Hermetic Aluminum Electrolytic Capacitors

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Outline

• Brief overview of CDE capacitor products
• New series MLSH hermetically sealed aluminum electrolytic
• Construction and ratings
• Advantages of hermeticity and prismatic form factor
• Electrical and other parametric data
• Test specifications and test results
• Comparison to wet tantalum capacitors
• Lifetime and reliability models
• Summary
CDE Product Overview: Some of our 250 product lines
CDE prismatic and hermetic packaging options

CDE prismatic capacitor MLP and MLS series (the two largest capacitors in the above photograph) have been used in military aircraft applications for over 20 years.
## Type MLSH Ratings

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Cap (µF)</th>
<th>Catalog Part Number</th>
<th>ESR max 25 °C (Ω)</th>
<th>Ripple (A) Case @ 85 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>120 Hz 10 kHz</td>
<td>120 Hz 10 kHz</td>
</tr>
<tr>
<td>30 Vdc @ 125 °C</td>
<td>3200  8000</td>
<td>MLSH322M030JKOC MLSH802M030JB0C</td>
<td>0.103 0.098</td>
<td>6.6 6.8</td>
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<td></td>
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<td>0.043 0.041</td>
<td>15.2 15.8</td>
</tr>
<tr>
<td>40 Vdc @ 125 °C</td>
<td>2200  5300</td>
<td>MLSH222M040JK0C MLSH532M040JB0C</td>
<td>0.105 0.1</td>
<td>6.6 6.8</td>
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<td></td>
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<td>0.045 0.043</td>
<td>14.9 15.3</td>
</tr>
<tr>
<td>50 Vdc @ 125 °C</td>
<td>1700  4000</td>
<td>MLSH172M050JK0C MLSH402M050JB0C</td>
<td>0.108 0.101</td>
<td>6.6 6.8</td>
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<td></td>
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<td>0.046 0.043</td>
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<td>60 Vdc @ 125 °C</td>
<td>1100  2700</td>
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<td>0.047 0.044</td>
<td>14.7 15.3</td>
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<td>75 Vdc @ 125 °C</td>
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<td>0.096 0.091</td>
<td>8.2 8.5</td>
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<td>100 Vdc @ 125 °C</td>
<td>400  1000</td>
<td>MLSH401M100JK0C MLSH102M100JB0C</td>
<td>0.387 0.31</td>
<td>5 5.5</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>0.387 0.31</td>
<td>5.5 5.5</td>
</tr>
<tr>
<td>150 Vdc @ 125 °C</td>
<td>210  500</td>
<td>MLSH211M150JK0C MLSH501M150JB0C</td>
<td>1.019 0.815</td>
<td>2.2 2.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.019 0.815</td>
<td>2.2 2.4</td>
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<tr>
<td>200 Vdc @ 125 °C</td>
<td>160  380</td>
<td>MLSH161M200JK0C MLSH381M200JB0C</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1.274 1.019</td>
<td>1.9 2.1</td>
</tr>
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<td>250 Vdc @ 125 °C</td>
<td>120  290</td>
<td>MLSH121M250JK0C MLSH291M250JB0C</td>
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<td>1.9 2.2</td>
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<tr>
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<td></td>
<td></td>
<td>1.200 0.96</td>
<td>1.9 2.2</td>
</tr>
</tbody>
</table>

0.47” × 1.00” x 1.50” to 3.00” (12 x 25 x 38-76 mm)
Type MLSH Construction Diagram
Advantages of hermetic seal and prismatic form factor

Hermetic aluminum electrolytic vs conventional:
• Glass to metal, non-polymeric seals are 100% helium leak tested
• The most stable internal construction must be used
• Much less than 1% of the mass loss rate occurs during life testing
• No electrolyte dry-out occurs during life testing

Advantages of prismatic packaging vs conventional cylindrical:
• Flattened winding offers highly efficient packaging
• Flat package shape is conducive to efficient end-user packaging
• Prismatic capacitor is easy to heat-sink:

\[ \theta = 19 \, ^\circ C/W \]
- in natural convection
\[ 6.4 \, ^\circ C/W \]
- one side heatsinked
\[ 4.2 \, ^\circ C/W \]
- two sides heatsinked
MLSH222M040JK0C Impedance Curves

Cap vs. Frequency & Temp

ESR vs. Frequency & Temp

|Z| vs. Frequency & Temp
Type MLSH Leakage Current Data

Typical 125 °C DC Leakage Current During 125 °C Life Test

- 2400μF@10Vdc
- 1200μF@60Vdc
- 360μF@250Vdc
- 410μF@200Vdc
- 380μF@100Vdc

Hours at 125°C @ Rated Vdc

0.0001
0.001
0.01
0.1

24 72 250 500 1000 4000 5000 6000 8000
Weight Measurement during 105 °C and 125 °C Life Tests:

- Consumer grade electrolytic is on the order of 100 mg/kh.
- CDE non-hermetic, prismatic capacitors lose 10-30 mg/kh.
- Hermetic MLSH weight loss is not measurable by us (± 1 mg/kh).

Typical helium leak test rate per MIL-STD-883 Method 1014.12 (Section 3.1, Condition A2, Package Volume > 0.40 cc’s):

- \( R_1 < 2 \times 10^{-8} \text{ cc/s (He)} \) from leak detector instrument
- \( L(\text{air}) < 5 \times 10^{-7} \text{ std cc/s (air)} \) from Howl-Mann Equation
## Type MLSH Test Specifications

<table>
<thead>
<tr>
<th>TYPICAL TESTS</th>
<th>MIL-STD/Method</th>
<th>TEST CONDITIONS</th>
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<tbody>
<tr>
<td>Dc Life test</td>
<td>MIL-STD-202/108</td>
<td>Catalog lists DC Life &amp; Endurance Life; Application Guide lists expected base life hours</td>
</tr>
<tr>
<td>Derated ripple life</td>
<td>EIA IS-749, MIL-PRF-39018</td>
<td>Catalogs list multipliers for VDC, Frequency &amp; Ripple</td>
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<tr>
<td>Stability</td>
<td>MIL-PRF-39018</td>
<td>Catalog lists Z ratio; Application Guide lists suggested performance</td>
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<tr>
<td>Moisture resistance</td>
<td>MIL-STD-202/106</td>
<td>MIL-PRF-39018 provides guidelines</td>
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<tr>
<td>Vent</td>
<td>MIL-PRF-39018</td>
<td>Details included in MIL-PRF-39018</td>
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<tr>
<td>Shock</td>
<td>MIL-STD-202/213</td>
<td>MIL-PRF-39018 Provides general guidelines</td>
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<tr>
<td>Terminal Strength</td>
<td>MIL-STD-202/211</td>
<td>Catalog &amp; Application Guide provides general guidelines</td>
</tr>
<tr>
<td>DWV</td>
<td>MIL-STD-202/301</td>
<td>Application Guide Provides general guidelines</td>
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<tr>
<td>Altitude simulation</td>
<td>MIL-STD-202/105</td>
<td>Application Guide provides limits</td>
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<tr>
<td>Reverse voltage</td>
<td>MIL-PRF-39018</td>
<td>MIL-PRF-39018 Provides general guidelines</td>
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<tr>
<td>Ripple Life test</td>
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<td>Catalog lists DC Life &amp; Endurance Life; Application guide lists expected base life hours</td>
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<tr>
<td>Derated DC life</td>
<td>MIL-STD-202/108</td>
<td>DC Lifetime &amp; voltage temperature multipliers per CDE literature</td>
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<td>Shelf Life</td>
<td>MIL-STD-1131B</td>
<td>Catalog lists Shelf Life, Application Guide also provides general guidelines</td>
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<tr>
<td>Surge</td>
<td>MIL-PRF-39018*</td>
<td>Catalog lists Surge, Application Guide lists suggested performance</td>
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<tr>
<td>Solderability</td>
<td>MIL-STD-202/208</td>
<td>Details included in MIL-STD-202</td>
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<tr>
<td>Thermal shock</td>
<td>MIL-STD-202/107*</td>
<td>Catalog lists temperature extremes, Application Guide suggests operation between extremes</td>
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<tr>
<td>Temp Cycle &amp; Immersion</td>
<td>MIL-STD-202/104*</td>
<td>MIL-STD-202 provides additional details</td>
</tr>
<tr>
<td>Salt Atmosphere</td>
<td>MIL-STD-202/101</td>
<td>Details included in MIL-STD-202</td>
</tr>
</tbody>
</table>
Type MLSH Thermal Cycle Test Results

Thermal Shock Test Conditions:
• 100 cycles -55 °C to +125° C
• < 5-minute transition, air-to-air
• 1-hour dwell at temperature extremes
• 1 group of 5 MLSH capacitors

Thermal Shock Test Results:
• No visual inspection failures
• No electrical parameter failures
Type MLSH Life Test Ratings

Type MLSH Operating Life in Kilohours vs Ripple Current

Expected Operating Life, kh

Rated Ripple-Current Multiple

Temperature Levels:
- 55°C
- 65°C
- 75°C
- 85°C
- 95°C
- 105°C
- 115°C
Type MLSH Comparison to Wet Tantalum

Relative low-temperature capacitance retention is good

![Cap Ratio: CDE MLSH121M250JK0C to 3 series 220 µF 85V Tantalums](image)

Relative ESR is good across a broad range of frequencies and temperatures

![ESR Ratio: CDE MLSH121M250JK0C to 3 series 220 µF 85V Tantalums](image)
Type MLSH Lifetime and Reliability Models

\[ L = L_b \times M_v \times 2^{((T_m - T_a - \Delta T)/10)} \] wearout lifetime

\[ \lambda = \frac{4 \times 10^5 \times V_a^3 \times C^{0.5}}{[L_b \times V_r^2 \times 2^{((T_m - T_a - \Delta T)/10)}]} \] ppm/kh failure rate (before onset of wearout)

where

- \( L \) = Lifetime (h)
- \( L_b \) = Base lifetime (h) = 5 kh min / 10 kh typical
- \( V_a \) = Applied DC voltage
- \( V_r \) = Rated DC voltage
- \( M_v = 4.3 - 3.3 \, V_a/V_r \) = DC voltage multiplier
- \( T_m = \) Maximum rated core temperature (at end of life) (°C) = 128 °C
- \( T_a = \) Ambient temperature (°C)
- \( \Delta T = \) Heat rise due to ripple current (°C)
- \( C = \) Capacitance (F)

Example Calculations:
- MLSH222M040JK0C 2200 µF 40V is used at 70 °C core temperature at 28 VDC.

Lifetime Estimate:
- \[ L = (5000)(1.99)(2^{5.8}) = 554 \, kh > 60 \, years \]

Failure Rate Estimate:
- \[ \lambda = (4 \times 10^5)(28^3)(0.0022^{0.5})/[(5000)(40^2)(2^{5.8})] = 0.92 \, ppm/kh \text{ ("FIT")} \]
Summary

• New hermetic, prismatic capacitor MLSH series
• Leverages 25 years of CDE flatpack military capacitors
• Glass to metal seals eliminate electrolyte dry-out
• Prismatic form factor is easy to mount and heatsink
• 0.47”×1.00”× 1.5 to 3.0 inches length
• 30 to 250 VDC rating, -55 to +125 °C
• Single-device alternative to multiple wet tantalums
• 5,000 hours at +125 °C life test rating
• Good capacitance and ESR especially at low temperature
Thank you