Capacitors for Military/Aerospace
Capacitors for Military/Aerospace

What types of capacitors go into Military/Aerospace Applications?

- Ruggedized
- High Vibration
- Wide temp range, especially -55 °C at the low end
- High Altitude
- Stable & Long-Life
- Hermetic
- Established reliability
- Burn-in
- Compact, Low-profile
- Light weight
- Non RoHS (No tin whiskers)
Capacitors for Military/Aerospace
Capacitors for Military/Aerospace

MILITARY/AEROSPACE CAPACITORS

Engineering Tools
- Military at a Glance
- Military/Aerospace Presentation

CMR Dipped Mica - Established Reliability  Dipped Mica Capacitors  Metal Clad Mica Capacitors

Hermetic Aluminum Electrolytic Capacitors  Flatpack Aluminum Electrolytic Capacitors  Radial Aluminum Electrolytics

Screw Terminal Aluminum Electrolytic Capacitors  High Vibration Capacitors
Applications for Aluminum Electrolytic Capacitors in Military – Aerospace

- Most are used for bulk storage, holdup applications in power supplies, communications and radar systems.
  - Radar
  - Onboard communications
  - Aircraft Power Supplies
  - Programs examples:
    - KC-135
    - F-18
    - F-22
    - X-33 Space Shuttle
    - JSF Joint Strike Fighter
    - F-18
    - F-16
    - E-2C
    - Osprey

- Customers: Lockheed, Raytheon, Rockwell Collins, Northrup Grumman, UTC, Boeing, L-3, BAE, General Dynamics
## Capacitors for Military/Aerospace

### RADIAL ALUMINUM ELECTROLYTICS

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Form Factor</th>
<th>Temperature (°C)</th>
<th>Voltage (Vdc)</th>
<th>Load Life (h@°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>300/301</td>
<td>Long Life, Switching Power Grade, 105°C</td>
<td></td>
<td>-55 to +105</td>
<td>6.3-250</td>
<td>4000 @ +105</td>
</tr>
</tbody>
</table>

### SCREW TERMINAL ALUMINUM ELECTROLYTICS

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Form Factor</th>
<th>Temperature (°C)</th>
<th>Voltage (Vdc)</th>
<th>Load Life (h@°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>101C</td>
<td>Low-ESR, Wide-Temperature Grade</td>
<td></td>
<td>-55 to +105</td>
<td>7.5-250</td>
<td>2000 @ +105</td>
</tr>
<tr>
<td>125</td>
<td>Ultra-High Temperature, Military Grade, 125°C</td>
<td></td>
<td>-55 to +125</td>
<td>6.3-40</td>
<td>2000 @ +125</td>
</tr>
</tbody>
</table>
### Capacitors for Military/Aerospace

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Form Factor</th>
<th>Temperature (°C)</th>
<th>Voltage (Vdc)</th>
<th>Load Life (h@°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLP</td>
<td>Aluminum Case, 85°C, 10g, 80K altitude, long life</td>
<td><img src="image" alt="MLP Icon" /></td>
<td>-40/55 to +85</td>
<td>7.5-420</td>
<td>2000 @ +85</td>
</tr>
<tr>
<td>MLS</td>
<td>Stainless Steel Case, 125°C, 50g, 80K altitude, long life</td>
<td><img src="image" alt="MLS Icon" /></td>
<td>-55 to 125</td>
<td>5-250</td>
<td>2000 @ 125</td>
</tr>
<tr>
<td>MLSG</td>
<td>125 °C, 5000 hr, Stainless Steel Flatpack, 50g, 80K altitude, longest life under rated conditions</td>
<td><img src="image" alt="MLSG Icon" /></td>
<td>-55 to +125</td>
<td>20-250</td>
<td>5000 @ 125</td>
</tr>
</tbody>
</table>

*For new designs please review the MLSG series*
Flatpack Capacitors

- Standard (non-hermetic) Flatpack capacitors, types MLP (85°C) and MLS (125°C) have been used extensively in military/aerospace applications for more than 20 years.

- Radar
- Cockpit communications
- Aircraft Power Supplies
- Programs

KC135
F18
F22
X33 Space Shuttle
JSF Joint Strike Fighter
F18
F16
E2C
Osprey

MLP, Aluminum Case (85°C)

MLS, Stainless Steel Case (125°C)
Benefits of MLP/MLSG Capacitors

- High capacitance density in 12.5 mm profile
- Efficient stackable form factor
- Heatsinking is simple and effective
- Extremely long life due to near-hermetic seal and high-purity materials.
  - Recent electrolyte developments have allowed us to assign a 5000 hr life rating ($V_r @ 125 \degree C$) to the MLSG series. Previously 2000 hr.
- Superior low-temperature impedance up to 250 V
Flatpack Capacitors

Efficient Stacking / Packaging
Recent Additions to Aluminum Capacitor Technology for Military-Aerospace

- MLSG-S, Slimpack
  - 1.00” wide, 5000 hr

- MLSH, Hermetic Slimpack

- HHT, 175°C Axial

- THA & THAS Thinpack
  - THA (8.2mm, 85 °C)
  - THAS (9.0mm, 105 °C)
MLSH, Hermetically Sealed Aluminum Electrolytic Capacitors

- Convention aluminum electrolytic capacitors (e.g. snap-ins, axial, radial) lose electrolyte over time.
- The out-gassing of electrolyte results in cap loss and increased ESR.
- Standard MLP and MLSG Flatpacks have a near-hermetic seal and lose very little electrolyte over their life.
- Hermetic Slimpack capacitors lose no electrolyte.

The graph shows the average weight change during a 105 °C life test for MLS Flatpacks, both non-hermetic and hermetic, with 11 mF and 40V.
Hermetically Sealed Aluminum Electrolytic Capacitors - MLSH

Type MLSH 125 °C Hermetic Slimpack, Ultra Long Life, Aluminum Electrolytic

Highlights
- Hermetically sealed with no dry out
- Alternative to axial wet tantalum
- High capacitance retention @ -55 °C
- 5000 Hr DC life test
- Up to 80g vibration
Hermetically Sealed Aluminum Electrolytic Capacitors

Hermetic Aluminum versus Wet Tantalum:

- Replaces 3 or more D-sized (a.k.a.T4) wet tantalum caps
- Wet tantalum caps have poor capacitance retention at low temperature.
- Almost all mil/aero applications specify parts using the full temp range of -55 °C to 125°C.
- A single hermetically sealed aluminum electrolytic capacitor saves weight, size and cost when compared to banks of wet tantalum capacitors.

<table>
<thead>
<tr>
<th></th>
<th>MLSH, 2200µF, 40 Vdc @ 125 °C</th>
<th>4 x T4 Wet Ta, 1000µF, 40 Vdc @ 125 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacitance @ 125 °C, 120 Hz</td>
<td>2100µF</td>
<td>4910µF</td>
</tr>
<tr>
<td>Cap Change at -55 °C, 120 Hz</td>
<td>-20%</td>
<td>-68%</td>
</tr>
<tr>
<td>Capacitance @ -55 °C, 120 Hz</td>
<td>1675µF</td>
<td>1580µF</td>
</tr>
<tr>
<td>Weight (g)</td>
<td>32</td>
<td>59</td>
</tr>
<tr>
<td>Cost</td>
<td>1X</td>
<td>2X</td>
</tr>
</tbody>
</table>
Hermetically Sealed Aluminum Electrolytic Capacitors

Hermetic Aluminum versus Wet Tantalum:

- Tantalum caps require derating at higher temps, 33% voltage derating at 125 °C. aluminum electrolytics do not require derating.
- Hermetic aluminum electrolytics are available up to 250 Vdc @ 125 °C, Wet Tantalum max voltage is 85 Vdc @ 125 °C.
- Using a single capacitor versus multiple capacitors simplifies board layout and assembly.
- A single cap solution enhances reliability.
- Tantalum is a mined material that has cyclical supply shortages (price goes up, lead times go out).
- Tantalum is a conflict material.
CDE HHT Series Axial-Lead Aluminum Electrolytic Capacitors

175 °C, RUGGEDIZED DESIGN FOR MISSION CRITICAL APPLICATIONS
CDE HHT Series Ruggedized Axial-Leaded Aluminum Electrolytic Capacitors

The HHT is the only axial-lead electrolytic featuring a glass-to-metal seal to prevent dry-out of the capacitor electrolyte.

- Rated at 175 °C, for 2,000 hours and an industry-best 5,000 hours at 150 °C with ripple current ratings up to 10 Arms
- Withstands vibrations up to 20 g’s

In short, HHT capacitors go where others can’t.
THA and THAS, *Thinpack*, Aluminum Electrolytic Capacitors

**HIGHEST ENERGY-DENSITY ELECTROLYTIC IN A VERY LOW-PROFILE DESIGN**
CDE THA and THAS Thinpack High-Energy Density Aluminum Electrolytic Capacitors.

Offers the highest energy density available in low-profile aluminum electrolytic technology.

- Ideal for the lowest-profile circuits
- THA 8.2mm thin, offers 3,000 hr. life @ 85 °C
- THAS 9.0 mm thin offers 3,000 hr. life @ 105 °C
- Designed for high capacitance bulk storage and filtering applications
- Can replace arrays of SMT, radial or axial aluminum electrolytic and solid tantalum capacitors
- Increases reliability– one device vs. many; fewer PCB connection points
- Less weight, lower cost.
Mica Capacitor Technology for Mil-Aero Applications
Capacitors for Military/Aerospace

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Mica Capacitor Technology for Mil-Aero Applications

Why Mica?

- Superb performance in RF Applications (e.g. military radios, cockpit communications)
- Capacitance stability with temperature, voltage and frequency.
- Robust package can withstand high shock & vibration and high altitudes.
- Wide temp range: (-55 °C to 125 °C standard, up to 200 °C)
- Tight capacitance tolerance
- Established reliability for military applications
  - Burn-in
Mica Capacitor Technology for Mil-Aero Applications - CMR

High-Reliability Dipped Capacitors/MIL-PRF-39001

Type CMR meets requirement of MIL-PRF-39001, Type CMR high-reliability dipped silvered mica capacitors are ideal for high-grade ground, airborne, and spaceborne devices, such as computers, jetcraft, and missiles.

Specifications

- **Voltage Range:** 50 Vdc to 500 Vdc
- **Capacitance Range:** 1 pF to 91,000 pF
- **Capacitance Tolerance:** ±½ pF (D), ±1% (F), ±2% (G), ±5% (J)
- **Temperature Range:** –55 °C to +125 °C (O), –55 °C to 150 °C (P)

P temperature range available only for CMR04, CMR05, CMR06, CMR07, CMR08

**Reliability:** Meets Requirements of MIL-PRF-39001 Established reliability to 0.1% 1,000 hours failure rate
**Mica Capacitors, Standard Dipped**

Types CD10, D10, CD15, CD19, CD30, CD42, CDV19, CDV30

Stability and mica go hand-in-hand when you need to count on stable capacitance over a wide temperature range. CDE's standard dipped silvered mica capacitors are the first choice for timing and close tolerance applications. These standard types are widely available through distribution.

**Highlights**

- Reel packaging available
- High temperature – up to +150 °C
- Dimensions meet EIA RS153B specification
- 100,000 V/μs dV/dt pulse capability minimum
- Non-flammable units that meet IEC 695-2-2 are available

**Specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacitance Range</td>
<td>1 pF to 91,000 pF</td>
</tr>
<tr>
<td>Capacitance Tolerance</td>
<td>±1/2 pF (D), ±1 pF (C), ±1/2% (E), ±1% (F), ±2% (G), ±5% (J)</td>
</tr>
<tr>
<td>Rated Voltage</td>
<td>100 Vdc to 2500 Vdc</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>−55 °C to +125 °C (O) −55 °C to +150 °C (P)*</td>
</tr>
<tr>
<td>Dielectric Strength Test</td>
<td>200% of rated voltage</td>
</tr>
<tr>
<td>RoHS Compliant</td>
<td></td>
</tr>
</tbody>
</table>

* P temperature range available for types CD10, CD15, CD19, CD30 and CD42
# Mica Capacitor Technology for Mil-Aero Applications – Metal Clad

Types MCM and MIN SMT Clad RF Capacitors

<table>
<thead>
<tr>
<th>Types</th>
<th>MCM</th>
<th>MIN</th>
</tr>
</thead>
</table>

Multilayer High Power, High Temperature Mica and PTFE Capacitors

Types MCM and MIN SMT clad PTFE and mica capacitors are top performers for high power applications requiring low inductance at high frequencies and can operate at temperatures up to 200 °C and voltages to 1000 Vdc. Choosing from 16 different configurations offers easy mounting with options for surface mount as well as through-hole and mechanical assembly. To assure high current capability in the smallest capacitors, low-capacitance ratings use polytetrafluoroethylene (PTFE) that has ultra-low dielectric absorption - better than polypropylene, polystyrene and NPO ceramic.

**Highlights**

- 200 °C rated with no voltage derating
- Wave solderable
- No cracking or delaminating
- CTE \(\approx 18 \text{ ppm/°C}\) compatible with FR4 PCBs
- Highly thermal conductive package
- Gull-wing terminal minimizes stress
- Typical 100 pF ESR, \(<11 \text{ mΩ}\) @ 100 MHz
- Nonmagnetic for minimal RF loss
- Very low ESL for excellent by-pass action
- Ultra stable: no change with (t), (V) and (f)
- Exact capacitance with tolerances from \(\pm 0.25 \text{ pF}\)
Applications for Mica Capacitors in Military – Aerospace

- Most are used for communications or in power supplies.
  - Onboard communications
  - Aircraft Power Supplies
  - Two-Way mobile radios
  - Customers: Lockheed, Raytheon, Rockwell Collins, Northrup Grumman, UTC, Boeing, L-3, BAE, General Dynamics
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## Capacitors for Military/Aerospace - High Vibration

<table>
<thead>
<tr>
<th>Capacitor Code</th>
<th>Specifications</th>
<th>Temperature Range</th>
<th>Life (hr)</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLSG</td>
<td>125 °C, 5000 hr, Stainless Steel Flatpack, 50g, 80K altitude, longest life under rated conditions</td>
<td>-55 to +125</td>
<td>20-250</td>
<td>5000 @ 125</td>
</tr>
<tr>
<td>MLSG-S</td>
<td>125 °C, 5000 hr, Stainless Steel Slimpack, 80g, 80K altitude, volume constrained conditions</td>
<td>-55 to +125</td>
<td>10-250</td>
<td>5000 @ 125</td>
</tr>
<tr>
<td>MLSH</td>
<td>125 °C Hermetic Aluminum Electrolytic Slimpack, 80g, 80K altitude, volume constrained conditions</td>
<td>-55 to +125</td>
<td>30-250</td>
<td>5000 @ 125</td>
</tr>
<tr>
<td>AFK_V</td>
<td>High Vibration withstands 30 G V-Chip</td>
<td>-55°C to +105°C</td>
<td>6.3-100</td>
<td>10-6800</td>
</tr>
<tr>
<td>HZA_V</td>
<td>High Vibration, Very Low ESR V-Chip</td>
<td>-55°C to +105°C</td>
<td>25-80</td>
<td>22-330</td>
</tr>
<tr>
<td>HZC_V</td>
<td>High Vibration, Very Low ESR V-Chip</td>
<td>-55°C to +125°C</td>
<td>25-63</td>
<td>33-330</td>
</tr>
</tbody>
</table>
Military/Aerospace At A Glance

Capacitors for Military/Aerospace Applications

Cernell Dubillier Electronics needs with capacitor technology to meet the demanding requirements for military and aerospace applications. Our capacitors are used extensively in power supplies, inverters and communication systems for commercial and military aircraft and sea-going vessels. Ground-based applications include radar systems, two-way mobile radios and DC link for inverters and power supplies used in military trucks and tanks. CDE has a full range of testing capabilities per MIL-STD-202D requirements.

FLATPACK ALUMINUM ELECTROLYTIC CAPACITORS

FEATURES
High Capacitance Retention at -55°C
Surface Mount Factor for Tight Spaces
High Reliability
Available in Hermetic Case
High Altitude up to 10,000 ft

TYPES
MLP - Aluminum Case, E55°C
MLS - Stainless Steel Case, E55°C
HVLWS - High Vibration up to 50g
HMLWS - High Reliability, Stainless
MLAZH - Hermetic, Snap-pack - 10°C
MLG - Flatpack and Clip-pack - 105°C
THA, THLS - Thumper, High Energy Density

APPLICATIONS
Ground-based and Shipboard Radar
Strategic Power Supplies
Commercial and Military Aircraft


RF MICA CAPACITORS

FEATURES
High Q
Excellent Performance in RF Applications
High dL/dT
Stable Over Wide Temperature Range
Available up to 208°C
High Reliability Burn-in Available
No Ferroelectric Effect
No Cracking

TYPES
CMR - Dipped, High Rel, Meets MIL-MP-319001
CL, CDV - Dipped High Frequency
HCMW/HRW - Metal Clad for Ultra High Current

APPLICATIONS
Military and Avionics RF Communications
Satcom Communications
 flatspack Radio
Strategic Power Supplies

http://www.cde.com/solutions/military-aerospace

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(410) 664-2121 Fax (410) 843-3150
Email: cdeinfo@cde.com

For more high performance capacitors for military/aerospace visit: http://www.cde.com/solutions/military-aerospace
Thank You!