Hybrid Capacitor Technology for Hi-Rel Applications

What is a Hybrid Capacitor?

EVANSCAPS are hybrid wet tantalum capacitors. The operating principal lies within the combination of a Tantalum (Ta$_2$O$_5$) anode and a Ruthenium Oxide (RuO$_2$) cathode.

- Two electrodes $1/C_c$)
- The TaO$_5$ dielec   ges
- The high capac
- These series ce   ng all the
  benefits of parallel capacitor connection.

$$C_cV_c = Q = C_aV_a$$

Hybrid Capacitor and Unique Advantages

- Improved Electrical Performance

- Reliability

- SWaP Savings

- Stability and Desirable Frequency Characteristics

- Key parameters such as Size, Weight and Power

Top Critical Considerations: Environmental

- -60°C to 125°C and Beyond
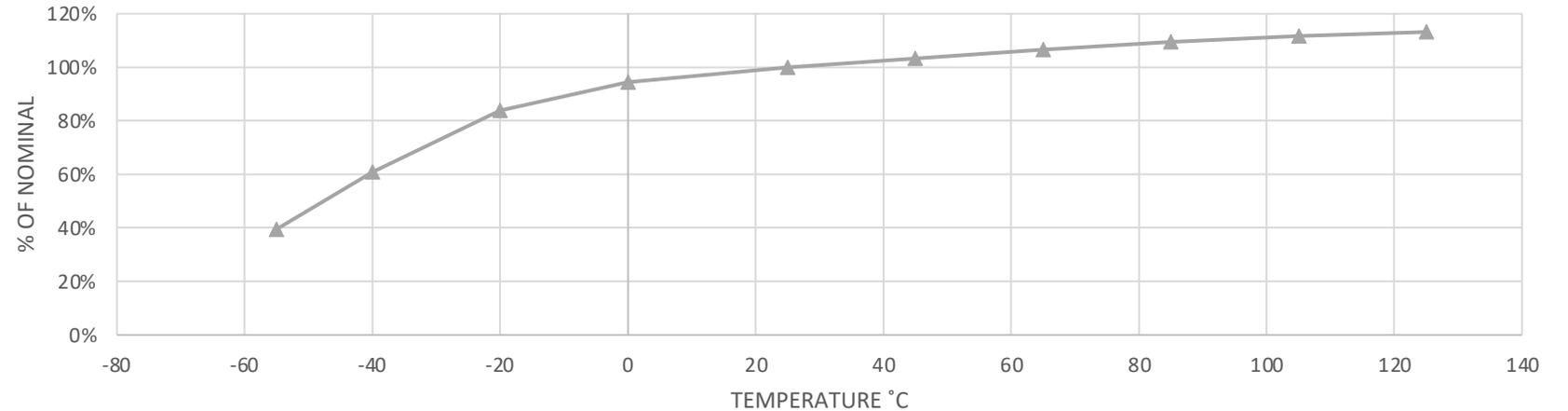- High Altitudes
- Underwater
- High Shock and Vibration
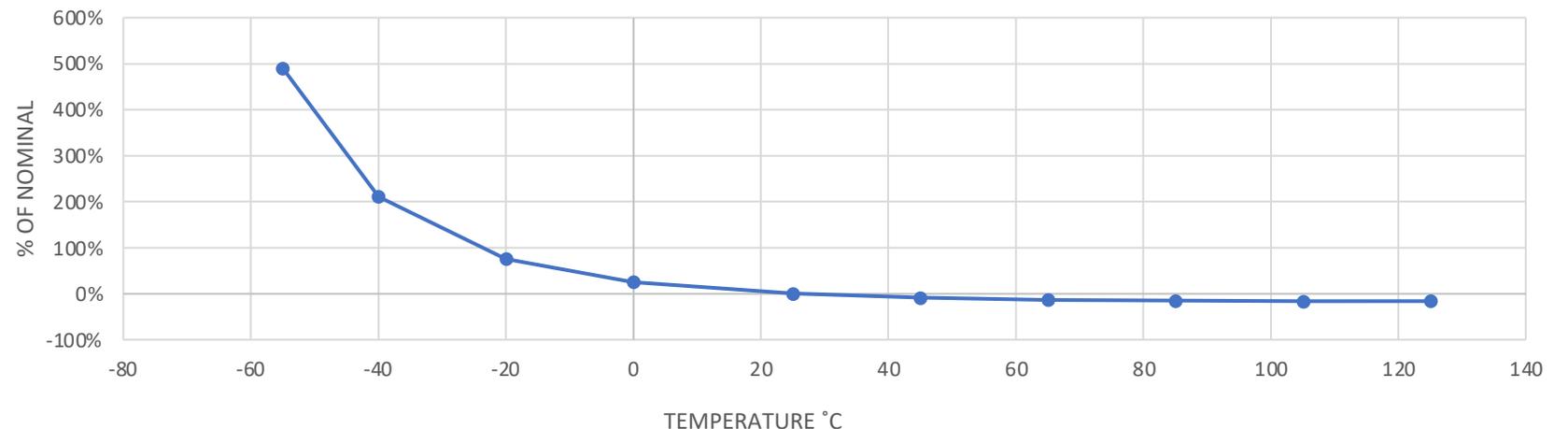
Top Critical Considerations: Electrical

- Low ESR and ESL

- Provide High Quality Pulse with Minimal Voltage Droop

- Generate Less Heat and Allows for the Elimination of Cooling Systems

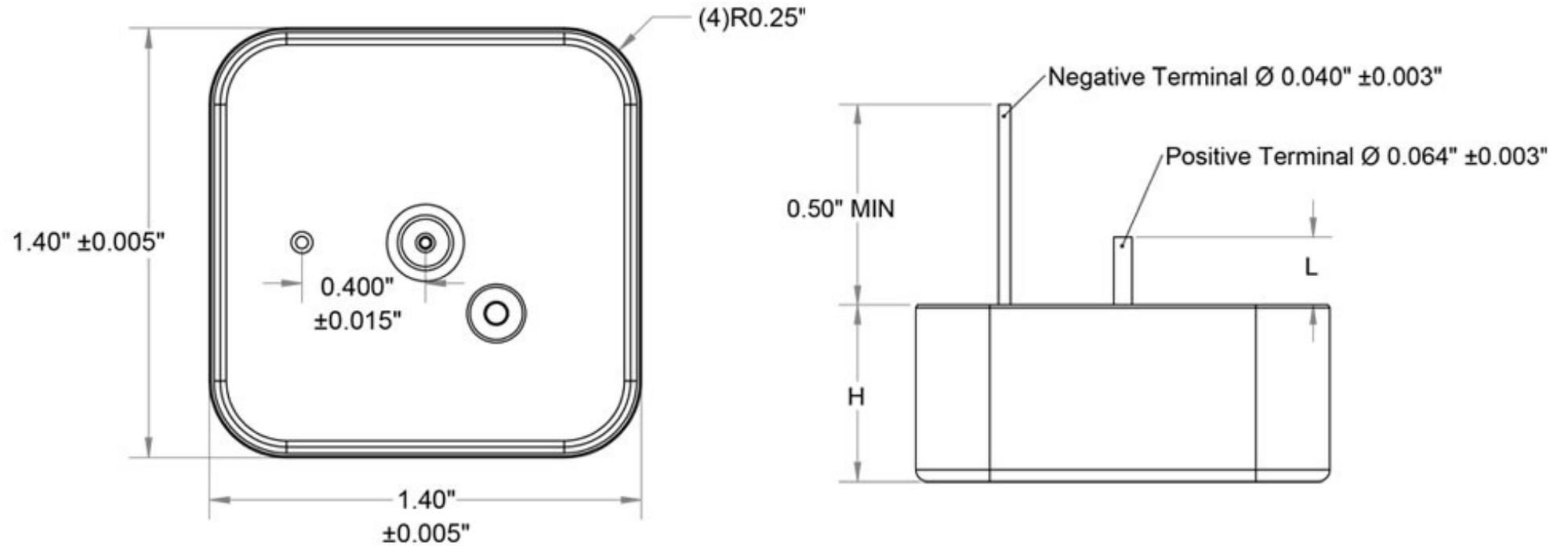- Allow Designers to Reduce Capacitor Size, Weight and Cost
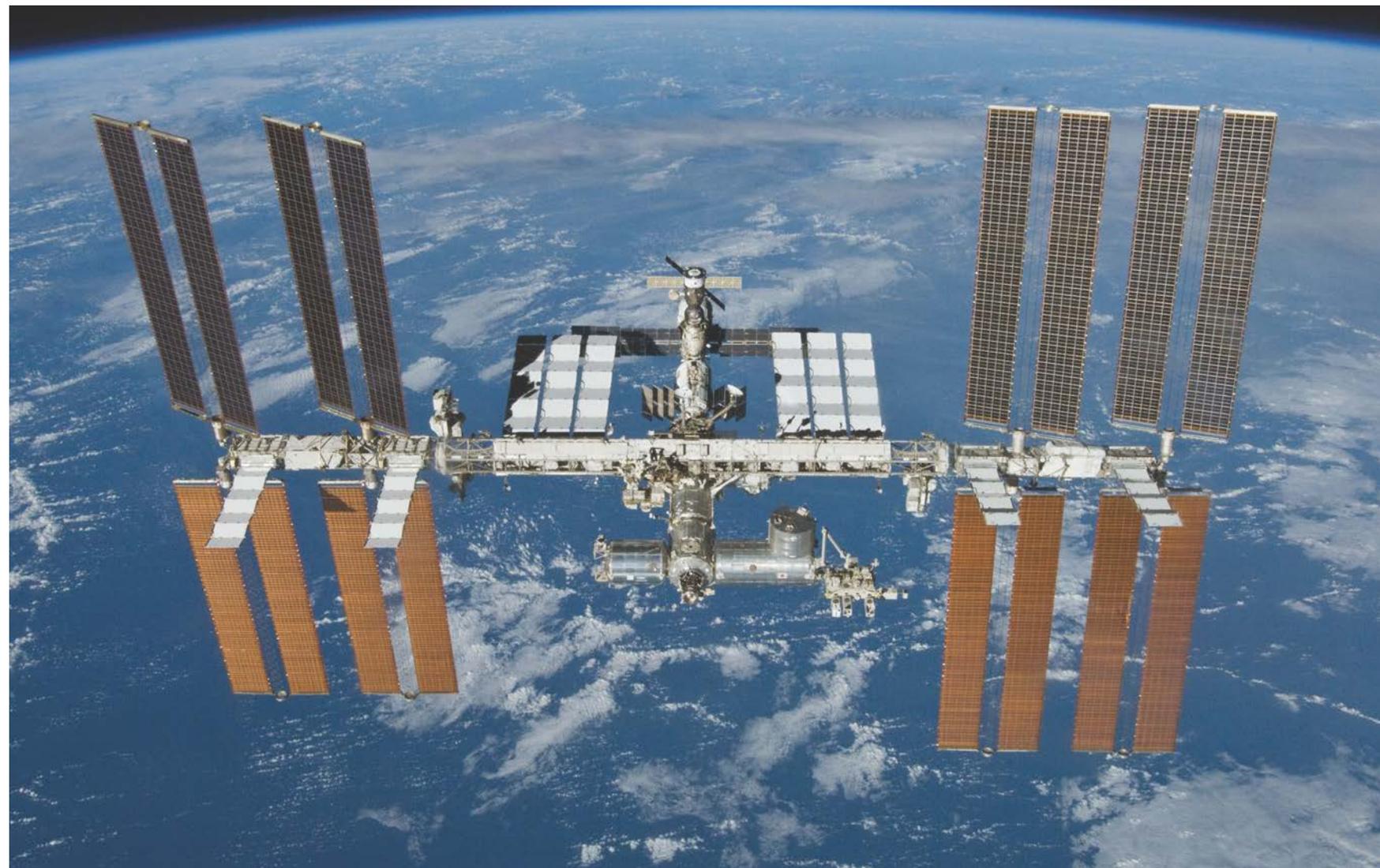

CAPACITANCE VS TEMP_TDD SERIES

ESR VS TEMP_TDD SERIES

Top Critical Considerations: Mechanical

Top Critical Considerations: Reliability

Capacitor Comparison

ASSUMPTIONS	
Working Voltage	**28**
Current (A)	**20**
Pulse Width (sec)	**0.002**
Allowable Volt Droop (V)	**1.75**

Description	Tantalum Wet	Hybrid Polymer	Tantalum Polymer	Slim Pack Aluminum	Stainless Steel Case Aluminum	Evans Tantalum Hybrid
Cost estimate	$ 85.00	$ 2.27	$ 30.00	$ 12.00	$ 190.00	$ 520.00
Voltage Rating	35	35	35	35	40	35
Capacitance Rating (F)	0.0028	0.00027	0.00033	0.0058	0.001	0.032
ESR (ohms)	0.35	0.02	0.18	0.05	0.036	0.02
Volume (L x W x H)	0.15	0.06	0.01	0.80	2.63	0.88
Weight (g)	15		5.54	20	93	86
# SERIES	1	1	1	1	1	1
#Parallel	12	85	74	5	3	1
Total Capacitance	0.034	0.023	0.024	0.029	0.003	0.032
V-drop due to ESR	0.583	0.005	0.049	0.200	0.240	0.400
CAP Required (F)	0.034	0.023	0.024	0.026	0.026	0.030
Footprint (sq inches)	30	211	184	12	16	2
Total Volume req (cu in)	1.8	5.3	0.9	4.0	7.9	0.9
Total Mass	180	0	409.96	100	279	86
Solution Cost	$ 1,020.00	$ 192.95	$ 2,220.00	$ 60.00	$ 570.00	$ 520.00
Shelf LIfe	Unlimited	1K hrs @105C	3 years	5 years @40C	500 hrs @125C	Ulimited
Vibration	20g		20g	10g	10g	20g

EVANS
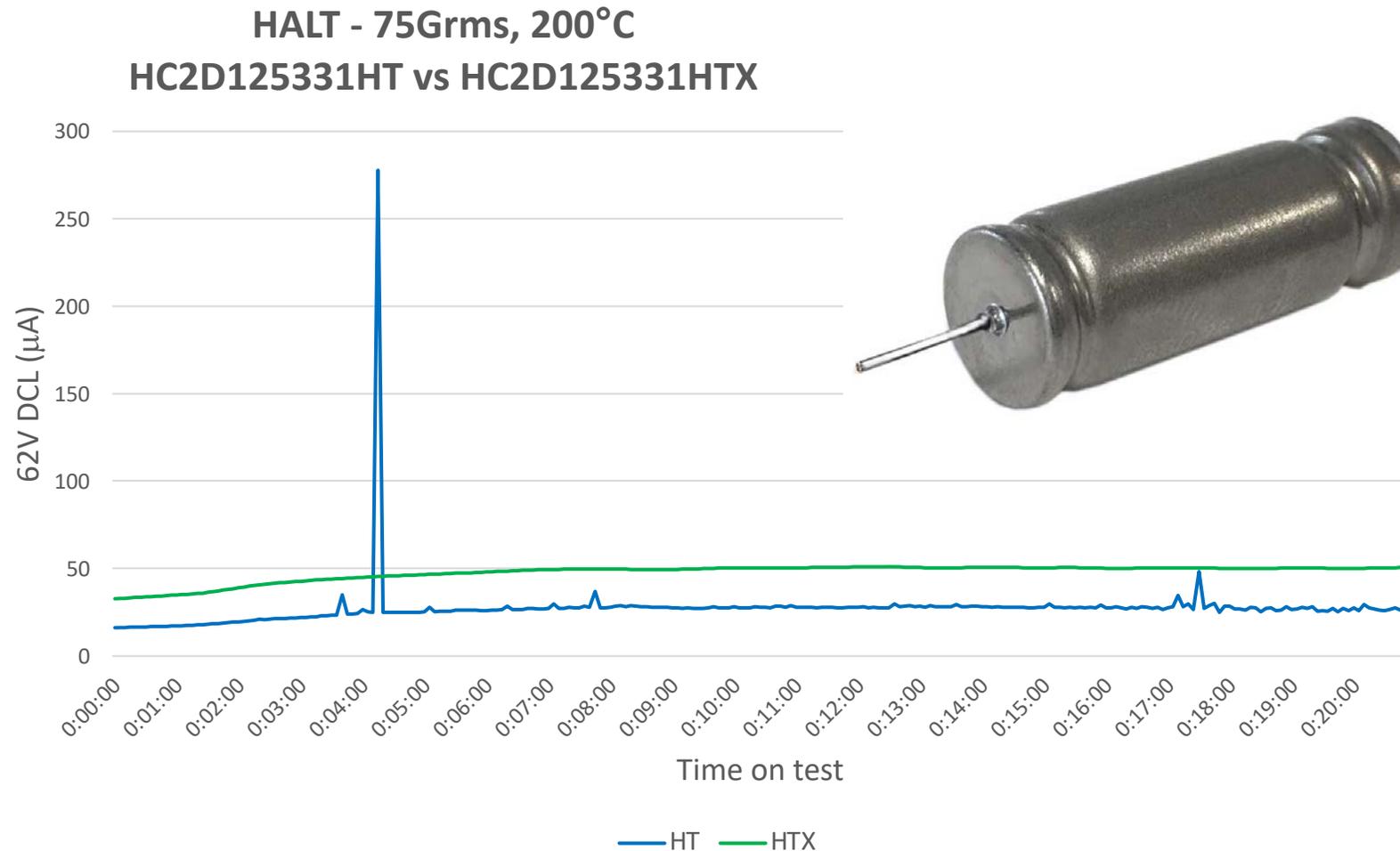A Quantic Company

Recent Advances in Hybrid Technology

Introducing the TDE Series

- Available in 60V – 110V

- More Capacitance in the Same Size

- Same Trusted and Proven Hi-Rel Design

Recent Advances in Hybrid Technology

Improve Shock and Vibration Withstand Capability

HALT - 75Grms, 200°C
HC2D125331HT vs HC2D125331HTX

Case Study: RADAR

$$I = 20A, \Delta T = 200\mu sec, T = 0.002 sec$$
$$f = 500Hz, Duty\,Cycle = 10\%$$

$$C(F) = \frac{I(A) \times \Delta T(sec)}{\Delta V(V)}$$

$$Duty\,Cycle(\%) = \frac{\Delta T}{T} \times 100$$

High power Amplifiers in modern phased array radars are in the range of $1KW - 10\,KW$. These systems need very high power pulses to transmit and must maintain that power throughout the pulse without voltage droop (**0.5V - 1 V is acceptable**). The operating voltage can be as high as **50V**.
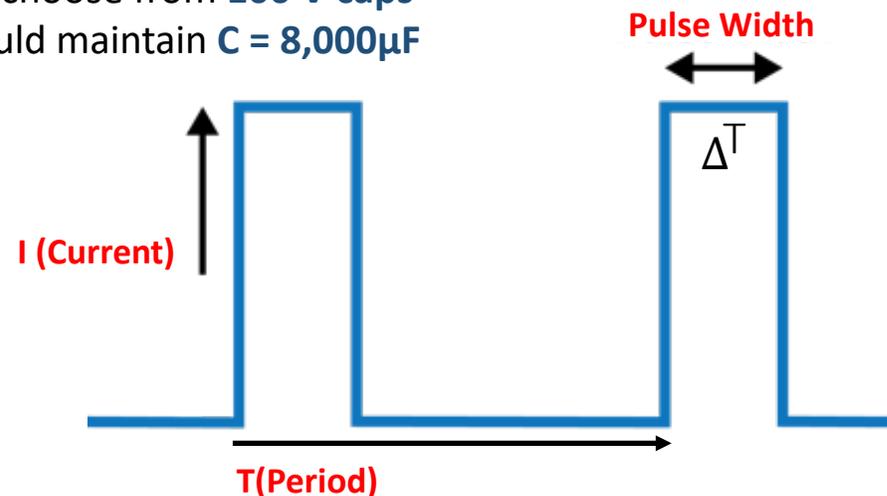
MAIN CHALLENGES
- Highest Power for Longest Pulse Width
- Light Weight / Compact Design
- Cooling Requirements
- Increasing Duty Cycles

Choosing A Cap for this Application
$C = I * \Delta T \; / \; \Delta V = 20A * 200\mu sec \,/\, 0.5V = 8{,}000\mu F$
Applying a very safe de-rate,
- We can choose from **100 V caps**
- We should maintain **C = 8,000µF**

Pulse Width

Δ^T

I (Current)

T(Period)

Case Study: RADAR

CAPACITOR SOLUTIONS
High Power Radar Application

Standard Aluminum
381LX392M100K052
100V and 3,900µF per unit
2 required
1.2" D x 2.0" H
Volume ≈ 4.5 in^3
Footprint = 2.9 in^2
Weight = 106g

Representative picture. Not image of actual part.

Aluminum Flatpack Stainless Steel Cased
MLSG132M100EB0D
100V and 1,300µF per unit
6 required
1.75" x 0.5'' x 3.0''
Volume ≈ 15.8 in^3
Footprint = 5.3 in^2
Weight = 558g

Aluminum Flatpack Stainless Steel + HERMETIC
MLSH401M100JK0C
100V and 400µF per unit
20 required
1.0" x 0.5'' x 1.5''
Volume ≈ 15 in^3
Footprint = 10.0 in^2
Weight = 640g

Traditional Wet Tantalum
DLA-93026
100V and 220µF per unit
36 required
0.375" D x 1.062" L
Volume ≈ 4.2 in^3
Footprint = 14.3 in^2
Weight = 648g

Extended Range Wet Tantalum
DLA-10004
100V and 470µF per unit
17 required
0.375" D x 1.062" L
Volume ≈ 2.0 in^3
Footprint = 6.7 in^2
Weight = 255g

HYBRID WET TANTALUM
EVANS TDD4100882
100V and 8,800µF per unit
1 required
1.4" x 1.4" X 0.755"
Volume ≈ 1.5 in^3
Footprint = 2.0 in^2
Weight = 145g

QUESTIONS

How critical is the ...

• SIZE (Volume)?

• WEIGHT?

• ESR?

• Reliability?

• Hermeticity?

• Cost Effectiveness?

• Shelf Life?

• Temperature Performance?

• High Current Capability?

100V and 8,000µF Capacitor Solutions

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Case Study: RADAR

Part Number	Quantity Required	Volume (in^3)	Weight (g)	Hermetic	Estimated Cost
381LX392M100K052 Aluminum	2	4.5	106		$30
DLA-93026 Traditional Wet Tantalum	36	4.2	648	✓	$3,200
MLSG132M100EB0D Stainless Steel "Flatpack"	6	15.8	558		$960
DLA-10004 Extended - Wet Tantalum	17	2.0	255	✓	$1,700
MLSH401M100JK0C Stainless Steel + Hermetic "Flatpack"	20	15	640	✓	$2,400
TDD4100882 EVANSCAP "Hybrid"	1	1.5	145	✓	$750

What is ESR and Why is it Important?

ESR is the "Equivalent Series Resistance" of the capacitor. As current flows through the capacitor, there is a voltage drop proportional to the resistance of the capacitor

Voltage Drop = I(Amps) x ESR (Ohms).

As Applications demand higher currents, the voltage droop attributable to the capacitor plays a larger and larger role.

So, our formula must really be amended to account for this.

$$C(F) = \frac{I(A) \times \Delta T(sec)}{\Delta V - \Delta V_{(cap)}} = \frac{I(A) \times \Delta T(sec)}{V_{droop} - [I(A) \times ESR_{cap}]}$$

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Voltage Droop ESR Effect

Application Example

60V Pulse	• 60V is near the top range of the most advanced GaN (Gallium Nitride) transistor switches.
20 Amps	
200 μSec	• Traditional de-rate is 60% of V-rated
1 Volt droop	

$$\frac{I(A) \times \Delta T(sec)}{V_{droop} - [I(A) \times ESR_{cap}]}$$

	TDD4100882 100V / 8800uF	MLSG132M100EB0D 100V / 1300uF
Current (A)	20	20
Pulse Width (Sec)	0.0003	0.0003
ΔV allowed (V)	1	1
Capacitor ESR(Ω)	0.015	0.143 ea /8 = 0.018
V droop across Cap	0.30	0.358
Cap required (μF)	8571	9,339
# of caps needed	1	8 (in parallel)
Volume (in^3)	1.5	21
Cost per "solution"	$750	$245 x 8 = $1,960

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