Choosing A Long-Life Aluminium Electrolytic Capacitor

The [illegible] an aluminium electrolytic capacitor can be crucial for the [illegible] ut interpreting that from the data sheets needs care.

Getting Started

Trying to find an ideal electrolytic capacitor for a particular application and at the right price can be tricky to say the least. Add in that a need for it to have a long operational life and the problem becomes worse, and it is not always made easy because of a lack of standardisation in the data sheets from the different manufacturers; each company wants to highlight the best features of their particular product and so comparing like for like is not always straightforward.

As with any capacitor, voltage and capacitance must be specified, and generally the higher these are, the dearer the device. On top of that is usually a need to reduce size and the equivalent series resistance (ESR), again adding cost. Plus all four of these factors are often inter-related.

These numbers are usually found in the data sheet but when it comes to long life, which also adds costs, then it is less easy because the life of the capacitor is related to the operating temperature, so one manufacturer may quote, say, so many hours at +85˚C while another may quote the hours at +105˚C.

Other Resources

View products

Aluminium Capacitors

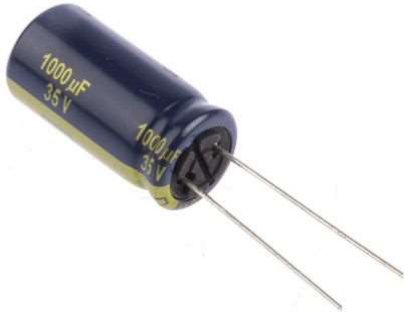
DesignSpark

The starting point, obviously, is to work out how many hours the devices need to last and then look at the environment in which they need to operate. Lifetimes are normally longer at lower temperatures and if the environment is never going to reach the higher temperatures, then going for a lower temperature device with a longer life may be the right way forward. While it is important also to consider the price, this needs to be weighed up against the cost of failure.

Related Products

Nichicon Aluminium Electrolytic Capacitor

RS Pro Aluminium Electrolytic Capacitor



Panasonic Aluminium Electrolytic Capacitor

EPCOS Aluminium Electrolytic Capacitor

For example, a common reason that a capacitor may need to operate for a long time is that the equipment in which it is installed is in a hard to reach place, such as an offshore oilrig. Here, the cost of the capacitor is almost nothing compared with the massive cost of fixing the equipment if the capacitor fails.

A designer also needs to check what the end of lifetime actually means. Many components will lose performance as they age but will still be considered to be within acceptable operating parameters. However, what might be acceptable for one application is not necessarily true for another. In a power supply application, when the capacitor is used as an input buffer, end of life is when the capacitance drops below the value needed to supply energy to the DC-DC converter when the output voltage is too low. For the output buffer, life ends when the impedance increases past the point where the ripple voltage on the output voltage causes problems in the circuits driven by the power supply.

The most common cause of failure is the electrolyte itself, which can evaporate over time, altering the electrical properties as it goes. The electrolyte is soaked into paper either side of which are the aluminium foils.

The capacitor is made up of two electrically conductive material layers that are separated by a dielectric layer. The anode is formed by an aluminium foil with an enlarged surface area. The oxide layer that is built up on this is used as the dielectric. The operating electrolyte is a conductive liquid, and it is this that evaporates. A second aluminium foil, the cathode foil, serves as a large-surfaced contact area for passing current to the operating electrolyte. Manufacturing techniques to increase the life time of the capacitor include over-anodisation and ensuring that the materials used have high degrees of purity.

Typically, the lifetime increases by a factor of two for every 10˚C fall in temperature over the normal operating range. Increasing the voltage rating to reduce the chance of a dielectric failure can have the opposite effect as this increases the ESR, which increases the capacitor’s temperature and thus the chance of failure. ESR also increases as temperature falls, which can increase output voltage ripple and loop gain. In a power supply, this can cause oscillations and thus instability.

Three companies that supply long-life aluminium electrolytic capacitors in Europe are Panasonic, Vishay and Epcos. Below are details of examples of the products from these companies showing how they vary in the way useful life and endurance are quoted.

Products and applications

A good example of a long-life electrolytic capacitor is the EEU-FR series from Panasonic. These radial leaded aluminium devices have a quoted lifetime of 10,000 hours at +105˚C, more than double that of the previous generation and with a capacitance about a third higher. They are suitable for switching mode adapters, line noise removal, LCD backlighting, LED systems and similar applications. These would be typically used in industrial controls, LED lighting, alternative energy equipment and home appliances.

The capacitance of the devices ranges from 22 to 8200μF and they have a full operating temperature range from -40 to +105˚C. The 10,000 hour life is only quoted for case sizes of 10mm diameter and larger, but the full range of case sizes is from 5 to 16mm. Below 10mm, the endurance can be notably shorter and that needs to be checked on the data sheet. For example, the EEU-FR1E470 is rated at 47μF with a case diameter of 5mm, and its endurance is only quoted at 2000 hours.

Also pushing endurance limits is Panasonic's EEU-TP series of radial aluminium electrolytic capacitors. Endurance here is 5000 hours at +125˚C and they can still manage 2000 hours at +135˚C, the quoted top operating temperature. Capacitance range is 100 to 5100μF. As well as power supplies, these can be used in automotive electric power steering applications.

Among Vishay's long-life offering are the 128 SAL-RPM radial leaded aluminium capacitors. These also have a quoted endurance of 10,000 hours, but at +125˚C, yet they also claim a useful life at that temperature of 20,000 hours. However, if the temperature jumps to +175˚C, then the useful life figure drops quickly to just 2000 hours. Given such high temperatures are rare in many applications, the Vishay data sheets sensibly quote the useful life at +40˚C, which in this case is more than 300,000 hours.

The capacitance of these devices ranges from 0.22 to 68μF and they have a low temperature limit of -55˚C; the top temperature though can be either +85 or +125˚C depending on voltage.

Applications for these range from audio-visual equipment to automotive, industrial high-temperature use and telecommunications, where they can be used for smoothing, filtering and buffering in small power supplies and DC-DC converters.

Then, there is the B41554 series of aluminium electrolytic capacitors with screw terminals from Epcos. These are rated from 1500 to 220,000µF and survive a voltage endurance test at +125˚C for 2000 hours. Useful life though is quoted higher at this temperature, being more than 2500 hours when the diameter is less than 51.56mm and more than 5000 hours when the diameter is larger than 64.3mm. However, the useful life rises dramatically at lower temperatures, the figures at +85˚C being 15,000 and 25,000 hours, respectively. For all sizes at +40˚C, this jumps to 200,000 hours.

However, a good example of an application for these types of capacitors that does not require such a high top temperature is their use in wind turbines based on full-conversion topologies that eliminate the mechanical gearbox, which is subject to mechanical degradation and wear. To be cost-effective in operation over the lifetime of the installation – often more than 20 years under typical operating conditions – it is important that the components within the turbines remain maintenance-free.

The Epcos B43564 and B43584 aluminium electrolytic capacitors with screw terminals meet these demanding requirements for capacitance as well as for reliability, long life and temperature. They have the high energy density required in confined wind power environments and can be connected in series and parallel to suit applications in wind power installations. They operate only up to +85˚C at which they have a useful life of above 12,000 or 15,000 hours depending on voltage. This rises to 250,000 hours at +40˚C. Capacitance is from 820 to 33,000µF.

Conclusion

Aluminium capacitors are normally used for low and high frequency filtering and energy storage. These demand high capacitance values and power ratings. The devices are small compared with other technologies, and are relatively insensitive to voltage spikes. The range of sizes is also large enough to match most applications. However, there is often a price penalty as capacitors are one of the most expensive passive components in a power supply, even though the aluminium electrolyte ones discussed here are the cheapest option.

But, as can be seen from the examples above, selecting an aluminium capacitor can be time consuming as it often involves searching through data sheets that present the information in a variety of forms. Circuit simulation programmes can help but sometimes fall down when it comes to frequency dependent component characteristics. The designer also needs to understand how frequency dependent behaviour changes over time, which can be critical for the types of long-life application being discussed here.