Reliability of Lead (Pb)-Bearing Vishay Automotive Grade MLCCs

By Brian Ward

Building products with Automotive Grade quality begins with the manufacturing facility. The manufacturing process should be one that's driven by a quality system that promotes defect prevention, reduction of variation, and continuous improvement. Processes are statistically monitored with all key variables controlled by the quality management system. The requirements for such a system are established by the International Automotive Task Force (IATF) and maintained in the specification IATF 16949. The production facility must be recertified every three years. The location where Vishay's Lead (Pb)-Bearing Finish MLCCs are manufactured holds this certification.

In addition to the IATF 16949 specification requirements, Vishay's Corporate Quality department has implemented additional requirements for a facility to be classified as Vishay Automotive Grade. These include tight Cpk requirements on key variables, a maverick lot program to determine why a lot did not perform as expected, error-proofing programs, and traceability of raw materials used to build Automotive Grade products. Vishay's Lead (Pb)-Bearing Finish MLCCs hold this certification.

Once the factory achieves Automotive Grade status, the products must be qualified to the AEC-Q200 specification. The specific tests, conditions, and references for product qualification are identified by AEC-Q200 (see Table 1). These tests represent all key performance requirements for MLCCs in a high reliability automotive application. Vishay Lead (Pb)-Bearing Finish MLCCs are AEC-Q200 qualified. In fact, the AEC-Q200 specification allows qualification to different stress levels. Vishay qualifies to the highest automotive stress level grade: level 0. The extended test conditions are shown in Table 1.

It is interesting to note that many military standards are referenced by AEC-Q200. Vishay's manufacturing facility for the Lead (Pb)-Bearing Finish MLCCs is certified to MIL-STD-790, producing many MIL-standard products, including MIL-PRF-123, MIL-PRF-55681, and DSCC. In fact, the same production line used to build these MIL-standard products is used to build the Lead (Pb)-Bearing Finish MLCC series.

There are many similarities in the manufacturing of MIL-standard and Automotive Grade products, including construction methods, in-process DPAs, tighter AQLs on all sample inspections, the use of automated visual inspection, single-lot date code requirements, and formal customer notification requirements for any change. There are also some differences, such as design margins, minimum shim thickness requirements, and implementation of PDAs on the MIL-grade products.

The Automotive Grade products exhibit excellent reliability. One critical measure of product reliability includes failure in time (FIT), which defines the number of failures per billion hours of operation. The inverse of FIT is the mean time to failure (MTTF). These values are determined by collecting failure data at accelerated test conditions, with voltage above rated voltage and temperature above typical values. The data can be used to calculate the FIT or MTTF at specified conditions. For reference, an operating voltage equal to 50 % of the rated voltage and an operating temperature of 25 °C are common conditions. Representative values of FIT and MTTF for Vishay's Lead (Pb)-Bearing Finish series MLCCs are summarized in Table 2. From this table, we see the largest FIT value is 0.130, or a MTTF of 7.69×10^9 hours: that's a MTTF of over 875 000 years. Of course, a specific part will have a specific value based on its design and the applied conditions (and this can be calculated), but certainly the Lead (Pb)-Bearing Finish series of MLCCs offers a level of reliability sufficient for many applications where tin whiskers must be avoided but the stringent space-level reliability standard is not absolutely required.

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TABLE 1 - AEC-Q200 QUALIFICATION TESTING		
AEC-Q200 TEST	**CONDITIONS**	**REFERENCE**
High temp exposure (storage)	AEC-Q200: 1000 h, 125 °C Vishay: 2000 h, 150 °C	MIL-STD-202, method 108
Temperature cycling	1000 cycles (-55 °C to +125 °C), 30-minute dwell time	JESD 22, method JA-104
Destructive physical analysis		EIA-469
Moisture resistance	25 % to 65 % RH / 24 h per cycle / 10 cycles	MIL-STD-202, method 106
Biased humidity	1000 h at 85 °C and 85 % relative humidity at rated voltage 1000 h at 85 °C and 85 % relative humidity at 1.5 V	MIL-STD-202, method 103
Operation life	AEC-Q200: 1000 h, 125 °C, rated voltage Vishay: 2000 h, 150 °C, 2 x rated voltage (for rated voltage ≤ 250 V)	MIL-STD-202, method 108
External visual		MIL-STD-883, method 2009
Physical dimension	As specified on datasheet	JESD 22, method JB-100
Mechanical shock	Condition F, figure 1	MIL-STD-202, method 213
Vibration	5 *g* for 20 minutes, 12 cycles each in each of 3 orientations, from 10 Hz to 2000 Hz	MIL-STD-202, method 204
Resistance to solder heat	Test condition D	MIL-STD-202, method 210
ESD		AEC-Q200-002
Solderability		J-STD-002
Electrical characterization		User spec
Board flex	2 mm board bending with ≥ 60 s holding time	AEC-Q200-005
Terminal strength		AEC-Q200-006
Beam load		AEC-Q200-003

TABLE 2 - SUMMARIZED FIT / MTTF VALUES FOR VISHAY'S LEAD (Pb)-BEARING FINISH SERIES OF MLCCS				
BODY SIZE	**NP0**		**X7R**	
	FIT [1]	**MTTF [1] (YEARS)**	**FIT [1]**	**MTTF [1] (YEARS)**
0402	0.0122	9 360 731	0.013	8 618 721
0603	0.0308	3 710 046	0.101	1 130 137
0805			0.072	1 575 342
1206			0.130	877 854
1210			0.092	1 244 292

Note

[1] 25 °C and 50 % rated voltage

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