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

INVERTER CAPACITORS
- High Ripple Polypropylene Film
- IGBT Snubber Selection
- Inverter Grade Aluminum DC-Link Bus Capacitors
- Inverter Grade DC-Link Films
- AC Harmonic Filter Capacitors

MILITARY/AEROSPACE CAPACITORS
- Flatpack Aluminum Electrolytics
- Hermetic Aluminum Electrolytics
- High Vibration Capacitors
- Radial Aluminum Electrolytics
- Screw Terminal Aluminum Electrolytics

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

MILITARY AT A GLANCE
- POWER SUPPLY CAPACITORS
  - Switching Capacitors
  - Ferroresonant Capacitors

- PULSE, HIGH FREQUENCY & SNUBBER CAPACITORS
  - IGBT Snubber Modules
  - Polypropylene Pulse & High Frequency Capacitors

- MICA PULSE & HIGH FREQUENCY
- Oil Filled Snubber Capacitors

- RF CAPACITORS
  - RF Clad Capacitors
  - Mica, High Frequency Capacitors
  - RF Chip Capacitors

- HIGH VOLTAGE CAPACITORS
  - High Voltage Mica Capacitors
  - Polypropylene Capacitors
  - Paper/Film Capacitors

- MOTOR START CAPACITORS
- MOTOR RUN CAPACITORS
- HID LIGHTING CAPACITORS

STROBE CAPACITORS
- PHOTO FLASH CAPACITORS
- BATTERY BACKUP
- NOISE SUPPRESSION
- SURFACE MOUNT CAPACITORS
- Aluminum Electrolytic SMT
- Hybrid Polymer Aluminum
- Solid Polymer Alum Chip
- Multilayer RF Chip
- Multilayer RF Clad
- Film Chip Capacitors
- SMT Mica Kits

INDUCTION HEATING
Capacitors for Military/Aerospace

MILITARY/AEROSPACE CAPACITORS

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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
  - F18
  - F22
  - X33 Space Shuttle
  - F35 Joint Strike Fighter
  - F16
  - E2C
  - 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

## Flatpack 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>MLP</td>
<td>Aluminum Case, 85°C, 10g, 80K altitude, long life</td>
<td><img src="image" alt="MLP" /></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" /></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" /></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)
Flatpack Capacitors

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 (Vr @ 125 °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 ºC)
  - THAS (9.0mm, 105 ºC)
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.

**Average Weight Change during 105 ºC Life Test**

<table>
<thead>
<tr>
<th>Weight Loss (Grams)</th>
<th>Test Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0200</td>
<td>0</td>
</tr>
<tr>
<td>0.0180</td>
<td>500</td>
</tr>
<tr>
<td>0.0160</td>
<td>1000</td>
</tr>
<tr>
<td>0.0140</td>
<td>1500</td>
</tr>
<tr>
<td>0.0120</td>
<td>2000</td>
</tr>
<tr>
<td>0.0100</td>
<td>2500</td>
</tr>
<tr>
<td>0.0080</td>
<td>3000</td>
</tr>
<tr>
<td>0.0060</td>
<td>3500</td>
</tr>
<tr>
<td>0.0040</td>
<td>4000</td>
</tr>
<tr>
<td>0.0020</td>
<td>4500</td>
</tr>
</tbody>
</table>

**MLS Flatpack, Non-Hemetic vs Hermetic, 11 mF, 40V**

<table>
<thead>
<tr>
<th>Weight Loss (Grams)</th>
<th>Test Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.0000</td>
<td>0</td>
</tr>
<tr>
<td>-0.0020</td>
<td>500</td>
</tr>
<tr>
<td>-0.0040</td>
<td>1000</td>
</tr>
<tr>
<td>-0.0060</td>
<td>1500</td>
</tr>
<tr>
<td>-0.0080</td>
<td>2000</td>
</tr>
<tr>
<td>-0.0100</td>
<td>2500</td>
</tr>
<tr>
<td>-0.0120</td>
<td>3000</td>
</tr>
<tr>
<td>-0.0140</td>
<td>3500</td>
</tr>
<tr>
<td>-0.0160</td>
<td>4000</td>
</tr>
<tr>
<td>-0.0180</td>
<td>4500</td>
</tr>
</tbody>
</table>

Hermetic
Non-Hemetic
Hermetically Sealed Aluminum Electrolytic Capacitors - MLSH

Type MLSH 125 ºC Hermetic Slimpack, Ultra Long Life, Aluminum Electrolytic

Highlights
- Hermetically sealed with no dry out
- Alternative to axial wet tantalum
- High capacitance retention @ -55 ºC
- 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>Capacitance @ 125 °C, 120 Hz</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>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>
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

MILITARY/AEROSPACE CAPACITORS

Flatpack Aluminum Electrolytics
Radial Aluminum Electrolytics
Dipped Mica Capacitors

Hermetic Aluminum Electrolytics
Screw Terminal Aluminum Electrolytics
Metal Clad Mica Capacitors

High Vibration Capacitors
CMR Dipped Mica - Established Reliability
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:** ±1/2 pF (D), ±1% (F), ±2% (G), ±5% (J)
- **Temperature Range:** –55°C to +125°C (O), –55°C to 150°C (P)
- **Reliability:** Meets Requirements of MIL-PRF-39001
  Established reliability to .01%/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>
</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

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 ≈ 18 ppm/°C compatible with FR4 PCBs
- Highly thermal conductive package
- Gull-wing terminal minimizes stress
- Typical 100 pF ESR, <1 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 ±0.25 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
Capacitors for Military/Aerospace

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- High Vibration Capacitors
- CMR Dipped Mica - Established Reliability
## Capacitors for Military/Aerospace - High Vibration

<table>
<thead>
<tr>
<th>Capacitor Type</th>
<th>Operating Conditions</th>
<th>Voltage Range</th>
<th>Max Temp.</th>
<th>Life Span</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>MLGG-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>MLGH</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</td>
<td>V-Chip</td>
<td>-55°C to +105°C</td>
<td>6.3-100</td>
</tr>
<tr>
<td>HZA_V</td>
<td>High Vibration, Very Low ESR</td>
<td>V-Chip</td>
<td>-55°C to +105°C</td>
<td>25-90</td>
</tr>
<tr>
<td>HZC_V</td>
<td>High Vibration, Very Low ESR</td>
<td>V-Chip</td>
<td>-55°C to +125°C</td>
<td>25-63</td>
</tr>
</tbody>
</table>
Military/Aerospace At A Glance

CDE AT A GLANCE

Capacitors for Military/Aerospace Applications:
Cornell Dubilier 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 inverter and power supplies used in military trucks and tanks. CDE has a full range of testing capabilities per MIL STD 810D requirements.

FLATPACK ALUMINUM ELECTROLYTIC CAPACITORS

FEATURES
- High Capacitance Retention at -65°C
- Temperature Factor for Tight Spaces
- High Voltage up to 50V
- High Reliability
- Available in Hermetic Case
- High Altitude up to 30,000 ft

TYPES
- MLP: Aluminum Case, 85°C
- MLS: Stainless Steel Case, 125°C
- HVWLS: High Vibration up to 50G
- HLHS: High Reliability Dugout
- MLHS: Hermetic, Stacked - 50G
- MLGS: Flatpack and Stacked - RFS
- THS, THW: Flatpack, High Energy Density

APPLICATIONS
- Ground-based and Shipboard Radars
- EW Countermeasures
- Weapon Systems

RF MICA CAPACITORS

FEATURES
- High Q
- Excellent Performance in RF Applications
- High dV/dt
- Stable Over Wide Temperature Range
- Available up to 200°C
- High Reliability Burn-in Available
- No Pyroelectric Effect
- No Cracking

TYPES
- CMR: Dipped, High Rel, Meets: MIL-M-39001
- CD, CEV: Dipped High Frequency
- MCM-WM: welded, High for Ultra High Current

APPLICATIONS
- Military and Aerospace RF Communications
- Radars, Sonar, ECM Communications
- Inverters, Power Supplies


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

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

http://www.cde.com/solutions
Thank You!