Super Capacitor Development At NASA MSFC

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Super Capacitor Development

- **Concept**
- **Proof of Concept Testing**
- **Areas of Focus**
  - Classifications of Super Capacitors
  - Chemical Double Layer Capacitors
  - Psuedocapacitors (Electrochemical)
- **An Added Advantage**

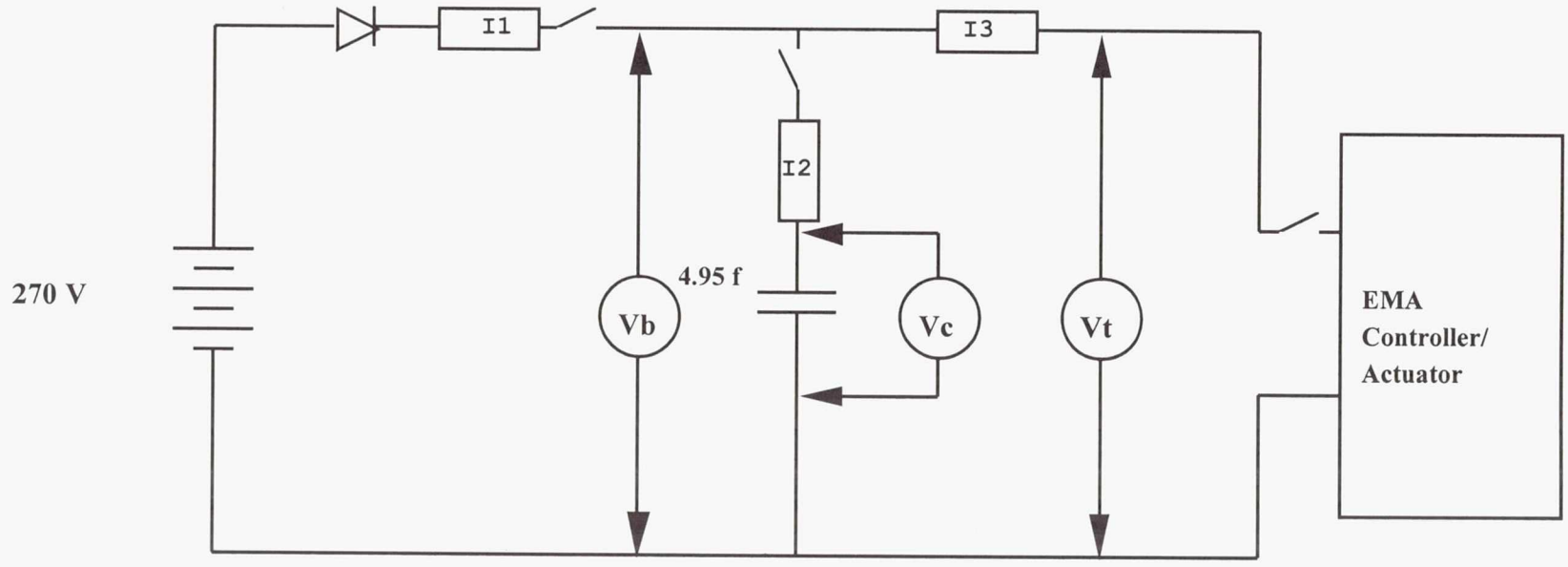
Concept

- **Problem: Need for a lighter weight energy source that can deliver high power pulses while maintaining minimum voltage sag. Applications include electromechanical actuators (EMA's), and electric vehicles.**
- **Hybrid Power Source Rationale: Combine the energy density of a conventional power source with the power density of a capacitor bank to yield a high-power, high energy power source capable of pulse power applications that weighs less than a conventional source sized for the same application.**

Proof of Concept Testing

- Tests performed using a 25 hp EMA in a hydraulic rate vs. load bench loaded to 15 klb. with a 270 V Lead acid battery bank and a 270 V, 5 farad capacitor bank (Panasonic) made by AU-SPI.
- Results showed voltage in Batt. Only tests sagged 40%, while Batt/Cap. configuration's voltaged sagged only 13%.

Test Set-up

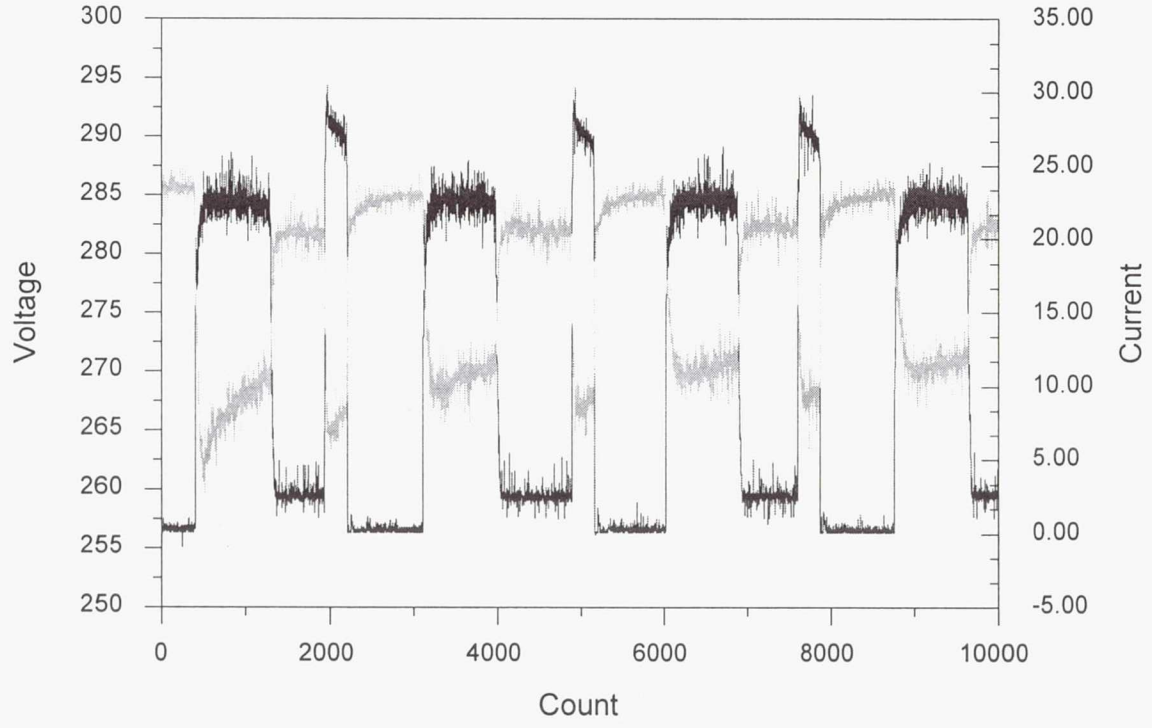


Proof of Concept Testing

- Repeated the tests with "flight type" batteries sized to do the task in the Battery Only configuration, and for a hybrid Batt/Cap configuration.
- Selected primary Ag-Zn batteries for pulse discharge capabilities. Wanted to limit bus voltage sag to 15% or less.
- Selected an 80 A-hr Ag-Zn for Battery Only tests, and a 20 A-hr Ag-Zn to be used in the hybrid configuration with the 5 Farad capacitor bank.

Battery Only - 15 kLb Test

Voltage Sag 7% initially to approx. 5%.

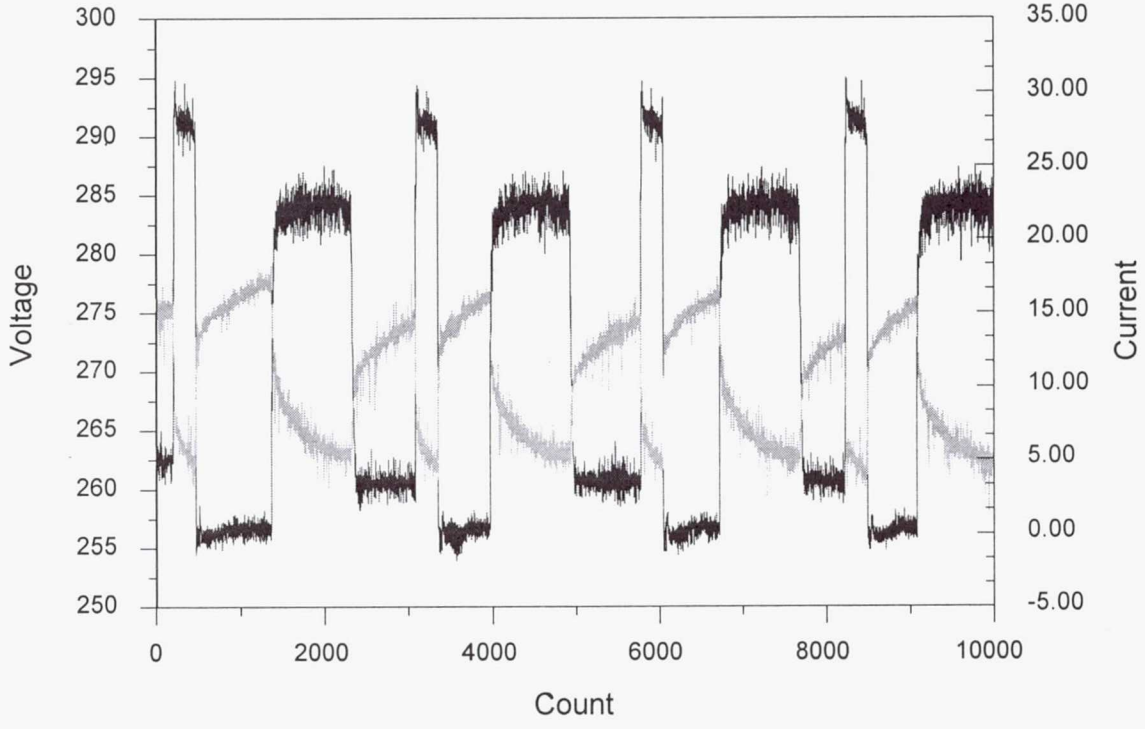


Current -------
Voltage -------

80 A-hr Ag-Zn: 450 Lbs.

Batt./Cap 15kLb Test

Voltage Sag 6% constant.



Current -------
Voltage -------

20 A-hr Ag-Zn: 100 Lbs, Cap. 85 Lbs.
Total: 185 Lbs. *59% WEIGHT SAVINGS*

Classification of Super Capacitors

- By Electrode Type
  - Activated Carbon Powder
  - Carbon/Metal Fiber
  - Activated Synthetic Carbon
  - Doped Conducting Polymer Films on Carbon Cloth
  - Mixed Metal Oxides Deposited on Conductive Foils
- By Electrolyte Type
  - Aqueous
  - Organic
  - Solid
- By Energy Storage Mechanism
  - Double Layer Capacitance
  - Pseudocapacitance

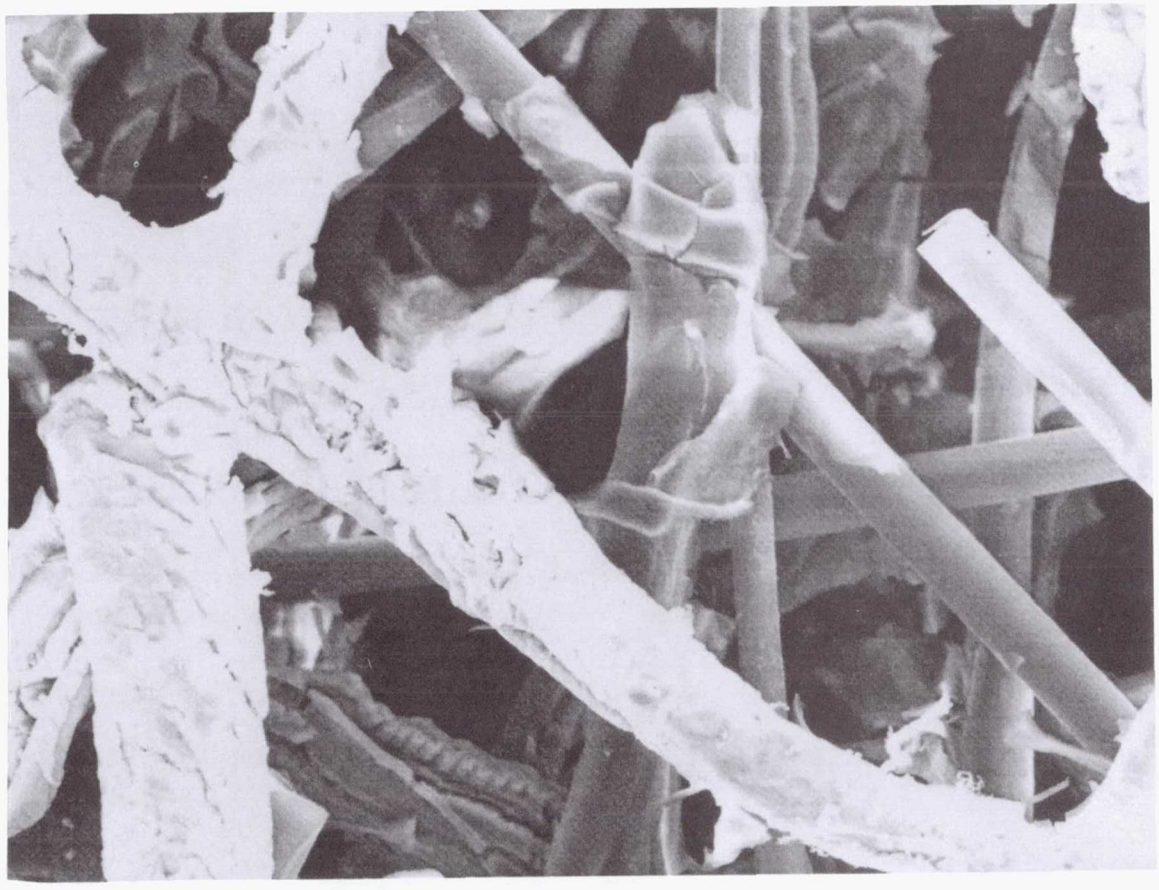
MSFC Focus

- Electrode Types; carbon/metal fiber (Ni-C), mixed metal oxides and carbides deposited on conductive foils (Ru-O, V-Nitride).
- Electrolyte Type; Aqueous, Potasium Hydroxide and Sulfuric Acid.
- Energy Storage Mechanism; double layer capacitance (Ni-C, V-N), and pseudocapacitance (RuO).

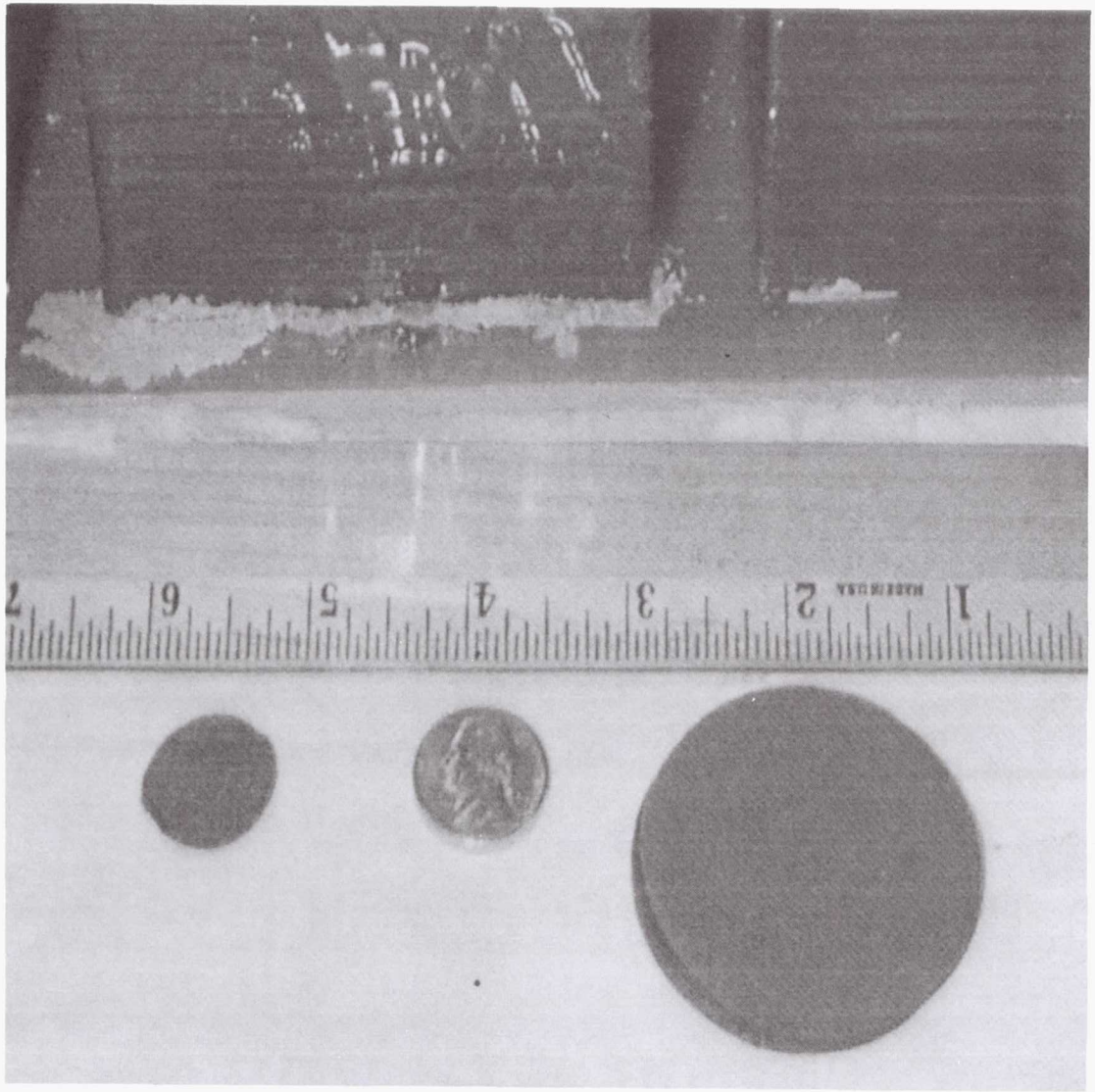
Ni-C CDL

- Electrodes are sinter bonded to metalic current collectors in a bi-polar configuration.
- Carbon powder has very high surface area properties. *Approx. 2500 m^2/g.*

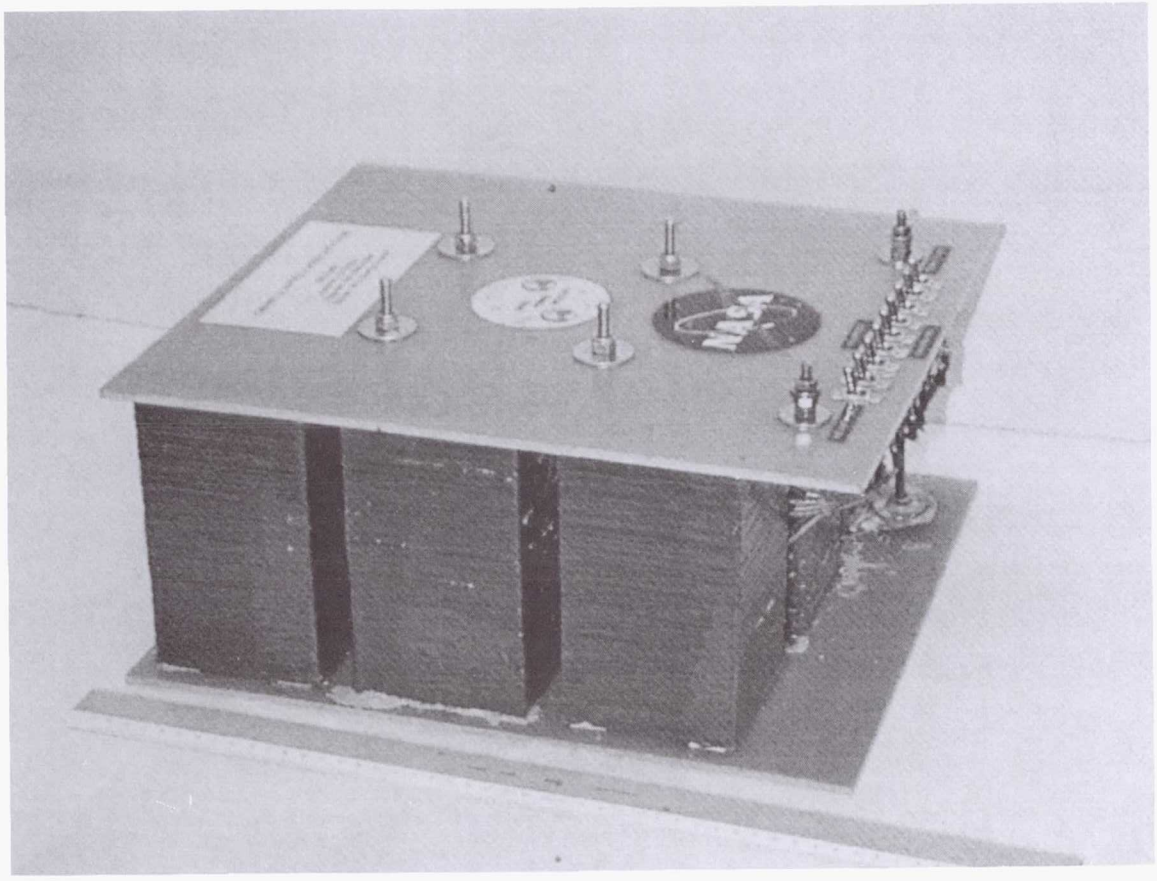
Ni-C CDL Sinter Bonding



Ni-C CDL Electrode Material



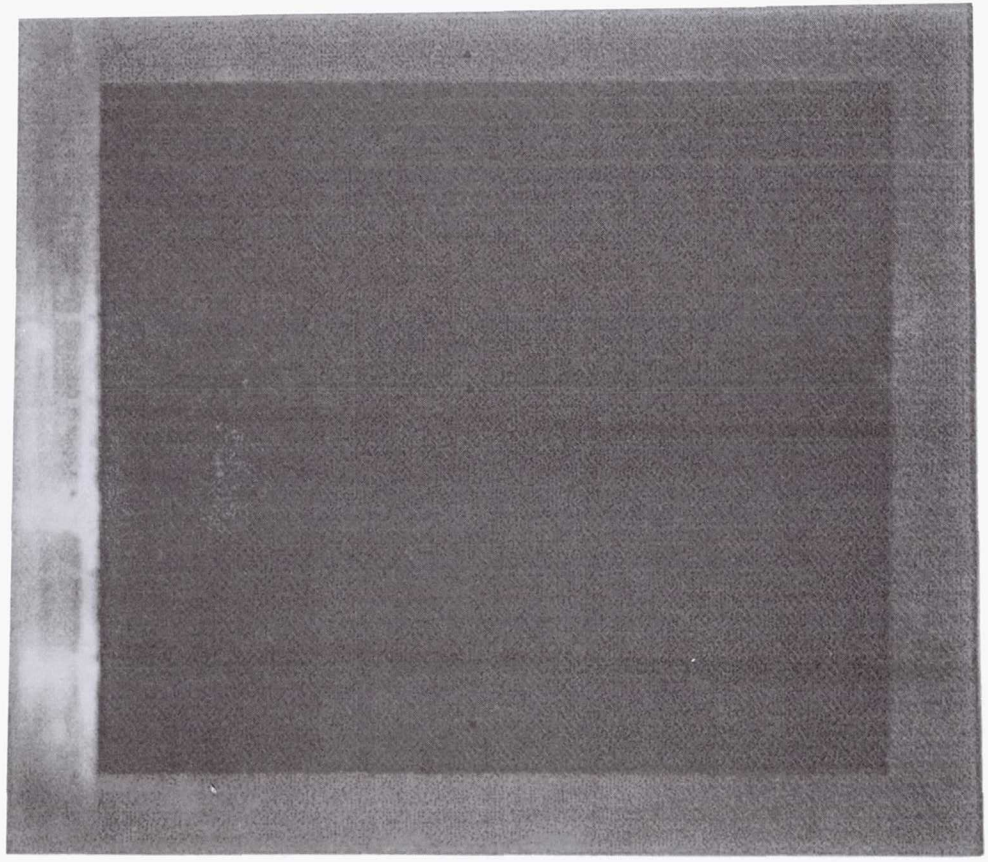
Ni-C CDL 1 F, 300 V Cap Bank



Ru-Oxide Psuedo-Cap

- Utilizes a Redox reaction, "fast battery" characteristics along with high capacitance.
- Target of > 10 W/g power density.

Ruthenium Oxide "psuedo-cap"



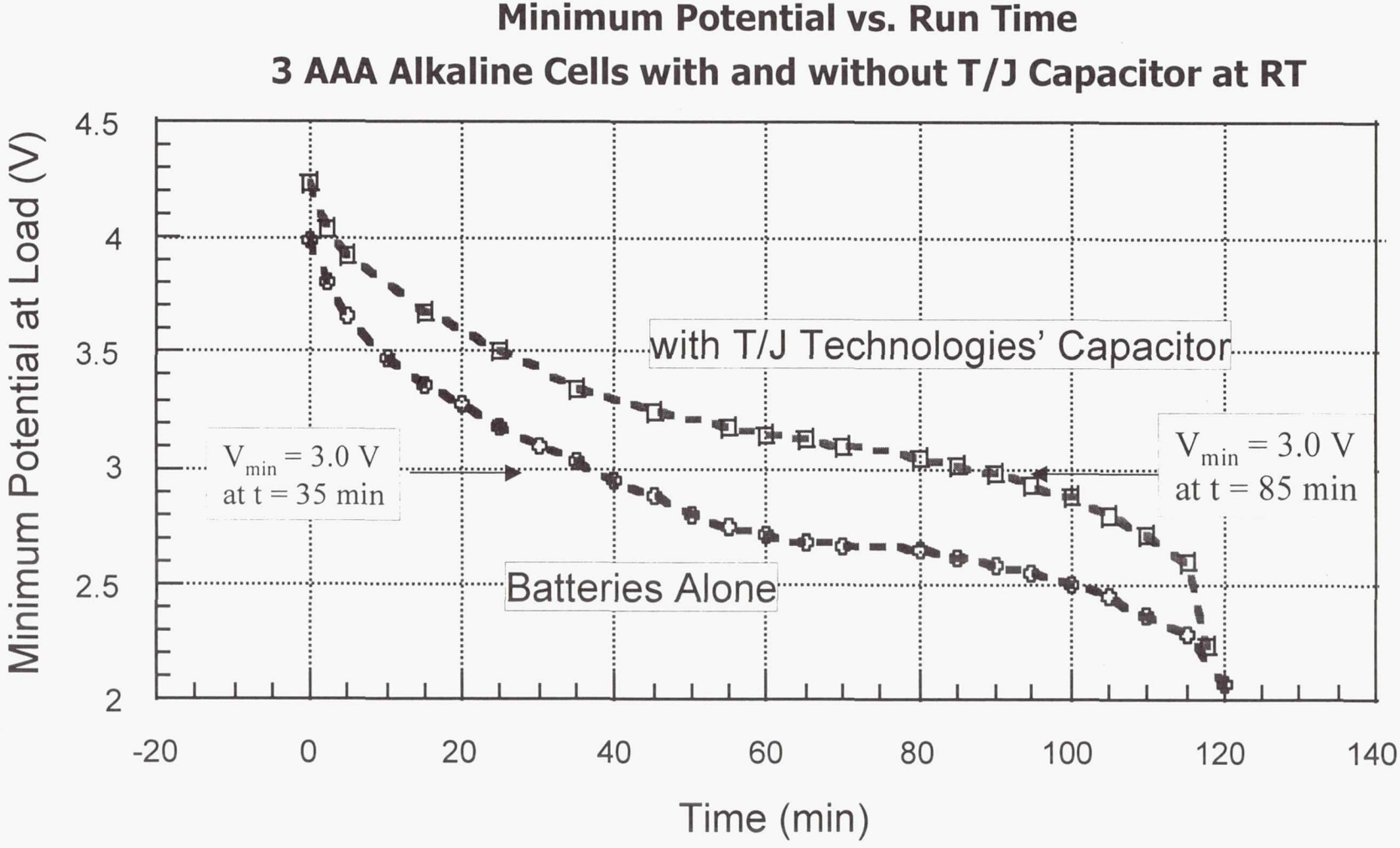
Ru-Oxide 2 F, 30 V Capacitor

Added Advantage

- Other testing has shown that use of Super Capacitors in hybrid power sources not only improves pulse loading power performance, but also extends battery life.
- *Data shown taken from a 0.5 F, 5 V, 6 cell Vanadium Nitride super capacitor. (GSM Protocall profile 217 Hz, 13% duty cycle, 0.16 - 1.3 A load.)*

Ultracapacitor extends the run time of alkaline battery

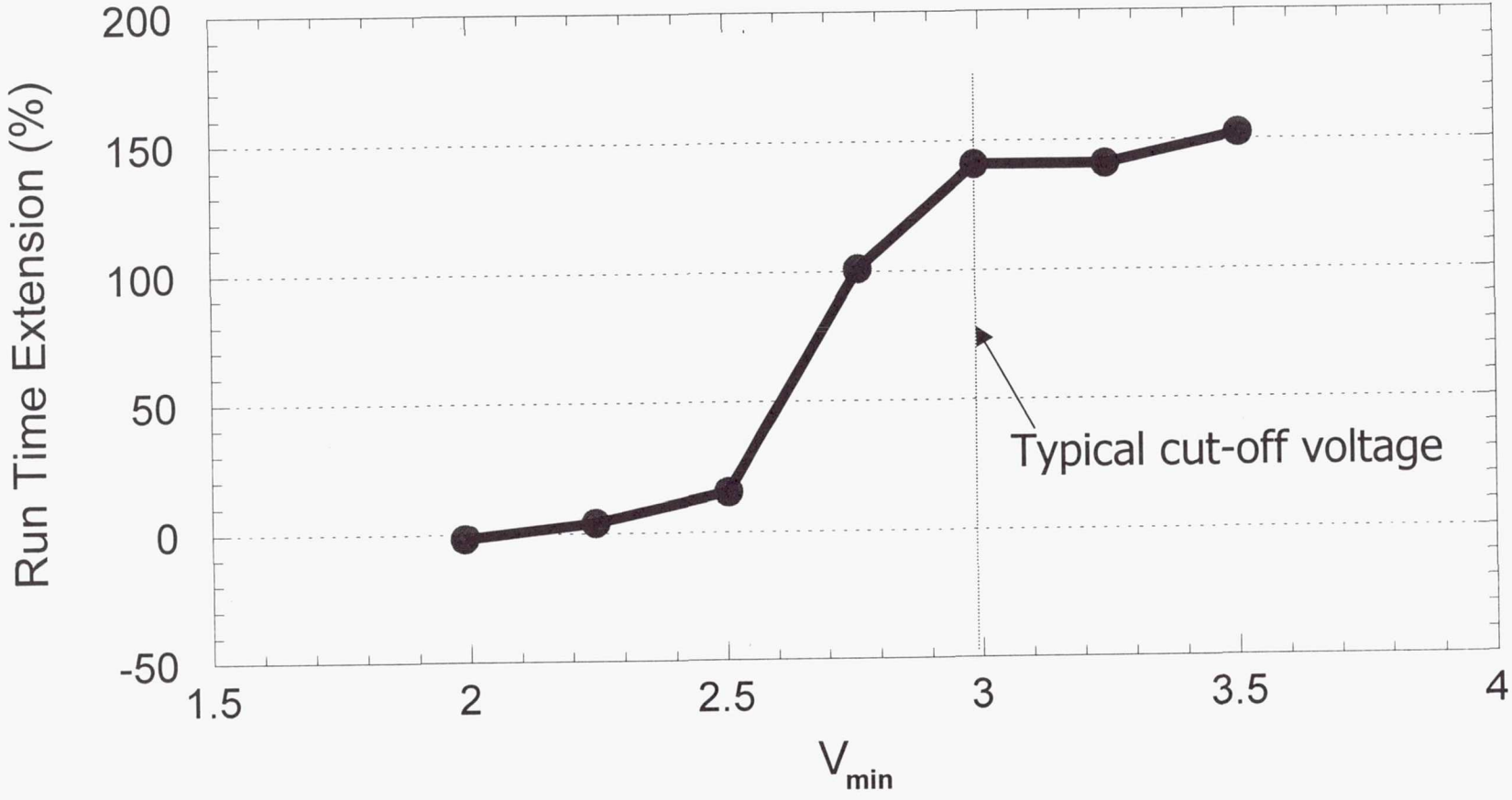
T/J Technologies Inc.



Run time extension vs. minimum voltage

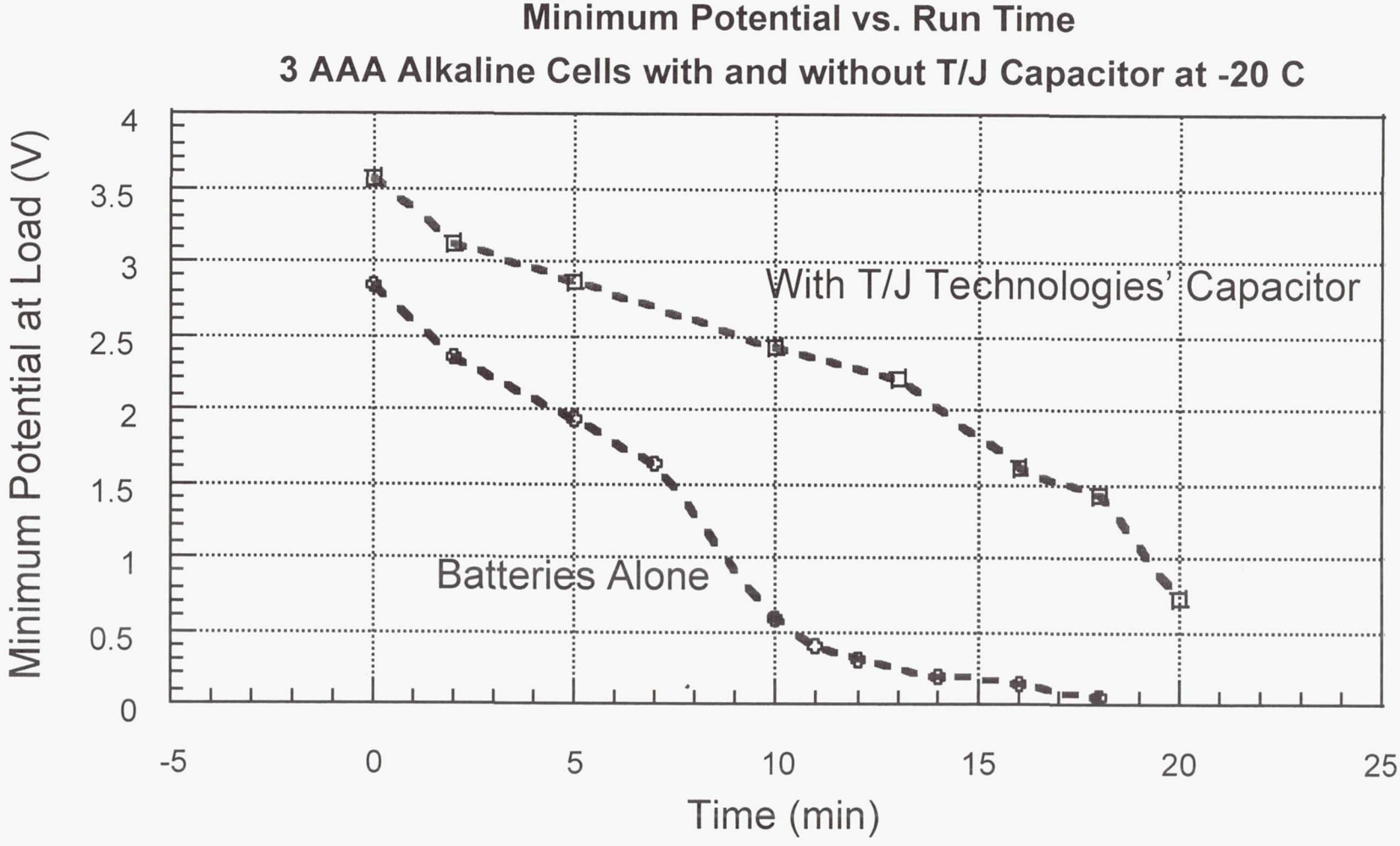
T/J Technologies Inc.

3 AAA Alkaline Cells with T/J Capacitor at Room Temperature



Ultracapacitor enhances battery performance at low temperature

T/J Technologies Inc.



Reference Material

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