PolyStor
CORPORATION

Application Brief #3

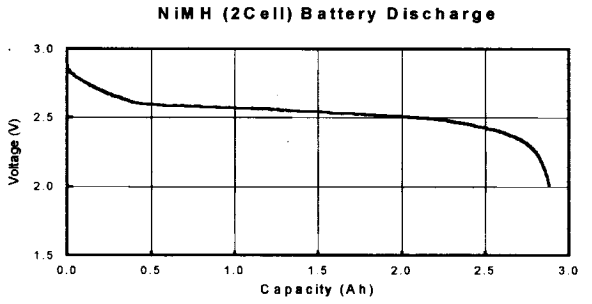
Hybrid Power Packs

Screening Aerogel Capacitor Applications

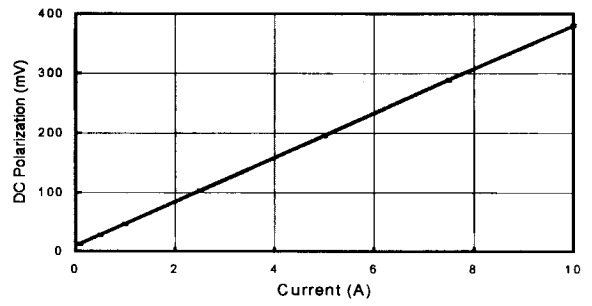
Data Requirements

- Battery discharge curve
  - A battery discharge voltage curve at the standby rate is acquired.
- Battery polarization data
  - Polarization data for various pulse currents is measured for the battery.
- Aerogel Capacitor ESR and Capacitance
  - The Aerogel Capacitor ESR and capacitance must be known.
- Discharge conditions
  - Pulse energy and standby times of the application device must be known.
  - These are used to determine if the Aerogel Capacitor can sustain the pulse and recharge sufficiently between pulses.
  - Depending on desired accuracy, data used may be a function of rate, state-of-charge, etc.

Battery Discharge Curve



Battery Polarization Data



Methodology

- Check:
  - Energy of pulse is less than available energy in Aerogel Capacitor to end voltage
  - Standby time allows sufficient recharge of capacitor
- Determine:
  - effective internal resistance for battery and hybrid power source for resistor network
  - voltage polarization for known pulse currents
- Plot:
  - battery and hybrid source pulse discharge curve

Check:

- Pulse energy must be less than available energy in the capacitor above the lower cutoff voltage of the application device.
- $I_P t_P V_{SB} < 1/2\ C\ (V_{SB}^2 - V_{LCV}^2)$.
  - where I_P = pulse current, t_P = pulse time (sec), V_{SB} = standby voltage, C = Capacitance and V_{LCV} = pulse voltage.
- Standby time must be sufficient for recharge of capacitor.

Determine:

- Battery resistance: $R_B = \Delta V / I$.
- Hybrid Power Pack resistance $R_H = 1 / ((1 / R_B) + (1 / R_{cap}))$.
  - where R_{cap} = capacitor resistance.
- Battery pulse discharge voltage: $V_B = R_B (I_P - I_{SB})$.
  - where I_{SB} = standby or background current
- Hybrid Power Pack pulse discharge voltage: $V_H = R_H (I_P - I_{SB})$.

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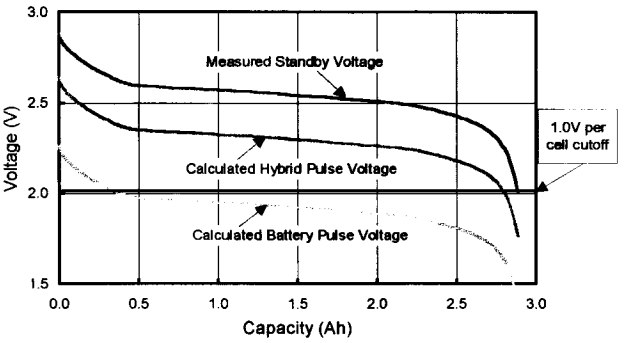
Hybrid Power Packs

Screening Aerogel Capacitor Applications

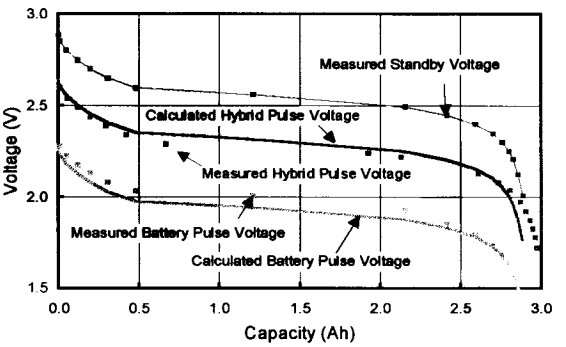
Calculated Voltage Curves

Calculated Battery and Hybrid Pulse Data



Verification of Methodology

Comparison with Measured Pulse Data



- On a spreadsheet, the hybrid and battery pulse voltage curves are calculated using the measured battery voltage curve for a standby current of 0.28A or 0.1C as a baseline.
- This example uses two NiMH 4/3A cells for the conventional battery.
- The Hybrid Power Pack in this example uses two NiMH 4/3A cells and one Aerogel Capacitor.
- Note, the larger voltage drop of the conventional battery when subjected to a pulse current of 8.4A or 3C.
- Using a typical 1.0V per cell cutoff, the calculations predict the capacity of the conventional battery to be only 17% that of the hybrid pack.
- The calculated pulse discharge curves are verified by the experimental data plotted with boxes.
- This simple, fast method can be used for screening potential Hybrid Power Pack applications with limited battery and capacitor data.
- More and more applications, in particular digital, require short, high pulse discharges.
- These applications can now be quickly screened to determine the potential benefit of an advanced Hybrid Power Pack.

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