Aluminum electrolytic capacitors for automotive electronics

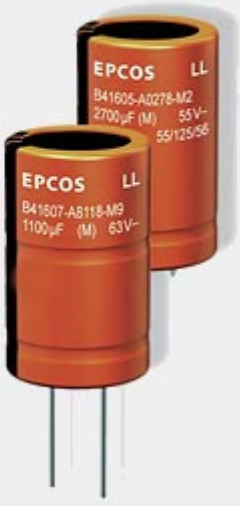
January 2006

Tough enough

PROFILE	LARGE-SIZE SERIES

Featuring high vibrational strength, temperature stability up to 150 °C, high current-handling capability and maximum reliability, aluminum electrolytic capacitors of series B41605 and B41607 from EPCOS are ideal for demanding automotive and industrial applications.

Vibrational strength:	up to 40 g
Rated voltage:	25 to 63 V
Capacitance:	2100 to 6800 µF
Service life:	20 000 hours at 105 °C



In automotive applications, shock and vibration frequently cause premature failure of aluminum electrolytic capacitors. EPCOS has addressed this problem and now offers designs with significantly higher mechanical stability.

Resistance to shock and vibrations of 2 to 3 g is sufficient for most automotive electronics applications. Many manufacturers of aluminum electrolytic capacitors quote a vibrational strength of 10 g in their data sheets. At first glance, this figure seems quite sufficient with ample reserves. But the test conditions under which this seemingly generous value was determined have little in common with real operating conditions: the tests last no longer than six hours, are conducted at room temperature, and the device under test is new.

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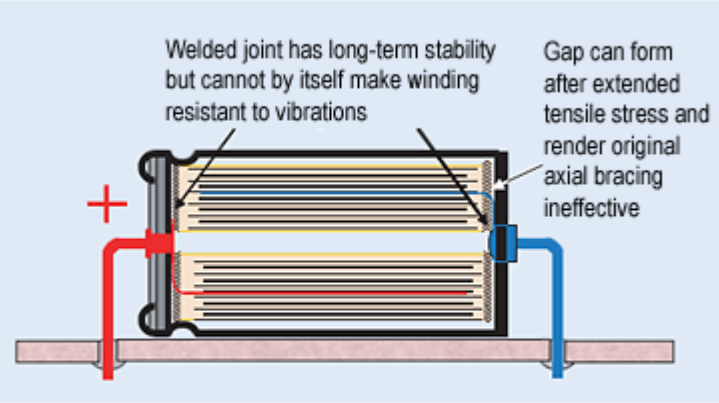
In larger aluminum electrolytic capacitors with can diameters of more than 10 mm, the terminal wires soldered to the circuit board repeatedly prove to be the weakest links despite reinforcement. The cross-section of the wire poses the greatest problem when vibrations occur. For this reason, EPCOS offers the thick, 1 mm wire versions exclusively for all axial-lead capacitors targeted at automotive applications. But this is not the only measure that enhances long-term stability. If aluminum electrolytic capacitors are operated over extended periods at elevated temperatures, the fixing of the winding in the can turns out to be the weak link in the presence of vibrations.

The winding anchorage weakens during continuous operation for two reasons. First, the mounting system, i.e. the aluminum can in combination with the cover disk, can buckle under the effect of high temperatures and the fixing forces, so that the winding is no longer held securely in place. Second, electrolyte diffuses from the mounted winding in the long term and the winding becomes softer, so that the bracing within the fixing system suffers accordingly. The tensile or holding force of the classical axial bracing, for which a value of 10 g is usually warranted, derives from the rather elastic region at the end of the winding → 1. If the electrolyte content in this region is reduced, the holding forces will be correspondingly smaller. In an extreme case, the axial bracing can become ineffective. The welded joints between the winding and the feedthroughs, which are vital to operation and should really be protected by the bracing, must then assure sufficiently high residual vibrational strength → 1.

1 | Basic structure of aluminum electrolytic capacitor



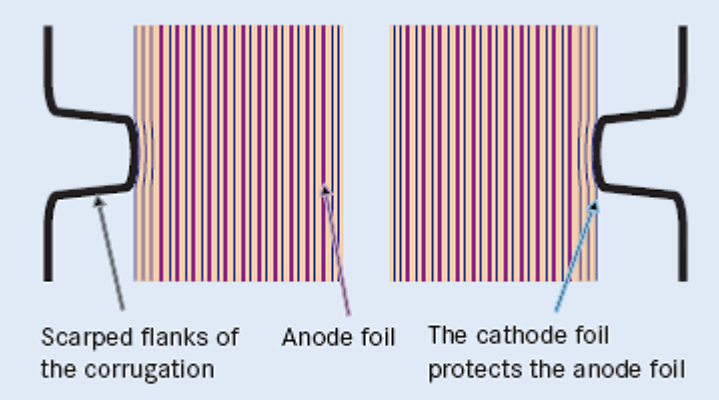
1 When the tensile force of the winding weakens toward the end of its useful life and the capacitor is exposed to vibration, a gap can form between winding and case. The axial bracing buckles – and the welded electrical connection alone cannot ensure the mechanical holding function during vibration.

In general, the bulk of the winding reacts less sensitively to the loss of electrolyte because it is held in place by aluminum strips. The same applies to its diameter. EPCOS consequently fits an additional corrugation to the center of the can in all axial-lead automotive series to give the winding radial stability. The warranted value of 20 g obtained from tests on these axial-lead series is twice as high as that for the standard version. In the long term too, i.e. at the end of their service life, these aluminum electrolytic capacitors rated at 20 g still have significantly greater vibrational strength than the standard versions.

Standing up to high radial forces

The normal radial bracing that suffices for axial electrolytic capacitors is not enough to withstand the forces to which larger electrolytic capacitors with diameters of 22 to 35 mm and heavy windings, such as those mounted on automobile engines, are exposed. A special reinforced corrugation is required that does not buckle even under high radial forces at high temperatures. The corrugation shown in → 2 has proved effective in such cases. Thanks to its scarped flanks, it can protect the winding from stronger radial counterforces for the same material thickness without buckling.

2 | New corrugation in detail



2 Thanks to its scarped flanks, the new corrugation can protect the winding from stronger radial counterforces without buckling and with the same material thickness.

In the parallelogram of forces, the bracing forces are transferred directly to the almost perpendicular corrugation wall without contributing to the large axial forces associated with the conventional flat corrugation. This also enables the new corrugation, which is used in the largesize B41605 and B41607 series from EPCOS, to withstand greater radial bracing forces. This design has passed all vibration tests up to 40 g and 2 kHz. Even after the aluminum electrolytic capacitors were subjected to prolonged thermal pre-stressing for 2000 hours at 125°C, they passed a vibration test at 30 g and up to 2 kHz. The same applies to vibration tests performed after degradation by fast and slow temperature cycling. This corrugation → 3 is currently used in all large-size aluminum electrolytic capacitors intended for motor vehicles or machine tools.

3 | Snap-in electrolytic capacitor with additional center corrugation

3 The snap-in models are complemented by the large-size design in which wires instead of snap-in clamps are welded to the feedthroughs. This version is also available with customer-specific bent wires and without insulation.

Attachment of the aluminum electrolytic capacitor to the circuit board is just as critical. A new design was consequently developed from the original snap-in type. It can be bonded with wires that can be soldered and welded. The decisive factor is that the wires are flexible so that electrical contact is not interrupted even if the aluminum electrolytic capacitor moves relative to its mount → 4. Both the soldered joint on the circuit board and the welded joint on the capacitor feedthrough are thus protected.

The exterior of the large-size series is similar to that of single-ended capacitors. In contrast, their internal construction resembles that of a snap-in electrolytic capacitor with a flexible strip contact. Like all EPCOS electrolytic capacitors in

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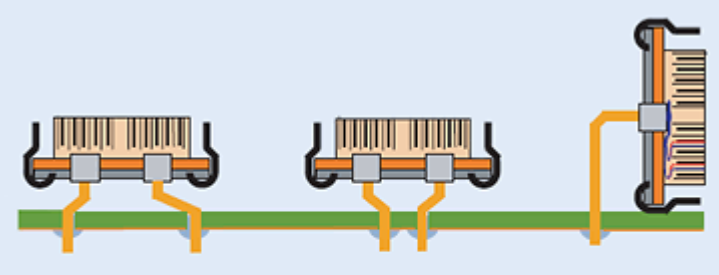
cans, this series has fully welded contacts. The new corrugation can also be used for the smaller aluminum electrolytic capacitors exposed to high vibrational stress, such as axial-lead and solder-star types. However, the standard corrugation has proved adequate for automotive applications up till now. EPCOS can nevertheless offer customers samples of existing types with the new corrugation added that can satisfy the tougher vibrational strength requirements.

Tests have shown that the new corrugation design can be used independently of the can diameter. This means that large cans with screw terminals can also be manufactured with center corrugations in future. Initial attempts are in progress to fit aluminum electrolytic capacitors with corrugations of various designs in order to keep improving their vibrational strength.

4 Improved anchorage ensures higher vibrational strength



4 Independently of alignment, the wires should be bent so that any possible relative movements between circuit board and capacitor do not stress the soldered and welded joints. In contrast with the usual single-ended capacitors, the large-size capacitor is insensitive to axial thrusts applied to the feedthrough thanks to its internal strip bonding.