FastCap®
Ultracapacitors
A Nanoramic® Labs Technology

ULTRACAPACITORS: OPERATE IN ENVIRONMENTS BEYOND BATTERY CAPABILITIES

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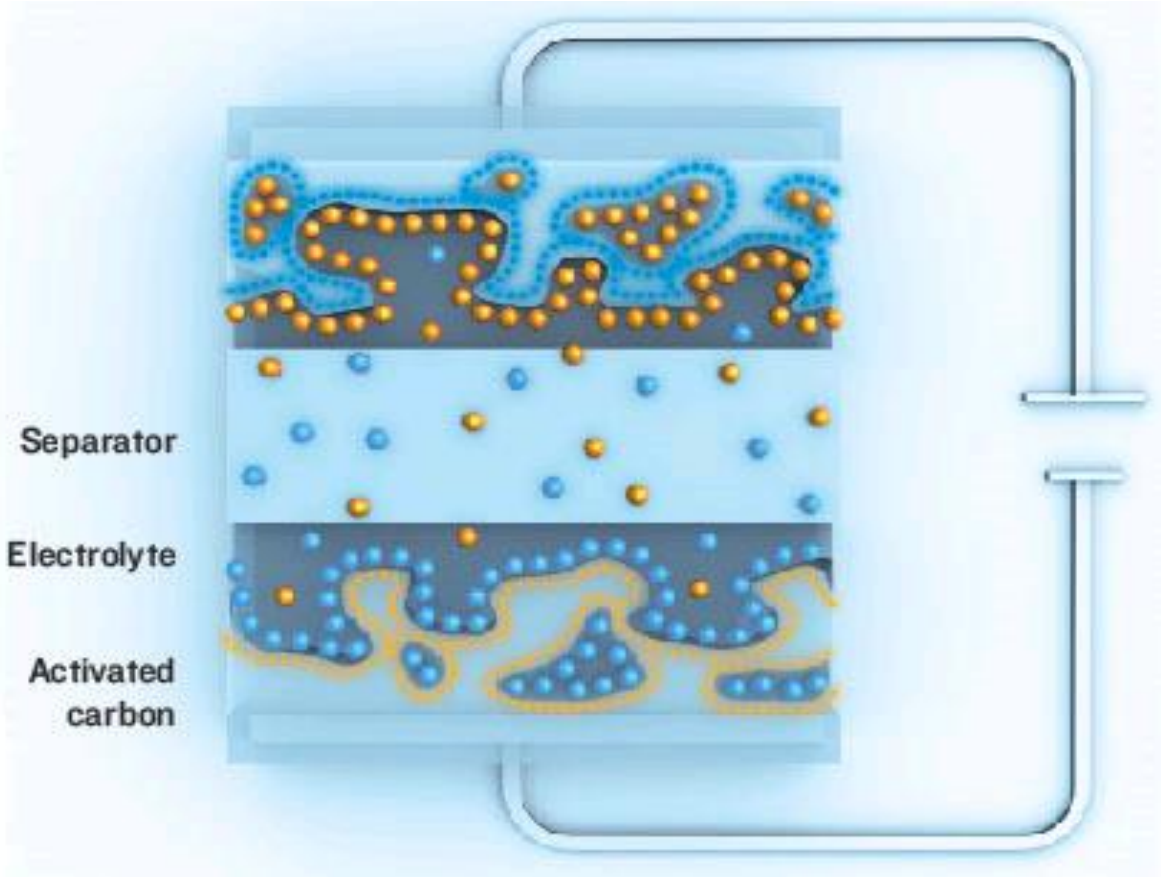
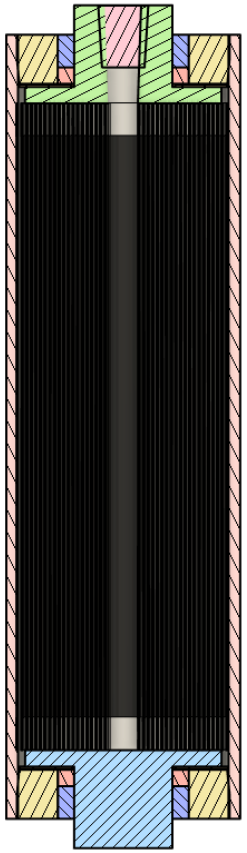
WHAT IS AN ULTRACAPACITOR?



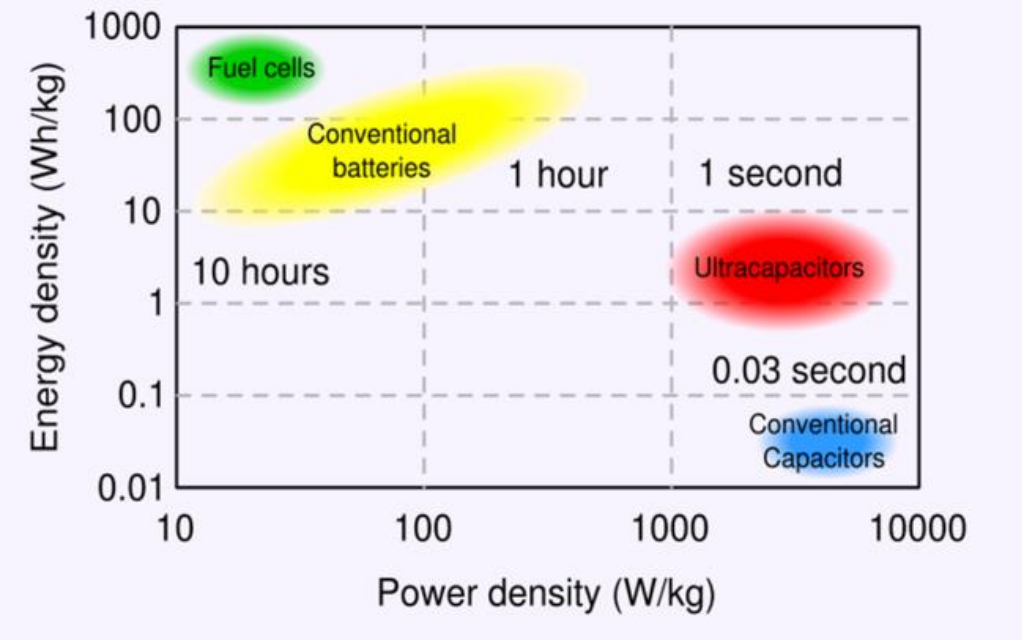
- Stores Energy based on static charge, not chemically
- Ultracapacitors use carbon-based electrode materials with high surface area to store energy.
- Works on the principle of electric double layer – polarization of electrolyte on carbon surfaces
- High Energy densities compared to Tantalum and other electrolytic capacitors
- Low ESR enables high power densities

SIMILARITIES TO BATTERIES



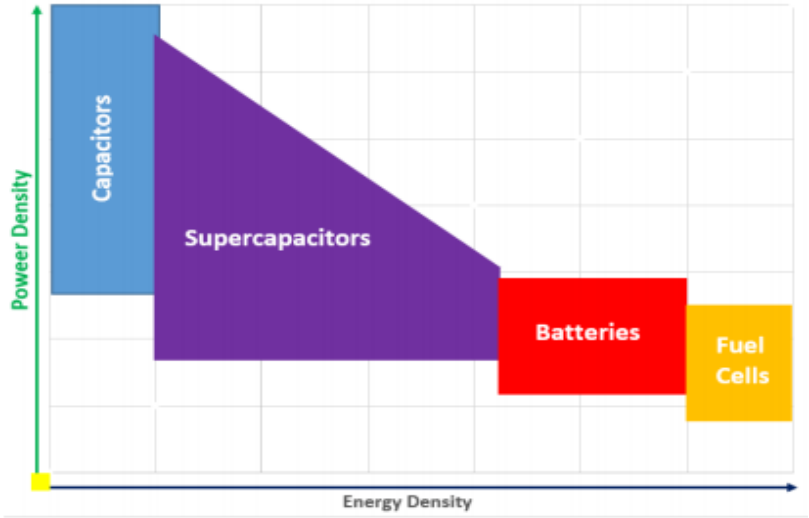
- Both devices store energy
- Both devices have a variety of mechanical construction: Cylindrical, prismatic, pouch, coin, etc.
- Both have cathode/anode/electrolyte, separator construction
- Both are commercially available in a variety of sizes and shapes
- Both are manufactured using similar processes

WHY USE AN ULTRACAPACITOR?



- Charges and discharges very quickly – in seconds if required
- Virtually unlimited charge/discharge cycles, hundreds of thousands to millions of cycles
- 10-100 times higher energy density than tantalum or electrolytic capacitors – reduce size and weight
- Much greater power density than batteries
- Work time from seconds to hours

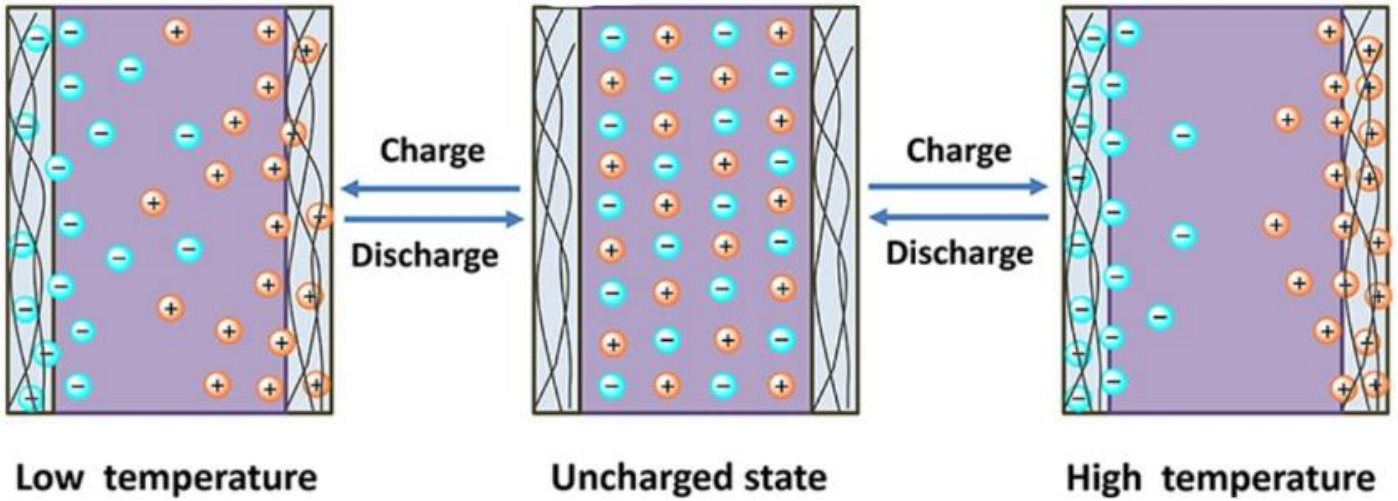
WHY USE AN ULTRACAPACITOR?



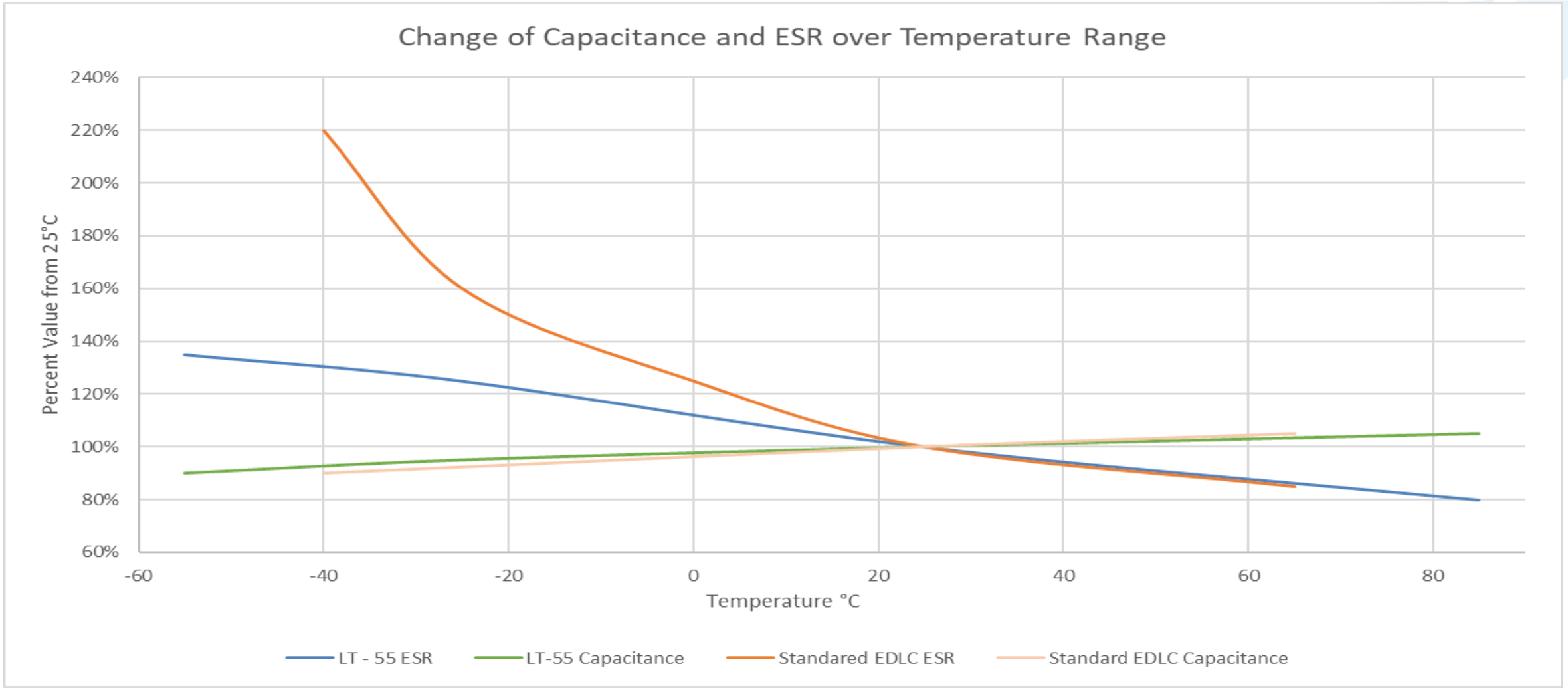
- Can be used in series and/or parallel configurations
- Safety – no thermal runaway risk
- No shipping restrictions – lowers overall cost
- Does not require extensive control electronics – lowers overall cost
- Capable of extreme temperatures – from -55C to +150C
- Less heat generation during fast charge and discharge

TEMPERATURE EFFECTS ON ENERGY STORAGE DEVICES

- Effect of Low Temperature on Ultracapacitor Performance
  - Ultracapacitors use different electrolytes then batteries, allowing for a wider temperature range.
  - Low temperatures increase the viscosity of the electrolyte, increasing the ESR of cells
  - Ion mobility is limited, lowering the capacity of the cell
  - Most Ultracapacitors lose 20% or more capacitance at -40°C and increase ESR by double or more



LIMA – LOW TEMPERATURE ULTRACAPACITOR



FastCap® Ultracapacitors

Low Temperature Ultracapacitor
PN: 01-0019-0.0 - LT-55-35: -55C, 2.0V

KEY FEATURES:

- Designed to maintain high capacitance and low resistance throughout entire operable temperature range
- Vibration and shock resistant
- Minimum operating temperature of -55°C
- Ideal candidate for applications operating at high altitude
  - e.g., flight data recorders and high-altitude distributed power buffering

TECHNICAL SPECIFICATIONS

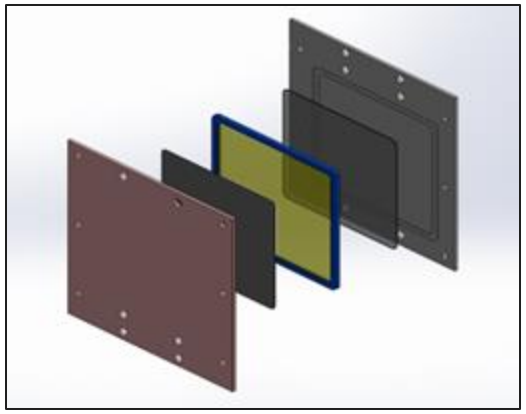
Test	Description	Min	Typ	Max	Units
Electrical					
Rated Capacitance	Room Temperature	35	38	40	F
Rated Low Temperature Capacitance	-55°C	30	35	40	F
Rated Voltage			2		V
Series Resistance	Room Temperature	25	30	35	mΩ
Low Temperature Series Resistance	-55°C	35	40	45	mΩ
Leakage Current @ Rated Voltage High Temp	After 72 hours	0.2	0.3	0.4	mA
Leakage Current @ Rated Voltage Low Temp	After 72 hours	0.001	0.005	0.01	mA
Operating Temperature		-55		85	°C
Storage Temperature	Fully Discharged Cell	-65		100	°C

LOW TEMPERATURE AA LT35-55

Nanoramic Laboratories Low Temperature Solution

- Minimal Loss of Capacitance
  - <10% lower initial capacitance at -55°C
- Minimal Increase in ESR
  - <40% increase in ESR at -55C
- Rated to High Altitude
  - Qualified to 150,000 ft
- Wide Operating Temperature Range
- Nanoramic Laboratories Ruggedized Design
  - Compliant with MIL-STD-202G
    - Shock
    - Vibration
    - Barometric pressure
    - Thermal shock

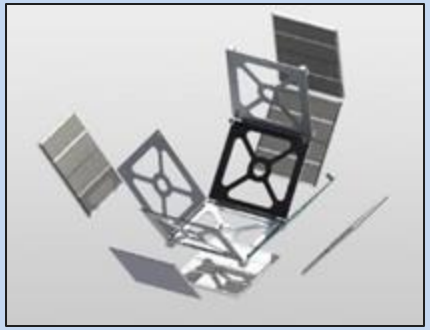
STRUCTURAL ULTRACAPACITOR OVERVIEW



Add energy storage where it wasn't possible before.

Structural cells combine energy storage and structural strength for extremely high energy and power density solutions.

Small Satellites



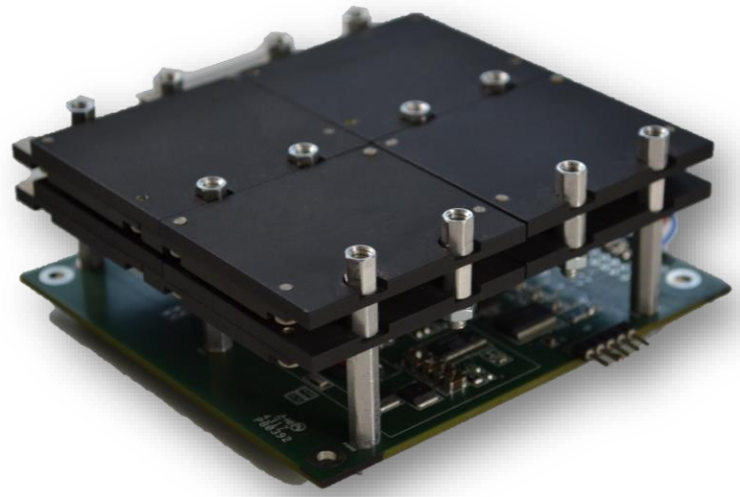
Missile Systems

Defense

Space

STRUCTURAL ULTRACAPACITOR COMPARISON

	Pumpkin BM2 3500 mAh	Nanoramic Ultracap Module (2 Layer)
Power Density	0.229 kW / kg	3.330 kW / kg
Energy Density	143 Wh / kg	0.25 Wh / kg
Mass	700 g	450 g
Volume	484 mL	367 mL
V_{bus}	12.6 V	12 V
I_{max}	20 A	> 30 A
ESR	25 mΩ (single cell)	20 mΩ (8 cell module)
Cost to Launch*	**$41,300**	**$26,550**

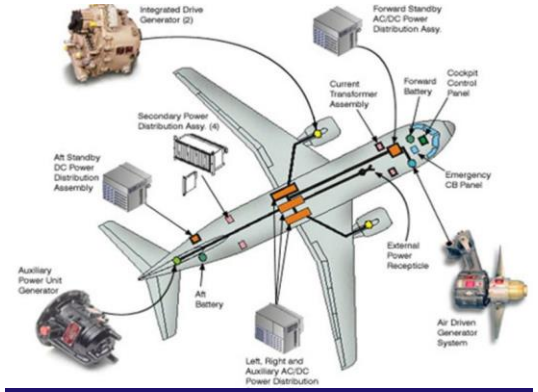


Operation down to -40 C

* Cost to launch assumes $59,000 per kg, LEO, (Spaceflight Industries, Seattle, WA)

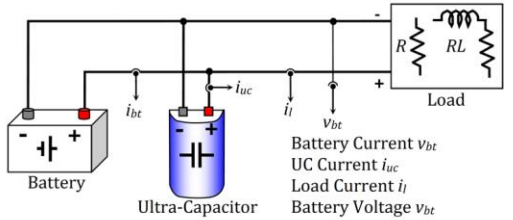
POTENTIAL USES

REPLACE BATTERY FOR LOW ENERGY HIGH POWER APPLICATION



RELIABLE POWER FOR AIRCRAFT ELECTRONICS

LOW TEMPERATURE ENGINE START



HYBRID BATTERY-ULTRACAPACITOR SYSTEMS

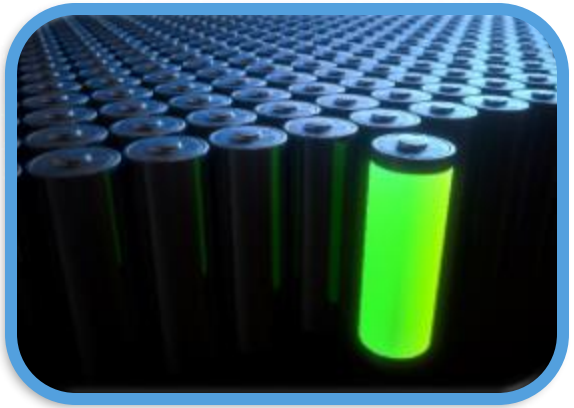
ADVANTAGES OF ULTRACAPACITORS VS LI-ION BATTERIES

Ultracapacitor

- Safer
- Shorter Charge Times
- Less Heat Generation During Fast Charge
- Higher Current Delivery
- Options for Mechanical Packages
- Higher Cycle Life
- Longer Service Life
- Better Temperature Performance
- Save $ On Control Circuits
- No Shipping Restrictions

VS

Li-ion Battery



- Higher Energy Density
- Lower Self-Discharge Rate
- Exponential Discharge Curve

CONCLUSION

- Nanoramic Ultracapacitors have great temperature range performance
  - Currently operate down to -55 C and up to +150C
  - Proof of concept down to -100 C and up to +300C
  - Much better performance than batteries
- Nanoramic Ultracapacitors can be used in series/parallel to meet different voltage/current requirements
- Nanoramic Ultracapacitors can be used as a structural component in your design
- Nanoramic is ready to help you improve your design with our innovative and patented technologies including electrodes, electrolytes, and mechanical packages

CONTACT US

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