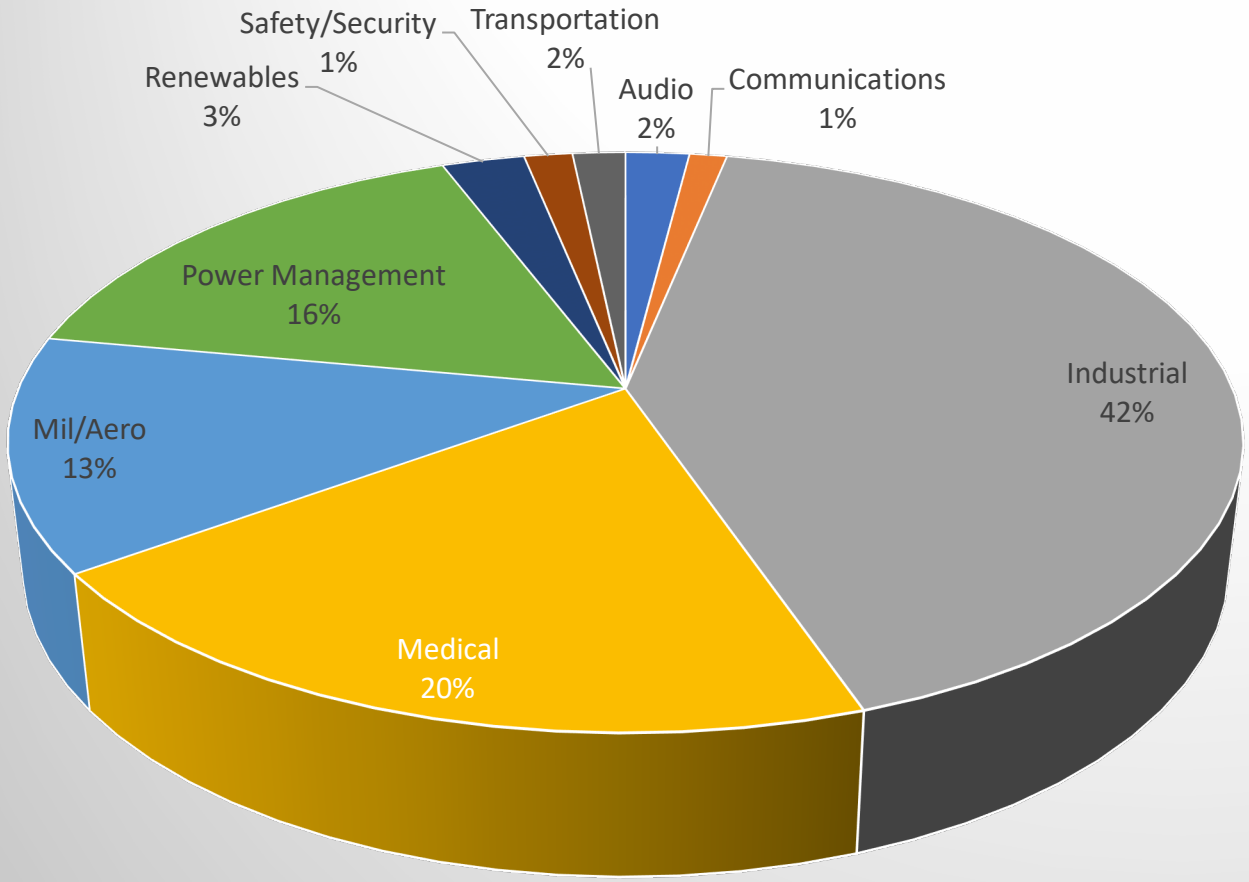
CAPACITORS FOR MILITARY & AEROSPACE

The presentation will begin shortly

CDÉ ENERGIZING IDEAS

CORNELL DUBILIER

Markets served



Total Company Market Breakout 2019

Markets

Audio (Audio amplifiers, guitar toning)

Communications (Routers, civilian communications)

Medical (Defibrillators, ventilators, medical lasers, MRI, X-RAY, medical equipment)

Mil/Aero (Military and commercial aircraft, radar systems, ground and in-flight communications, space

Power Management (UPS, flywheel energy storage, backup power systems, power factor correction**,** power conditioning)

Industrial (Motors, motor drives, welders, battery chargers, industrial lasers, lighting, pumps, oil and gas, misc. industrial)

Renewables (Wind, solar, fuel cell inverters)

Safety/Security (Tasers, fire and smoke, RFID, monitoring systems)

Transportation (Trains, commercial vehicles, farming and mining equipment)

Where our capacitors are used

Cornell Dubilier Electronics excels with capacitor technology to meet the demanding and often critical requirements for military and aerospace applications

Commercial and Military Aircraft

- On-board power
- Cockpit communications
- Wingtip lighting
- Ground-based power

Naval ships and submarines

- Power supplies and inverters
- Communication systems

Ground-based applications

- Radar systems
- Missile defense
- Two-way mobile radios
- DC link for inverters and power supplies used in military trucks and tanks

CDE ENERGIZING IDEAS CORNELL DUBILIER

Capacitor types we supply to Mil-Aero

Ruggedized

- High Vibration
- Wide temp range,
- Low Temp, especially -55 °C at the low end
- High Temp, up to 200 ºC
- High Altitude, up to 80,000 ft

Highly Reliable & Long-Life

- Stablility over a wide range of operating conditions
- Hermetic or near-hermetic
- Established reliability
- Burn-in
- Solder Terminals with 5 % minimum Lead content (No tin whiskers)

Space and Weight Saving

- Wet Tantalum Alternatives: Replace banks of wet tantalum with fewer components
- Compact, Low-profile
- Light weight

CDÉ CORNELL DUBILIER
ENERGIZING IDEAS

Capacitor technologies for Mil-Aero

CDE has four principal technologies used extensively in Mil-Aero application

Aluminum Electrolytic

Ruggedized form factors

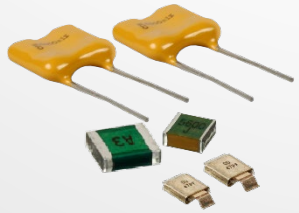
Space-saving

Alternative technology to wet tantalum capacitors

RF Mica

Stable over wide temperature and frequency range

High Reliability



Alternative technology to Class I ceramics

Specialty Film

High voltage, high energy discharge, high current

Supercapacitors

High energy and power density

CDE ENERGIZING IDEAS

CORNELL DUBILIER

Rugged aluminum electrolytic capacitors

Ruggedized

- High vibration versions available
- Wide temp range, especially -55 °C at the low end up to 175ºC at the high end
- Most capacitor types have been tested to 80,000 feet

Stable & Long-Life

- Decades of field experience
- Established Reliability Testing available
- Burn-in

- Wide range of sizes available
- Voltages from 6.3 to 550 Vdc with cap range from 100 µF to 3 F
- Solder Terminals with 5% minimum Lead content (No tin whiskers)

CDE CORNELL DUBILIER
ENERGIZING IDEAS

Rugged screw terminal aluminum electrolytic capacitors

Type	Description	Form Factor	Temperature (°C)	Voltage (Vdc)	Load Life (h@°C)
101C	Low-ESR, Wide-Temperature Grade		-55 to +105	7.5-250	5000 @ +105
125	Ultra-High Temperature, Military Grade, 125°C		-55 to +125	6.3-40	5000 @ +125
300/301	Low ESR		-55 to +105	6.3-250	4000 @ +105

CDE ENERGIZING IDEAS
CORNELL DUBILIER

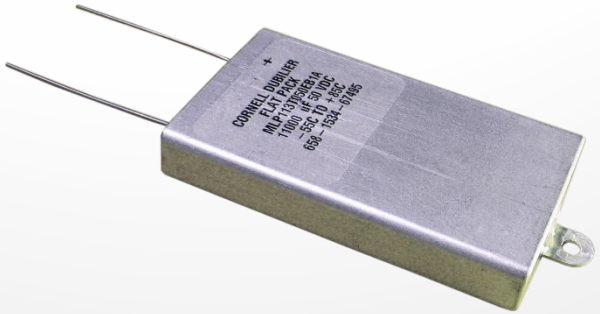
Flatpack aluminum electrolytic capacitors

Types MLP (85 °C) and MLSG (125 °C) have been used extensively in military/aerospace applications for more than 20 years

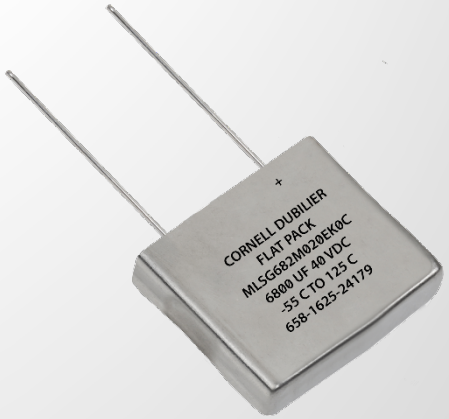
Applications:

- Radar
- Cockpit communications
- Aircraft Power Supplies

Program Examples:
KC135
F18
F22
X33 Space Shuttle
JSF Joint Strike Fighter
F18
F16
M1A2 Abrams
Bradley Fighting Vehicle



MLP, Aluminum Case (85 °C)



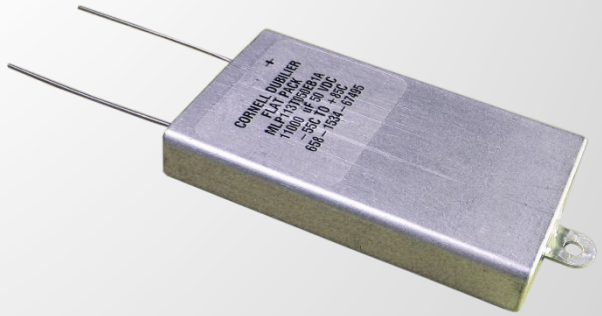
MLSG, Stainless Steel Case (125 °C)

CDE ENERGIZING IDEAS
CORNELL DUBILIER

Flatpack aluminum electrolytic capacitors

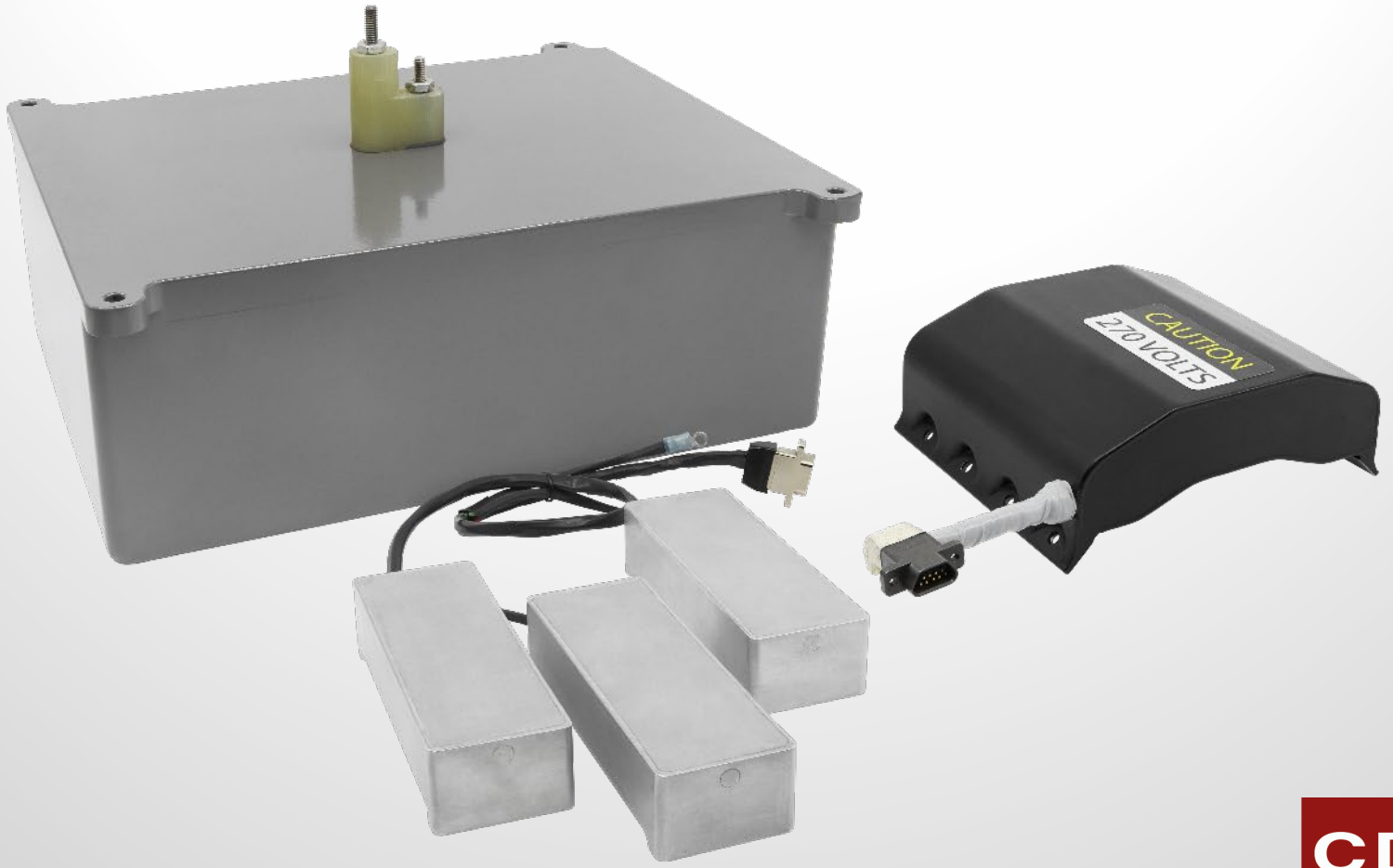
Flatpack Advantages

- Low profile, just 12.5 mm thin!
- Efficient, stackable form factor
- Heatsinking is simple and effective
- Extremely long life due to near-hermetic seal and high-purity materials
- Recent developments have allowed us to assign a 5,000 hour life rating (Vr @ 125 °C) to the MLSG series
- Superior low-temperature impedance up to 250 V
- Available with high vibration tolerance up to 50g



CDE ENERGIZING IDEAS
CORNELL DUBILIER

Custom aluminum electrolytic assemblies

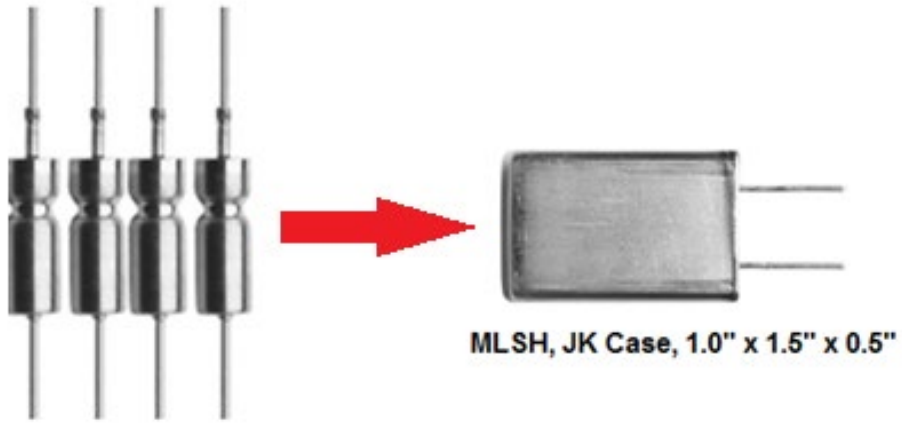


CDÉ CORNELL DUBILIER
ENERGIZING IDEAS

MLSH, hermetically sealed aluminum electrolytic capacitors

Alternative to Wet Tantalum Capacitors

- 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

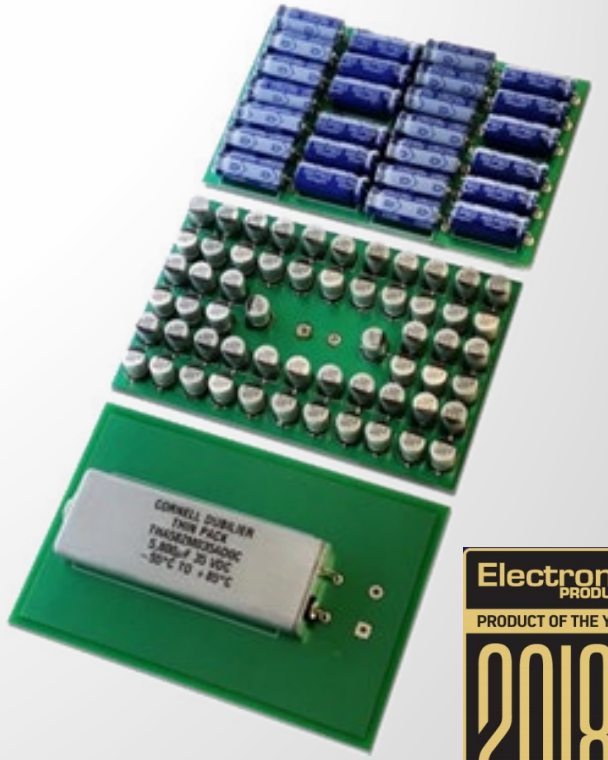


	MLSH, 2200µF, 40 Vdc @ 125 °C	4 x T4 Wet Ta 1000µF, 40 Vdc @ 125 °C
Capacitance @ 125 °C, 120 Hz	2100µF	4910µF
Cap Change at -55 °C, 120 Hz	-20%	-68%
Capacitance @ -55 °C, 120 Hz	1675µF	1580µF
Weight (g)	32	59
Cost	1X	3X

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 5,000 hr. life @ 85 °C
  - THAS 9.0 mm thin offers 5,000 hr. life @ 105 °C
- Designed for high capacitance bulk storage and filtering applications
- Alternative to arrays of SMT, radial or axial aluminum electrolytic and solid tantalum capacitors
  - Improves reliability– one device vs. many; fewer PCB connection points
  - Less weight
  - Lower cost



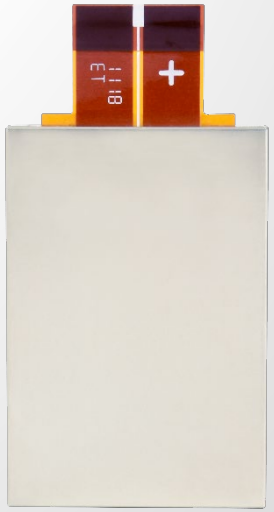
Electronic PRODUCTS
PRODUCT OF THE YEAR
2018 AWARD WINNER

CDE ENERGIZING IDEAS
CORNELL DUBILIER

ULP ultra-low profile

Ultra-thin package design: 2 mm or 3 mm

- One ULP capacitor can replace large banks of tantalum chip capacitors
- Up to 0.4J/cc energy density
- Values from 500 µF to 24,000 µF; 4 to 63 WVDC.
- Rated at 3,000 hours at 85 °C.
- Improves reliability – one device vs. many; fewer PCB connection points



Electronic PRODUCTS
PRODUCT OF THE YEAR
2019
AWARD WINNER

CDE
ENERGIZING IDEAS
CORNELL DUBILIER

PPC 1 mm aluminum polymer

Offers the highest energy density available in a 1 mm profile aluminum polymer technology

- Ideal for the lowest-profile circuits
- High ripple current, up to 60A
- Ideal for remote mounting locations
- 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
- PPC offers 2,000 hr. life @ 125 °C

Winner of the WTWH 2020 Leap Award
Category: Power Electronics
LEAP AWARDS

CDE CORNELL DUBILIER
ENERGIZING IDEAS

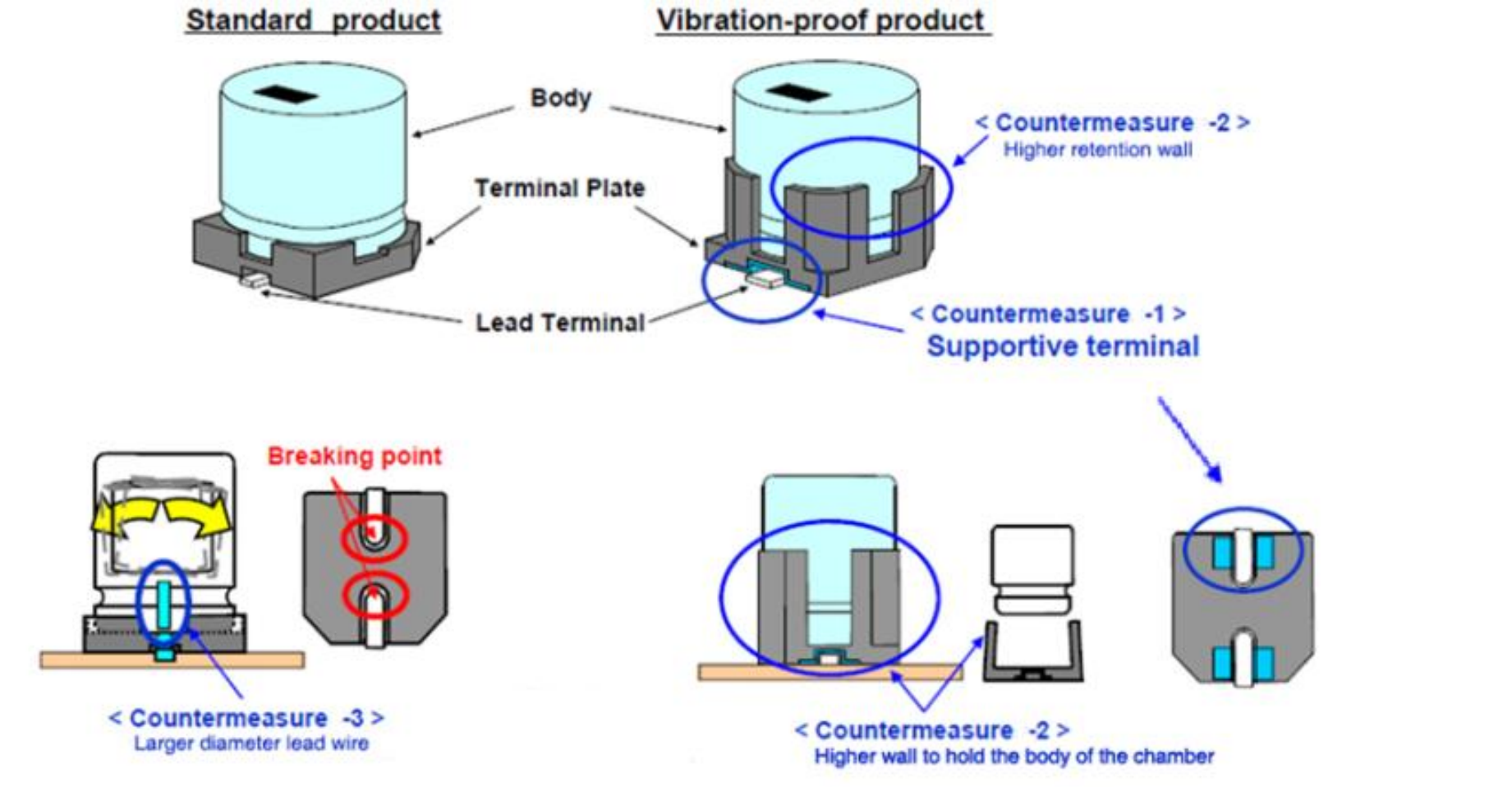
High Vibration, SMT aluminum electrolytic capacitors

SMT offerings in both Aluminum Electrolytic and Low Loss Hybrid Polymer-Aluminum Electrolytic capacitors with vibration withstand of up to 30G, AEC-Q200 Compliant

Type	Description	Form Factor	Style	Temperature (°C)	Voltage (Vdc)	Capacitance Range (µF)
AFK_V	High Vibration withstands 30 G		V-Chip	-55°C to +105°C	6.3-100	10-6800
HZA_V	Hybrid polymer, High Vibration		V-Chip	-55°C to +105°C	25-80	22-330
HZC_V	Hybrid Polymer, High Temperature, High Vibration		V-Chip	-55°C to +125°C	25-63	33-330

CDÉ CORNELL DUBILIER
ENERGIZING IDEAS

Vibration-proof design

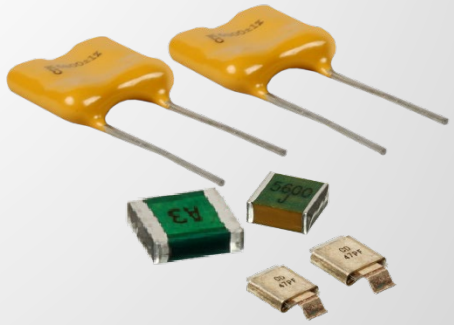


CDÉ CORNELL DUBILIER
ENERGIZING IDEAS

Mica capacitor technology

Why Mica?

- Superb performance in RF Applications up to 1 GHz (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 150 °C)
- Tight capacitance tolerance
- Alternative to Class I ceramics
  - No Cracking
  - No piezoelectric effect
- Established reliability for military applications
  - Burn-in



CDE CORNELL DUBILIER
ENERGIZING IDEAS

Applications for mica capacitors

Most are used for communications or in power supplies

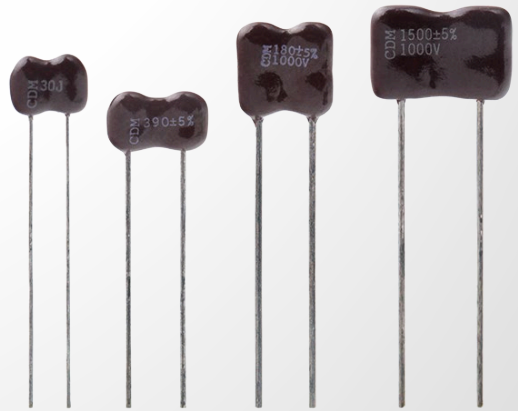
- Onboard communications
- Radar
- Aircraft Power Supplies
- Two-Way mobile radios
- Customers: Lockheed, Raytheon, Rockwell Collins, Northrop Grumman, UTC, Boeing, L-3, BAE, General Dynamics

CDÉ CORNELL DUBILIER
ENERGIZING IDEAS

Mica capacitor technology, high reliability

High-Reliability Dipped Capacitors/MIL-PRF-39001

- Type CMR dipped mica capacitors meet the requirements of MIL-PRF-39001
- Burn-in and testing meet established reliability requirements for high-grade ground-based and airborne applications such as radar systems, fighter jets and missile defense



CDE CORNELL DUBILIER
ENERGIZING IDEAS

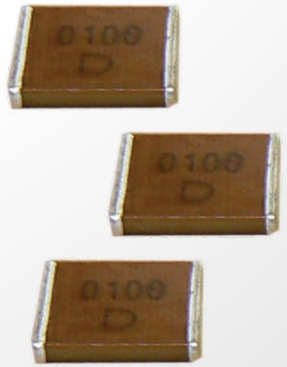
Mica capacitor technology, SMT chip

Applications

- •Alternative to Class 1 MLCCs
  - •No cracking
  - •No Piezoelectric effect
- •Signal coupling and decoupling
  - • Antenna coupling
- •Wave filters
  - • Band pass, band reject
- • Snubber

Where Used

- •Avionics instrumentation
- •Wireless communication
- •RF instrumentation
- •High frequency power supplies

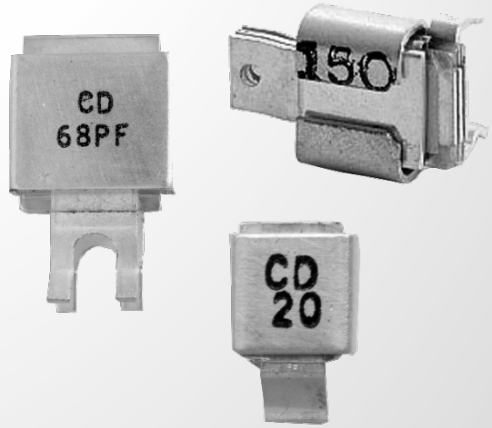


CDE CORNELL DUBILIER

ENERGIZING IDEAS

Metal clad mica

Benefits of Metal Clad Technology



Run Cool

Silver plated brass case and terminations act like miniature heat sinks, keeping the part cool by spreading the heat

Carry High Current

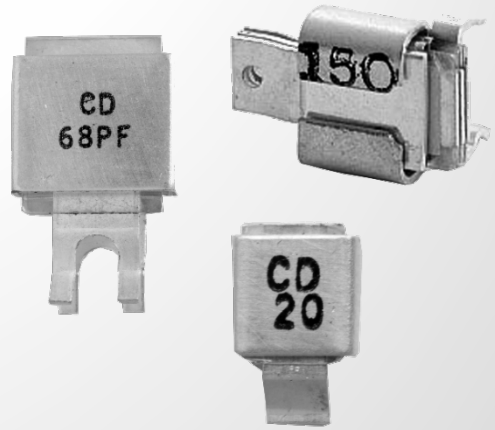
High Q , Ultra low resistance (ESR) keeps internal heating (I^2 x ESR losses) to a minimum at high current

CDE CORNELL DUBILIER
ENERGIZING IDEAS

Metal clad mica

Applications

- RF and microwave power amplifiers and transmitters
- Mobile radio – typically 10 to 200 watts
- Handheld, Manpack, vehicular and base station radios
- Airborne, ground, naval military & commercial radios
- Telemetry
- Alternative to multiple ceramic or porcelain caps



CDE CORNELL DUBILIER
ENERGIZING IDEAS

Film capacitor technology

Film Technology and Capabilities

- High current, low loss technology for inverter applications
  - DC Link
  - Snubber
- Low loss and high energy density for pulse discharge applications
  - Strobe lighting
  - Pulse forming networks – High Energy Discharge (e.g. railgun)
- Custom packaging

Military defense, weapons, propulsion systems and research

• Air defenses • High-power lasers • Electromagnetic Propulsion •Rail Gun • Strobe lights • Particle accelerators • Radar systems

CDE ENERGIZING IDEAS CORNELL DUBILIER

Custom power film

Designed and tested for the most challenging military applications

Cornell Dubilier excels at the design and manufacture of custom high energy storage and power conversion applications

Pulse Discharge

- Strobe Lighting (wingtip, runway)
- Lasers
- Electromagnetic Launchers (projectiles, aircraft)

Inverters

- DC Link
- Snubber

CDE CORNELL DUBILIER
ENERGIZING IDEAS

Supercapacitor technology

Our Supercapacitor cells and modules are used in a wide variety of energy storage, power backup applications. Standard cells available in coin type or radial form factors up to 3.0 Vdc or work with us to develop a higher voltage custom module with active or passive balancing

Applications:

- Autonomous Weapons
- Guidance Control Systems
- Security
- UPS
- Drones
- Vehicle Fire Suppression Systems

CDE CORNELL DUBILIER

ENERGIZING IDEAS

Military testing & standards

CDE has a full range of testing capabilities for military applications

Mil Certified Test Lab

- 500g shock
- Vibration (random and sine)
- High temperature/low temperature thermal cycling
- Humidity test
- Moisture resistance
- 400Hz 120A ripple test
- Pulse Discharge Testing

Mil Certified Test Lab

- MIL STD 202 (test procedures)
- MIL STD 790 (DOD standard practices)
- MIL STD (testing)

CDE CORNELL DUBILIER
ENERGIZING IDEAS

Thank You!