .

However, they have a capability that can be fully used within the life of equipment when used under the proper conditions. (Refer “The Life” in details)

Therefore, you don’t need to replace the battery. Also, in overseas, there are many regulations for batteries. It can be said Gold Capacitors are the best source for use in overseas.

Wide operating temperature range

Compared to Gold Capacitors, batteries lose much of their energy with exposure to heat and are susceptible to leakage with exposure to temperatures below 0°C. Gold Capacitors are suitable where the operating temperature conditions are need to be considered, such as automobile stereo set for import, etc.

No need of charge control

Secondary batteries generate heat for over-charge and discharge, which make the life shorter. A charge control circuit is needed. However, Gold Capacitors have no limit for charge and discharge and do not need a charge control.

Speed charge, repeated charge/discharge cycles

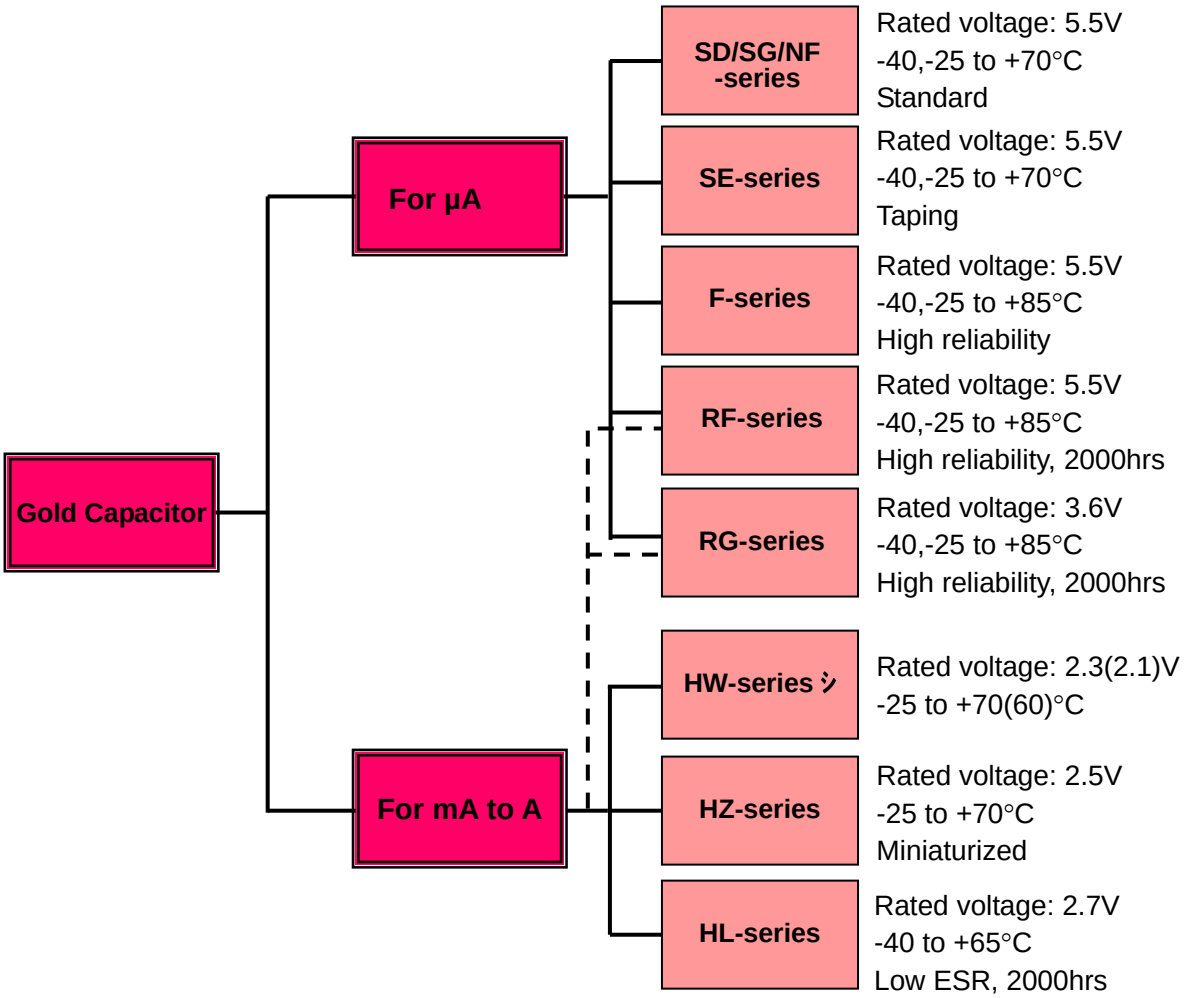
Speed charge is possible for Gold Capacitors. Repeated rapid charge and discharge cycles are acceptable because there is no internal chemical reaction like batteries. It suits the circuit that repeats charge and discharge for a short time, which can not take a long charge time.

Good for environmental as secondary source

There are no toxic materials such as cadmium, mercury in Gold Capacitors. Europe has recently restricted the use of products containing toxic materials due to pollution, and this action will be expanded. Our Gold Capacitors do not use cadmium and mercury. And LED lights using our Gold Capacitors are very popular for clean energy applications in Europe. Thus, Gold Capacitors are suitable for Europe and America where the restriction will be stricter.

3.Product type & selecting method of Gold Capacitors

3-1 Product system



Capacitance range

Series		104	224	334	474	684	105	155	335	475	106	226	306	506	706	107
Standard	SD		O	O												
	SE		O													
	SG				O		O	O								
	NF		O		O		O	O								
High Reliability	F	O			O	O	O									
	RG		O				O	O								
	RF	O				O	O									
Low ESR	HZ								O	O	O					
	HW											O	O	O	O	
	HL													O		O

Capacitance code: 104=0.1F, 105=1F, 106=10F *HW706:2.1V

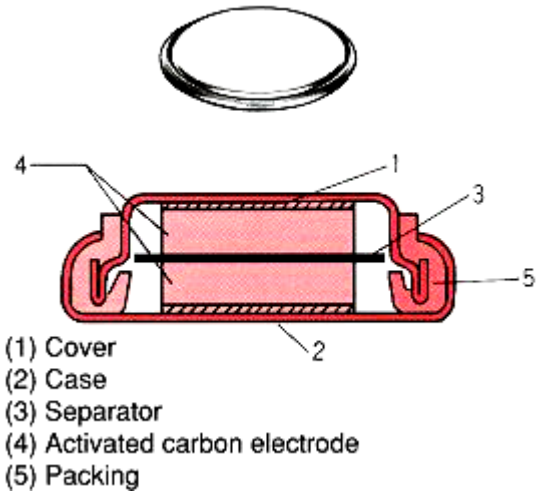
3-2 Construction, features and applications of each type

3-2-1 Coin style cell

(Construction)

The structural drawing of Coin type Gold Capacitor is shown in Fig.16.

The activated carbon used as the electrode is solidified in powder activated carbon. This activated carbon is connected with the cover and the case through a conductive point. This separator functions as an insulator but does not restrict the movement of ions through it. Packing is added to seal the cover and case.



(Fig.16)

(Features)

The physical appearance looks like a coin type battery. Unlike the battery, Coin type Gold Capacitor does not need charge/discharge control circuit, and it is good for the environment.

(Applications)

1. Memory backup during battery replacement of mobile phone, DSC and PDA.
2. Secondary power source for solar watches.

ϕ18 ϕ9

Coin type cell

(Fig.17)

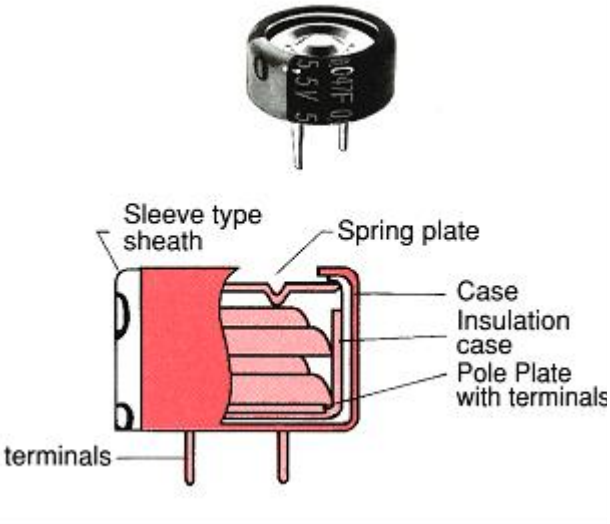
3-2-2 RF, F and NF series

(Construction)

The RF, F and NF series capacitor is constructed with 2 or 3 coin style cells series, and connected with a spring plate. (Fig.18)

(Features)

The maximum operating temperature of RF/F series is 85°C, and suitable for conditions at relatively high temperatures such as car audio ,electronical formula meter etc. It can be used for the set which needs long life because it has over double long life compared to 70°C products(The RF series has five times or more longevity for the guarantee products of 85℃2000 hour.)



(Fig.18)

We also have low profile product (70°C guarantee) for NF series.

(Application)

RF/F series

1. Memory backup for equipment used at relatively high temperatures (car audio, industrial robot, etc.)
2. Memory backup, data backup for equipment requiring relatively long life (computer, office apparatus, etc.)

NF series

Memory backup for equipment requiring low profile (DVD, audio)

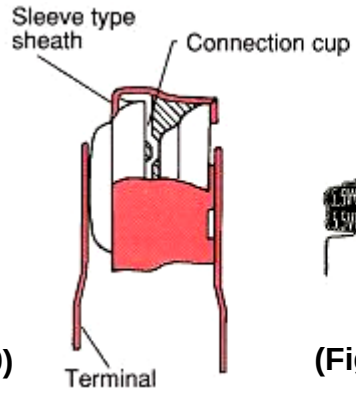
3-2-3 RG, SG, SD and SE series

(Construction)

These series are constructed from two series connected cells in connector cup by laser and welded terminals in it. It is the smallest construction in the series products. (Fig.19)

(Features)

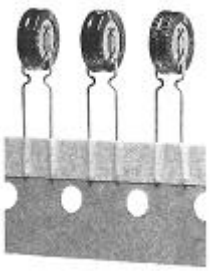
Type SD series are designed for miniaturization. There are type H for low profile (Fig.20) and type V for reduction of mount area (Fig.21). SE series (Fig.22) has a standard packaging format of tape and box for automatic insertion. These products are small and light, can be used for general equipment with 3 series including taping.



(Fig.19)

(Fig.20)

(Fig.21)



(Fig.22)

(Applications)

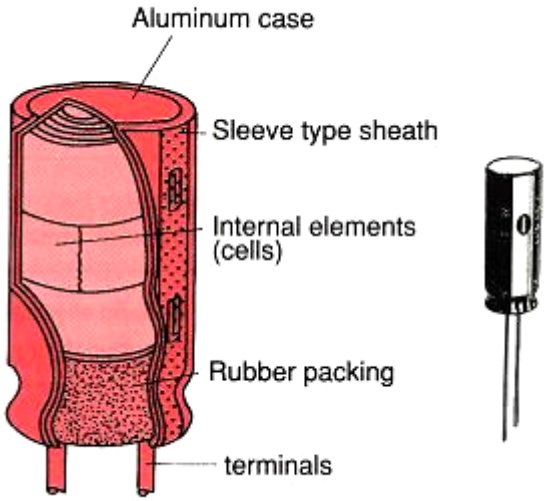
Memory backup for general equipment (DVD, TV, Audio, etc.).

(RG-series (70°C 2000h) can be used for the same usage as RF/F-series)

3-2-4 HW / HZ / HL series

(Construction)

Series HW /HZ / HL are constructed from activated carbon particles which are mixed with a binder then deposited on strips of aluminum foil. Then, lead wire is connected, and these foil strips are wound together with a separator and inserted into aluminum case. Electrolyte is added, the case is then sealed with a rubber packing and sleeved (Fig.23).



(Fig.23)

(Features)

These series are developed for use in applications requiring large current, its internal resistance is less than 1/100 of general products. Due to the development of this product, application of Gold capacitor expanded from memory backup to motor driving. For example, the motor can work over 3 minutes with charging for a few seconds. Over 100 thousand times of charge/discharge is possible, so that it is suitable for the applications such as toys and LED light.

(Applications)

1. Solar battery circuit (e.g. Road guidance flasher, LED light)
2. Toys (Motor-drive)
3. Server/Storage

3-3 Applications in typical sets and recommended series

Application in typical sets and recommended series

Set	Application	Recommended series
DVD/Blu-ray recorder	At the time of power failure and a power supply off, **For RTC and channel backup**	SD, SG
Digital TV	At the time of power failure and a power supply off, **For RTC and channel backup**	SD, SG, NF
PC, Server, Storage, Data center	At the time of power failure and a power supply off, **For RTC and channel backup**	RF, F, RG, HW, HZ, HL
Mobile phone base station	At the time of power failure and a power supply off, **For RTC and channel backup**	RF, F HW, HZ,HL
Inkjet printer	At the time of power failure and a power supply off, **For the time of intact backup**	SD, SE, SG, NF
Smart meter	At the time of power failure, **For RTC and data backup**	RF, F, RG
	At the time of power failure, **For sending data**	HW, HZ
LED light with solar battery	**For LED lighting in the night** (Charges by the solar cell in daytime)	HW, HZ, HL
Toy (Motor drive)	**For motor drive**	HW, HZ
FA, Robot, IPC	At the time of power failure and a power supply off, **For RTC and data backup**	RF, F
Car audio (Memory)	At the time of battery exchange. **For RTC backup**	RF, F, RG
Drive recorder	At the time of traffic accident, **For data backup**	HW, HZ

3-4 Basic idea for product selection

3-4-1 Estimated enough initial backup time

Backup time of Gold Capacitors decrease with use and time. Especially, where the applied current is large or the operating condition is severe such as high temperature, backup time decreases a lot. Therefore, initial backup time should be considered to have enough margins.

Avoid setting the minimum backup time. (Refer the life design in details)

3-4-2 Select the optimum Gold capacitor according to applied current

Where the applied current of Gold Capacitors is large, flash voltage drop (IR drop) may occur by the applied current and internal resistance of Gold Capacitors when changing to backup mode. Therefore, product should be selected according to operating applied current. The amount of applied current (discharge current) has different resistance against product kind, so that we recommend the current shown in chart below. (Please consult Panasonic when the applied current is used beyond recommendation range.)

Series	Maximum operating (discharge) Current			
	0.1 to 0.33F	0.47 to 1.5F	3.3 to 4.7F	10F to 70F
SG, SD, SE, NF	300μA	1mA	–	–
F	300μA	1mA	–	–
RG(-40℃/-25℃)	300μA / 1mA	1mA / 20mA		
RF(-40℃/-25℃)	300μA / 3mA	1mA / 20mA	—	—
HW/HZ	–	–	300mA	1A
HL	–	–	–	10A

4. Operational technique of Gold Capacitor

4-1 Life design

4-1-1 Useful life

Gold Capacitors have a limited life the same as aluminum electrolytic capacitors. It is greatly different depending on use conditions. Therefore, the useful life of Gold Capacitors can be considered the time that is satisfied with backup time set by customers in their use conditions.

4-1-2 Example of expected life

Generally, the Arrhenius low (Double-speed acceleration at 10°C) is applied to similar aluminum electrolytic capacitor. The guaranteed life time of Gold Capacitors is

After 1000 hours at 70°C (SD/SE/SG/NF)

Capacitance change: ±30% of initial value

Internal resistance: 4 times or less of initial spec value

(Refer to the SPEC sheet or catalog for details)

When assuming that this capacitor is used at 30°C, the expected life becomes following.

$$T_{30} = 1000 \times 2^{\frac{70-30}{10}}$$
$$= 16000 \quad \text{[hours]}$$

Please have the margin in initial capacitance, when you use Gold Capacitors. As a result, there is a possibility to be able to back up even if the capacitance becomes over the minus 30%. In this case, please refer to Chapter 5 in this book “Gold capacitor characteristic data” and Panasonic web for the reliability test data for the typical value of the characteristic change of our Gold Capacitors.

Example of calculating backup time

The case to use the SG series Gold Capacitor EECS5R5V155 in the following conditions is calculated.

Applied voltage ; 5.5V

Cut-off voltage ; 2V

Current during backup ; 10uF

The backup time after 70℃2000 hour is forecast from data. (We think the item of the leakage current is 0.8uA in this case.)

The characteristic after 70℃2000 hour (reference to data of Chapter 5)

Capacitance change about -32%, Internal resistance 120Ω

The Initial capacitance 1.2[F] (1.5[F] about -20%)

$t = CV/I$

$= C \times (V_0 - i \times R - V_1)/(I + i_L)$

$= 1.2 \times 0.68 \times (5.5 - 0.0012 - 2)/((10+0.8) \times 10^{-6})$

t: Backup time (s)

C: Capacitance of Gold capacitor (F)

V_0: Applied voltage (V)

=260000s

=73hours

V_1: Cut-off voltage (V)

i: Current during back-up (A)

i_L: Leakage current(A)

R: Internal resistance (Ω) at 1kHz

70℃2000 hour is converted by applied the Arrhenius low (Double-speed acceleration at 10°C) and the calculation shows the backup time to be 79 hours after 3.6 years.

Even if the endurance change rate is exceeded with room in initial capacitance on the real use, with room in initial capacitance, Gold Capacitor can be still used (It is possible to backup). It seems that the life time is postponed. However the characteristic change has not been decreased in this case and the life of the Gold Capacitor has not been postponed. The circuit of each equipment will be designed on the condition that can be used even if the life of the Gold Capacitor is exceeded.

Generally, to decrease the capacitance change in the Gold Capacitor please refer to the following.

① The use temperature (ambient temperature) is lowered

As for the characteristic change in the Gold Capacitor, the Arrhenius low (Double-speed acceleration at 10°C) is applied generally as previously mentioned. The expected life becomes double by lowering the temperature at 10℃.

② The 85℃ guarantee products are used.

The expected life increases to about 2.8 times that of 70℃ guarantee products when using it at the same temperature.

③ The applied voltage to the Gold Capacitor (charge voltage) is lowered.

The applied voltage influences the characteristic change in the Gold Capacitor. The acceleration calculation like the temperature acceleration is not clear now.

However, in the case 5.5V products are used by 5.0V: about 1.3 times. In the case 5.5V product are used by 3.3V: about 2.8 times. This kind of level can be expected. (The RF/F series is excluded.)

④ The electrical charge and discharge is intermittent and the charging time is shortened.

The characteristic change of Gold Capacitor is not influenced from electrical charge and discharge cycle number but from the time that the voltage is applied. Therefore, please design for the electrical charge and discharge when it is necessary. The characteristic change can be suppressed at time that is not charged.

The result that a very long term backup can be expected in calculation might be obtained by use conditions. However, please consider checking regularly and exchanging it when using it for the set that long-term reliability is basically demanded from the Gold Capacitor.

4-2 Notes in using Electric Double Layer Capacitors

4-2-1 Circuit design

4-2-1.1 Product Life

Electric Double Layer Capacitors (Gold Capacitors, hereafter referred to as capacitors) have a limited life.

The life of an electric double layer capacitor is limited. Its capacitance will decrease and its internal resistance will increase over time.

The life of a capacitor greatly depends on the ambient temperature, humidity, applied voltage and discharging currents. Capacitor life can be extended when these parameters are set well below the ratings.

The guaranteed durability of electric double layer capacitors is between 500 hours at 60°C and 2000 hours at 85°C. Generally, it is 1000 hours at 70°C. The life of the capacitor is guaranteed to be 16000 hours at a normal temperature (30°C) by applying the acceleration double for every 10°C.

If your application incorporates this capacitor over a long period of time then check it periodically and replace it when necessary.

4-2-1.2 Polarity and voltage

Capacitors have polarities

Do not apply a reverse or AC voltage. If a reversed voltage is applied to a capacitor for a long period of time, then its life will be reduced and critical failures such as electrolyte leakage may occur.

Do not apply an over-voltage (a voltage exceeding the rated voltage).

If voltage exceeding the rating is applied to the capacitor for a long time, then its life will be reduced and critical failures such as electrolyte leakage or physical damage due to gas generated by electrochemical reaction or explosion may occur.

4-2-1.3 Circuits through which ripple currents pass

When using a capacitor in a circuit through which ripple currents pass, monitor the allowable temperature range.

The internal resistance of electric double layer capacitors is higher than that of electrolytic capacitors. Electric double layer capacitors may generate heat due to ripple currents.

The allowable temperature rise due to ripple currents is 3°C measured on the surface of the capacitor.

4-2-1.4 Ambient temperature and product life

Capacitor life is affected by usage temperatures. Generally speaking, capacitor life is approximately doubled when the temperature is decreased by 10°C. Therefore, lower the usage temperature as much as possible.

Using capacitors beyond the guaranteed range may cause rapid deterioration of their characteristics and cause them to break down.

The temperature referred to here includes the ambient temperature within the equipment, the heat

produced by heat generating devices (power transistor, resistors, etc.), self-heating due to ripple currents, etc. Take all of these factors into consideration when checking the capacitor's temperature.

Do not place any heat generating devices on the back of the capacitors.

Life acceleration can be calculated with the following equation:

$$L_2 = L_1 \times 2^{\frac{T_1 - T_2}{10}}$$

L_1:Life at temperatureT_1°C(h)
L_2:Life at temperatureT_2°C(h)
T_1:Catregory's upper limit temperature(°C)
T_2:Ambient temperature to calculate the life + heat generation due to ripple current(°C)

Humidity also affects the capacitor's life. When using capacitors outside the following conditions, please contact Panasonic.

A temperature at +55°C and a relative humidity of 90% to 95% for 500 hours.

4-2-1.5 Voltage drop

Pay particular attention to the instantaneous working current and the voltage drop due to the capacitor's internal resistance when used in backup mode. The discharging current level is different depending on the capacitor's internal resistance. Use a capacitor below maximum discharging current. (Ref 3-4)

4-2-1.6 Series connection

When connecting capacitors in series, add a bleeder resistor in parallel with each capacitor by taking the leak current into consideration so that the balanced of voltages is not disrupted.

4-2-1.7 Electrolyte is used in the products

Electrolyte is used in the capacitors. Therefore, misuse can result in rapid deterioration of characteristics and functions of each product. Electrolyte leakage will damage printed circuit boards and can affect their performance, characteristics, and functions.

4-2-1.8 External sleeve

The external sleeve is not electrical insulation, and thus capacitors should not be used in an environment that requires electrical insulation.

4-2-2 Mounting

4-2-2.1 Heat stress due to soldering

When soldering a capacitor to a printed circuit board, excessive heat stress could cause the deterioration of the capacitor's electrical characteristics. For example, the integrity of the seal can be compromised causing the electrolyte to leak, and short circuits could occur in addition to failure of appearance.

Please observe the following guidelines:

(1) Manual soldering

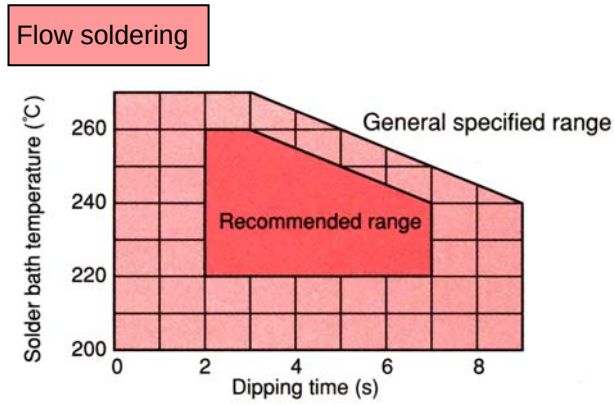
Do not touch the capacitor body with a soldering iron. Solder the capacitor using a soldering tip temperature of 350°C or less for 4 seconds or less. Solder the capacitor three times or less at intervals of 15 seconds or more.

(2) Flow soldering

1) Do not dip the body of the products into a soldering bath.

2) Keep the product's surface temperature at or below 100°C for no more than 60 seconds (the peak 105°C) when soldering.
Please refer to the chart at right to set soldering conditions. It is recommended to check the product temperature before you use.

3) The terminals of the NF/F/RF type are designed so the bottom of the product floats from the PCB.
This is to protect against heat stress during soldering. Do not touch the bottom of the product directly to the PCB.



Pre-heating temperature : 110℃ or under (on the surface of circuit board)
100℃ or under (on the surface of capacitor)
Pre-heating time : 60 seconds or under
Board thickness : 0.8 mm or more

(3) Other heat stress

1) Keep the product's surface temperature at or below 100℃ for no more than 60 seconds (the peak 105℃) when applying heat to bake the PCB or fixing resin, etc.
The capacitor voltage must be 0.3V or less.

2) Do not use a product more than once after it has been mounted on the PCB. Excessive heat stress is applied when detaching it from the PCB. Please observe "(1) Manual soldering" when adjusting it.

3) Be sure that excessive heat stress is not applied to the Gold Capacitor when other parts in its surroundings are detached or adjusted.

(4) Others

1) The lead wires and terminals are plated for solderability. Rasping lead wires or terminals may damage the plating layer and degrade the solderability.

2) Do not apply a large mechanical force to the lead wires or terminals. Otherwise, they may break or come off or the capacitor characteristics may be damaged.

4-2-2.2 Circuit Design

Do not set wiring pattern directly to the mounted capacitor, and pass between terminals. If the electrolyte leaks, short circuit may occur and tracking or migrations are anticipated.

If a capacitor is directly touching a PCB, then the bottom of the capacitor and the circuit pattern may short-circuit. On PCBs, blowing flux or solder may cause the capacitor's external sleeve to break or shrink, potentially affecting the internal structure.

4-2-2.3 Residual voltage

Gold Capacitors can hold a large charge and could have residual voltage. Therefore, some electronic components with a low withstand voltage, such as semi-conductors, may be damaged.

Since Gold Capacitors can hold great charge, there may be residual electric charge that could damage other low-withstanding voltage parts such as semiconductors.

4-2-2.4 Circuit board cleaning

Apply the following conditions for flux cleaning after soldering. (Excepted for NF,F and RF series)

Temperature: 60°C or less

Duration: 5minutes or less

Rinse sufficiently and dry the boards.

[Recommended cleaning solvents include]

Pine Alpha ST-100s, Sunelec B-12, DK be-clear CW-5790, Aqua Cleaner 210SEP, Cold Cleaner P3-375, Cllear-th-ru 750H, Clean-thru 750L, Clean-thru 710M, Techno Cleaner219, Techno Care FRW-17, Techno Care FRW-1, Techno Care FRV1

♦ Consult Panasonic if you are using a solvent other than any of those listed above.

♦ The use of ozone depleting cleaning agents is not recommended in the interest of protecting the environment.

4-2-3 Precautions for using equipment

Avoid using mounting equipment in environments where:

(1) Capacitors are exposed to water, salt water or oil.

(2) Capacitors are exposed to direct sunlight.

(3) Capacitors are exposed to high temperature and humidity where water can condense on the capacitor surface.

(4) Capacitors are subject to various active gases.

(5) Capacitors are exposed to acidic or alkaline environments.

(6) Capacitors are subject to high-frequency induction.

(7) Capacitors are subject to excessive vibrations or mechanical impact.

A brown excretion might be caused around the sealing, depending on the conditions of use. This excretion is insulation and does not have influence on the electrical characteristics.

4-2-4 Maintenance Precautions

Periodically check capacitors used in industrial equipment. When checking and maintaining capacitors, turn off the equipment and discharge the capacitors beforehand. Do not apply stress to the capacitor lead terminals.

Periodically check the following items.

(1) Significant appearance abnormalities (deformation, electrolyte leakage, etc.)

(2) Electrical characteristics (described in the catalog or delivery specifications)

If any abnormalities are found, then replace the capacitors or take appropriate actions.

4-2-5 Emergency procedures

If the capacitors generate heat, then smoke may come out of the exterior resin. Under these conditions turn off the equipment immediately and stop using it.

Do not place your face or hands close to the capacitor, burns may be caused.

4-2-6 Storage

Do not store capacitors in a high-temperature or high-humidity environment. Store capacitors at a room temperature of 5°C to 35°C and a relative humidity of 85% or less.

Store capacitors in their packaging as long as possible.

Avoid storing capacitors under the following conditions.

(1) Exposed to water, high temperatures or humidity, or when condensation can occurs.

(2) Exposed to oil or in environments filled with gaseous oil contents.

(3) Exposed to salt water or environments filled with saline substances.

(4) In environments filled with harmful gases (hydrogen disulfide, sulfurous acid, nitrous acid, chlorine, bromine, bromomethane, etc.)

(5) In environments filled with harmful alkaline gases such as ammonia.

(6) Exposed to acid or alkaline solvents.

(7) Exposed to direct sunlight, ozone, ultraviolet or radial rays.

(8) Exposed to vibrations or mechanical impact.

4-2-7 Discarding

Dispose of capacitors as industrial waste. They are comprised of various metals and resin.

4-2-8 Others

4-2-8.1 The purpose of these specifications is to ensure the quality of components as individual components. Before use, check and evaluate their operation when mounted on your products.

4-2-8.2 Do not use our components outside of the corresponding specifications.

4-2-8.3 When using this capacitor in a product where safety is critical

We take great care in the quality of this product. However, performance may deteriorate and short-circuiting or open-circuiting may occur. If it will be used in transportation equipment (e.g. trains, cars, traffic lights), airborne equipment, aerospace equipment, electric heating appliances, combustion/gas equipment, rotating equipment, disaster/crime prevention equipment, or other equipment where a defect in this component may cause the loss of human life or other significant damage. Ensure that the target equipment has a failsafe design and is provided with the following

systems to guarantee adequate safety.

(1) Ensure the safety of the whole system by installing a protection circuit and a protection device.

(2) Redundant circuits, etc. to maintain the safety of the entire system so that a single independent failure will not lead to unsafe conditions.

4-2-8.4 Conditions of use

This products is intended to be use in electronic equipment for general-purpose standard applications and is not designed for use in any special environments. When this capacitor is used in a special environment or under special conditions, its performance may be affected. Before use, verify the performance and reliability of the capacitor.

The precautions for the use of Electric Double Layer Capacitors (Gold Capacitor) follow the “Precautionary guidelines for the use of fixed Electric Double Layer Capacitors for electronic equipment”, RCR-2380A issued From EIAJ in July, 2008.

4-3 When making an order

When ordering Gold Capacitors, please provide information on the items below,

Inquiry check list

Gold Capacitor / Check sheet	
Application	
Condition of Charging	
Charging Voltage	
Charging Time（Max. Min.）	
Charging Current （Balanced Resister, If any）	
Condition of Discharging	
Backup Current （Max.　Min.　Typical.）	
Minimum Holding Voltage	
Required Backup Time	
Backup for xxx （RTC, SRAM　etc.）	
Operating Condition	
Expected Life	
Ambient Temperature	

5. Gold Capacitors Characteristics data

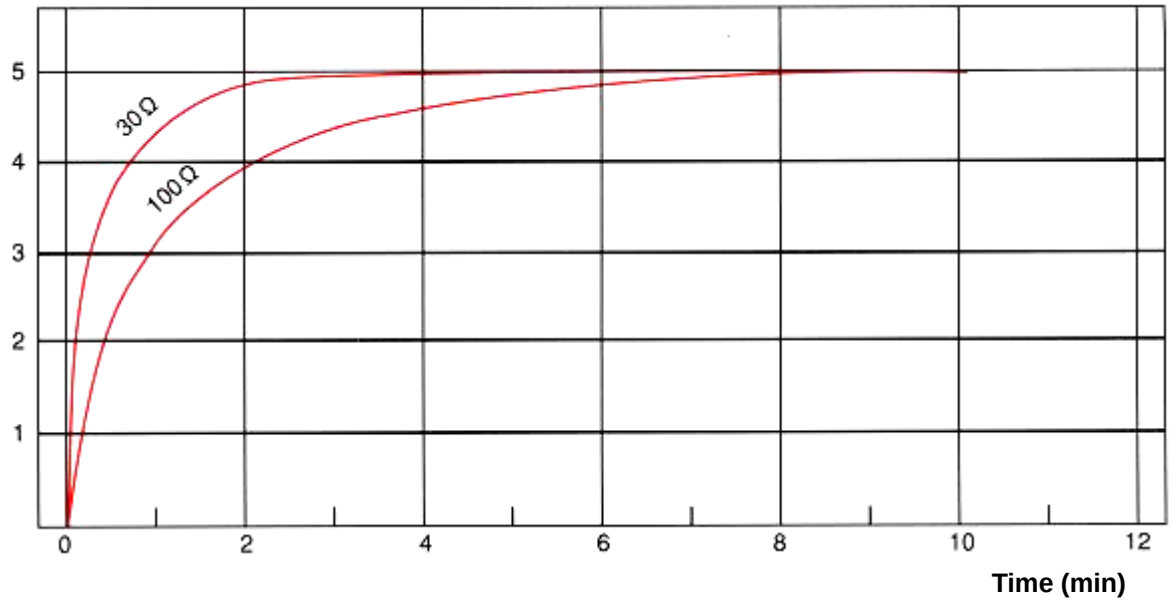
- **Charging characteristics**
- **Self-discharging characteristics according to charging time**
- **Influence of ambient temperature on self-discharging characteristics**
- **Discharge characteristics**
- **Influence of ambient temperature on discharging characteristics**
- **Current characteristics**
- **Relations between applied voltage and capacitance change**
- **Relations between ambient temperature and capacitance change**
- **Reliability and temperature characteristics data**

This data is typical data. It does not guarantee life time.

Before using the products, carefully check the effects on their quality and performance.

Charging characteristics

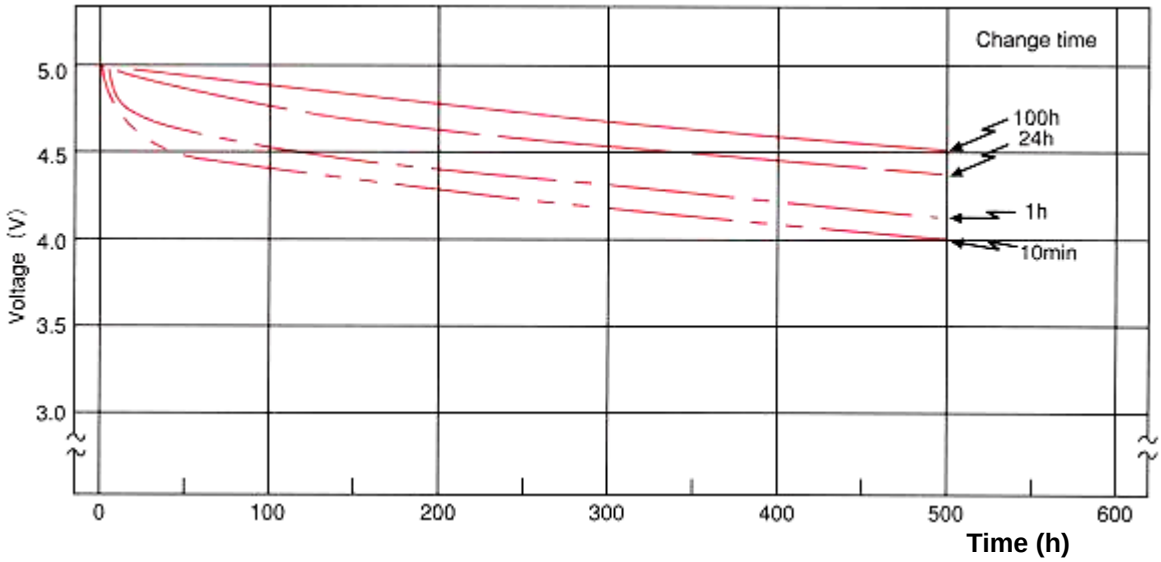
5.5V 1.0F



Self-discharging characteristics according to charging time

Charging condition: 5V

5.5V 1.0F

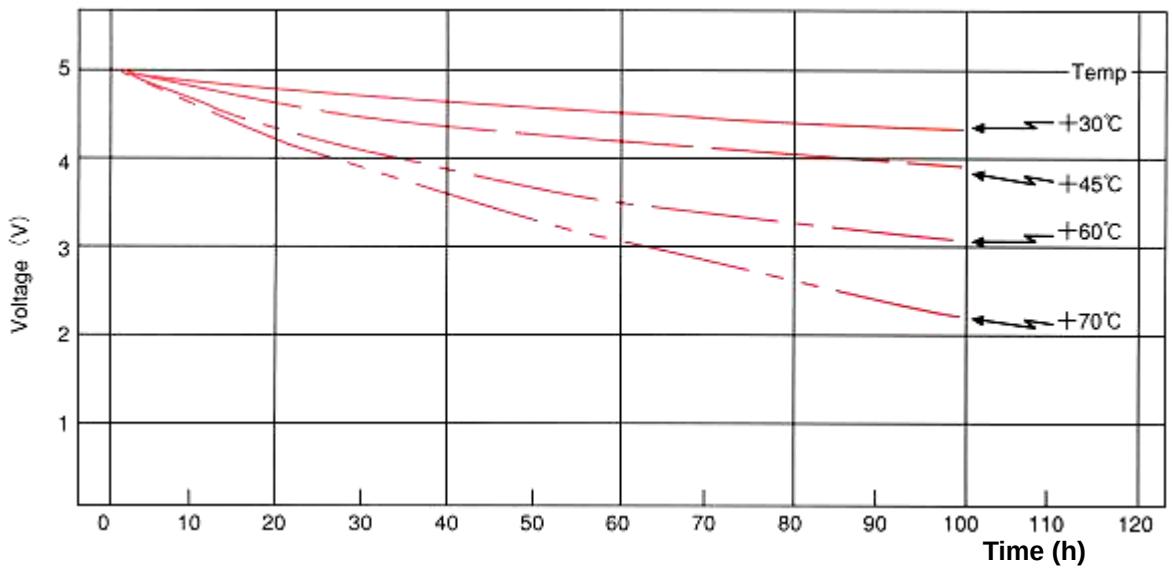


(Note) If charging time is brief, complete charge is not attained, and initial voltage due to internal charge is increased.

Influence of ambient temperature on self-discharging characteristics

Charging condition: 5V, 24hours

5.5V 0.1F



(Note) In the self-discharge characteristics, the terminal voltage drop is affected by ambient temperature. This means a self-discharge current becomes great as ambient temperature rises. In case where it is used with a micro applied current of nano-ampere order, ambient temperature allows a difference to occur in backup time.

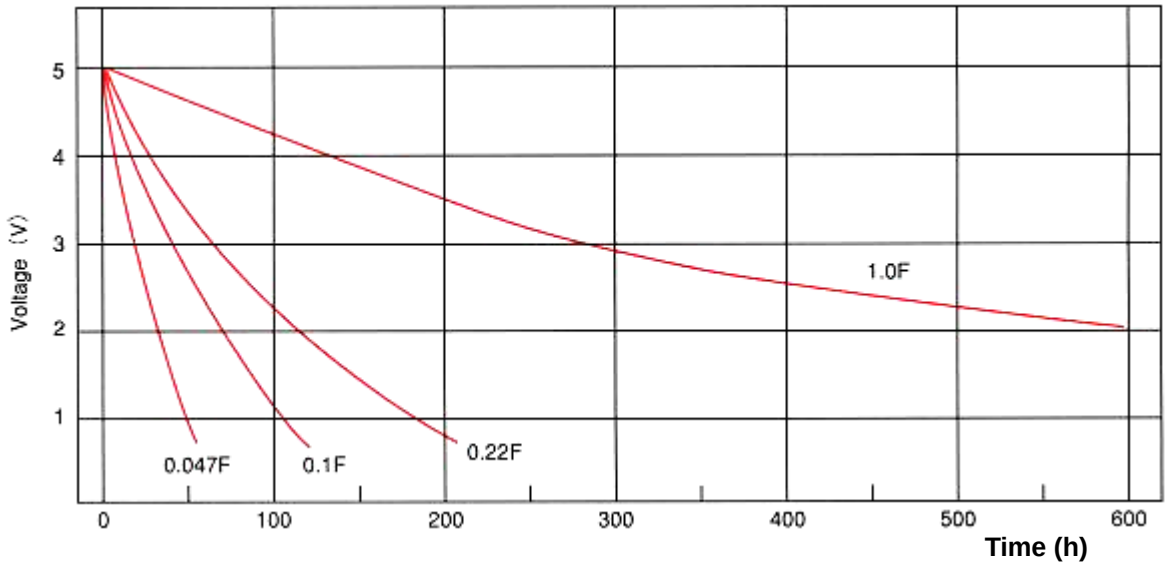
Discharging characteristics

Constant resistance discharge: 1MΩ

Charge voltage: 5V

Charge time: 24hours

Measurement temp: +20°C

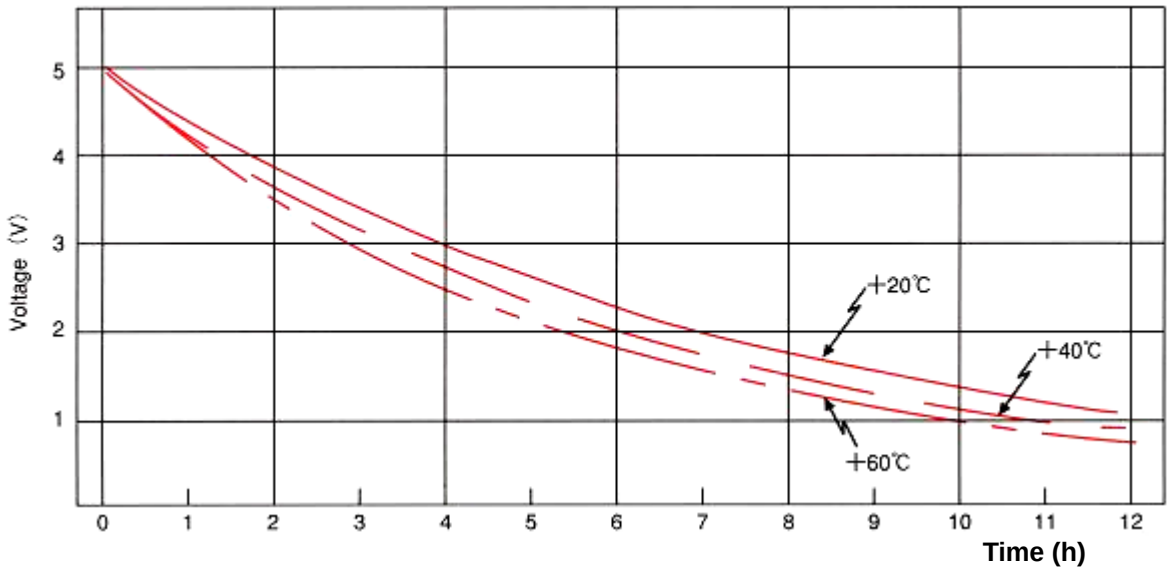


Influence of ambient temperature on discharge characteristics

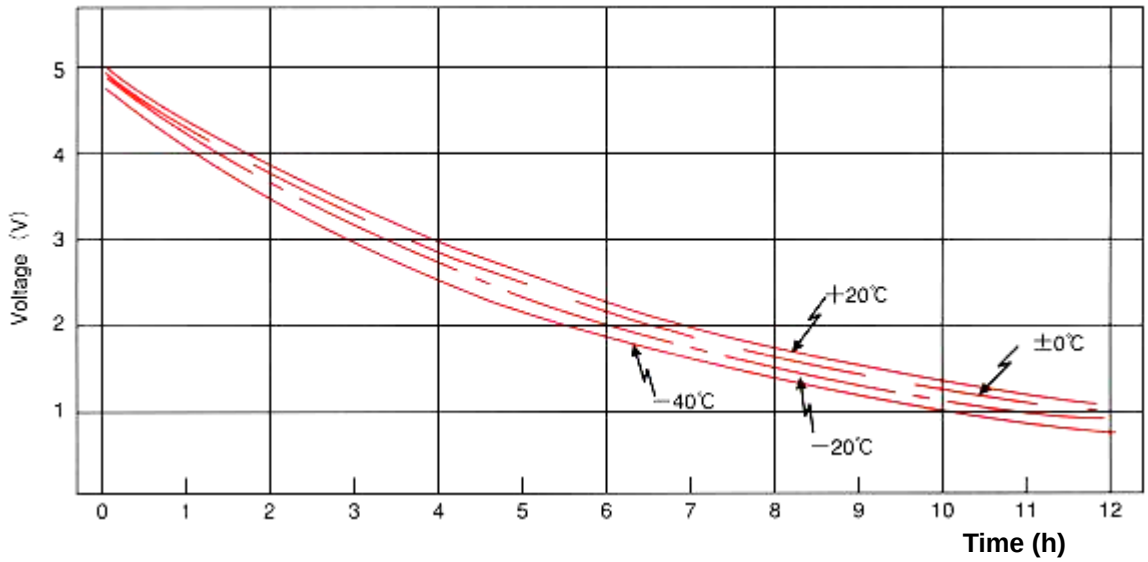
Constant resistance discharge: 250kΩ

Charge time: 24hours

5.5V 0.1F



(Note) Voltage drop gets a little faster as ambient temperature rise. This occurs because the rise in ambient temperature causes a self-discharge current added to applied current.



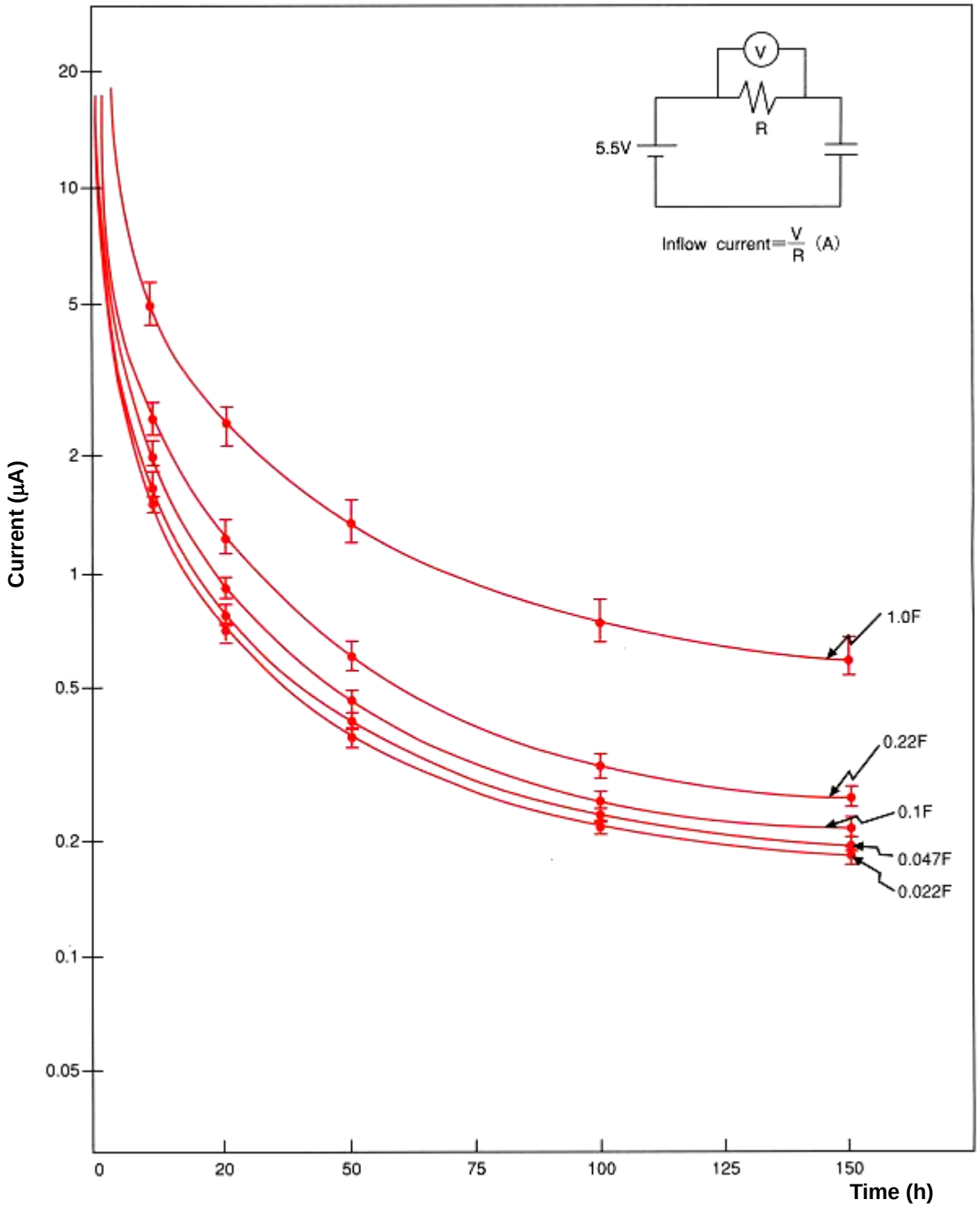
(Note) In low temperature area, ion movement for the formation of electric double layers becomes slow, and time required for complete charge takes longer. Consequently, The voltage drop is large in the condition with low temperature when there is no difference at charging time..

Current characteristics

Initialization of test samples

The samples shall be measured after applying 5.5V for 2hours 300Ω resistance in the temperature (20±10°C, 65±10% not being wetted with dew) and discharging in short circuit for 12 to 24hours.

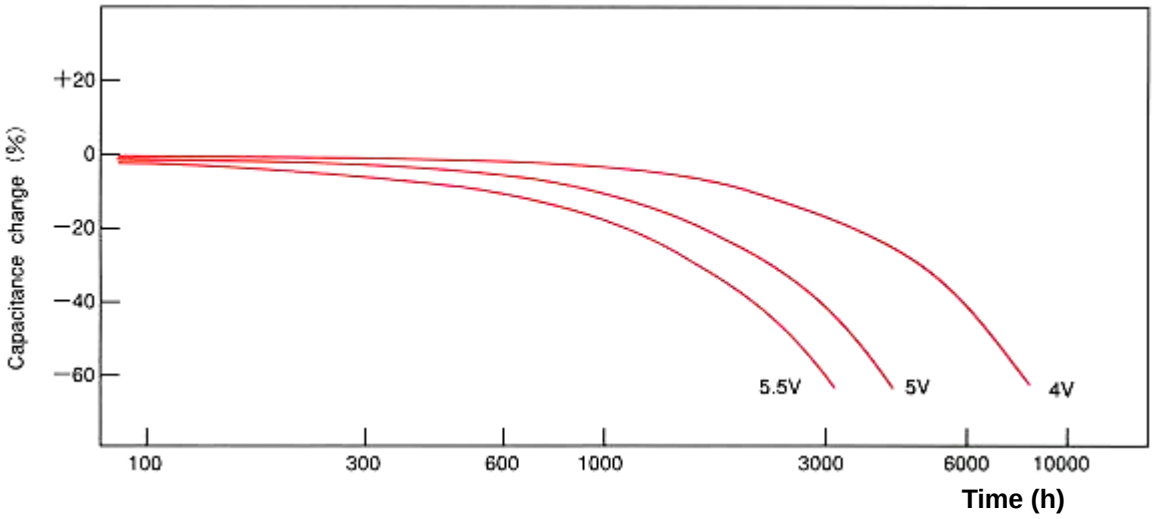
(n =20)



Relations between applied voltage and capacitance change

Test condition: +70°C 5.5V

Applied voltage: 4, 5, 5.5V

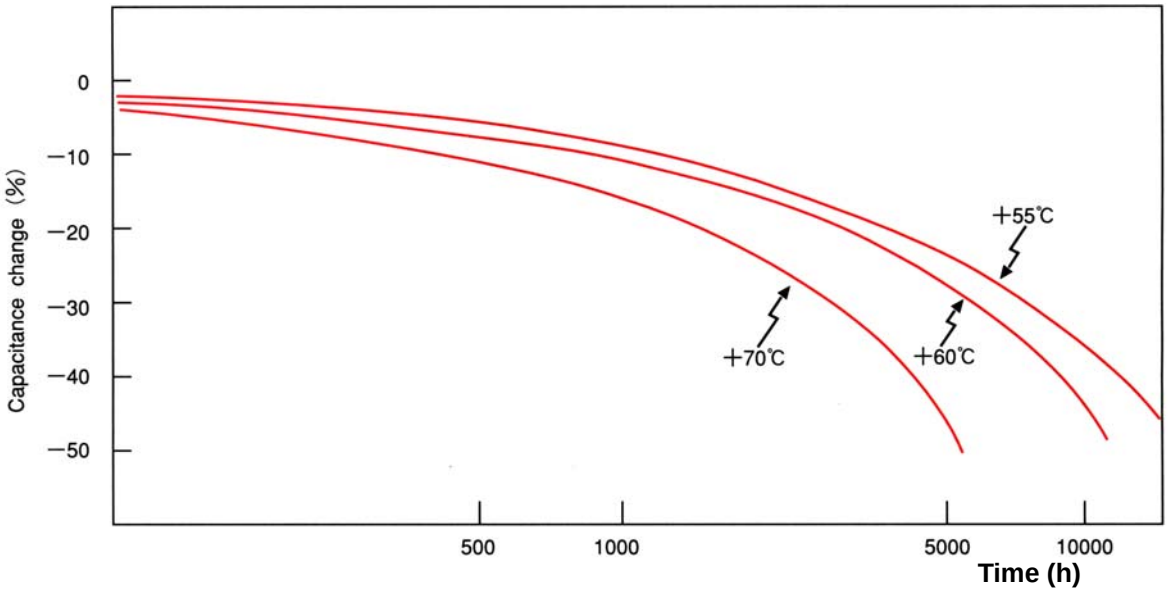


(Note) Capacitance changes at the life test vary from applied voltage. The lower the voltage is, the smaller it becomes. Almost no capacitance change due to no-load shelving.

Relations between ambient temperature and capacitance change

Test condition: +70, +60, +55°C

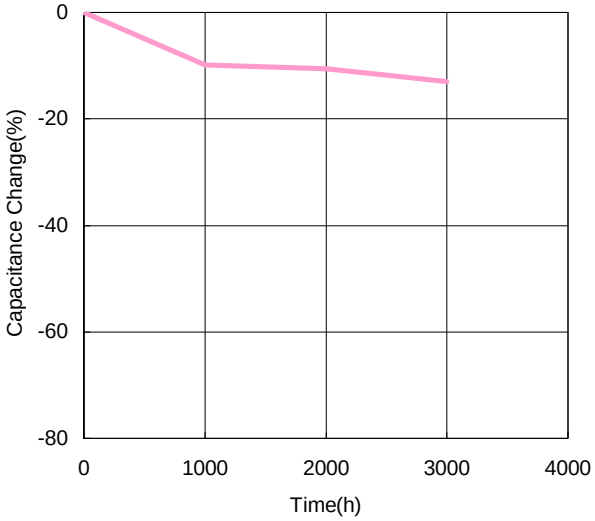
Applied voltage: 5.5V

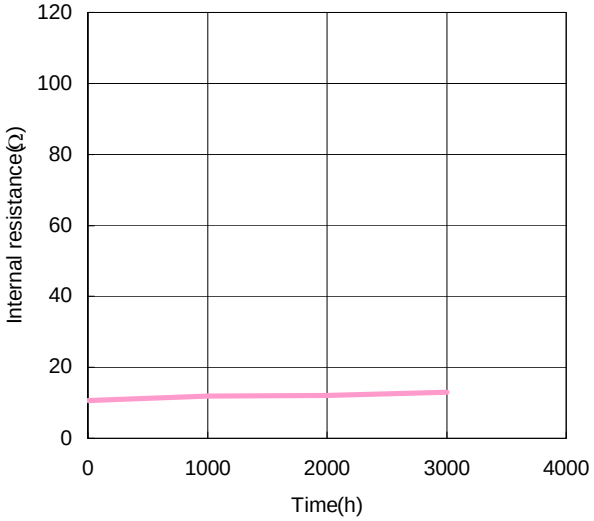


Reliability and temperature characteristics data

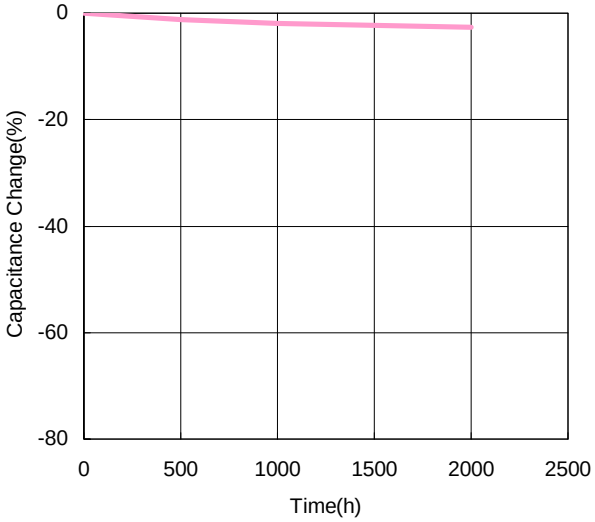
Part number: EECRF0H684 (5.5V, 0.68F)

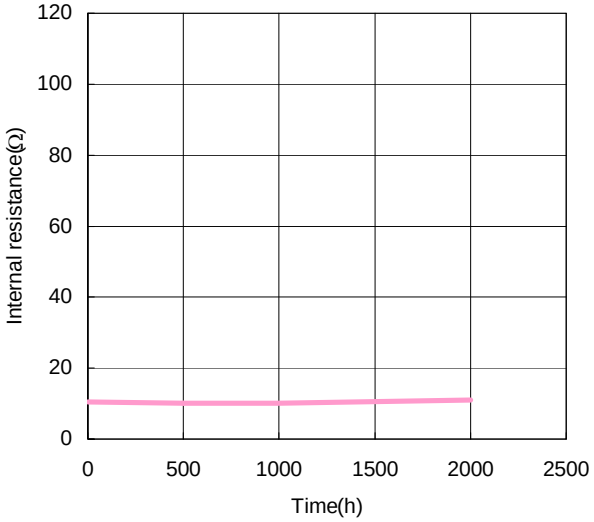
Endurance (at 85°C, 5.5V applied)



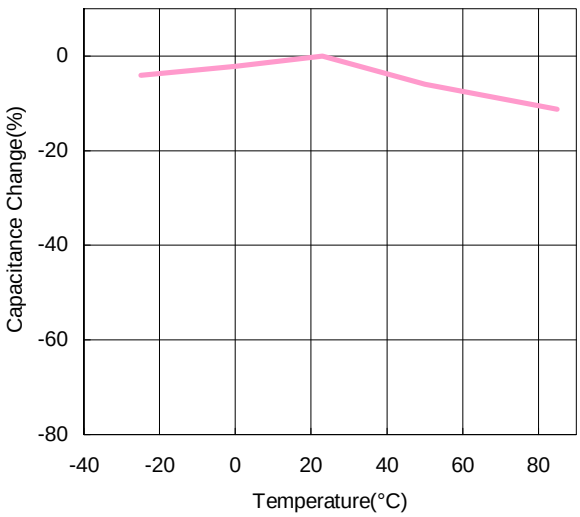


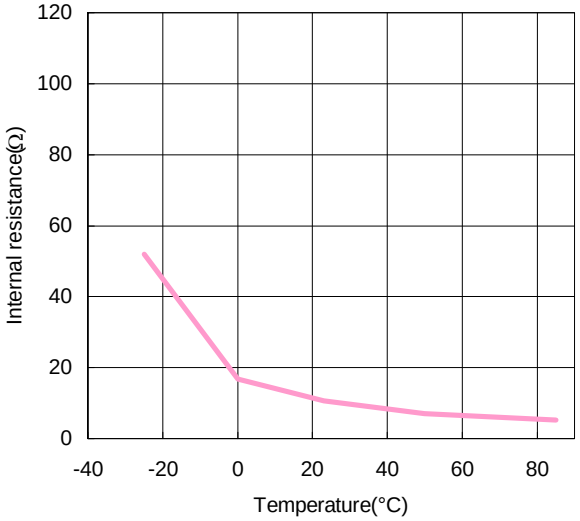
Shelf life (at 85°C)





Temperature characteristics



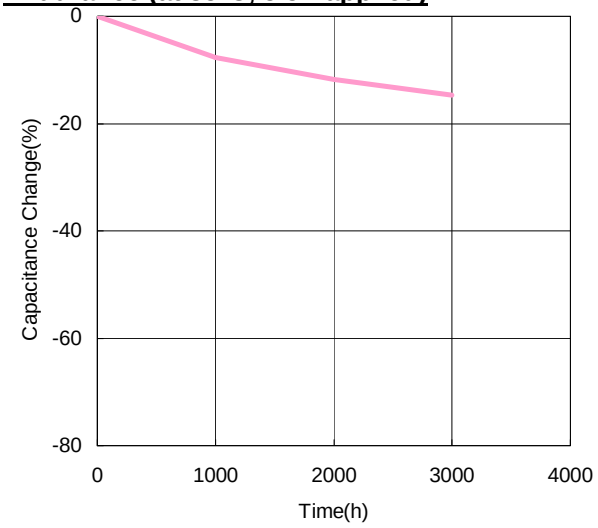


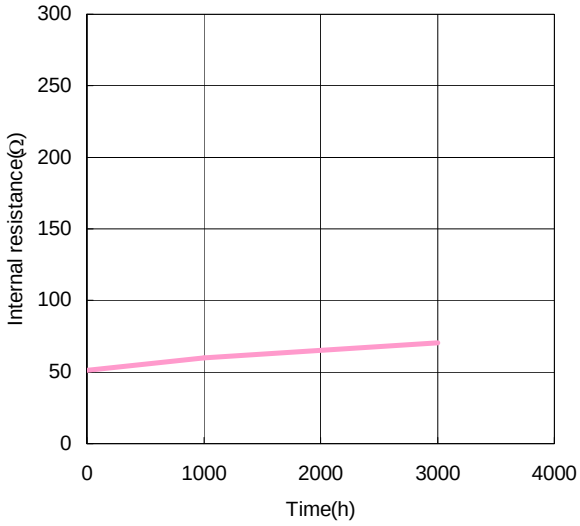
(The discharge current shall be calculated by the capacitance value in a ratio of 1mA/F)

Reliability and temperature characteristics data

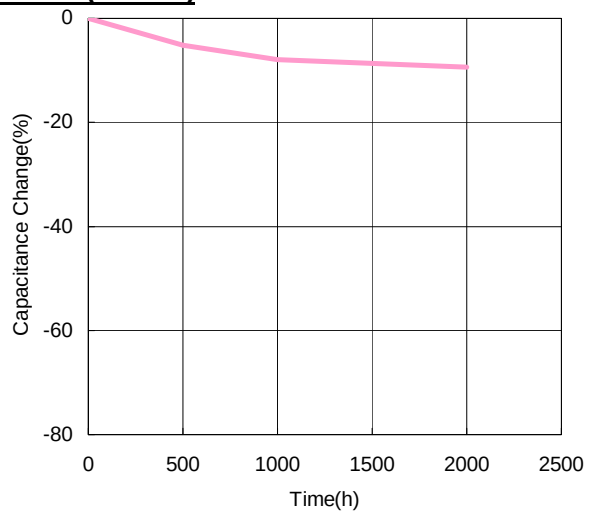
Part number: EECRF0H104 (5.5V, 0.1F)

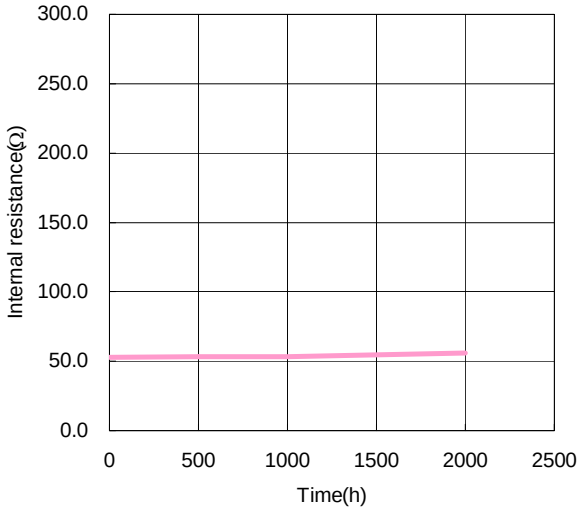
Endurance (at 85°C, 5.5V applied)



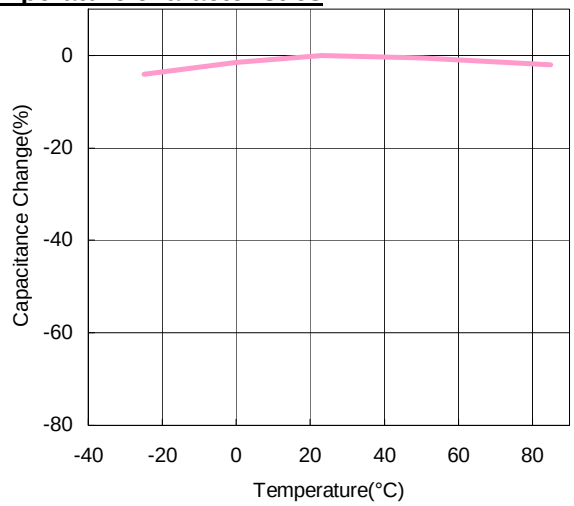


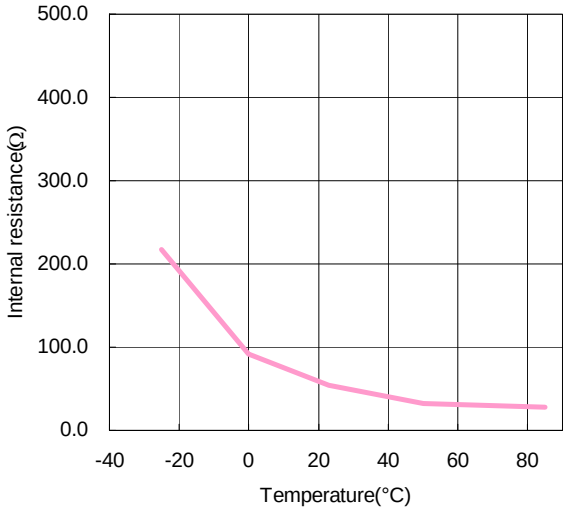
Shelf life (at 85°C)





Temperature characteristics



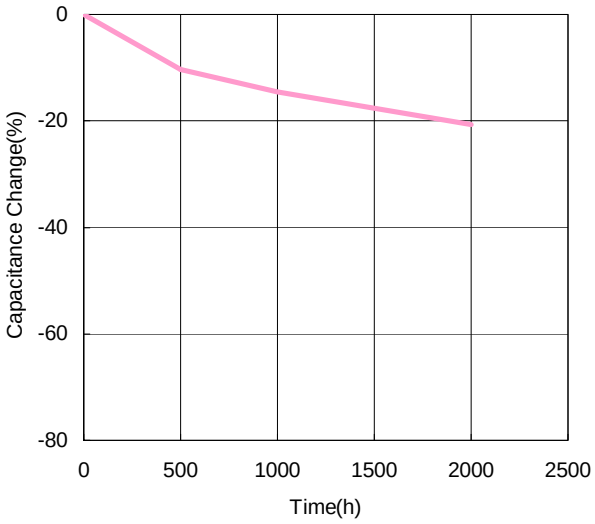


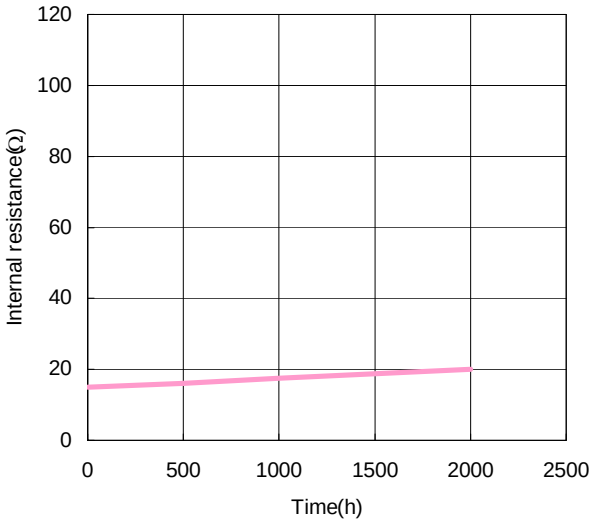
(The discharge current shall be calculated by the capacitance value in a ratio of 1mA/F)

Reliability and temperature characteristics data

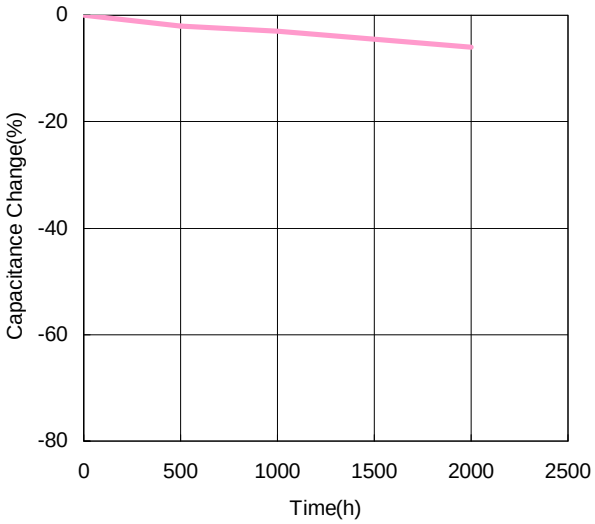
Part number: EECF5R5H105 (5.5V, 1.0F)

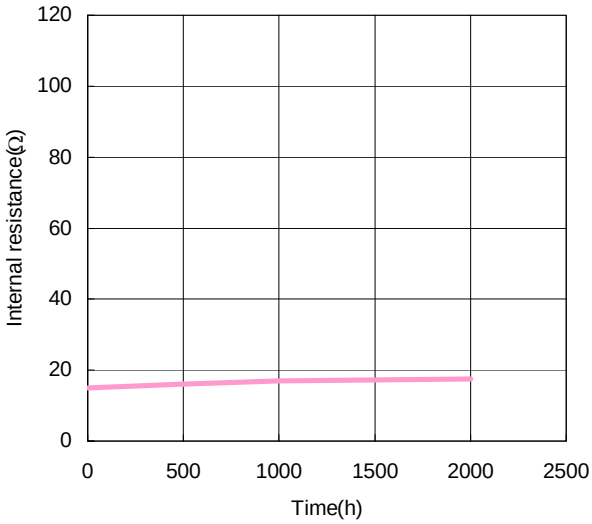
Endurance (at 85°C, 5.5V applied)



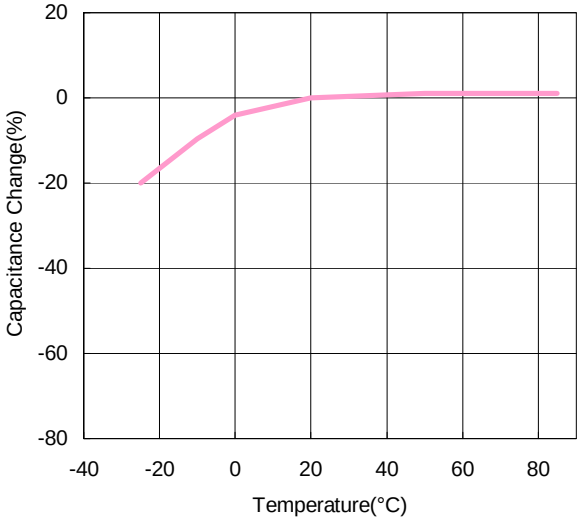


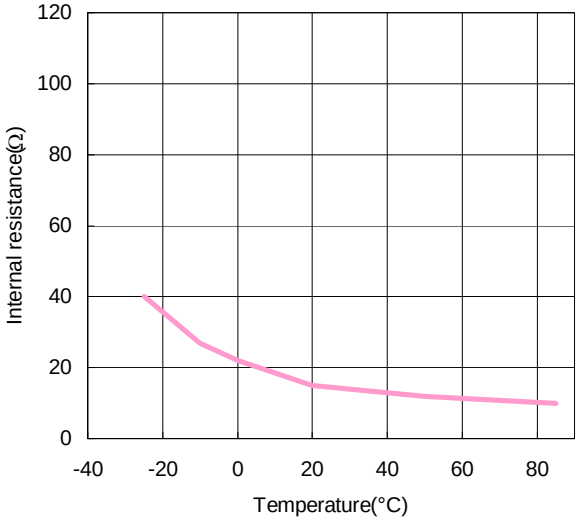
Shelf life (at 85°C)





Temperature characteristics



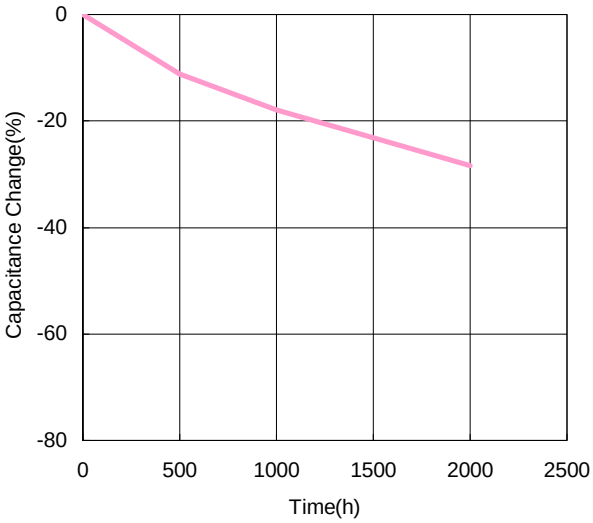


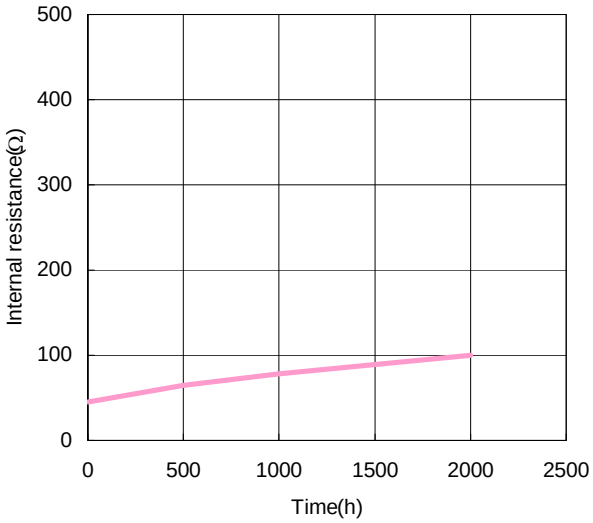
(The discharge current shall be calculated by the capacitance value in a ratio of 1mA/F)

Reliability and temperature characteristics data

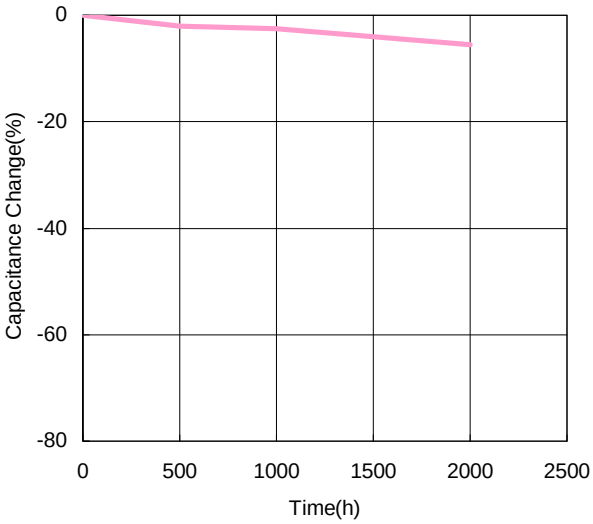
Part number: EECF5R5H104(5.5V, 0.1F)

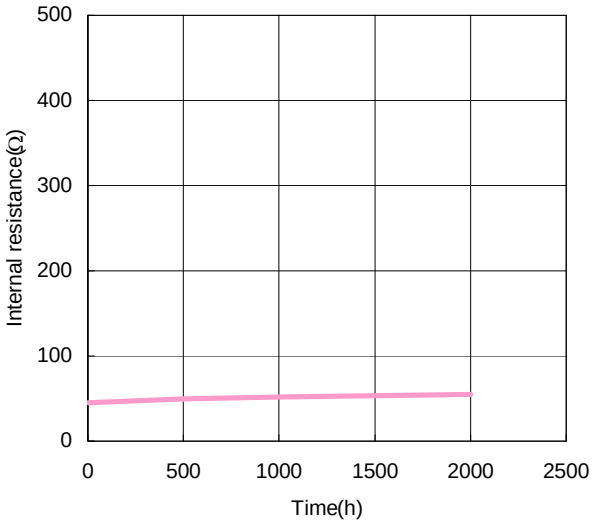
Endurance (at 85°C, 5.5V applied)



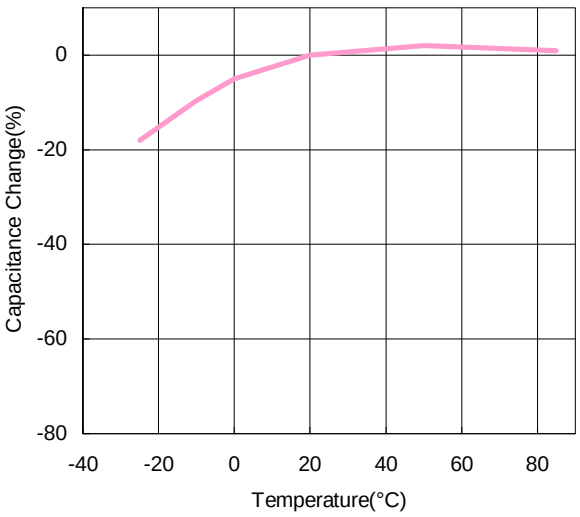


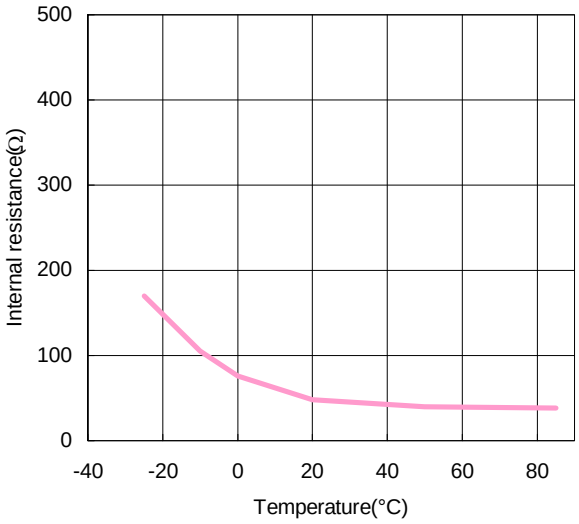
Shelf life (at 85°C)





Temperature characteristics



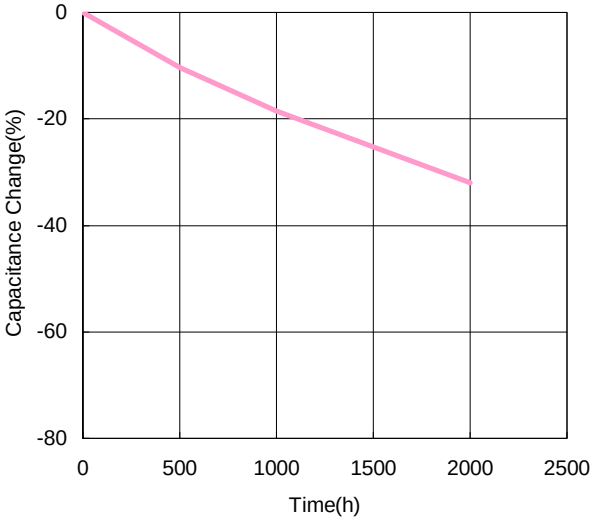


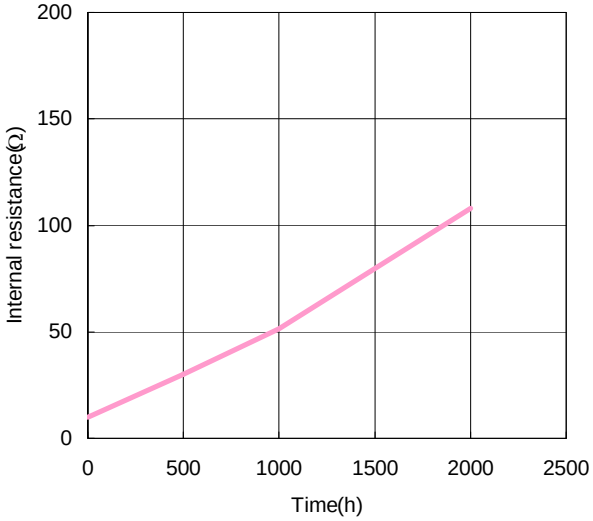
(The discharge current shall be calculated by the capacitance value in a ratio of 1mA/F)

Reliability and temperature characteristics data

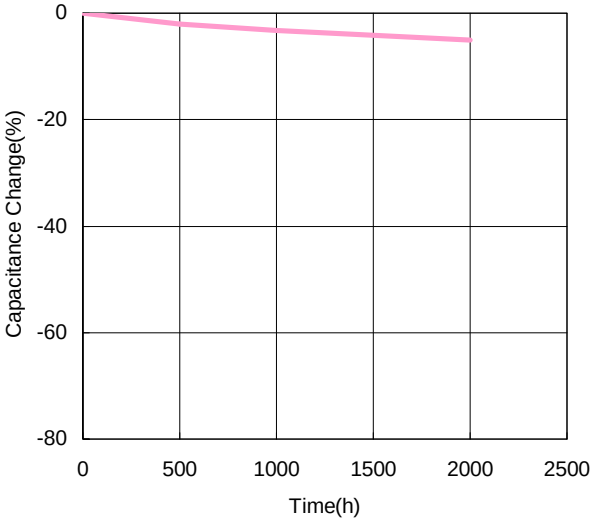
Part number: EECS5R5V155(5.5V, 1.5F)

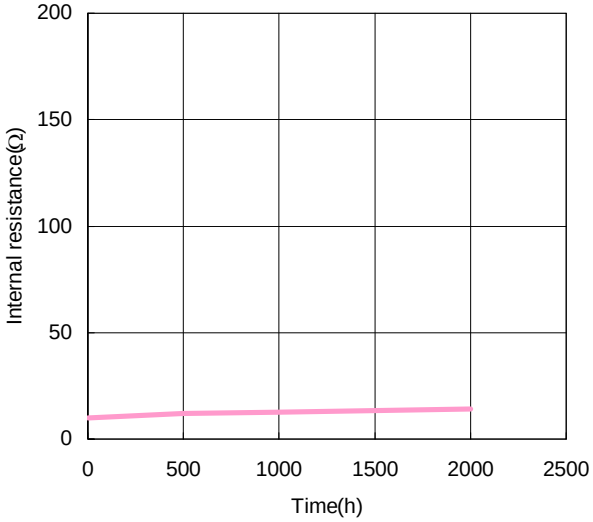
Endurance (at 70°C, 5.5V applied)



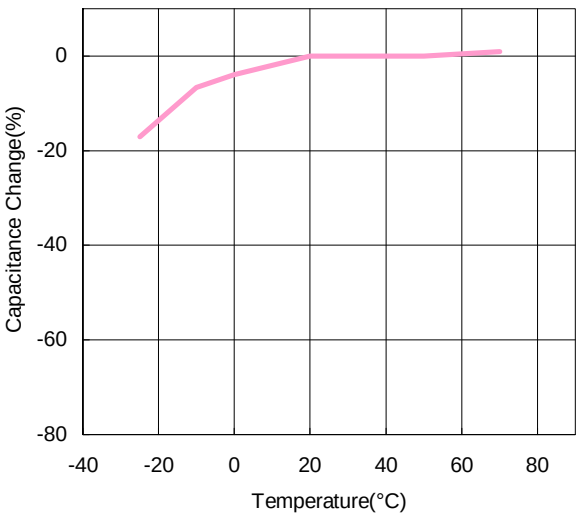


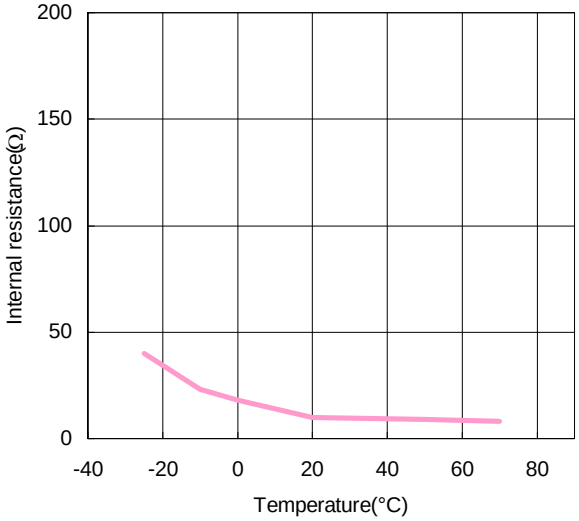
Shelf life (at 70°C)





Temperature characteristics



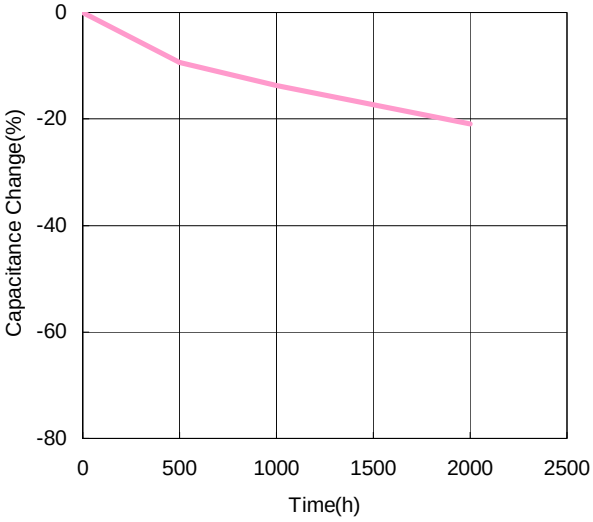


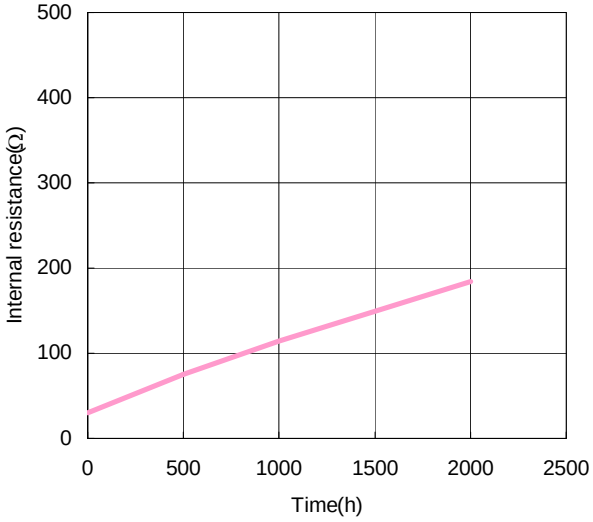
(The discharge current shall be calculated by the capacitance value in a ratio of 1mA/F)

Reliability and temperature characteristics data

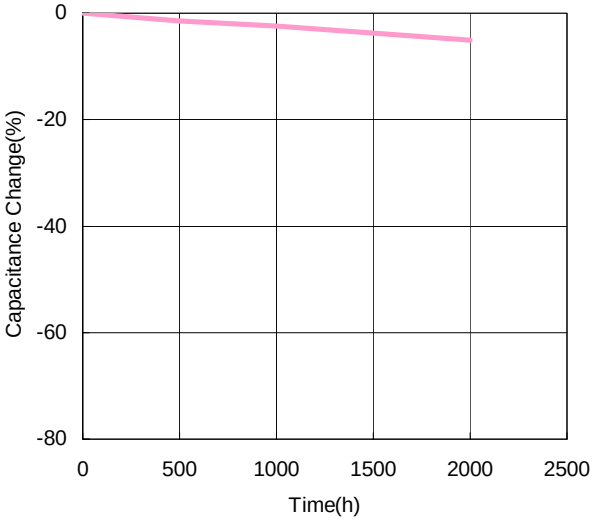
Part number: EECS0HD224V(5.5V, 0.22F)

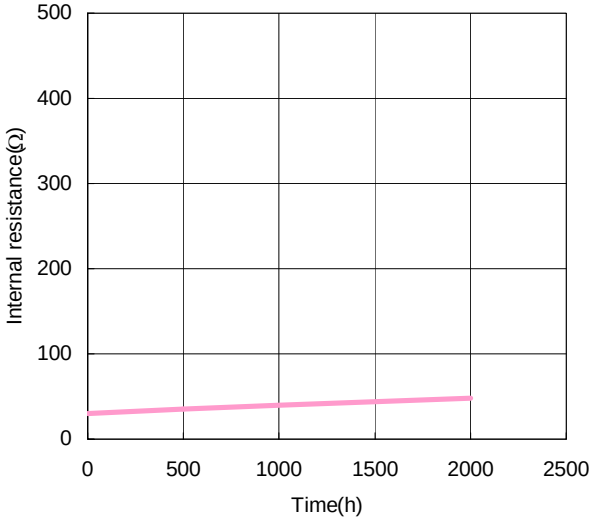
Endurance (at 70°C, 5.5V applied)



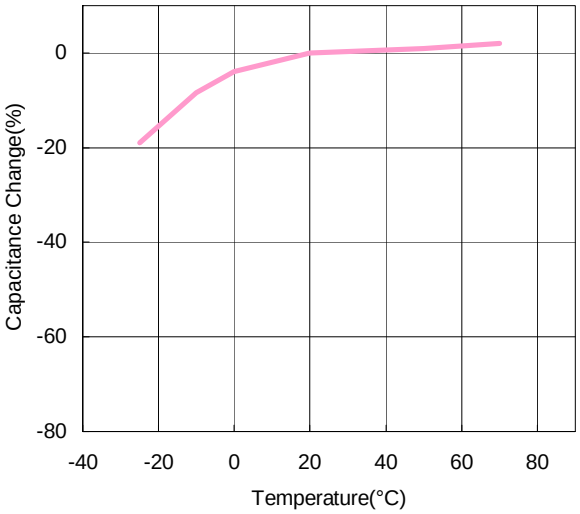


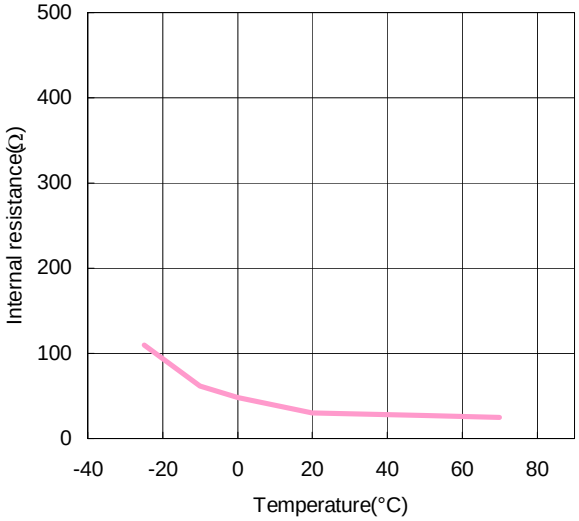
Shelf life (at 70°C)





Temperature characteristics



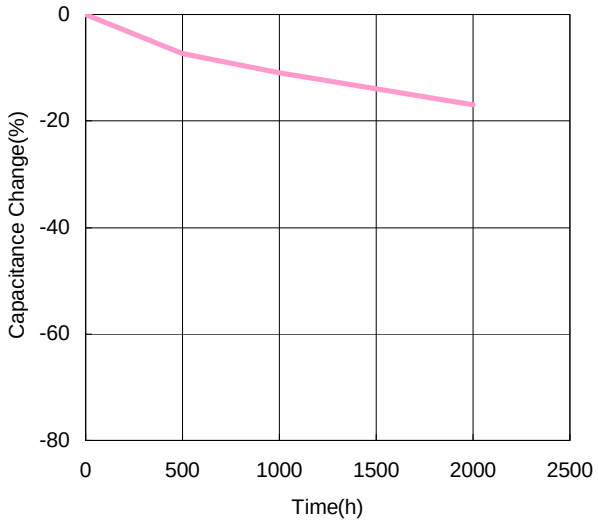


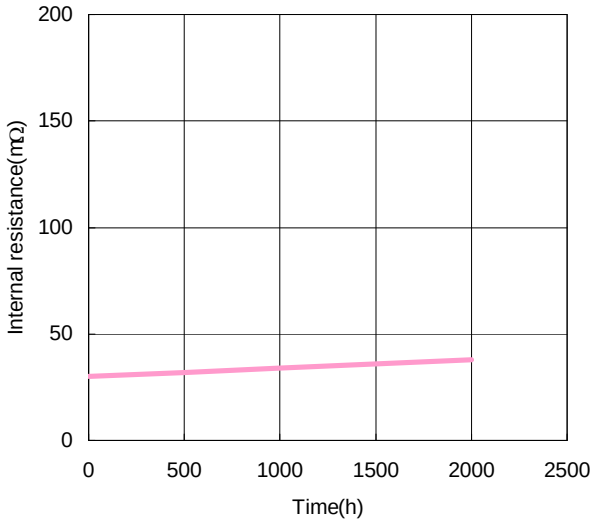
(The discharge current shall be calculated by the capacitance value in a ratio of 1mA/F)

Reliability and temperature characteristics data

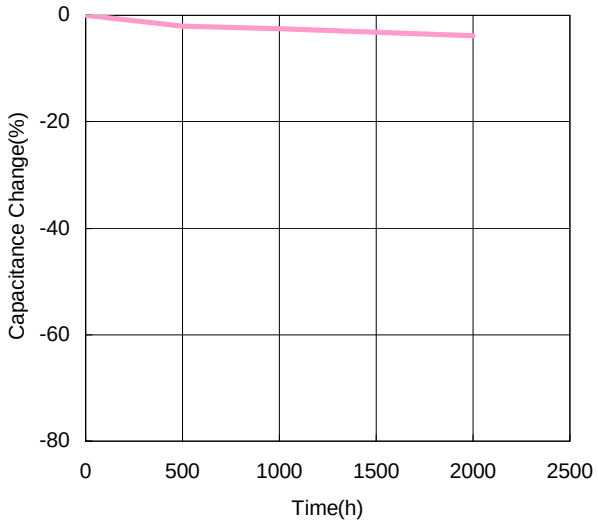
Part number: EECHW0D506(2.3V, 50F)

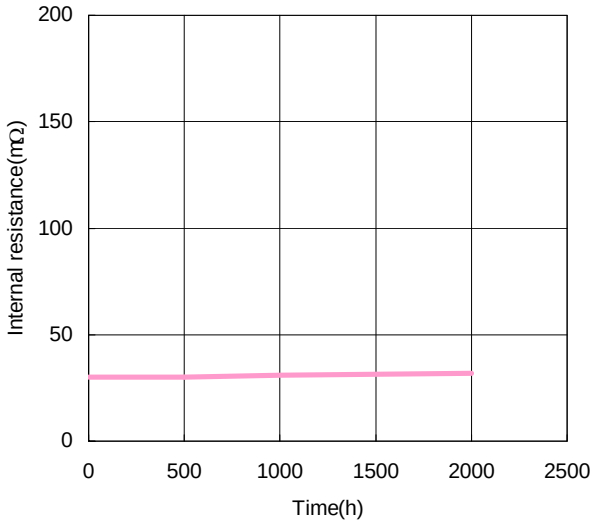
Endurance (at 60°C, 2.3V applied)



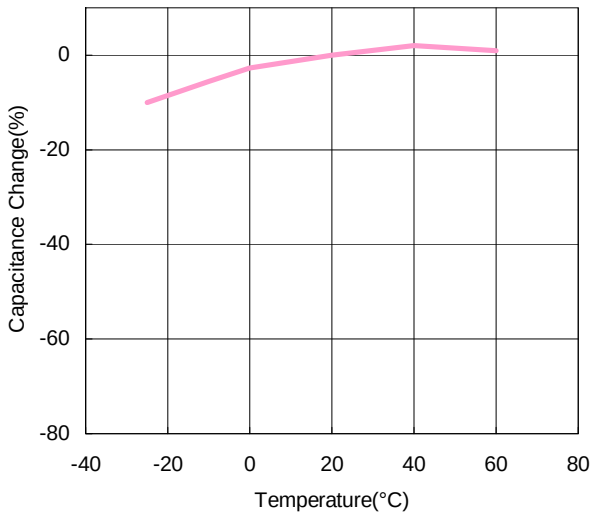


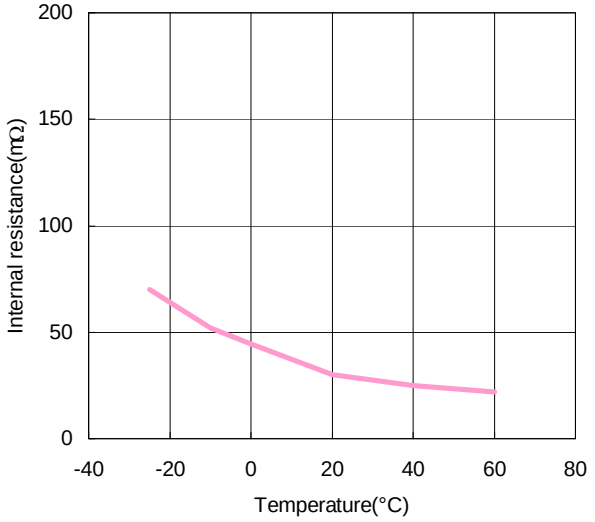
Shelf life (at 60°C)





Temperature characteristics



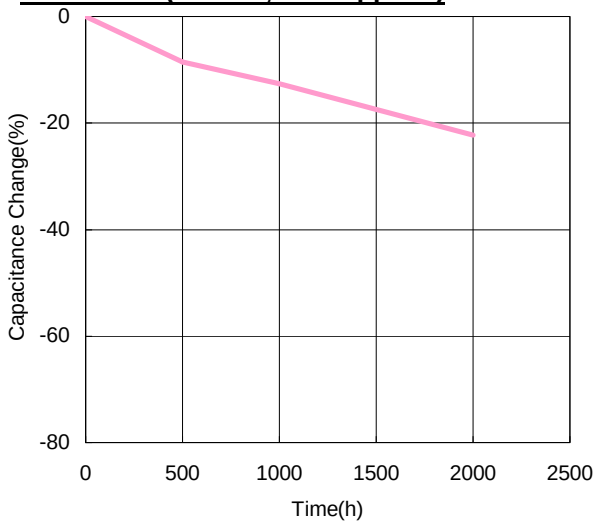


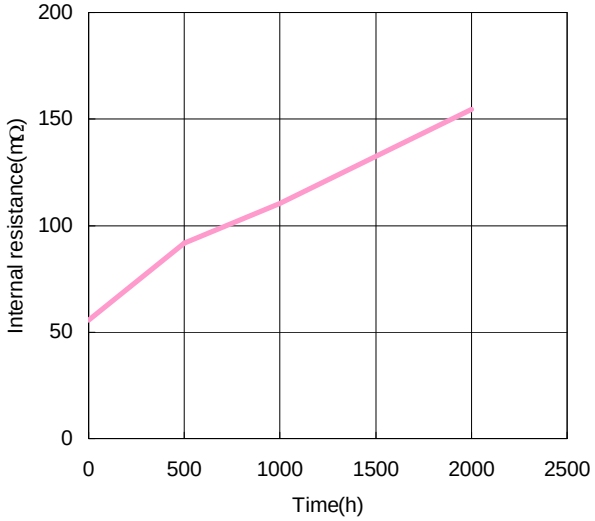
(The discharge current shall be calculated by the capacitance value in a ratio of 1mA/F)

Reliability and temperature characteristics data

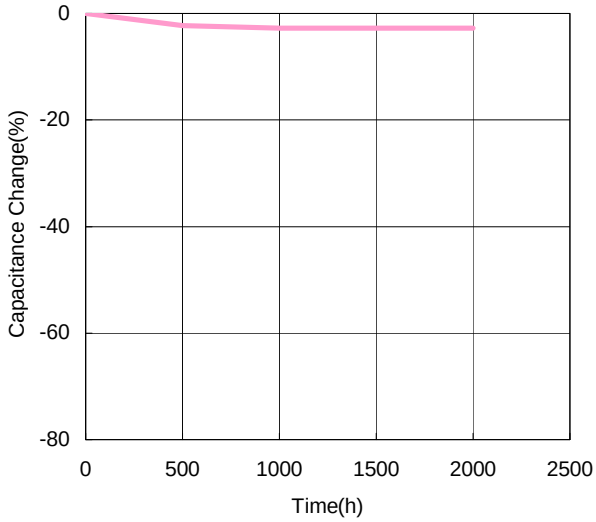
Part number: EECHZ0E106(2.5V, 10F)

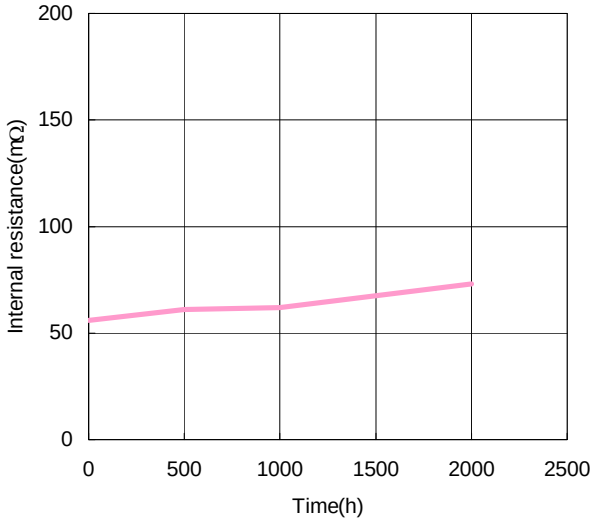
Endurance (at 70°C, 2.5V applied)



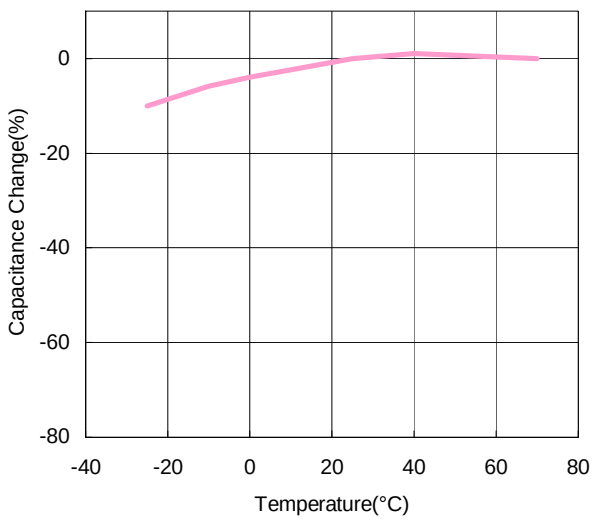


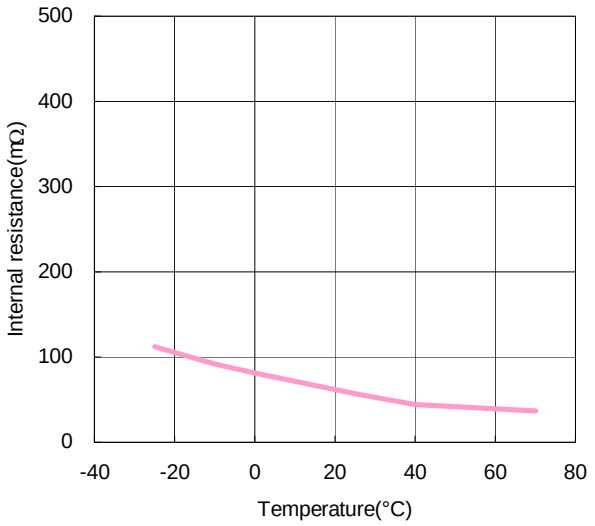
Shelf life (at 70°C)





Temperature characteristics



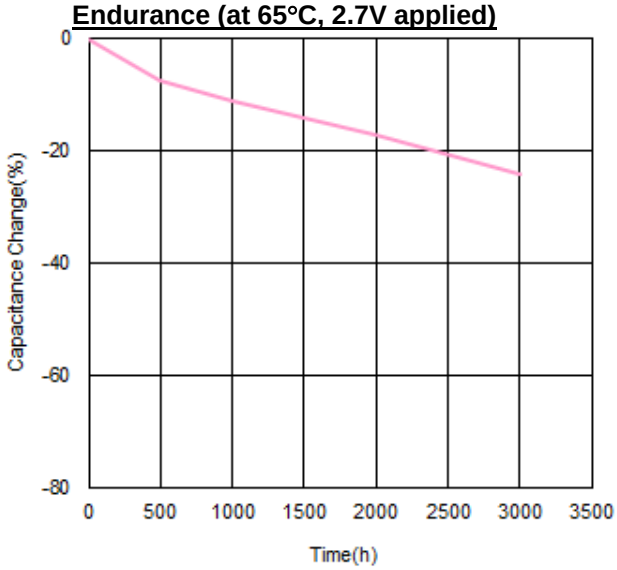


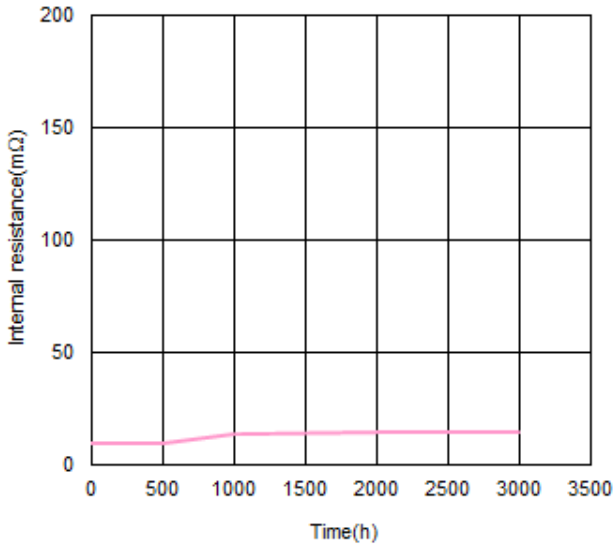
(The discharge current shall be calculated by the capacitance value in a ratio of 1mA/F)

Reliability and temperature characteristics data

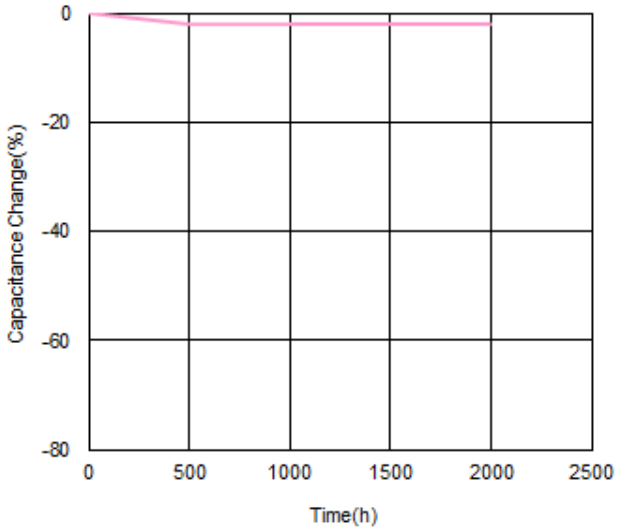
Part number: EECHL0E107(2.7V, 100F)

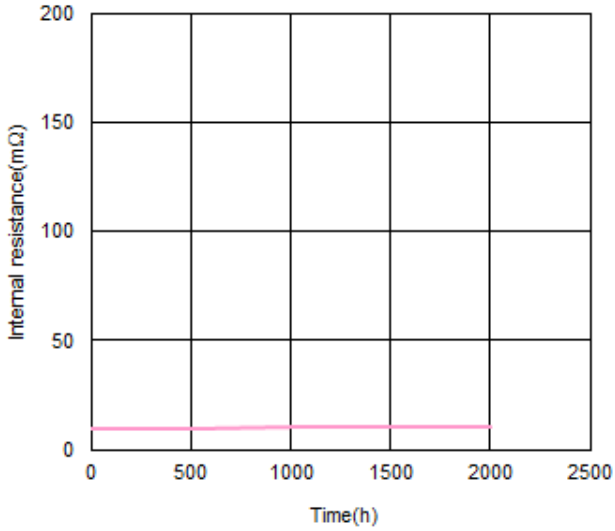
Endurance (at 65°C, 2.7V applied)



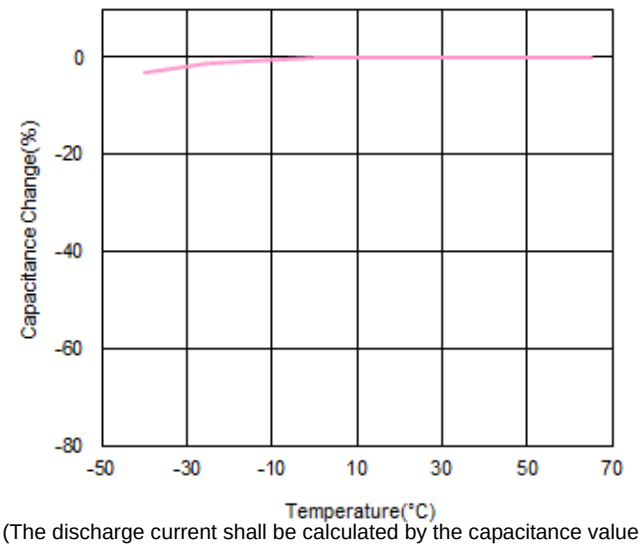


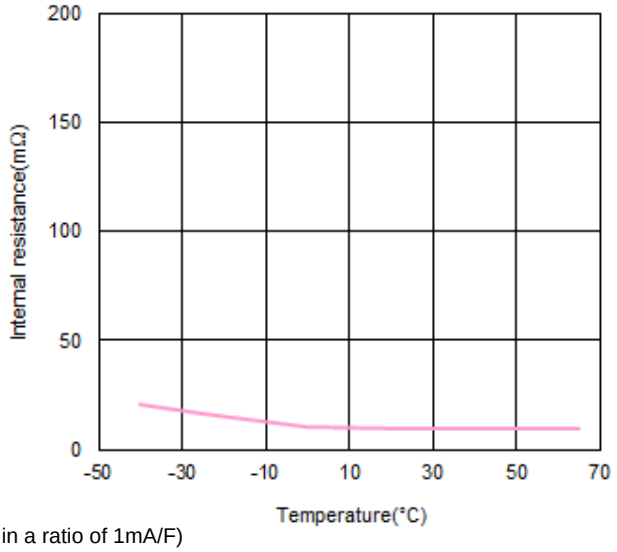
Shelf life (at 85°C)





Temperature characteristics





(The discharge current shall be calculated by the capacitance value in a ratio of 1mA/F)

<M E M O>

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