VISHAY

The DNA of tech.®

Maximum Energy Density Tantalum Capacitors for High Reliability Applications

CMSE

"WHERE COMPONENT ENGINEERS MEET"

Jon Rhan

What Is Tantalum?

- Chemical element, silver-gray metal. Atomic number 73. High density, high melting point (3269 ºC), high resistance to acids
- Discovered in 1802 by Anders Ekeberg, Sweden
- Commonly found as an oxide mineral in combination with columbium (same as niobium) ore – known as “tantalite.” Largest sources are in Africa, Australia, Brazil, Canada, China, and Thailand
- Complex multi-step chemical and metallurgical process used to convert tantalite into capacitor-grade tantalum powder
- Besides the capacitor industry, tantalum metal in various forms is used in the chemical industry, electronics, aerospace, and nuclear equipment

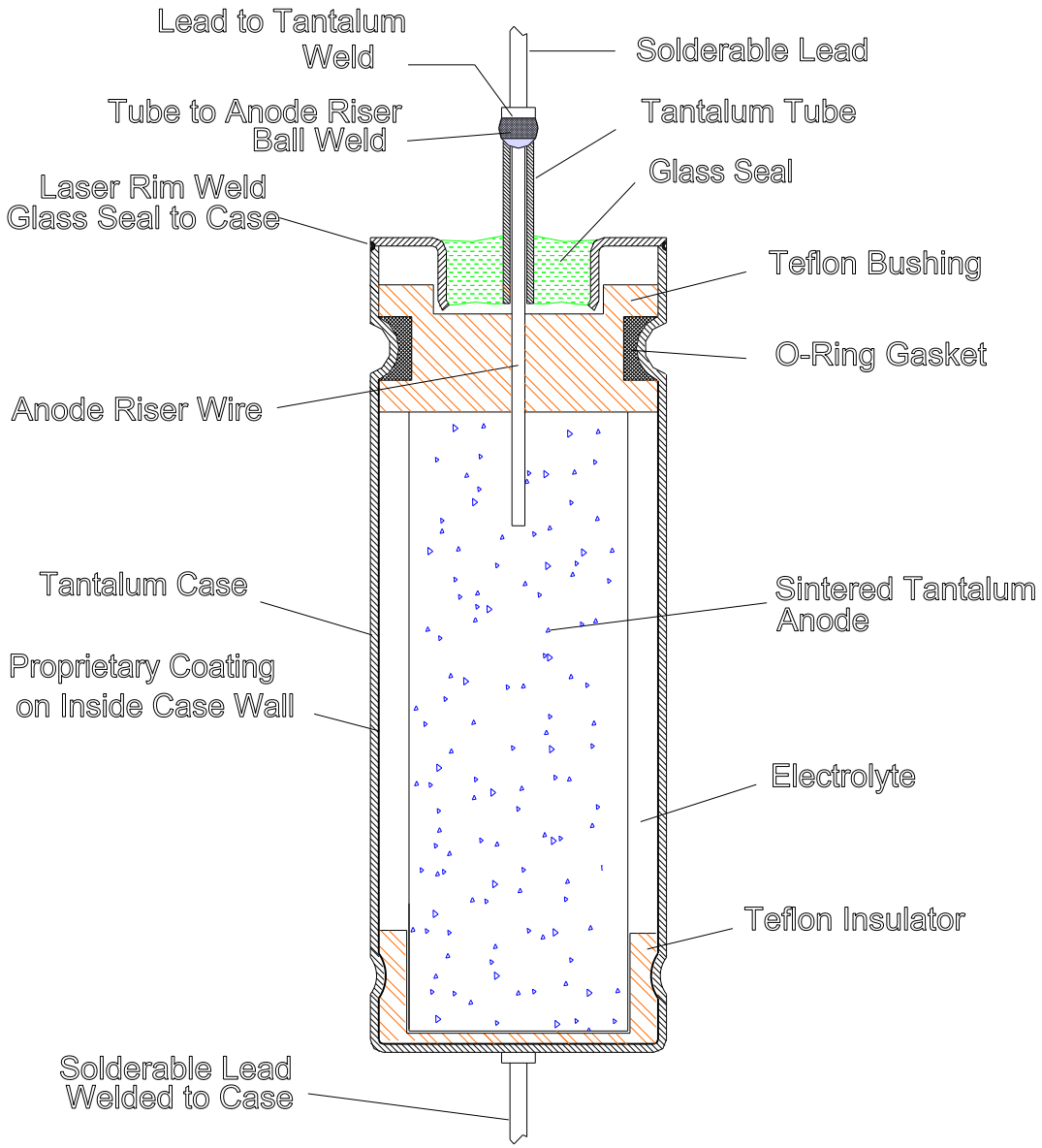
Why Tantalum Capacitors?

- Combination of high dielectric constant ε, large surface area A, and thin dielectric d allows tantalum capacitors to reach the highest capacitance per unit volume:

  Capacitance $C = \varepsilon A/d$

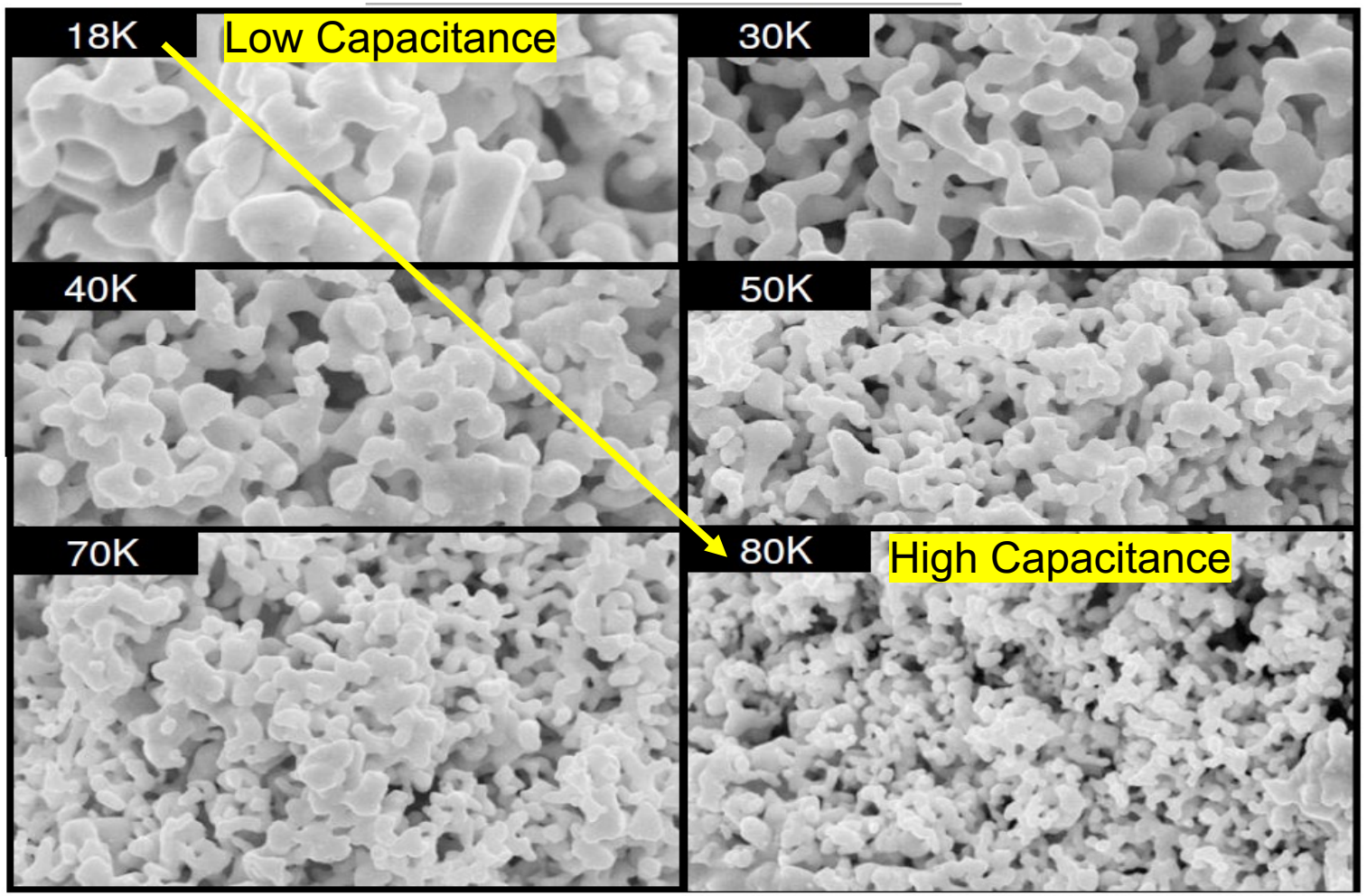
- Most volumetrically efficient (CV/cc, E/cc)
- Practically unlimited service life
- Wide temperature range (-65 ºC to +230 ºC)
- High reliability
- Stable capacitance (no temperature or bias effects), DCL (t)

Wet Tantalum Capacitor Construction

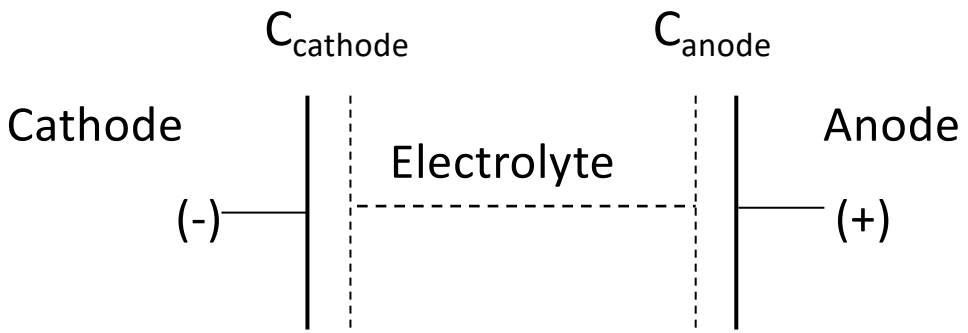


Sintered Tantalum Anode Made of High Purity Tantalum Powder

- It is common to define the specific charge of tantalum powder in [KCV/g]. A higher value of CV/g means that the particle size is smaller, hence the surface area and capacitance are larger

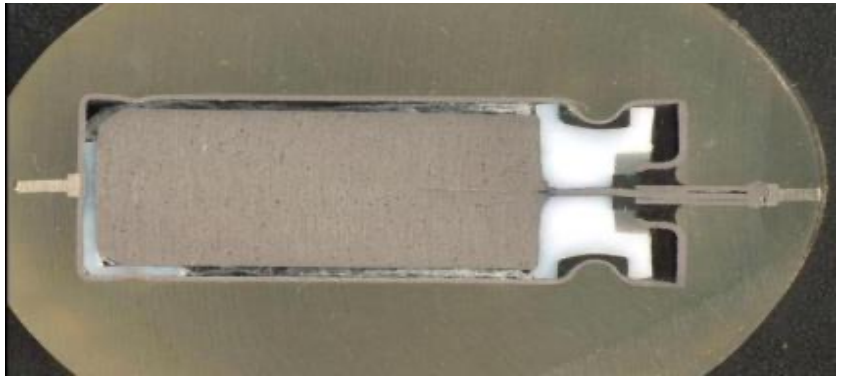


Wet Tantalum Capacitance



$$1/C_{total} = 1/C_{anode} + 1/C_{cathode} \qquad C_{cathode} \gg C_{anode}$$

$$1/C_{total} = 1/C_{anode} + 0 \qquad \gg\gg\gg\gg \qquad C_{total} = C_{anode}$$



WETS CAPACITANCE EXPLANATION

Cathode CAP

1. Large surface area
2. Extremely thin dielectric layer
3. EDLC and pseudo-capacitance effect

Anode CAP

1. Powder CV (particle size)
2. Sintering, density, weight
3. Dielectric thickness determines capacitor voltage

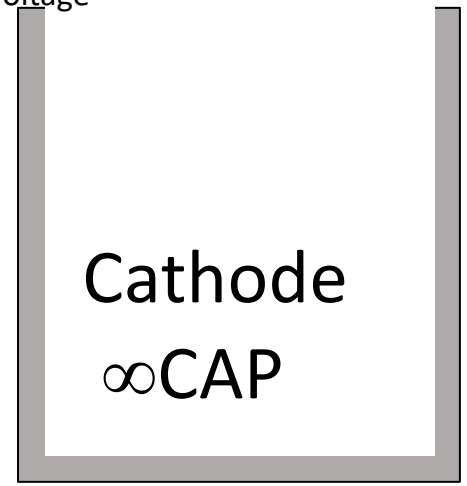
$$C = \varepsilon_0 k \frac{A}{d}$$

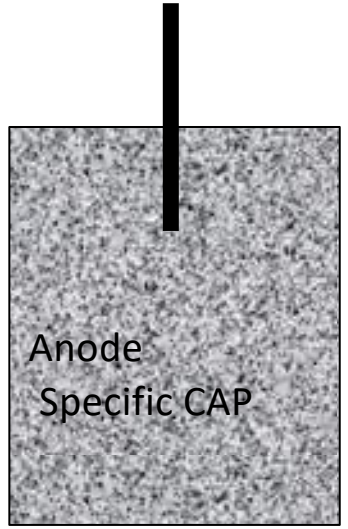
ε_0 - vacuum permittivity constant

k - dielectric constant of material

$$\frac{Dielectric}{Thickness} \propto Voltage$$

$$\frac{Dielectric}{Thickness} \propto {}^{1}/_{Cap}$$





Anode Capacitance

Formula of capacitance : $C = \varepsilon A/d$, where:

C - capacitance

ε - dielectric constant of material ($Ta_2O_5 \sim 27$)

A - surface area of a plate – *defined by Ta powder CV/g*

d - thickness of dielectric film

d = 17Å/v ∗ V formation. A thicker dielectric means a higher voltage capacitor

Cathode Capacitance

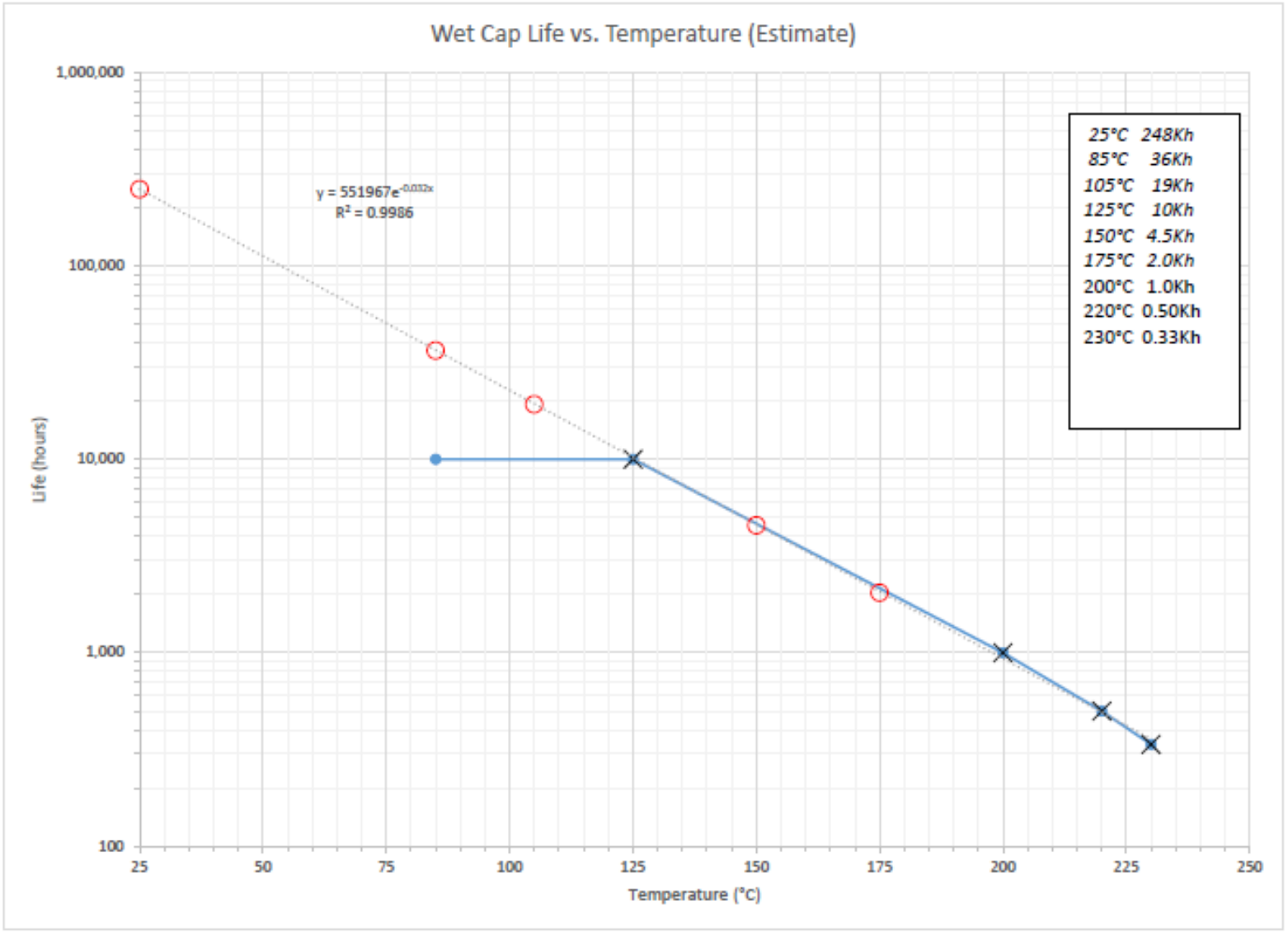
Type 1: Ta cathode – high capacitance due to very large surface area and extremely thin dielectric film. Reverse voltage capability!

Type 2: Pd cathode – extremely high capacitance due to pseudo-capacitance (charge transfer) effect.

Why Wet Tantalum Capacitors?

- ✓ Best in class volumetric efficiency; energy density up to 2 J/cc, capacitance levels up to 72 mF
- ✓ Wide voltage range: 10 V – 150 V
- ✓ All tantalum, hermetically sealed case; no humidity-related wear-out mechanism
- ✓ Low leakage current for long term stability
- ✓ High reliability – up to MIL FRL = R (0.01 % / 1000 h)
- ✓ Reverse voltage capability on select products
- ✓ Non-burning failure mode
- ✓ Available in surface-mount and thru-hole constructions
- ✓ Long operation life; qualified for
  - ❑ 10 000 h; MIL products; established reliability
  - ❑ 2000 h; 85 °C at RV, 125 °C at 67 % RV
  - ❑ 1000 h at 200 °C at 50 % to 60 % RV
- ✓ Capable of withstanding harsh mechanical conditions / environments suitable for various AMS applications; up to
  - ❑ 300 cycles thermal shock from -55 °C to +125 °C
  - ❑ 500 g shock
  - ❑ 80 g high frequency vibration
  - ❑ 54 g random vibration

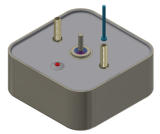
Wet Tantalum Life Prediction Curve



Wet Tantalum - High Energy Designs

Hermetically sealed

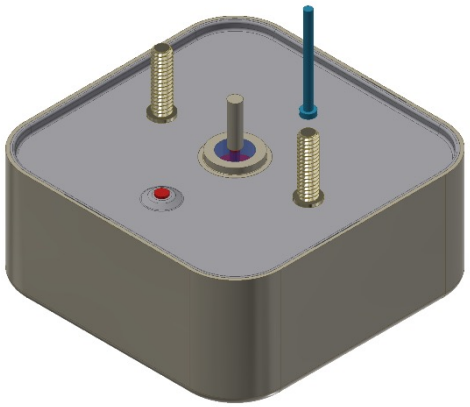




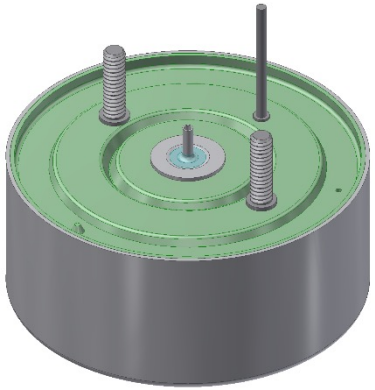
Commercial Series	HE Series	T22 / T24	EP
Military	DLA 10011	DLA 19001, Space Grade: 20012 includes LAT	DLA 20002
Operating Temperature	-55 °C to +125 °C	-55 °C to +125 °C (200 °C for T24)	-55 °C to +125 °C
Capacitance Range	1100 µF to 72 000 µF	10 µF to 110 µF	1500 uF to 96 000 uF
Voltage Range	25 VDC to 125 VDC	50 VDC to 125 VDC	25 VDC to 125 VDC
Case Sizes	A, B, C	C 0.354 [9.0] x 0.279 ± 0.008 [7.1 ± 0.2] x 0.291 ± 0.008 [7.4 ± 0.2] 0.098 ± 0.008 [2.5 ± 0.2]	*A*, B, C, *D*
Failure Rate	Non-ER	S = 48 h burn-in	Non-ER
Vibration	50 G shock, 20 G sine, 12 G random	500 G shock, 80 G sine, 53.79 G random	50 G shock,20 G sine, 19.4 G random
Features	Mounting studs available	NASA paper: https://nepp.nasa.gov/files/29192/NEPP-TR-2018-Teverovsky-T22-Capacitors-TN52048.pdf	Molded modules

EP2 / HE5 High Energy Capacitor Series

EP2C



HE5C



Wet Tantalum Hybrid Capacitors, High Energy, Ultra High Capacitance, -55 °C to +125 °C Operation

FEATURES

- High energy, very high capacitance design
- All tantalum, hermetically sealed case
- Utilizes Vishay proven SuperTan® technology
- EP1A and EP2: 2 termination options: SMD and radial
- PATENT(S): www.vishay.com/patents
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free Available

RoHS* Available

Note

* This datasheet provides information about parts that are RoHS-compliant and / or parts that are non RoHS-compliant. For example, parts with lead (Pb) terminations are not RoHS-compliant. Please see the information / tables in this datasheet for details

LINKS TO ADDITIONAL RESOURCES

3D Models

APPLICATIONS

- Industrial
- Avionics / military / space
- Ideal for capacitor banks

PERFORMANCE CHARACTERISTICS

Operating Temperature:
-55 °C to +85 °C (to +125 °C with voltage derating)

Capacitance Tolerance:
at 120 Hz, +25 °C ± 20 % standard
± 10 % available as special

Contact marketing for availability of 10 % tolerance

DC Leakage Current (DCL Max.):
at +25 °C: leakage current shall not exceed the values listed in the Standard Ratings tables.

Life Test:
capacitors are capable of withstanding a 2000 h life test at a temperature of +85 °C at the applicable rated DC working voltage.

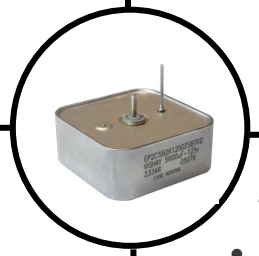
EP Series High Energy Capacitors

Our Advantage

- Largest capacitance in a given package size and voltage rating
- Surface-mount option

What You Should Know

- Hermetically sealed
- Lowest DCL of any tantalum technology
- Available as DLA15010 (on selected ratings)
- Available in array form to reach higher voltages or more capacitance



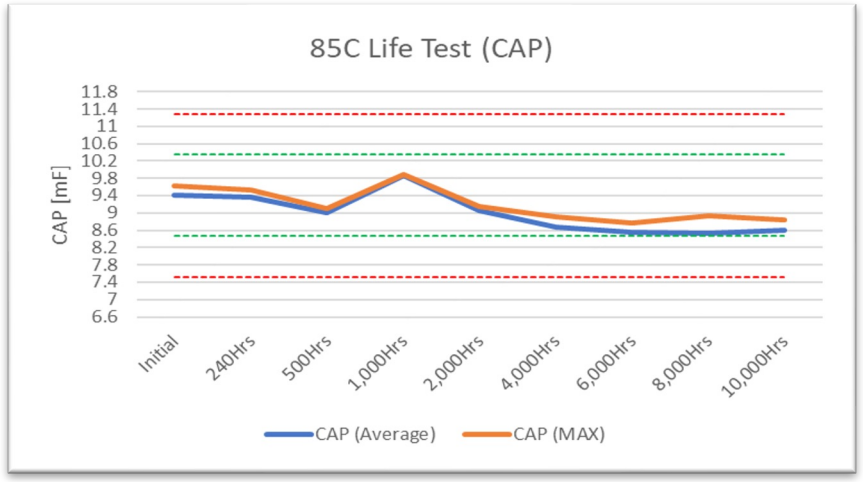
Specifications

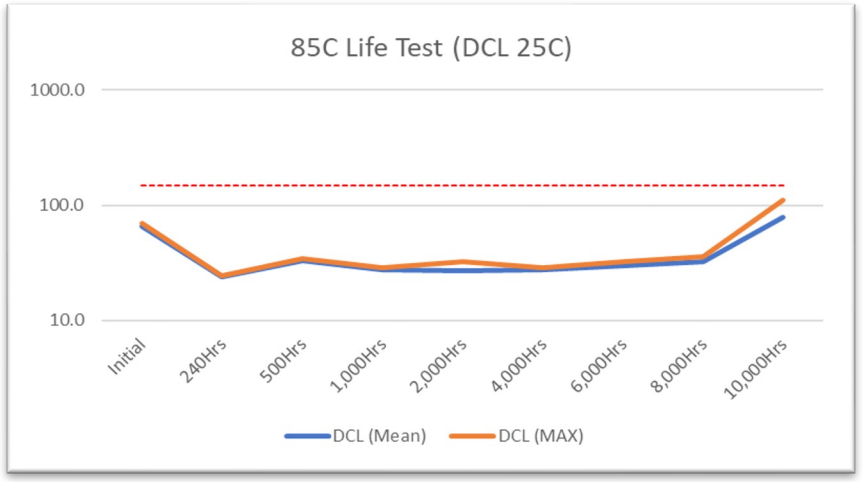
- Capacitance range: 1500 µF to 96 000µF
- Voltage range: 25 V to 125 V
- Operating temperature range: -55 °C to +125 °C
- 2000 h life tested at 85 °C and rated voltage

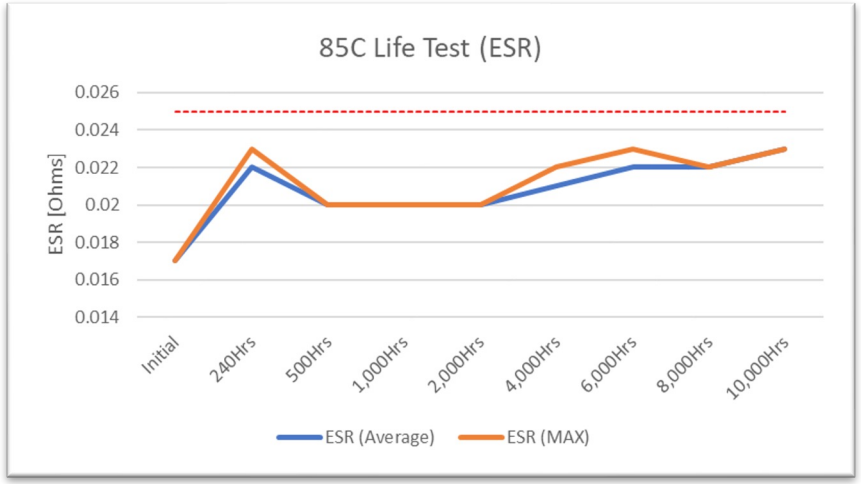
Market Segments / Applications

- Avionics
- Pulsed radar and communications
- Holdup power
- Capacitor banks
- Onboard aircraft WiFi

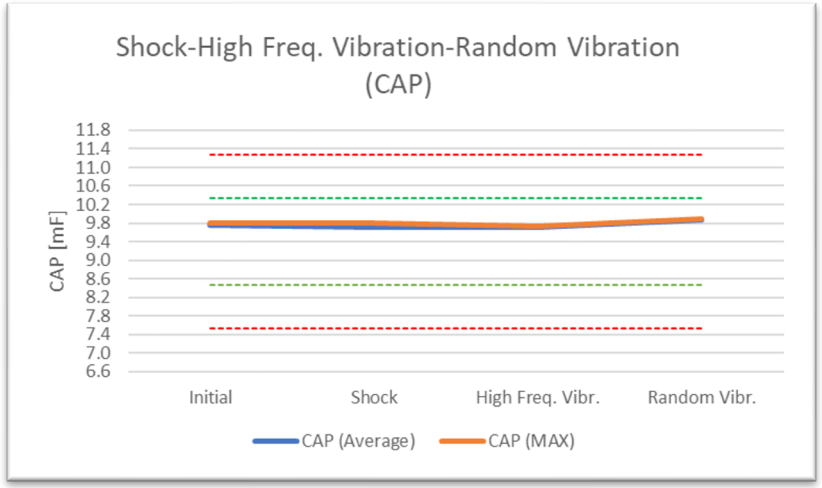
EP2B 9.4 mF – 63 V Reliability Performance

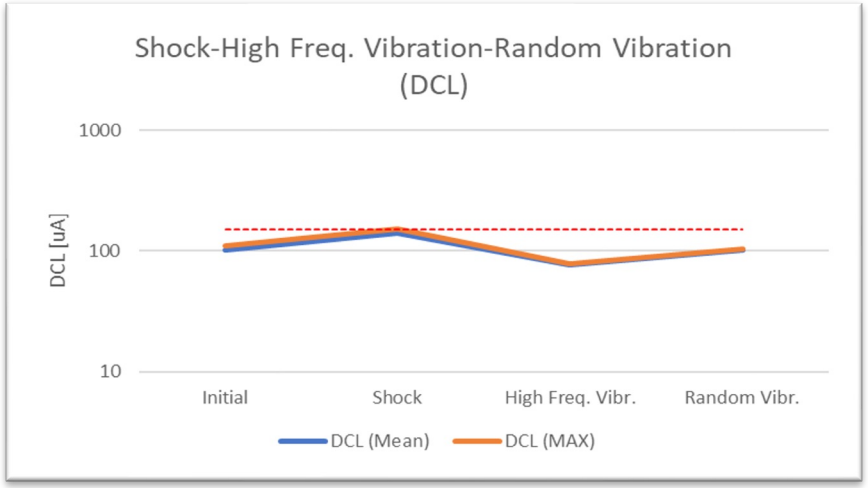


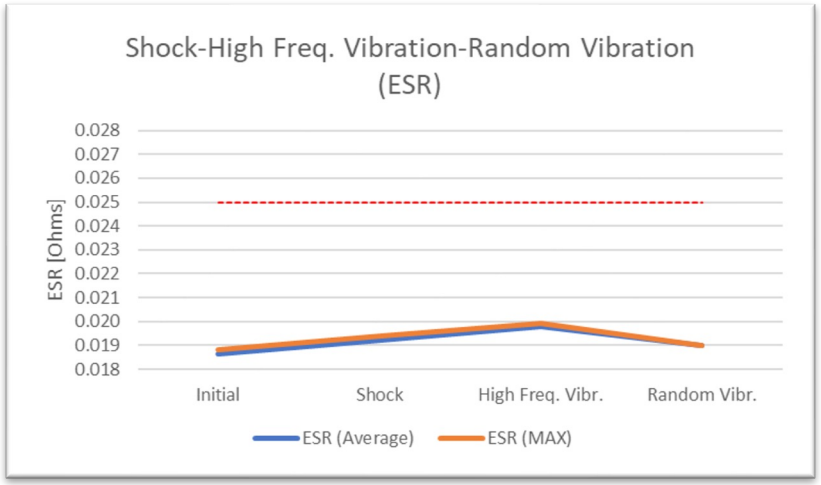




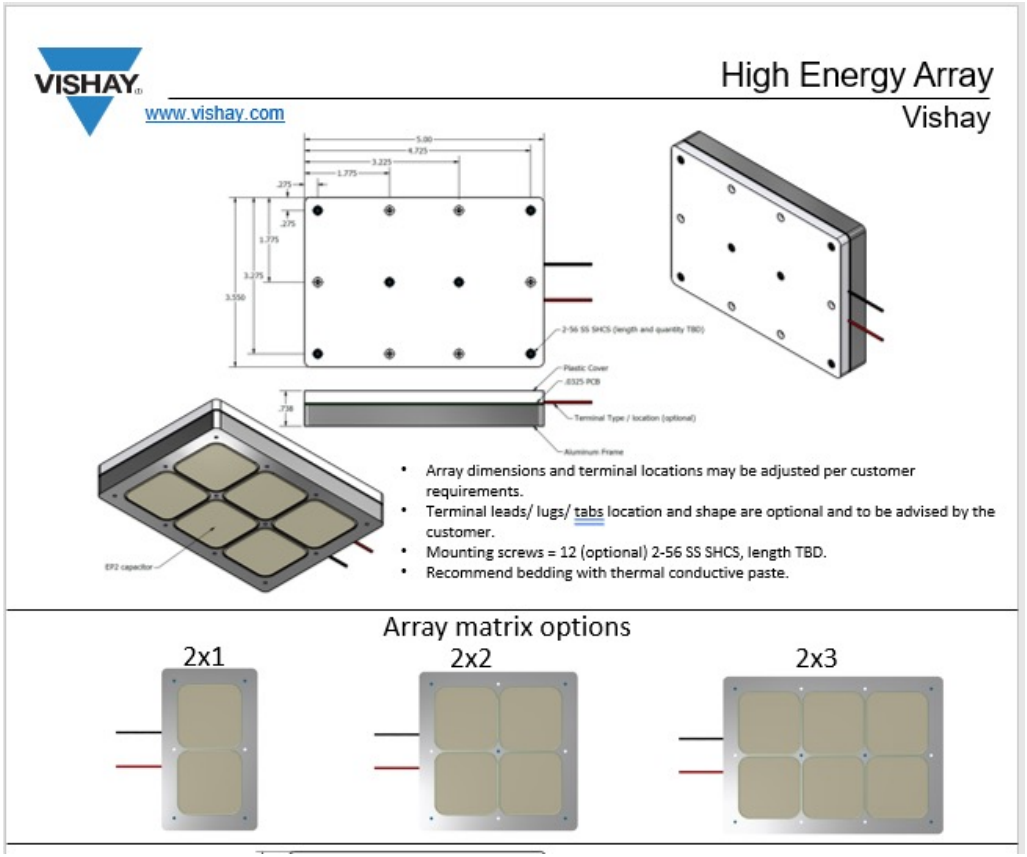
EP2B 9.4 mF – 63 V Reliability Performance







EP2 Arrays



- Any termination is feasible
- Up to 750 V in 2 x 3 configuration
- Up to 36 mF at 125 V
- 2 x 2 array – 1400 uF at 500 V
- 1 x 3 array – 1900 uF at 375 V
- 1 x 2 array – 88 mF at 50 V