



CORNELL  
DUBILIER

ENERGIZING IDEAS

# 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)

# 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:

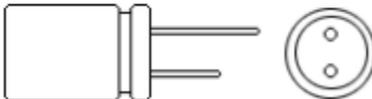
KC135  
F18  
F22  
X33 Space Shuttle  
JSF Joint Strike Fighter  
F18  
F16  
E2C  
Osprey



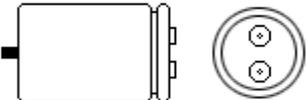
- Customers: Lockheed, Raytheon, Rockwell Collins, Northrup Grumman, UTC, Boeing, L-3, BAE, General Dynamics

# Capacitors for Military/Aerospace

## RADIAL ALUMINUM ELECTROLYTICS

Type	Description	Form Factor	Temperature (°C)	Voltage (Vdc)	Load Life (h@°C)
 300/301	Long Life, Switching Power Grade, 105°C		-55 to +105	6.3-250	4000 @ +105

## SCREW TERMINAL ALUMINUM ELECTROLYTICS

Type	Description	Form Factor	Temperature (°C)	Voltage (Vdc)	Load Life (h@°C)
 101C	Low-ESR, Wide-Temperature Grade		-55 to +105	7.5-250	2000 @ +105
 125	Ultra-High Temperature, Military Grade, 125°C		-55 to +125	6.3-40	2000 @ +125

# Capacitors for Military/Aerospace

## FLATPACK ALUMINUM ELECTROLYTICS

Type	Description	Form Factor	Temperature (°C)	Voltage (Vdc)	Load Life (h@°C)
 MLP	Aluminum Case, 85°C, 10g, 80K altitude, long life		-40/55 to +85	7.5-420	2000 @ +85
 MLS	Stainless Steel Case, 125°C, 50g, 80K altitude, long life <b>"For new designs please review the MLSG series"</b>		-55 to 125	5-250	2000 @ 125
 MLSG	125 °C, 5000 hr, Stainless Steel Flatpack, 50g, 80K altitude, longest life under rated conditions		-55 to +125	20-250	5000 @ 125

# 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  
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MLP, Aluminum  
Case (85°C)



MLS, Stainless Steel  
Case (125°C)

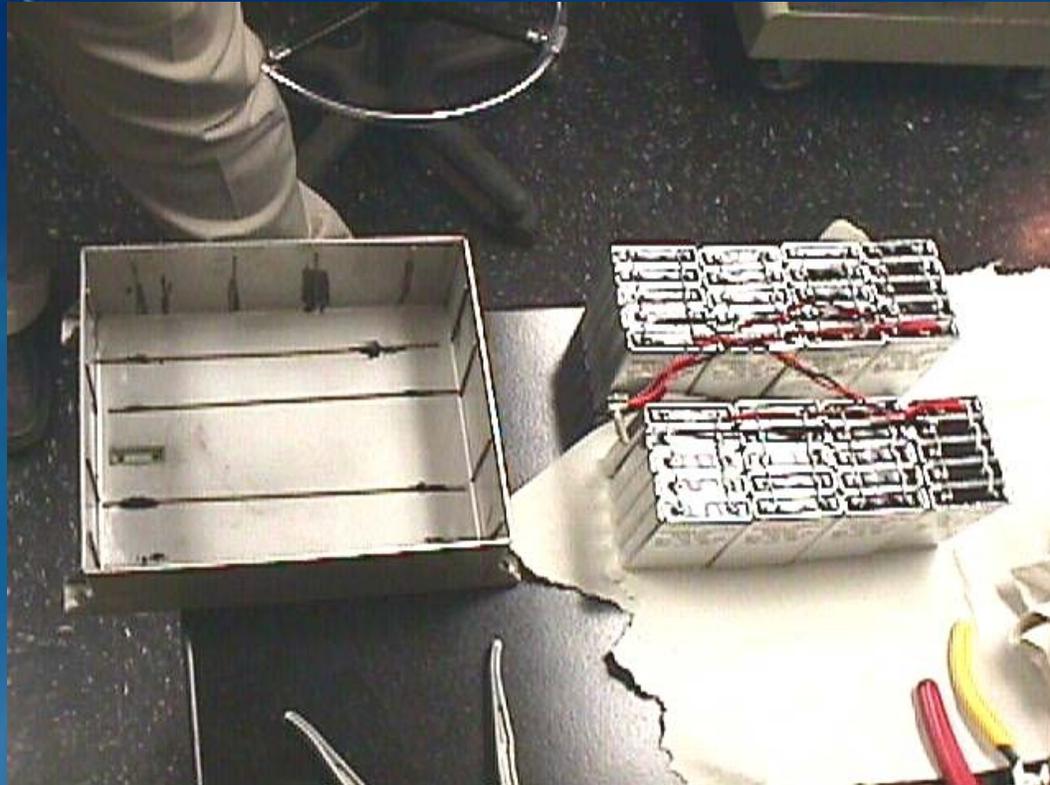
# Flatpack Capacitors

## 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 ( $V_r @ 125\text{ }^\circ\text{C}$ ) 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

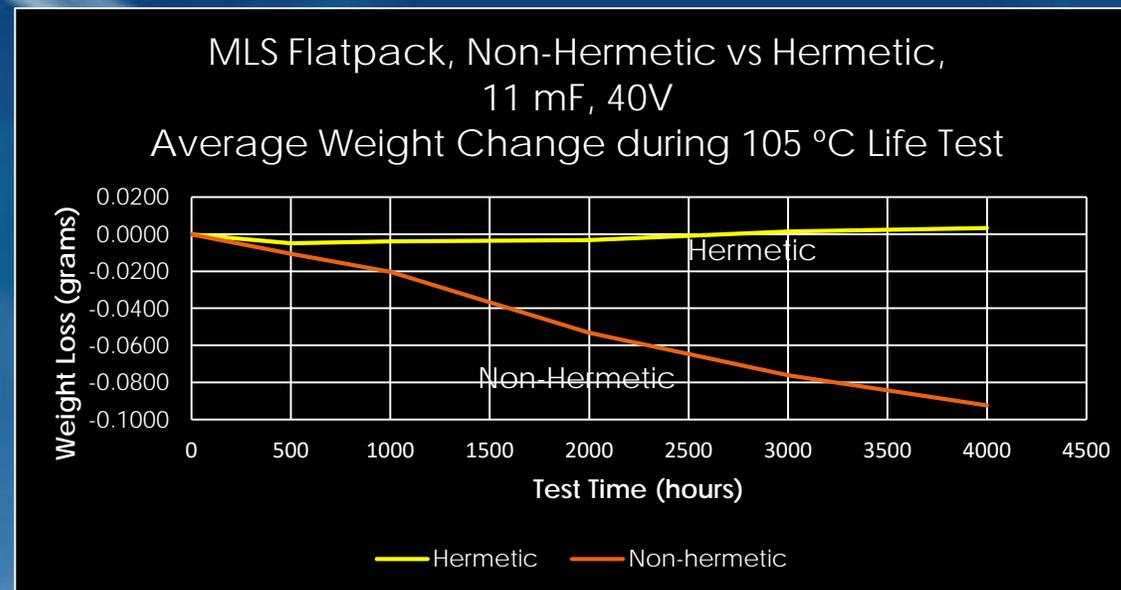


- THA & THAS Thinpack
  - THA (8.2mm, 85 °C)
  - THAS (9.0mm, 105 °C)



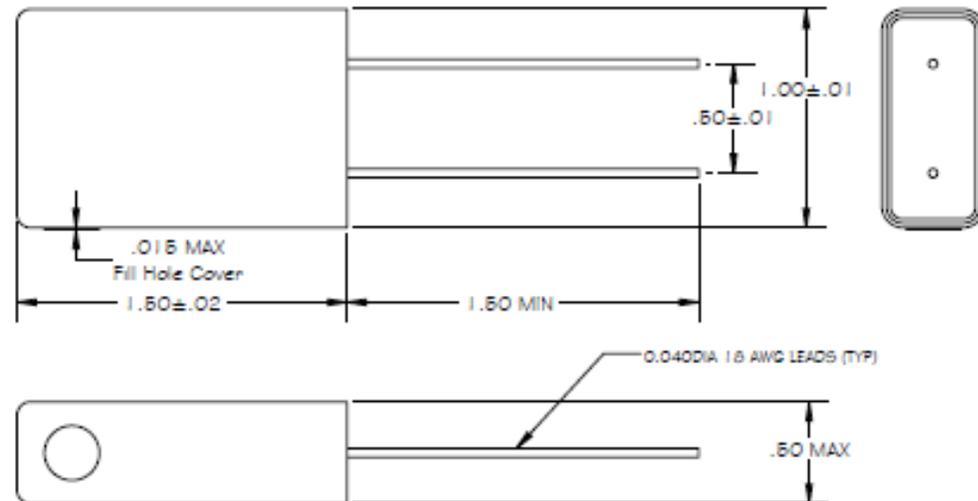
# MLSH, Hermetically Sealed Aluminum Electrolytic Capacitors

- Conventional 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.



# 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.



	MLSH, 2200 $\mu$ F, 40 Vdc @ 125 °C	4 x T4 Wet Ta 1000 $\mu$ F, 40 Vdc @ 125 °C
Capacitance @ 125 °C, 120 Hz	2100 $\mu$ F	4910 $\mu$ F
Cap Change at -55 °C, 120 Hz	-20%	-68%
Capacitance @ -55 °C, 120 Hz	1675 $\mu$ F	1580 $\mu$ F
Weight (g)	32	59
Cost	1X	2X

# 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 Cap



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



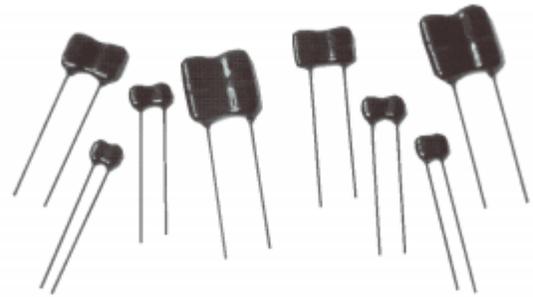
# Mica Capacitor Technology for Mil-Aero Applications

## Why Mica?

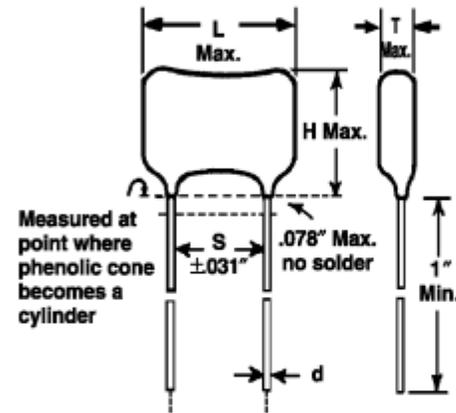
- ▶ Superb performance in RF Applications (e.g. military radios, cockpit communications)
- ▶ Capacitance stability with temperature, voltage and frequency.
- ▶ Robust package can withstand high shock & vibration and high altitudes.
- ▶ Wide temp range: (-55 °C to 125 °C standard, up to 200 °C)
- ▶ Tight 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.



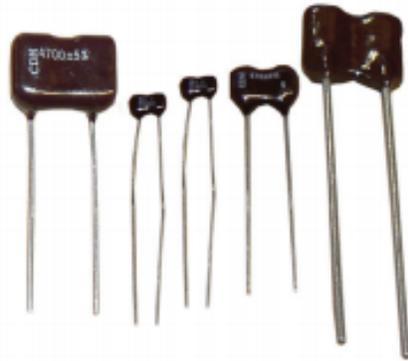
## Specifications

<b>Voltage Range:</b>	50 Vdc to 500 Vdc
<b>Capacitance Range:</b>	1 pF to 91,000 pF
<b>Capacitance Tolerance:</b>	±½ pF (D), ±1% (F), ±2% (G), ±5% (J)
<b>Temperature Range:</b>	-55 °C to +125 °C (O), -55 °C to 150 °C (P) P temperature range available only for CMR04, CMR05, CMR06, CMR07, CMR08
<b>Reliability:</b>	Meets Requirements of MIL-PRF-39001 Established reliability to .01%/1,000 hours failure rate

# Mica Capacitor Technology for Mil-Aero Applications – Standard Dipped

## 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/ $\mu$ s dV/dt pulse capability minimum
- Non-flammable units that meet IEC 695-2-2 are available

### Specifications

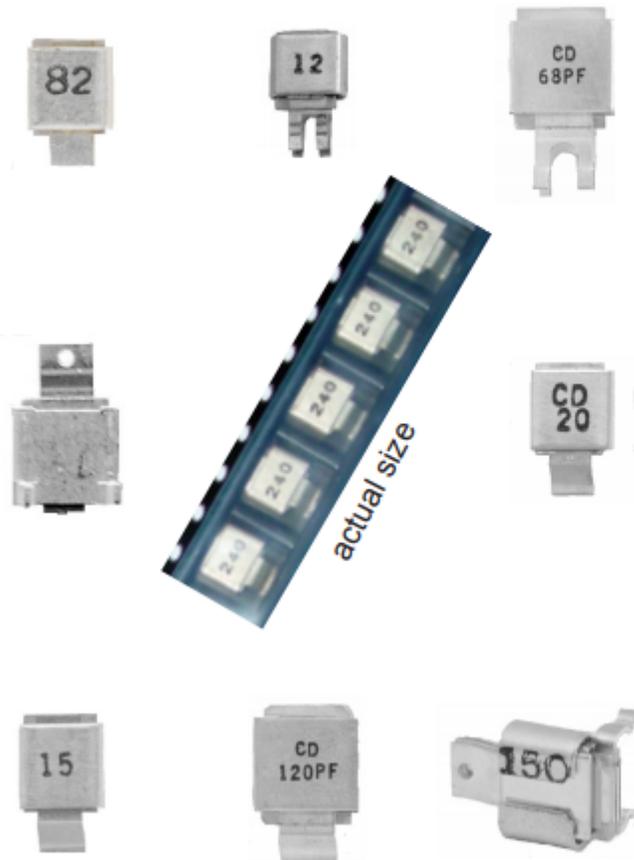
Capacitance Range	1 pF to 91,000 pF
Capacitance Tolerance	$\pm 1/2$ pF (D), $\pm 1$ pF (C), $\pm 1/2\%$ (E), $\pm 1\%$ (F), $\pm 2\%$ (G), $\pm 5\%$ (J)
Rated Voltage	100 Vdc to 2500 Vdc
Operating Temperature Range	-55 °C to +125 °C (O) -55 °C to +150 °C (P)*
Dielectric Strength Test	200% of rated voltage
RoHS Compliant	

\* 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 polytetrafluorethylene (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 ppm/°C compatible with FR4 PCBs
- Highly thermal conductive package
- Gull-wing terminal minimizes stress
- Typical 100 pF ESR, <11 m $\Omega$  @ 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  $\pm 0.25$  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 - High Vibration

 MLSG	125 °C, 5000 hr, Stainless Steel Flatpack, 50g, 80K altitude, longest life under rated conditions		-55 to +125	20-250	5000 @ 125	
 MLSG-S	125 °C, 5000 hr, Stainless Steel Slimpack, 80g, 80K altitude, volume constrained conditions		-55 to +125	10-250	5000 @ 125	
 MLSH	125 °C Hermetic Aluminum Electrolytic Slimpack, 80g, 80K altitude, volume constrained conditions		-55 to +125	30-250	5000 @ 125	
 AFK_V	High Vibration withstands 30 G		V-Chip	-55°C to +105°C	6.3-100	10-6800
 HZA_V	High Vibration, Very Low ESR		V-Chip	-55°C to +105°C	25-80	22-330
 HZA_V	High Vibration, Very Low ESR		V-Chip	-55°C to +125°C	25-63	33-330

# Military/Aerospace At A Glance

## CDE AT A GLANCE

### Capacitors for Military/Aerospace Applications

Cornell Dubilier Electronics excels 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 202 requirements.



### FLATPACK ALUMINUM ELECTROLYTIC CAPACITORS



#### FEATURES

- High Capacitance Retention at +55 °C
- Flat Form Factor for Tight Spaces
- High Vibration up to 80Gs
- High Reliability
- Available in Hermetic Case
- High Altitude up to 80,000 ft

#### TYPES

- MLP - Aluminum Case, 85 °C
- MLS - Stainless Steel Case, 125 °C
- HVMLS - High Vibration up to 50g
- HRMLS - High Reliability Burn-In
- MLSH - Hermetic Slimpack - RoHS
- MLSG - Flatpack and Slimpack - RoHS
- THA / THAS - Thinpack, High Energy Density

#### APPLICATIONS

- Ground-based and Shipboard Radar
- In-flight Power Supplies
- Commercial and Military Aircraft

<http://www.cde.com/solutions/military-aerospace/flat-pack-aluminum-electrolytics>

### 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 Piezoelectric Effect
- No Cracking

#### TYPES

- CMR - Dipped, High Rel., Meets MIL-PRF-39001
- CD, CDV - Dipped High Frequency
- MCM/MIN - Metal Clad for Ultra High Current

#### APPLICATIONS

- Military and Avionics RF Communications
- Cockpit Communications
- Manpack Radio
- In-flight Power Supplies

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



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

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**Thank You!**