Ceramic Capacitors | White Paper

Lead (Pb)-Bearing, Vishay Automotive Grade MLCCs for Tin Whisker Mitigation in Low Earth Orbit Satellites

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Executive Summary

- Vishay's VJ….32 Lead-Bearing Finish Series of MLCCs is the industry's first to combine a lead (Pb)-bearing termination finish with Vishay Automotive Grade reliability
- Termination finish with a minimum lead (Pb) content of 4 %
- Qualified to AEC-Q200
- Provides designers with a cost-effective alternative to more expensive MIL-qualified and hi-rel products in low earth orbit (LEO) satellites in which tin whiskers must be avoided but space-level reliability is not required

INTRODUCTION

Multilayer ceramic chip capacitors (MLCCs) are increasingly being used in high reliability applications. And while there will always be demanding applications that require long lifetimes (space exploration vehicles and geo-synchronous orbit (GEO) satellites come to mind), many are designed for shorter lifespans, including low earth orbit (LEO) satellites or NASA class B devices. These LEO satellites provide key advantages over traditional satellites, one of which is signal latency, which is not a problem for broadcasting but is an issue for communications. The signal latency for high orbit satellites is typically around 600 ms, while LEO satellites have a latency of 20 ms, and as technology evolves it will be reduced even further. In addition, by operating at a lower orbit, LEO satellites cost less to put into orbit. Putting a device into GEO costs on the order of $30 000 per kg; that same device in LEO only costs about $5000 per kg [(1)].

Note

(1) http://cannae.com/space-freighter/

WHY A LEAD (Pb)-BEARING SOLUTION IS REQUIRED

While LEO satellites operate at only 5 % the distance above the earth when compared to traditional communication satellites, they still suffer from a potential problem: the formation of tin whiskers. Tin whiskers are electrically conductive structures that can grow from the surface of a component with tin as the final surface finish. However, tin is an extremely popular finish for electrical components, particularly MLCCs. If a tin whisker breaks off, it can - since it is electrically conductive - cause a short circuit that results in the failure of electronic systems.

While the exact mechanism of how a tin whisker forms is not fully understood, the best way to avoid the whisker is to avoid the use of pure tin-plated components. Alloying tin with lead (Pb) is accepted as a whisker mitigation technique as long as the lead (Pb) content is a minimum of 3 %.

WHY AN ALTERNATIVE TO MIL CERTIFICATION IS NEEDED

The option of a lead (Pb)-bearing finish is certainly not available for commercial- or commodity-grade products: these components service markets that must meet RoHS, REACH, or Green requirements. Instead, the inclusion of lead (Pb) in the termination finish is historically offered only on military-grade, space-grade, or hi-rel components. In the MLCC world, this could be products that meet MIL-PRF-123, MIL-PRF-32535, MIL-PRF-55681, or manufacturer-defined high reliability standards (source-controlled drawings). This is acceptable from a tin-lead (Pb) alloy termination perspective, but these MIL-certified products also require intense manufacturing (e.g. 100 % acoustic scanning, which is manually labor intensive) and extreme reliability tests that include a 2000-hour life test as a requirement. These steps dramatically increase the cost of the device; selling prices for MIL-PRF-123 products easily exceed $10 each, and not uncommonly approach $100 each.

WHITE PAPER

For technical questions, contact: mlcc@vishay.com

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THE ADVANTAGES OF VISHAY AUTOMOTIVE GRADE

An option that would provide a reliable part at a more reasonable price is to use Vishay Automotive Grade MLCCs that are qualified to AEC-Q200. In addition to 100 % testing for confirmation of the basic capacitor characteristics (capacitance value, dissipation factor, and insulation resistance), these parts must pass the reliability tests outlined in section “AEC-Q200 Tests”.

In addition to passing AEC-Q200 qualification, Vishay Automotive Grade products have more stringent manufacturing requirements compared to commercial or commodity grade. These include: DPA verification of internal design, statistical evaluation of product parameters to eliminate maverick lot escape, solderability testing on every lot, thermal shock testing, resistance to soldering heat, and burn-in after thermal shock to assure no thermal shock cracking. The sample sizes for quality assurance tests are also four times the size of commercial products, and there is a zero defect limit for visual sampling.

However, there is still one issue: the automotive world requires end of life vehicle (ELV) compliance and is moving toward RoHS-compliant / Green products, as is the commercial world. This environmental action eliminates the use of lead (Pb)-bearing terminations for automotive applications.

THE VISHAY VITRAMON VJ....32 LEAD-BEARING FINISH SERIES

This industry-first device combines the tin whisker mitigation properties of a lead (Pb)-bearing termination finish with the reliability of Vishay Automotive Grade MLCCs qualified to AEC-Q200. This series is available with C0G (NP0) and X7R dielectrics in five body sizes from 0402 to 1210. The range offering is summarized in the “Device Specifications” table.

AEC-Q200 TESTS

- Operational life: 1000 hours at rated voltage at 125 °C
- Biased humidity: 1000 hours at rated voltage at 85 °C and 85 % RH
- High temperature exposure: 1000 hours at 150 °C
- Moisture resistance
- Terminal strength
- Resistance to solvents
- Mechanical shock
- Resistance to solder heat
- Thermal shock: 1000 cycles from -55 °C to +150 °C
- ESD characterization based on the human body model
- Solderability

DEVICE SPECIFICATIONS

DIELECTRIC	CASE CODE	MAXIMUM VOLTAGE (V)	CAPACITANCE	
			MINIMUM	MAXIMUM
C0G (NP0)	0402	100	1.0 pF	220 pF
	0603	200	1.0 pF	820 pF
	0805	500	1.0 pF	3.9 nF
	1206	630	1.0 pF	8.2 nF
	1210	630	100 pF	12 nF
X7R	0402	100	120 pF	33 nF
	0603	200	330 pF	150 nF
	0805	200	330 pF	470 nF
	1206	630	220 pF	1.0 µF
	1210	630	390 pF	1.0 µF