

鋁電解電容器應用指南

Application Guidelines For Aluminum Electrolytic Capacitors

1. 電路設計 Circuit Design

1.1 請明確鋁電解電容器所處的環境和安裝條件應符合本說明書中規定的情況。 Please make sure the environmental and mounting conditions to which the capacitor will be exposed to are within the conditions specified in this catalog (or alternate specifications, such as series drawings).

1.2 工作溫度和紋波電流應小於本說明書中的規定。 Operating temperature and applied ripple current must be within the specification.

● 電容器不能用於超過規定的環境溫度。 The capacitor must not be used in an ambient temperature which exceeds the operating temperature specified in this catalog.

● 電容器不能用於超過規定的紋波電流。 Do not apply excessive current which exceeds the allowable ripple current.

1.3 設計電路時請選擇滿足產品壽命的電容器。 Appropriate capacitors which comply with the life requirement of the products should be selected when designing the circuit.

1.4 鋁電解電容器是有極性的。 不要施加反向電壓或交流電。在可能出現電壓極性相反的電路中，請使用無極性電容器。 注意：即使無極性電容器也不能在交流電情況下使用。 Aluminum electrolytic capacitors are polarized. Do not apply reverse voltage or AC voltage. Please use non-polarized capacitors for a circuit that can possibly see reversed polarity. Note: Even non-polarized capacitors can not be used for AC voltage application.

1.5 在需要快速和頻繁充/放電的電路中，請不要使用鋁電解電容器。它需要使用具有長壽命特徵的特別設計的電容器。 Do not use aluminum electrolytic capacitors in a circuit that requires rapid and very frequent charge/discharge. In this type of circuit, it is necessary to use a special design capacitor with extended life characteristics.

1.6 不要施加過高的電壓。 Do not apply excess voltage.

● 請注意直流電壓上疊加紋波電流時的峰值電壓不要超過額定電壓。 Please pay attention so that the peak voltage, which is DC voltage overlapped by ripple current, will not exceed the rated voltage.

● 在使用2個以上的鋁電解電容器串聯時，請注意施加的電壓應低於額定電壓。應在每只電容器并聯一只平衡電阻，使每只電容器承受的電壓相等。 In the case where more than 2 aluminum electrolytic capacitors are used in series, please make sure that applied voltage will be lower than rated voltage and the voltage will be applied to each capacitor equally using a balancing resistor in parallel with the capacitor.

1.7

● 電容器外面的套管不能保證是一個電的絕緣體，不要使用標準套管的電容器在需要電絕緣的場合。當需要特別的絕緣時，請與我們的業務部聯繫。 Outer sleeve of the capacitor is not guaranteed as an electrical insulator. Do not use a standard sleeve on a capacitor in applications that require the electrical insulation. When the application requires special insulation, please contact our sales office for details.

● 不要將具有多端子（三或四端子）的自立式產品的空端子（加固端子）連接到其他電路，這樣可能引起短路。 Do not connect the blank terminal (reinforcing terminal) of a multi-terminal (three- or four-terminal) product of the snap-in type to another circuit it may cause a short circuit.

1.8 電容器避免用在下面的情況: capacitors must not be used under the following conditions:

● (a) 暴露於水(包括露水)、鹽水或油。 Capacitors must not be exposed to water (including condensation), brine or oil.

(b) 在環境含有害氣體，如氫硫化物、亞硫酸、亞硝酸、氯、銨等等。 Ambient conditions that include toxic gases such as hydrogen sulfide, sulfurous acid, nitrous acid, chlorine, ammonium etc.

(c) 使電容器暴露於臭氧、紫外線和放射線環境中。 Ambient conditions that expose the capacitor to ozone, ultraviolet ray and radiation.

● 超過本說明書的劇烈振動和物理衝擊。 Severe vibration and physical shock conditions that exceed the specifications.

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1.9 當設計電路板時，請注意以下：When designing a circuit board, please pay attention to following;

- 線路板上的孔，要與電容器的引綫相應。Make the hole spacing on the PC Board match the lead space of the capacitor.
- 在電容器安全孔的上面不應有器件或電綫。There should not be any circuit pattern or circuit wire above the capacitor safety vent.
- 除非另有規定的，壓力釋放口上面的間隙應大于下表： Unless otherwise specified, following clearance should be made above the pressure relief vent.

鋁殼直徑 Case Diameter	需要的間隙 Gap Required
Φ 6.3 ~ 16	2mm or more
Φ 18 ~ 35	3mm or more
Φ 40 or more	5mm or more

- 假如壓力釋放口面向線路板（例如端面密封型），在線路板上的相應位置打一個孔以釋放氣體。In case the vent side is placed toward PC board (such as end seal vented parts), make a corresponding hole on the PC board to release the gas when vent is operated. The hole should be made to match the capacitor vent position.
- 不要將具有螺絲端的電容器的密封端面向下安裝。當水平安裝時，正極端一定要在較上的位置。Do not install screw terminal capacitor with end seal down. When you install a screw terminal capacitor in a horizontal mount, the positive terminal must be in the upper position.

1.10 用于電容器的主要化學成分電解液和隔離紙是易燃的。電解液是導電的，當它與線路板接觸時，可能造成腐蝕或短路甚至會燃燒和起火。因此不要在電容器密封端的下面布置任何綫條。The main chemical solution of the electrolyte and the separator paper used in the capacitors are combustible. The electrolyte is conductive, When it comes in contact with the PC board, there is a possibility of pattern corrosion or short circuit between the circuit pattern which could result in smoking or catching fire. Do not locate any circuit pattern beneath the capacitor end seal.

1.11 設計電路板時，不要在電容器的旁邊或下面（PCB板的另一面）放置發熱量較大的元器件，如電阻、變壓器等。Do not design a circuit board so that heat generating components such as resistor and transistors are placed near an aluminum capacitor or reverse side of PC board (under the capacitor).

1.12 鋁電容器的電特性隨溫度和頻率而變化。設計電路時請考慮這些變化。Electrical characteristics may vary depending on changes in temperature and frequency. Please consider this variation when you design circuits.

1.13 當設計雙面PCB板時，避免在電容器下面布置綫條或通孔。When you are designing capacitors for use on double-sided PC Boards avoid circuit patterns or through holes (such as to connect both sides), that are placed under the capacitor.

1.14 螺絲安裝型的鋁電解電容器接綫柱螺絲或支架螺絲的力矩必須在規定的範圍。The torque for terminal screw or brackets screws must be within the specified value on ACON'S drawings.

1.15 當用2個以上電容器并聯時，請考慮電容器電流的平衡。When you install more than 2 capacitors in parallel, consider the balance of current flowing into the capacitors.

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2. 安裝 Mounting

- 2.1一旦一個電容器已用在設備中并加上電壓，不要嘗試再將它使用在別的電路。Once a capacitor has been assembled in the set and power applied, do not attempt to reuse the capacitor in other circuits or application.
- 2.2在正負極之間可能存在電動勢，請使用一祇1kΩ電阻放電。Electric potential between positive and negative terminal may exist as a result of returned electromotive force, so please discharge the capacitor using a 1kΩ resistor.
- 2.3貯藏6個月以上漏電流可能增加。當漏電流已增加時，請使用1kΩ電阻做一次電壓修補。Leakage current of the parts that have been stored for more than 6 months may increase. When leakage current has increased, please perform a voltage treatment using 1kΩ resistor.
- 2.4在將電容器安裝到PCB板之前注意核實其額定值。Please confirm ratings before installing capacitors on the PC board.
- 2.5在將電容器安裝到PCB板之前注意核實其極性。Please confirm polarity before installing capacitors on the PC board.
- 2.6不要將電容器掉到地板上，也不要使用已掉到地板上的電容器。Do not drop capacitors on the floor, nor use a capacitor that was dropped.
- 2.7安裝時注意不要再改變已成型的電容器的引線。Be careful not to deform the capacitor during installation.
- 2.8請核實電容器的腳距符合PCB板的孔距。Please confirm that the lead spacing of the capacitor matches the hole spacing of the PC board prior to installation.
- 2.9自立式電容器(外形如JIS 692, 693, 694和695)安裝時，要緊貼PCB板(在PCB板與電容器底部間不允許有間隙。) Snap-in can type capacitor such as JIS configuration 692; 693; 694 and 695 type should be installed tightly to the PC board (Silo no gap between the PC board and bottom of the capacitor).
- 2.10注意自動插件機的夾力不要太強(≤2.5kg)。Please pay attention that the clinch force is not too strong when capacitors are placed and fixed by an automatic insertion machine(≤2.5kg).
- 2.11請注意自動插件機等機械設備不要對電容器產生機械衝擊。Please pay attention to that the mechanical shock to the capacitor by suction nozzle of the automatic insertion machine or automatic mounter, or by product checker, or by centering mechanism.
- 2.12焊接條件要滿足本說明書的有關規定。Soldering condition must be confirmed to be within The specification.
- 2.13將電容器焊接到PCB板後，請不要扳倒或轉動電容器。Do not tilt lay down or twist the capacitor body after the capacitor are soldered to the P.C. board.
- 2.14請不要靠拿住焊好的電容器移動PCB板。Do not carry the PC Board by grasping the soldered capacitor.
- 2.15請不要允許任何東西接觸焊接好的電容器。如果PCB板存放在貨架，請保證PCB板或其他器件不要接觸電容器。Please do not allow anything to touch the capacitor after soldering. If P.C. board are stored in stack, please make sure P.C. board or the other components do not touch the capacitor.
- 電容器不能受剛焊接好的PCB板或其他器件的熱輻射的影響。The capacitors shall not be effected by any radiated heat from the soldered P.C. board or other components after soldering.
- 2.16不要用鹵化物清潔電容器。Do not clean capacitors with halogenated cleaning agent.
- 2.17固定材料和塗復材料。Fixing materials and coating materials
- 不要使用任何含有鹵素成分的材料。Do not use any ingredients which contain halogen.
 - 請在塗復前，清除電容器密封端面與PCB板空隙中的焊劑和雜物。Please pay attention to remove flux and any contamination which remains in the gap between the end seal and PC board and dry that portion well before coating.
 - 祇能部分地而不是全部包住電容器。Please do not apply any material all around the capacitor body but apply it partially.
 - 了解有關塗復材料造成的不良影響，請與我們的業務部聯系。Please contact our sales office to make sure whether the curing condition of coating material would cause any problems.

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3. 貯存 Storage

當鋁電解電容器經過長期靜態貯存時，其性能會降低。變化的比率依溫度、濕度而變化。The characteristics of aluminum electrolytic capacitors degrade when stored in a static condition for long periods of time. The rate of deterioration depends upon temperature and humidity.

電容器應在溫度5℃~35℃濕度小於75%，無直接日光照射的環境貯存。Capacitors should be stored at the temperature of 5℃ to 35℃, the humidity of less than 75% RH and out of direct sunlight.

電容器經貯存一年以上在使用前應進行“電壓老化”，以再形成和修補氧化膜。Capacitors that have been stored for long periods normally over one year should be subjected to a “voltage aging” treatment before use, This will reform and repair the oxide dielectric.

建議老化過程是在監視漏電流不要超過規定值的情況下，逐漸地給電容器加壓直到電容器的額定電壓。當到達額定電壓後保持30–60分鐘。Suggested aging procedure is gradually apply the rated voltage to the capacitors while monitoring the leakage current. Do not exceed the specified leakage current value. when rated voltage has been reached, maintain for 30 to 60 minutes.

4. 印制板的清潔 Printed Circuit Board Cleaning

4.1 前言 foreword

現在家普遍都認為鹵類溶劑對鋁電解電容器是有危害的。這是因為溶液能滲透電容器密封。然後，溶解和釋放氯離子(Cl⁻離子)可腐蝕鋁電極。It had been generally accepted that halogen type organic solvents were hazardous to aluminum electrolytic capacitors, This is because an organic solvent can permeate the capacitor through the end seal. Then, the solvent dissolves and free chlorine ions(Cl⁻ ion), which can corrode the aluminum electrodes. 下面的方法是唯一可以預先避免這個現象的途徑。The following measures were previously the only way to avoid this phenomenon.

- 使用對電容器無害的清潔劑，如水或酒精。Use of cleaning agents, not hazardous to capacitors such as water or alcohol.
- 將電容器安裝在已事先經過鹵類溶劑清洗過的印制板上。Mount capacitors on PC boards cleaned with a halogen type solvent before hand.
- 端口使用環氧密封。Use of epoxy end seals.

這些方法在工作效率、清潔能力、成本等方面有缺點。因此，耐鹵類清洗劑的鋁電解電容器是大家所希望的。These measures have disadvantages with respect to working efficiency, cleaning capability, cost etc. Therefore, aluminum electrolytic capacitors which can withstand halogen type cleaning agents are desirable.

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4.2清洗劑的類型Types of Cleanig Agents

一般地有三種類型清洗劑。 Gtenerally there are three types of cleaning agents.

- 水類 Water type
- 酒精類 Alcohol type
- 滴素類 Halogen type

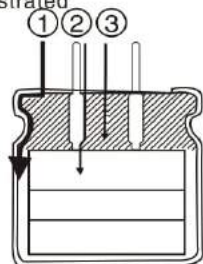
三類中，水和酒精即使滲進鋁電解電容器也僅有很微弱的影響。然而，滴素能引起鋁箔和引線的腐蝕。普通滴素類清洗劑列在下表： of these, water and alcohol will have little effect even if they permeate the capacitor. However, halogens can cause corrosion of aluminum foil and tab, Common types Of halogen cleaning agents are olsted in table below:

化學名稱	結構式代	表性商標名
三氯三氟代乙烷 Trichlorotrifluoroethane	$C_2Cl_3F_3$	Freon TF, Daiflon S-3
氟代三氯甲烷Fluorotrichloromethane	CCl_3F	Freon-11, Daiflon S-1
三氯甲烷（氯仿） Trichloroethane	$C_2H_3Cl_3$	Chloroethane
三氯乙烯Trichloroethylene	C_2HCl_3	Trichlene
甲基氯化物Methyl Chloride	CH_3Cl	MC

上表所列後四個溶劑可顯著地腐蝕鋁，不推薦使用這些清洗劑。 The last four solvents listed above are particularly corrosive to aluminum and are not recommended to use as cleaning solvents.

4.3溶劑滲透通道和腐蝕機制 Pemetrationchannel of Solventand Corrosion Mechanism

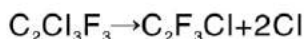
下圖書出溶劑滲入電容器的三條通道。 The three channels by which solvents can penetrate into the capacitor are illustrated



- ① 通過密封膠粒和鋁殼（曲線部分）之間的空隙滲入。 Penetration through a clearance between the rubber and the aluminum case (curled section)
- ② 通過密封膠粒和導針之間的空隙滲入。 Penetration through a clearance between the rubber and the lead wires.
- ③ 通過密封膠粒滲入。 Permeation through the rubber end seal.

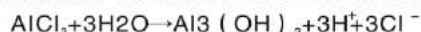
為減少溶劑進入電空器的可能性，加強密封以減少膠粒和鋁殼/導針間的空隙。 需要使用抗溶劑滲透的密封膠粒。 To reduce the possiblity of solvents entering a capacitor, tight seaiong is required to eliminate clearances between the tubber and the aluminum case/lead wires. A solvent resistant rubber material is also a necessity.

當一溶劑,例如三氯三氟代乙烷，滲入不抗溶劑滲透的電容器，其氯離子是自由的，如下面的反應公式。 when a solvent, for example, trichlorotrifluoroethane gets inside a non antisolvent capacitor, the chlorine ion is free as shown by the following reaction formula.



氯離子與鋁起反應如下： This chlorine ion reacts with aluminum as follows: $Al + 3Cl^- \rightarrow AlCl_3 + 3e^-$

AlCl₃溶液在水裏反應為： ThenALCl₃ resolves in water , and it becones:



如此，氯離子再一次自由并重復腐蝕鋁。 這個反應的度，依溶液的量，使用時電容的周圍溫度，施加的電壓和時間等等。 thus, the Cl^- ion is free again and repeats the corrosion of aluminum. The degree of this reaction depends on the volume of solvent, the ambient temperature of the capacitor in service, he applied voltage and time etc.

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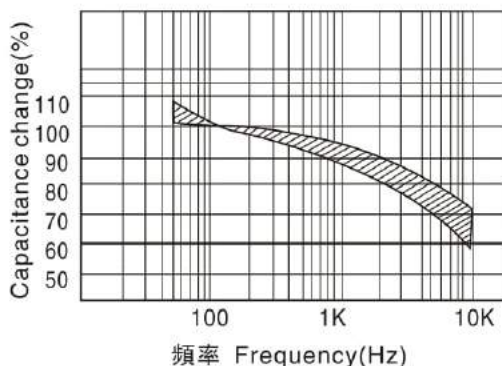
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5.基本電氣的特性 Basic Electrical Characteristics

電容量 Capacitance:

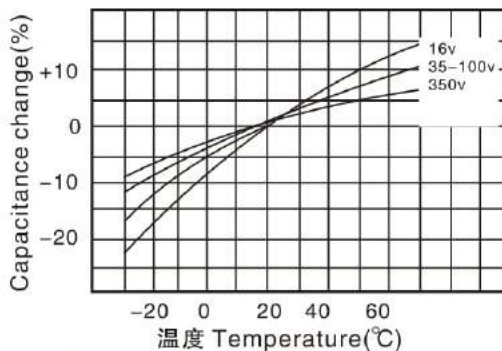
電容器的電容量可通過測量它的阻抗來確定其交流電容量。其交流電容量依賴于頻率、電壓和測量方法。JIS C 5102規定一個串聯等效電路 ($\bigcirc - \text{II} - \text{---} - \bigcirc$) 的串聯電容分量，是在頻率120HZ，交流電壓0.5Vrms加直流偏置電壓1.5–2.0V條件下測量出電容量。The capacitance of capacitor is determined as AC capacitance by measuring its impedance. As the AC capacitance depends on frequency, voltage and other measuring methods, JIS C 5102 prescribes that the series capacitive component of an equivalent series circuit ($\bigcirc - \text{II} - \text{---} - \bigcirc$) shall be considered as the capacitance by measuring it at a frequency of 120Hz and a maximum AC voltage of 0.5vrms with a DC bias voltage of 1.5 to 2.0V applied for aluminum electrolytic capacitors.

鋁電解電容器的電容量在測量頻率增加時變小。如下圖所示: The capacitance of an aluminum electrolytic capacitor shows smaller values as a measuring frequency increases. See the typical behavior shown below:



電容量與溫度的關係 Capacitance vs. Frequency

測量的溫度和頻率一樣同樣影響電容量。當溫度降低時電容量變小。如下圖所示: Measuring temperature as well as frequency effects the capacitance. As the measuring temperature decreases, the capacitance shows smaller values. see the typical behavior shown below:



電容量與溫度的關係 Capacitance vs. Temperature

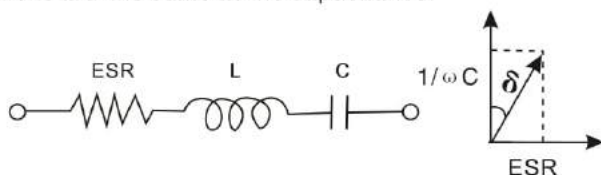
另一方面，直流電容量可以在施加一直流電壓時測量改變來確定，在正常溫度下它比交流電容量稍大，而超過這溫度範圍有較平的特性。On one hand, DC capacitance, which can be determined by measuring the change when a DC voltage is applied, shows a slightly larger value than the AC capacitance at a normal temperature and has the flatter characteristic over the temperature range.

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Tan δ (損失角的正切或損失因子):

Tan δ 是串聯等效電路的電阻分量 (ESR) 與容抗分量 ($1/\omega C$) 之比, 它的測量條件與電容量測量相同。The tan δ is the ratio of the resistive component (ESR) to the capacitive reactance ($1/\omega C$) in the equivalent series circuit, and its measuring conditions are the same as the capacitance.



$$\tan \delta = \text{ESR} / (1/\omega C) = \omega C \cdot \text{ESR}$$

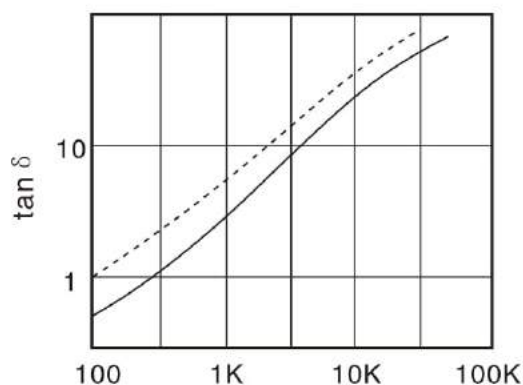
這裏: ESR=串聯等效電路在120Hz時的電阻

Where: ESR= Equivalent series resistor at 120Hz

$$\omega = 2\pi f$$

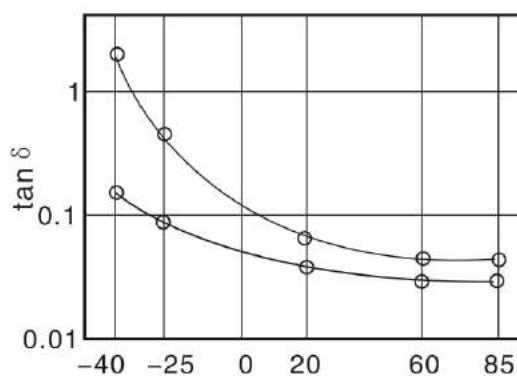
$$f = 120\text{Hz}$$

Tan δ 隨測量頻率的增加和測量溫度的減少而變大, 如下圖所示: The tan δ show higher values as a measuring frequency increases and a measuring temperature decreases, as follows:



頻率 Frequency(Hz)

tan δ 與頻率之間的關係 tan δ vs. Frequency



溫度 Temperature(°C)

tan δ 的溫度特性 Temperature Characteristics of Tan δ

等效串聯電阻 Equivalent series resistance (ESR)

ESR由鋁氧化膜、電解液、電解紙及其它受鉛箔長度、面積等影響產生的電阻。 ESR值依賴于溫度。 減小溫度使電解液的電阻率增加, 結果使ESR增加。當測量頻率增加, ESR減少并到達一個幾乎恒定的值, 主要是由電解液、電解紙獨立于頻率的電阻。The ESR is comprised of the resistance due to aluminum oxide layer and electrolyte/separator combination and other resistance effected with foillength, foil surface area, etc. The ESR value depends on the temperature. Decreasing the temperature makes the resistivity of the electrolyte increase with the result of the ESR increasing. As the measuring frequency increases, the ESR decreases and reaches an almost constant value that is mainly the frequency-independent resistance due to electrolyte/separator combination.

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阻抗 Impedance (z) :

阻抗是在一指定的頻率下阻礙交變電流流動的阻力。The impedance is the resistance which oppose the flow of alternating current at a specific frequency.

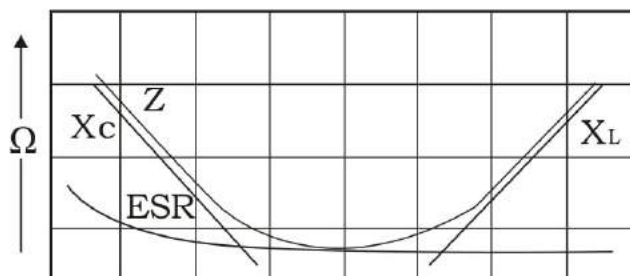
它與電容 (C) 的容抗和電感 (L) 的感抗, 也和ESR有關。表達式如下: It is related to capacitance (C) and inductance (L) in terms of capacitive and inductive reactance, and also related to the ESR. it is expressed as follows:

$$Z = \sqrt{ESR^2 + (X_L - X_C)^2}$$

$$\text{這裏: } X_C = 1/\omega C = 1/2\pi fC$$

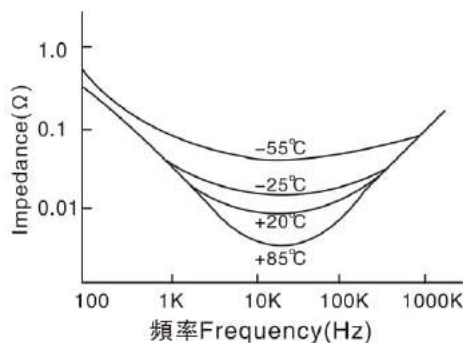
$$X_L = \omega L = 2\pi fL$$

如下所示, 容抗 (Xc) 統治低頻率範圍, 阻抗隨頻率增加而減少, 直到達到中間的頻率範圍的ESR。在更高的頻率的範圍, 感抗成為統治者, 阻抗隨頻率增加而增加。As shown below, the capacitive reactance (Xc) predominates at the range of low frequencies, and the impedance decreases with increasing frequency until it reaches the ESR in the middle frequency range. At the range of the higher frequencies the inductive reactance (XL) comes to predominate, so that the impedance increases with increasing the measuring frequency.



頻率 Frequency(Hz)
阻抗與頻率之間的關係 Impedance vs. Frequency

如下所示, 因為電解液的電導隨溫度而變化, 阻抗也隨溫度而變化。As shown below, the impedance value varies with temperature, because the resistance of the electrolyte strongly changes with temperature.



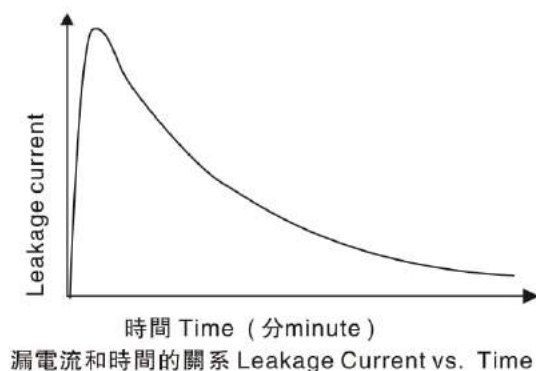
典型的阻抗溫度特性 Temperature Characteristics of impedance

鋁電解電容器應用指南

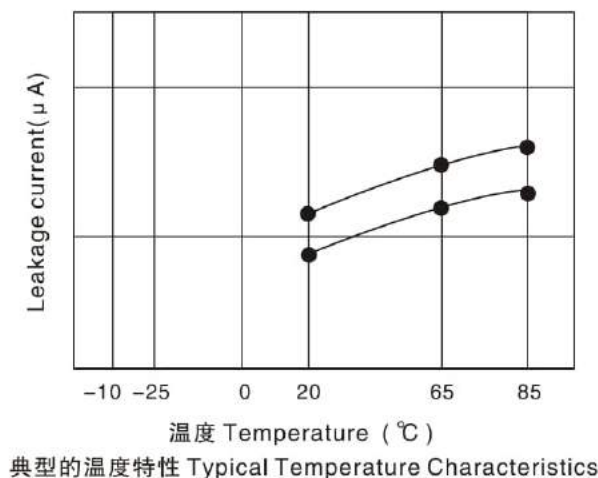
Application Guidelines For Aluminum Electrolytic Capacitors

漏電流 Leakage current

電容器的絕緣有很高的電阻，阻止直流電流的流動。然而，由于鋁氧化膜作為與電解液接觸的絕緣物，有一個小的電流叫做漏電流。當施加電壓時電流修補和再化成氧化膜。如下圖所示，當施加給電容器電壓前幾分鐘，有較高的漏電流，然後漏電流隨時間減小，並到達一個幾乎穩當的值。The dielectric of a capacitor has a very high resistance which prevents the flow of DC current. However, due to the characteristics of the aluminum oxide layer that functions as a dielectric in contact with electrolyte, a small amount of current, called leakage current, will flow to reform and repair the oxide layer while a voltage is being applied. As shown below, a leakage current flows in the first minutes as a voltage is applied to the capacitor, and then the leakage current will decrease and reach an almost steady-state value with time.



測量時的溫度和電壓影響漏電流。漏電流當溫度和電壓增加時變大。Measuring temperature and voltage effect the leakage current, The leakage current shows higher values as the temperature and voltage increase.



鋁電解電容器應用指南

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一般地，漏電流的測量是在20℃施加標稱電壓，與電容器串連一個1000Ω的電阻，當電容器的電壓到達額定電壓幾分鐘後進行測量。 本目錄描述了測量溫度和時間。 In general, the leakage current is measured at 20℃by applying the rated voltage , which is applied through a resistor of 1,000 connected in series with the capacitor , and several minutes after the capacitor reached tie rated voltage. The catalog prescribes the measuring temperature and time.

