

# Intelligent Li-Ion Polymer Power System Multiple Aerospace Platforms

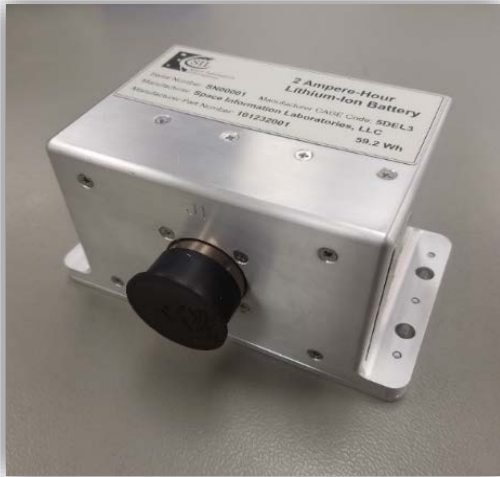
Rockets, Missiles, Hypersonic Vehicles, Strike Weapons, Satellites



## Intelli-Pack®

### Li-Ion Polymer 2Ah FTS Battery

Space Environmental Qual Tested



#### BATTERY MANAGEMENT SYSTEM

- Class III PCBA with automatic overvoltage, undervoltage, short circuit and thermal protection for all cells in series, and cell balancing
- Health status is provided in real-time via a Windows GUI that includes individual cell voltages, SOC, SOH battery current and temperatures

#### FEATURES AND BENEFITS

- 180 Wh/Kg NMC Cell Energy Density
- Battery box is composed of Intelli-Pack® Li-Ion Battery, 33.6Vdc, 2Ah
- Li-Ion Polymer Cells have no leakage and can be oriented in any direction
- Highly immune to shock and vibration
- Can be recharged from depletion to 96% in less than 1 hour (1C charge rate)
- Recharge Cycle Life > 1000 cycles
- Li-Ion Intelli-Pack® battery issues can be diagnosed and repaired in < 5 minutes
- RCC 319 for Range Safety Space Qualification for FTS Li-Ion Batteries

#### INTELLI-PACK® PCBA

- Up to 30 Amps continuous current 33.6 Vdc, 2 Ah Li-Ion Polymer Intelli-Pack® Battery
- Automatic cell balancing during charge and internal heater control with temperature set points
- Voltage monitoring and cell balancing of all Li-Ion Polymer series cells are displayed on a Windows GUI and Data Logger via portable computer or sent via telemetry (RS-422 or RS-485 Comm Ports)

# Li-Ion Polymer Battery

## Technical Information



### Battery Unit Physical Characteristic:

**Dimensions:** 5.7"L x 3.25"W x 3"H (inches)

**Weight:** 2.7 lbs (shown to right with internal BMS PCB and Connectors)

### Electrical:

**Power:** 33.6Vdc, 2Ah

**Current Sink:** 30 Amps Continuous  
60 Amps (Pulse, 200 msec)

### **Advanced Li-Ion Polymer Batteries for Aerospace Implementation Now!**

*Li-Ion Polymer combines high-energy and low internal resistance with the reliability and packaging flexibility to any box mechanical dimension*

1. **Electrolyte, no leakage:** All solid components, requiring no bulky cell housings. The result is a safer, more efficient package.
2. **Lightweight:** 180 Wh/Kg Li-Ion Polymer Cells can be stacked and wired in parallel or series to meet customer requirements
3. **Shock and Vibe:** Li-Ion Polymer meets or exceeds all shock and vibe requirements for all aerospace applications. It weighs less and has 2 to 3 times the energy density of batteries currently used on aerospace missions (i.e. Silver Zinc, Nickel Cadmium).

### Environmental Specifications:

#### **SPACE ENVIRONMENT QUAL:**

**Thermal Cycle:** -40C to +55C (24 cycles)

**Vacuum:** 1\*10<sup>-5</sup> Torr

**Random Vib.:** 16.4 grms, 3 mins per XYZ axis  
0 to 2000 Hz

**Sine Vibration:** 70 and 100Hz, 18G  
500 and 700Hz, 7.8G  
1100 and 1400Hz, .6G

| <b>Shock:</b> | Freq. (Hz) | Shock Level (g) |
|---------------|------------|-----------------|
|               | 100        | 226             |
|               | 1000       | 400             |
|               | 1800       | 735             |
|               | 10000      | 735             |

Three Hits: +/- XYZ Axis



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**USPTO Patent # 9,748,541 B2**

# Intelligent Li-Ion Polymer Power System Multiple Aerospace Platforms

Rockets, Missiles, Hypersonic Vehicles, Strike Weapons, Satellites



## Intelli-Pack®

### Li-Ion Polymer 2.1Ah FTS Battery

Space Environmental Qual Tested



#### BATTERY MANAGEMENT SYSTEM

- Class III PCBA with automatic overvoltage, undervoltage, short circuit and thermal protection for all cells in series, and cell balancing
- Health status is provided in real-time via a Windows GUI that includes individual cell voltages, SOC, SOH battery current and temperatures

#### FEATURES AND BENEFITS

- 180 Wh/Kg, NMC Li-Ion Cell Energy Density
- Battery box is composed of Intelli-Pack® Li-Ion Battery, 33.6Vdc, 2.1Ah
- Li-Ion Polymer Cells have no leakage and can be oriented in any direction
- Highly immune to shock and vibration
- Can be recharged from depletion to 96% in less than 1 hour (1C charge rate)
- Recharge Cycle Life > 1000 cycles at 100% Depth of Discharge to 80% Capacity
- Li-Ion Intelli-Pack® battery issues can be diagnosed and repaired in < 5 minutes
- RCC 319 for Range Safety Space Qualification for FTS Li-Ion Batteries
- Designed to pass UN38.3 Tests 1 thru 5, and 7
- Robust Design for Safety - NAVSEA S9310 Cell and Battery Level Destructive Testing

#### INTELLI-PACK® PCBA

- Up to 4A Amps continuous current  
33.6 Vdc, 2.1 Ah Li-Ion Polymer Intelli-Pack® Battery
- Automatic cell balancing during charge and internal heater control with temperature set points
- Voltage monitoring and cell balancing of all Li-Ion Polymer series cells are displayed on a Windows GUI and Data Logger via portable computer or sent via telemetry (RS-422 Comm Port)

# Li-Ion Polymer Battery

## Technical Information



### Battery Unit Physical Characteristic:

**Dimensions:** 6.36"L x 3.75"W x 1.5"H (inches)

**Weight:** 1.95 lbs (shown to right with internal BMS PCB and Connectors)

### Electrical:

**Power:** 33.6Vdc, 2.1Ah

**Current Sink:** 4 Amps Continuous  
6 Amps (Pulse, < 10 Secs)

### ***Advanced Li-Ion Polymer Batteries for Aerospace Implementation Now!***

*Li-Ion Polymer combines high-energy and low internal resistance with the reliability and packaging flexibility to any box mechanical dimension*

1. **Electrolyte, no leakage:** All solid components, requiring no bulky cell housings. The result is a safer, more efficient package.
2. **Lightweight:** 180 Wh/Kg Li-Ion Polymer Cells can be stacked and wired in parallel or series to meet customer requirements
3. **Shock and Vibe:** Li-Ion Polymer meets or exceeds all shock and vibe requirements for all aerospace applications. It weighs less and has 2 to 3 times the energy density of batteries currently used on aerospace missions (i.e. Silver Zinc, Nickel Cadmium, Nickel Metal Hydride).

### Environmental Specifications:

#### **ENVIRONMENT QUAL:**

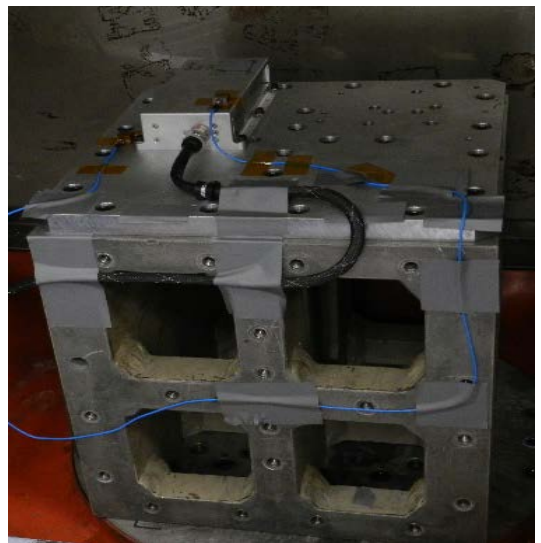
**Thermal Cycle:** -40C to +71C (24 cycles)  
-20C to +71C Fully Operational, No Heater

**Vacuum:** 1\*10<sup>-5</sup> Torr

**Thermal / Random Vib.:** +71C and -10C  
29.34 grms in Z Axis and 12.05 grms in X and Y Axis, 60 min per XYZ Axis, 0 to 2000 Hz

**Sine Vibration:** 70 and 100Hz, 18G  
500 and 700Hz, 7.8G  
1100 and 1400Hz, .6G

**Thermal / Shock:** +71C and -10C  
485G, SRS Shock in XYZ Axis  
50G, 50 msec pulse, Half-Sine Shock in XYZ Axis  
Three Hits: +/- XYZ Axis



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**USPTO Patent # 9,748,541 B2**

# Intelligent Li-Ion Polymer Power System Multiple Aerospace Platforms

Rockets, Missiles, Hypersonic Vehicles, Strike Weapons, Satellites



## Intelli-Pack®

### Li-Ion Polymer 3.3Ah FTS Battery

Space Environmental Qual Tested



#### BATTERY MANAGEMENT SYSTEM

- Class III PCBA with automatic overvoltage, undervoltage, short circuit and thermal protection for all cells in series, and cell balancing
- Health status is provided in real-time via a Windows GUI that includes individual cell voltages, SOC, SOH battery current and temperatures

#### FEATURES AND BENEFITS

- 180 Wh/Kg NMC Cell Energy Density
- Battery box is composed of Intelli-Pack® Li-Ion Battery, 33.6Vdc, 3.3Ah
- Li-Ion Polymer Cells have no leakage and can be oriented in any direction
- Highly immune to shock and vibration
- Can be recharged from depletion to 96% in less than 1 hour (1C charge rate)
- Recharge Cycle Life > 1000 cycles
- Li-Ion Intelli-Pack® battery issues can be diagnosed and repaired in < 5 minutes
- RCC 319 for Range Safety Space Qualification for FTS Li-Ion Batteries

#### INTELLI-PACK® PCBA

- Up to 30 Amps continuous current 33.6 Vdc, 3.3 Ah Li-Ion Polymer Intelli-Pack® Battery
- Automatic cell balancing during charge and internal heater control with temperature set points
- Voltage monitoring and cell balancing of all Li-Ion Polymer series cells are displayed on a Windows GUI and Data Logger via portable computer or sent via telemetry (RS-422 or RS-485 Comm Ports)

# Li-Ion Polymer Battery

## Technical Information



### Battery Unit Physical Characteristics:

**Dimensions:** 6.75"L x 4"W x 2.8"H (inches)

**Weight:** 3.25 lbs (shown to right with internal BMS PCB and Connectors)

#### Electrical:

**Power:** 33.6Vdc, 3.3Ah

**Current Sink:** 6.6 Amps Continuous  
16.5 Amps (Pulse, 20 msecs)

#### ***Advanced Li-Ion Polymer Batteries for Aerospace Implementation Now!***

*Li-Ion Polymer combines high-energy and low internal resistance with the reliability and packaging flexibility to any box mechanical dimension*

- 1. Electrolyte, no leakage:** All solid components, requiring no bulky cell housings. The result is a safer, more efficient package.
- 2. Lightweight:** 180 Wh/Kg Li-Ion Polymer Cells can be stacked and wired in parallel or series to meet customer requirements
- 3. Shock and Vibe:** Li-Ion Polymer meets or exceeds all shock and vibe requirements for all aerospace applications. It weighs less and has 2 to 3 times the energy density of batteries currently used on aerospace missions (i.e. Silver Zinc, Nickel Cadmium).

### Environmental Specifications:

#### **SPACE ENVIRONMENT QUAL:**

**Thermal Cycle:** -40C to +55C (24 cycles)

**Vacuum:** 1\*10<sup>-5</sup> Torr

**Random Vib.:** 16.4 grms, 3 mins per XYZ axis  
0 to 2000 Hz

**Sine Vibration:** 70 and 100Hz, 18G  
500 and 700Hz, 7.8G  
1100 and 1400Hz, .6G

| <b>Shock:</b> | Freq. (Hz) | Shock Level (g) |
|---------------|------------|-----------------|
|               | 100        | 226             |
|               | 1000       | 400             |
|               | 1800       | 735             |
|               | 10000      | 735             |

Three Hits: +/- XYZ Axis



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**USPTO Patent # 9,748,541 B2**



# Intelligent Li-Ion Polymer Power System Multiple Aerospace Platforms

Rockets, Missiles, Hypersonic Vehicles, Strike Weapons, Satellites



## Intelli-Pack®

Li-Ion Polymer 5Ah Avionics/Telemetry and/or FTS Battery  
Space Environmental Qual Tested



## INTELLI-PACK® PCBA

- Up to 30 Amps continuous current 33.6 Vdc, 5 Ah Li-Ion Polymer Intelli-Pack® Battery
- Automatic cell balancing during charge and internal heater control with temperature set points
- Voltage monitoring and cell balancing of all Li-Ion Polymer series cells are displayed on a Windows GUI and Data Logger via portable computer or sent via telemetry (RS-422 Comm Port)

## FEATURES AND BENEFITS

- 175 Wh/Kg LiPo NMC Cell Energy Density
- Battery box is composed of a Intelli-Pack® Li-Ion Battery Pack, 33.6Vdc, 5 Ah
- Li-Ion Polymer Cells have no leakage and can be oriented in any direction
- Advanced BMS within the battery for safety
- Can be recharged from depletion to 96% in less than 1 hour (1C charge rate)
- Recharge Cycle Life > 1000 cycles
- Li-Ion Intelli-Pack® battery issues can be diagnosed and repaired in < 5 minutes
- RCC 324-01 for Range Safety Space Qualification for FTS Li-Ion Batteries

USPTO Patent # 9,748,541 B2



## BATTERY MANAGEMENT SYSTEM

- Class III PCBA with automatic overvoltage, undervoltage, short circuit and thermal protection for all cells in series, and cell balancing
- Health status is provided in real-time via a Windows GUI that includes individual cell voltages, SOC, SOH battery current and temperatures

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Patent # 9.748,541 B2

# Li-Ion Polymer Battery

## Technical Information



### Battery Unit Physical Characteristic

Dimensions: 8.7”L x 3.275”W x 4.325”H (inches)  
Weight: 5.75 lbs (shown to right with internal BMS PCB and Connectors)

### Electrical:

Power: 33.6V, 5 Ah

Current Sink: 30 Amps Continuous  
60 Amps (Pulse < 200 msecs)

Advanced Li-Ion Polymer Batteries  
for Aerospace Implementation Now!

Li-Ion Polymer combines high-energy and low internal resistance with the reliability and packaging flexibility to any box mechanical dimension



### Environmental Specifications:

#### SPACE ENVIRONMENT QUAL:

- Thermal Cycle: -40C to +55C (24 cycles)
- Vacuum:  $1 \times 10^{-5}$  Torr
- Random Vib.: 16.4 grms, 3 mins per XYZ axis  
0 to 2000 Hz
- Three Hits: +/- XYZ Axis

### Electrolyte, with no leakage

*All solid components, requiring no bulky cell housings. The result is a safer, more efficient package.*

### Lightweight

*175 Wh/Kg Li-Ion Polymer Cells can be stacked and wired in parallel or series to meet customer requirements*

### Shock and Vibe

*Li-Ion Polymer meets or exceeds all shock and vibe requirements for all aerospace applications. It weighs less and has 2 to 3 times the energy density of batteries currently used on aerospace missions (i.e. Silver Zinc, Nickel Cadmium)*



- Sine Vibration: 70 and 100Hz, 18G  
500 and 700Hz, 7.8G  
1100 and 1400Hz, .6G

| - Shock: | Freq. (Hz) | Shock Level (g) |
|----------|------------|-----------------|
|          | 100        | 226             |
|          | 1000       | 400             |
|          | 1800       | 735             |
|          | 10000      | 735             |



# Intelligent Li-Ion Polymer Power System Multiple Aerospace Platforms

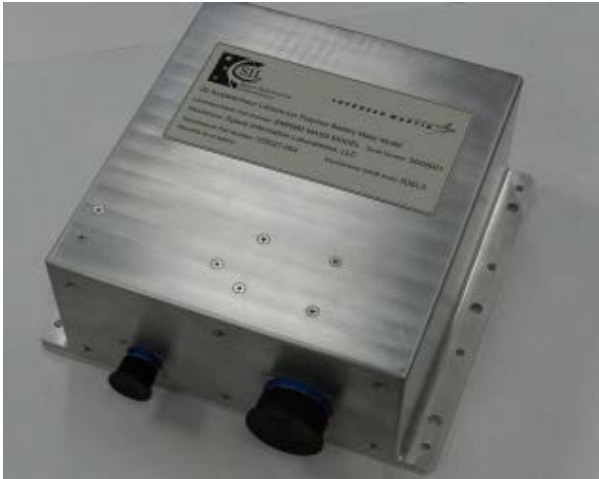
Rockets, Missiles, Hypersonic Vehicles, UAVs, Satellites



## Intelli-Pack®

### Li-Ion Polymer 20Ah Battery

Range Safety Space Qualified



#### BATTERY MANAGEMENT SYSTEM

- Class III PCBA with automatic overvoltage, undervoltage, and short circuit protection for all cells in series, and cell balancing
- Health status is provided in real-time via a Windows GUI that includes individual cell voltages, SOC, SOH battery current and temperatures

#### FEATURES AND BENEFITS

- 200 Wh/Kg LiPo LCO Cell Energy Density
- Battery box is composed of two redundant 33.6V, 10Ah Intelli-Pack® batteries with separate BMS for each
- Li-Ion Polymer Cells have no leakage and can be oriented in any direction
- Highly immune to shock and vibration
- Can be recharged from depletion to 96% in less than 1 hour (1C charge rate)
- Recharge Cycle Life > 500 cycles
- UN38.3 Certified for shipment
- S9310 Cell and Battery Destructive Tested
- Li-Ion Polymer Intelli-Pack® issues can be diagnosed and repaired in < 5 minutes
- RCC 324-01 and RCC 319 Range Safety Space Qualified for Telemetry and Avionics launch vehicle and missile applications

#### INTELLI-PACK® PCBA

- Up to 30 Amps continuous current  
33.6 Vdc, 20 Ah Li-Ion Polymer Intelli-Pack® Battery
- Intelli-Pack® PCBA within the battery has two independent BMS to protect, balance & monitor each of the two internal 33.6Vdc, 10Ah Battery Packs inside the battery
- Voltage monitoring and cell balancing of all Li-Ion Polymer series cells are displayed on a Windows GUI and Data Logger via portable computer or sent via telemetry (RS-422 or 1553 Comm Ports)

# Li-Ion Polymer Battery

## Technical Information



### Battery Unit Physical Characteristic:

**Dimensions:** 9" L x 9" W x 3.75" H (inches)  
**Weight:** 14.5 lbs (shown to right with internal BMS PCB and Connectors)

### Electrical:

**Power:** 33.6V, 20AH  
**Current Sink:** 30 Amps Continuous  
60 Amps (Pulse < 200 msecs)

### ***Advanced Li-Ion Polymer Batteries for Aerospace Implementation Now!***

*Li-Ion Polymer combines high-energy and low internal resistance with the reliability and packaging flexibility to any box mechanical dimension*

- 1. Electrolyte, no leakage:** All solid components, requiring no bulky cell housings. The result is a safer, more efficient package.
- 2. Lightweight:** 200 Wh/Kg Li-Ion Polymer Cells can be stacked and wired in parallel or series to meet customer requirements
- 3. Shock and Vibe:** Li-Ion Polymer meets or exceeds all shock and vibe requirements for all aerospace applications. It weighs less and has 2 to 3 times the energy density of batteries currently used on aerospace missions (i.e. Silver Zinc, Nickel Cadmium).

### Environmental Specifications:

**Operating Temp:** -20C to +60C

### SPACE QUALIFICATION:

**Thermal Vacuum:** 1<sup>^</sup>10<sup>-5</sup> Torr  
-10C to +55C

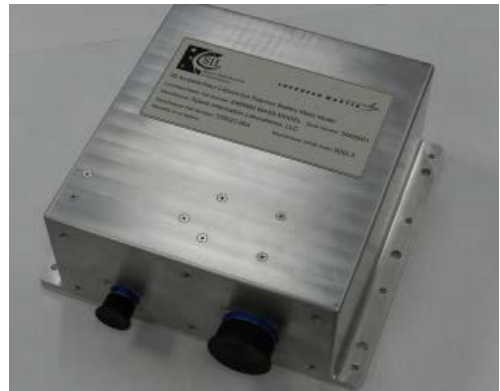
**Random Vib.:** 16.4 grms, 3 mins per XYZ axis  
0 to 2000 Hz

**Sine Vibration:** 70 and 100Hz, 18G  
500 and 700Hz, 7.8G  
1100 and 1400Hz, .6G

| <b>Shock:</b> | Freq. (Hz) | Shock Level (g) |
|---------------|------------|-----------------|
|               | 100        | 226             |
|               | 1015       | 400             |
|               | 1800       | 735             |
|               | 10000      | 735             |

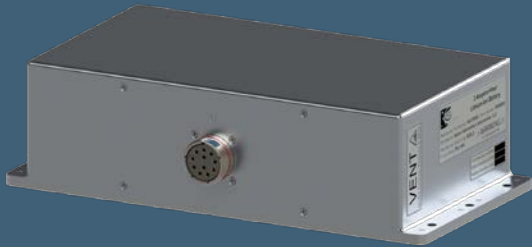
Three Hits: +/- XYZ Axis

**EMI:** RE102, CE101, CE102, CS-114, CS115, CS116, CS101, RS101, RS103, CE-07



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**Patent # 9,748,541 B2**

## 52Ah Intelli-Pack®



## Li-Ion Battery

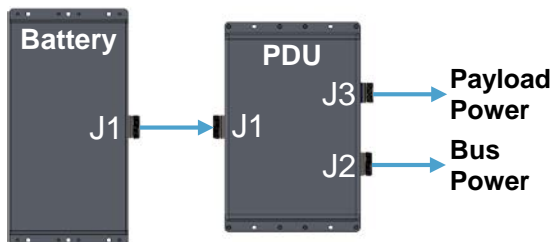
## Battery Specifications

|                                       |                                                                                                                                                                                 |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Cell Arrangement</b>               | 8s2p Li-Ion Intelli-Pack®                                                                                                                                                       |
| <b>Cell Chemistry</b>                 | Ultra-High Energy NMC, 248 Wh/Kg                                                                                                                                                |
| <b>Voltage Range</b>                  | 33.6 – 22.4 Vdc, Unregulated                                                                                                                                                    |
| <b>Capacity</b>                       | 52 Ah Beginning-of-Life                                                                                                                                                         |
| <b>Cycle Life</b>                     | 1,400 Cycles to End-of-Life                                                                                                                                                     |
| <b>Weight Max</b>                     | 11.9 kg (26.2 lbs.)                                                                                                                                                             |
| <b>Dimensions</b>                     | 7.0" W x 14.0" L x 5.5" H (with flanges)                                                                                                                                        |
| <b>Steady State Load</b>              | 104A (2C)                                                                                                                                                                       |
| <b>Pulse Load</b>                     | 208A (4C), < 10 second                                                                                                                                                          |
| <b>Telemetry</b>                      | RS-422 (1 Hz, broadcast only)                                                                                                                                                   |
| <b>Protection and Safety Features</b> | <ul style="list-style-type: none"> <li>Cell &amp; Pack Level Electrical Protection</li> <li>Vibration and Flame Suppressing Foam</li> <li>Durable Aluminum Enclosure</li> </ul> |
| <b>Temp Range</b>                     | -40 °C to +60 °C (Environment)                                                                                                                                                  |

## Li-Ion Polymer Intelli-Pack® Battery Features

- Ultra-High Energy Density Li-Ion Cell Pack with Integrated Heaters for Reduced System Mass
- Includes Internal Class III BMS PCBA with Integrated 38999 Connectors for High Reliability
- BMS Protects, Balances, and Monitors Every Cell for Safe Ground and Checkout Operations
- Discharge Protection Override Enables Uninterrupted Discharge During Mission Critical Operations
- Heritage Structure Protects Cells and is Flight Proven to Survive Extreme Aerospace Environments
- Vibration and Fire Suppressing Foam is built around Cell Packs for Protection and Safety

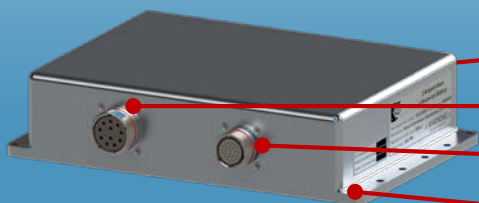
## System Interface Diagram



## Power Distribution Unit Specs

|                   |                                                                                                                         |
|-------------------|-------------------------------------------------------------------------------------------------------------------------|
| <b>Input</b>      | 33.6 Vdc – 22.4 Vdc Unregulated                                                                                         |
| <b>Output</b>     | +3.3 Vdc, 3.3W Max and +5Vdc, 10 Watts Max<br>12 Vdc, 120 Watts Max<br>28 Vdc, 120 Watts Max<br>180 Vdc, 2000 Watts Max |
| <b>Weight Max</b> | 4.3 kg (9.5 lb.)                                                                                                        |
| <b>Dimensions</b> | 8.0" W x 14" L x 3.0" H (with flanges)                                                                                  |
| <b>Temp Range</b> | -40 °C to +85 °C (Environment)                                                                                          |

## Power Distribution Unit



- Li-Ion Intelli-Pack® Input at J1 Connector (behind)
- Regulated 180Vdc & 28Vdc Output at J2 for Payload
- Regulated 3.3, 5 and 12 Vdc & Battery Voltage at J3
- Flight Proven Housing Similar to Intelli-Pack® Battery