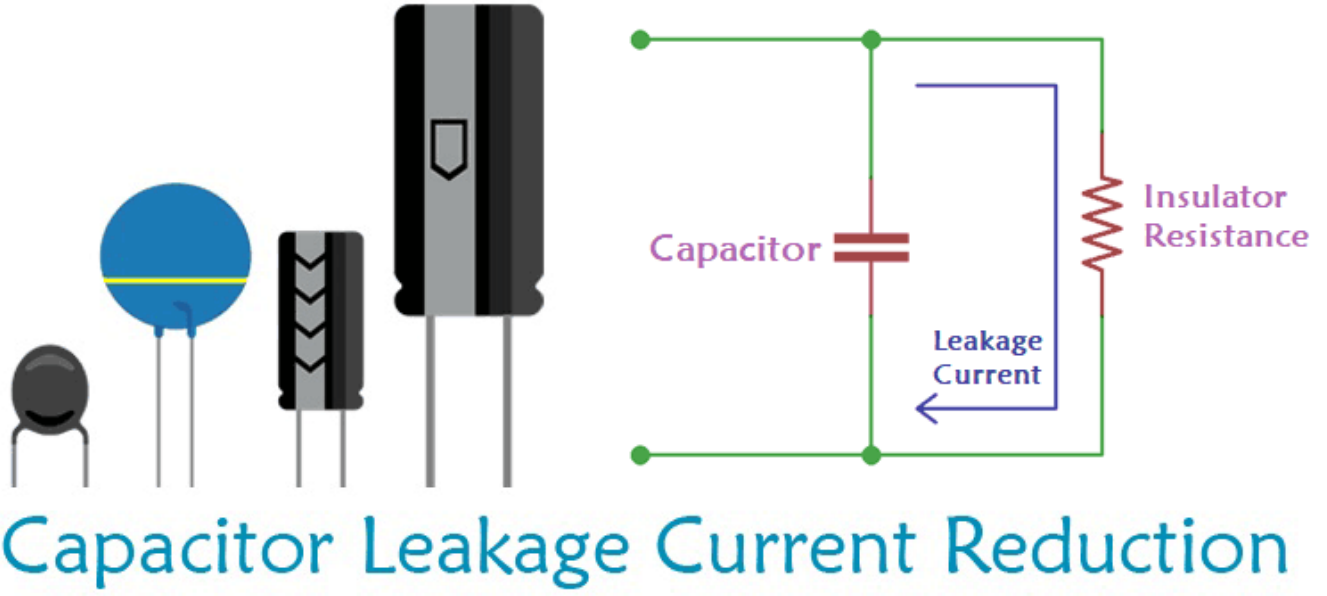
# What is Capacitor Leakage Current and How to Reduce It

By Sourav Gupta Apr 25, 2019 0



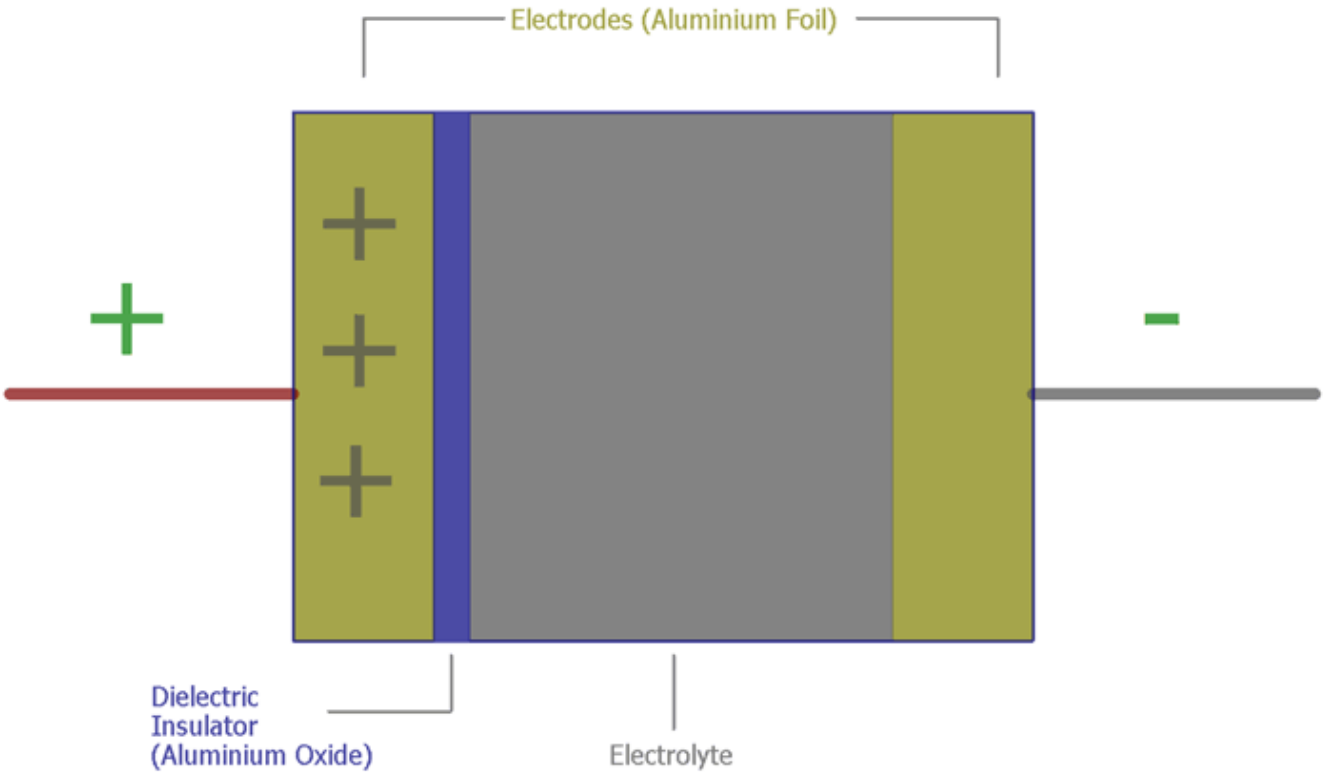

What is Capacitor Leakage Current and how to reduce it

The capacitor is the most common component in electronics and used in almost every electronics application. There are many types of capacitor available in the market for serving different purposes in any electronic circuit. They are available in many different values from 1 Pico-Farad to 1 Farad capacitor and Supercapacitor. Capacitor also have a different types of ratings, such as working voltage, working temperature, tolerance of the rated value and leakage current.

The leakage current of capacitor is a crucial factor for the application, especially if used in Power electronics or Audio Electronics. Different types of capacitors provide different **leakage current ratings**. Apart from selecting the perfect capacitor with proper leakage, circuit should also have the ability to control the leakage current. So first we should have a clear understanding of capacitor leakage current.

## Relation with Dielectric Layer

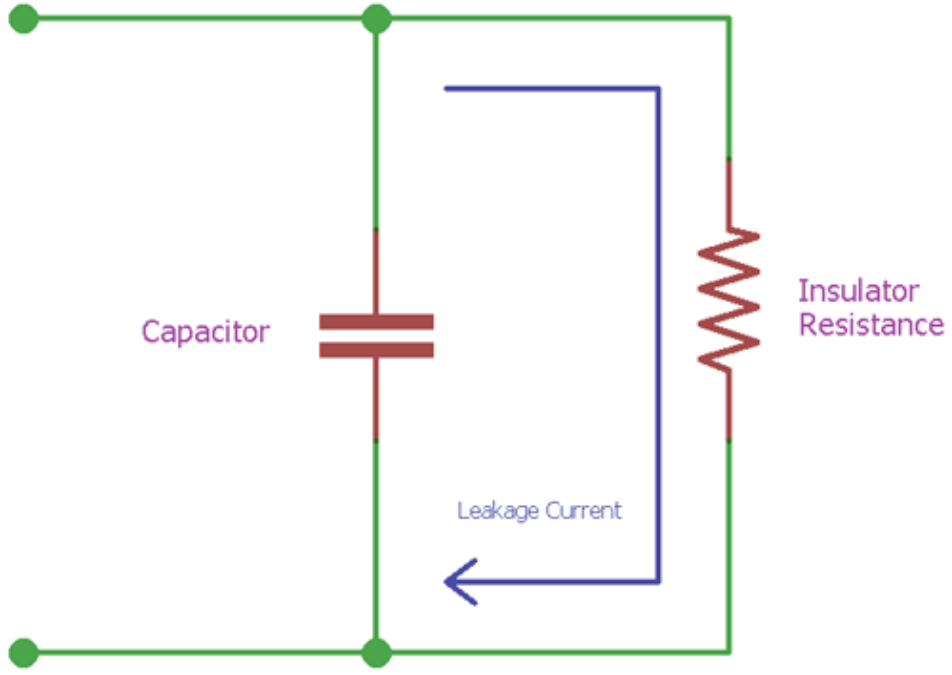
The leakage current of a capacitor has a direct relationship with the dielectric of the capacitor. Let's see the below image -




The above image is an **internal construction of the Aluminum Electrolytic Capacitor**. An Aluminum Electrolytic Capacitor has few parts which are encapsulated in a compact tight packaging. The parts are **Anode, Cathode, Electrolyte, Dielectric layer Insulator**, etc.

The dielectric insulator provides insulation of the conductive plate inside the capacitor. But as there is nothing perfect in this world, the insulator is not an ideal insulator and has an insulation tolerance. Due to this, a very low amount of current will flow through the insulator. This **current is called as Leakage current**.

The Insulator and the flow of current can be demonstrated by using a simple capacitor and resistor.




The resistor has a very high value of resistance, which can be identified as **an insulator resistance** and the capacitor is used to replicate the actual capacitor. Since the resistor has a very high value of resistance, the current flowing through the resistor is very low, typically in a number of nano-amperes. Insulation resistance is dependent on the type of dielectric insulator as different type of materials changes the leakage current. The low dielectric constant provides very good insulation resistance, resulting in a very low leakage current. For example,

polypropylene, plastic or teflon type capacitors are the example of low dielectric constant. But for those capacitors, the capacitance is very less. Increasing the capacitance also increases the dielectric constant. Electrolytic capacitors typically have very high capacitance, and the leakage current is also high.

## Dependent Factors for Capacitor Leakage Current

Capacitor Leakage Current generally depends on below four factors:

1. Dielectric Layer
2. Ambient Temperature
3. Storing Temperature
4. Applied Voltage

**1. The Dielectric layer is not working properly**
Capacitor construction requires a chemical process. The dielectric material is the main separation between the conductive plates. As the dielectric is the main insulator, the leakage current has major dependencies with it. Therefore, if the dielectric is tempered during the manufacturing process, it will directly contribute to the increase of leakage current. Sometimes, the dielectric layers have impurities, resulting in a weakness in the layer. A weaker dielectric decreases the flow of current which is further contributed to the slow oxidation process. Not only this, but improper mechanical stress also contribute to the dielectric weakness in a capacitor.

**2. Ambient Temperature**
The capacitor has a rating of the working temperature. The working temperature can be ranged from 85 degree Celsius to the 125 degree Celsius or even more. As the capacitor is a chemically composed device, the temperature has a direct relationship with the chemical process inside the capacitor. The leakage current generally increases when the ambient temperature is high enough.

**3. Storage of the Capacitor**
Storing a capacitor for a long time without voltage is not good for the capacitor. The **storing temperature is also a important factor for leakage current**. When the capacitors are stored, the oxide layer is attacked by the electrolyte material. The oxide layer starts to dissolve in the electrolyte material. The chemical process is different for different type of electrolyte material. The water-based electrolyte is not stable whereas inert solvent-based electrolyte contributes less leakage current due to the reduction of the oxidation layer.

However, this leakage current is temporary as the capacitor has self-healing properties when applied to a voltage. During the exposure to a voltage, the oxidation layer starts to regenerate.

**4. Applied Voltage**
Each capacitor has a voltage rating. Therefore, using a capacitor above the rated voltage is a bad thing. If the voltage increases, the leakage current also increases. If the voltage across the capacitor is higher than the rated voltage, the chemical reaction inside a capacitor creates Gases and degrade the Electrolyte.

If the capacitor is stored for a long time such as for years, the capacitor is needed to be restored into the working state by providing rated voltage for a few minutes. During this stage, the oxidation layer built up again and restores the capacitor in a functional stage.

## How to reduce Capacitor Leakage Current to improve the Capacitor Life

As discussed above a capacitor has dependencies with many factors. The first question is how the capacitor life is calculated? The answer is by calculating the time until the electrolyte is run out. The electrolyte is consumed by the oxidation layer. Leakage current is the primary component for the measurement of how much the oxidation layer is hampered.

Therefore, the reduction of leakage current in the capacitor is a major key component for the life of a capacitor.

1. Manufacturing or the production plant is the first place of a capacitor life cycle where **capacitors are carefully manufactured for low leakage current**. The precaution needs to be taken that the dielectric layer is not damaged or hampered.

2. The second stage is the storage. **Capacitors need to be stored in proper temperature**. Improper temperature affects the capacitor electrolyte which further downgrades the oxidation layer quality. Make sure to operate the capacitors in proper ambient temperature, less than the maximum value.

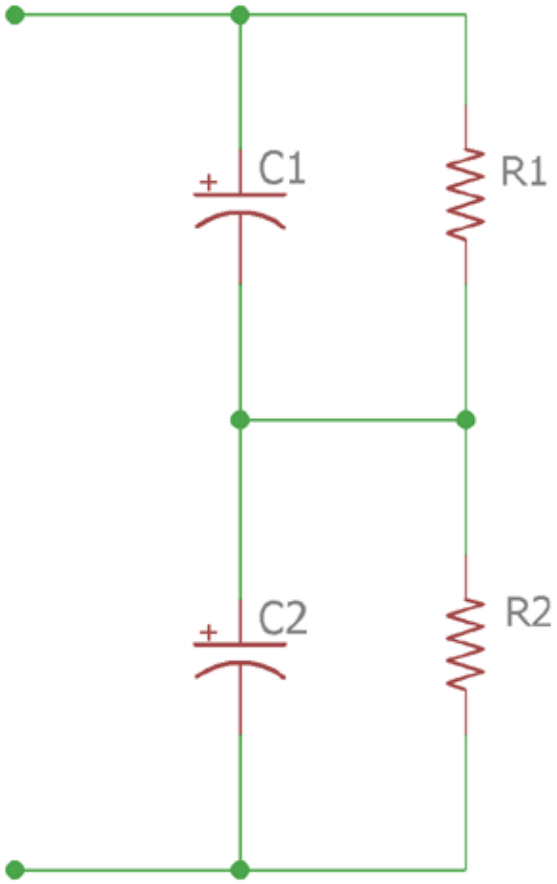
3. In the third stage, when the capacitor is soldered on the board, the soldering temperature is a key factor. Because for the electrolytic capacitors, the soldering temperature can become high enough, more than the boiling point of the capacitor. **The soldering temperature affects the dielectric layers across the lead pins and weakens the oxidation layer resulting in high leakage current**. To overcome this, each capacitor comes with a data sheet where the manufacturer provides a safe soldering temperature rating and maximum exposure time. One needs to be careful about those ratings for the safe operation of the respective capacitor. This is also applicable for the Surface Mount Device (SMD) capacitors too, the peak temperature of reflow soldering or wave soldering should not exceed than the maximum allowable rating.

4. As the voltage of the capacitor is an important factor, the **capacitor voltage should not exceed the rated voltage.**

5. Balancing the capacitor in Series connection. The **capacitor series connection is a bit complex job to balance the leakage current**. This is due to the imbalance of leakage current divide the voltage and split between the capacitors. The split voltage can be different for each capacitor and there can be a chance that the voltage across a particular capacitor could be excess than the rated voltage and the capacitor start to malfunction.

To overcome this situation, two high-value resistors are added across the individual capacitor to reduce the leakage current.

In the below image, the balancing technique is shown where **two capacitors in series are balanced using high-value resistors.**



By using the balancing technique, the voltage difference influenced by leakage current can be controlled.