Integration of Nanophosphate™ Prismatic Cells into the XM1124 Hybrid Electric HMMWV

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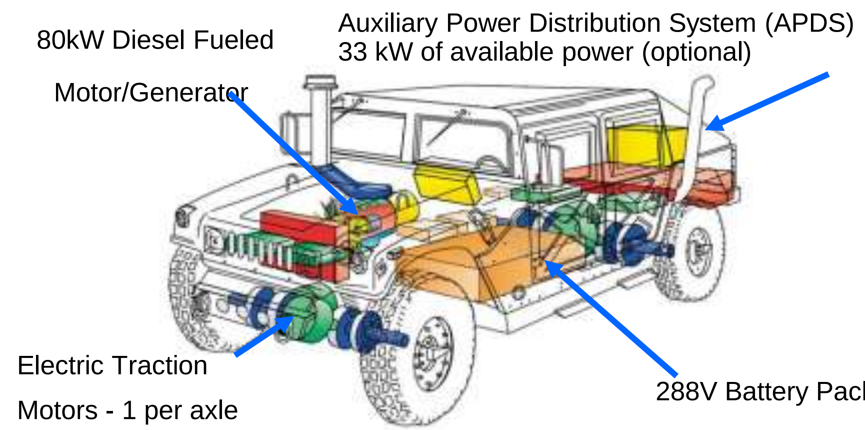
History

XM1124 Hybrid Electric HMMWV

Description

- Replaces the conventional HMMWV drive train with a hybrid drive train while retaining the capabilities of the standard HMMWV
- Quiet, mobile platform for silent watch, reconnaissance missions
- Reduced thermal and acoustic signatures
- Power generation capability



Key Requirements

- *Provide 33 kW of continuous power*
- *C130 Transportability*
- Multi-phase mobile power (AC/DC)
- Maintain HMMWV capabilities; mobility, transportability, and payload.
- Two level maintenance
- Open Architecture for upgrades

Why Hybrid Technology is Needed on Today's Battlefield

Manned or Unmanned Systems

Base Platform for Systems Approach development

Mobility

Equivalent mobility performance
Reduced Fuel Consumption
Delivers Utility Grade Power
Provides Silent Watch / Move
Mobile on-board power generation – Power on the Move
Reduced Logistic footprint
Payload Weight/Performance Trades

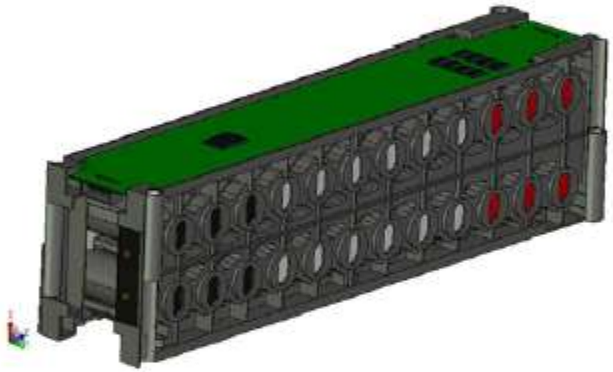
Power and Energy

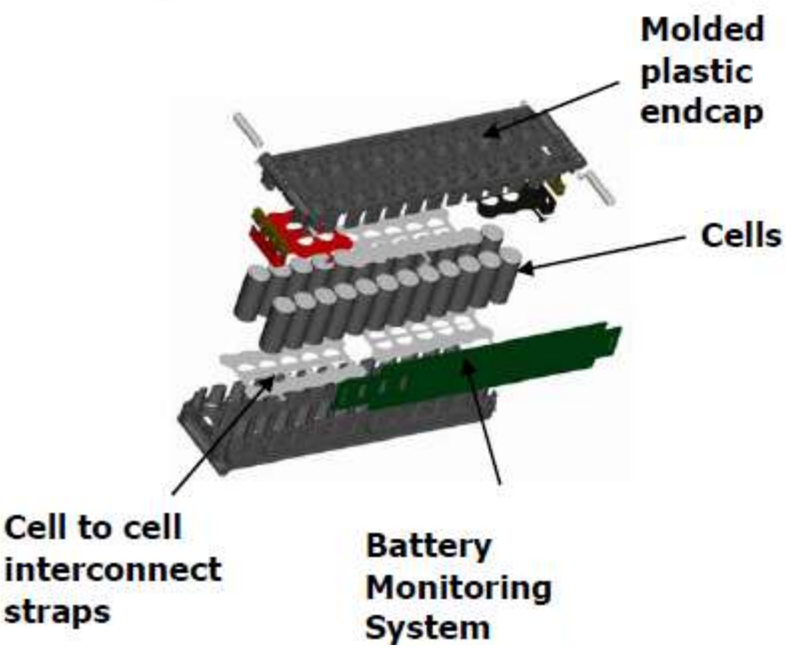
Full Spectrum Energy Performance
Reduced Logistics Footprint with ripple effects across the theater
Supports Warrior Batteries
Reduced Maintenance and Personnel
Provides Uninterruptible Power
Supports Integrated P&E Concepts

XM 1124 provides an immediate baseline for the assessment of energy centric hybrid vehicles and platforms -- Proves HE readiness for final development, and supports ONS/Requirements for the objective architecture

XM1124/A123 “Gen 1” Cylindrical Pack

Integrated and tested in 2008





A123 26650 Module

- Comprised of 24 – 26650 Cells
- Used as a “building block” for air cooled vehicle pack designs

**Details of this pack design are in the proceedings of the 2008 NDIA Power and Energy Workshop*

Nominal capacity and voltage	2.3 Ah, 3.3 V
Internal impedance (1kHz AC)	8 mΩ typical
Internal resistance (10A, 1s DC)	10 mΩ typical
Recommended standard charge method	3A to 3.6V CCCV, 45 min
Recommended fast charge current	10A to 3.6V CCCV, 15 min
Maximum continuous discharge	70A
Pulse discharge at 10 sec	120A
Cycle life at 10C discharge, 100% DOD	Over 1,000 cycles
Recommended charge and cut-off V at 25°C	3.6V to 2V
ecommended charge and cut-off V below 0°C	4.2V to 0.5V
perating temperature range	-30°C to +60°C
Storage temperature range	-50°C to +60°C
Core cell weight	70 grams

XM1124/A123 Gen 1 Cylindrical Pack

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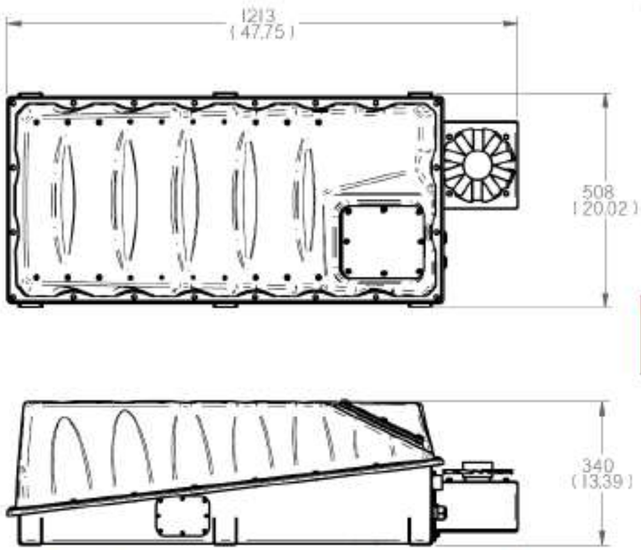

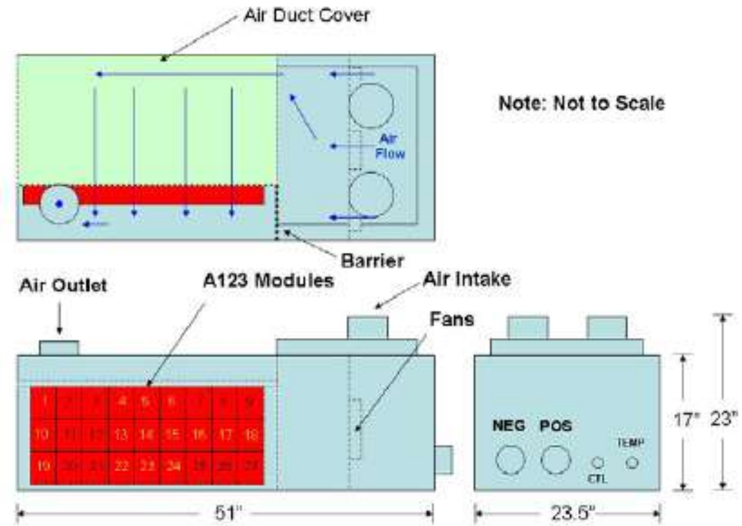

XM1124 Nanophosphate® Pack

XM1124 Based on A123 HD-100

Hybrid Energy Storage

- **100kW output power, 65kW input power**
- **350V nominal (250V-420V operating range)**
- **13.8Ah nominal capacity**
- **4.8kWh energy storage**
- **400A 10s max pulse**

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DRS TECHNOLOGIES

TARDEC

XM1124 “Gen 2” Battery Pack

Nanophosphate™ Technology

The Nanophosphate® Advantage

A123 SYSTEMS

Power

Superior power by weight or volume in a cost effective solution

- Fast charge capable
- Enables smaller, lighter battery pack
- Consistent power over wide state of charge (SOC) range for greater pack utilization

Safety

Nanophosphate® is stable chemically, providing the foundation for safe systems

- Superior safety and abuse tolerance compared to metal oxide lithium ion chemistries
- Independently validated by National Labs and multiple customers
- Multiple layers of protection at the chemistry, cell and system level mitigates risk

Life

Excellent calendar and cycle life with consistent performance over extended use

- Nanophosphate technology retains performance enabling less pack oversizing
- At low rates our cells can deliver thousands of cycles at 100% depth of discharge
- Energy and power capability retained over extended life
- High rate and deep cycling capabilities mean greater battery utilization

Energy

Higher useable energy means greater battery utilization and lower cost

- Deeper cycling and a wider usable SOC range means higher usable energy; more of the battery's energy can actually be utilized in the application.
- High usable energy enables less pack oversizing for superior price-performance

Superior Performance + Greater Battery Utilization = Price-Performance

Scalable Modular Architecture

A123 XM1124 "Gen 2" Battery Pack

Module sizes can be made to accommodate various customer solutions

Fully Automated process allows flexible module fabrication that results in a best overall value product

A123 Prismatic Cell

Nanophosphate® AMP20*M1HD-A*: Designed for plug-in hybrid and electric vehicle applications, the AMP20 prismatic cell is built to deliver high energy and power density combined. The AMP20 cell demonstrates industry-leading abuse tolerance coupled with excellent life performance under the most rigorous duty cycles. The AMP20 delivers high useable energy over a wide state of charge (SOC) range to minimize pack oversizing and offer very low cost per watt-hour.

Power: Over 2,400 W/kg and 4,500 W/L

Safety: Excellent abuse tolerance and environmentally friendly

Life: Excellent calendar and cycle life

Nominal voltage: 3.3V

Nominal capacity: 20Ah

MODULARITY

COST

26650 Cell

Prismatic Cell

A123 Hybrid Vehicle Solutions

A123 XM1124 "Gen 2" Battery Pack

Prismatic Core Technology allows for cost effective total solutions

- Technology commonly used for EV/HEV packs
- Scalable Prismatic Module
- Battery Control Module (BCM)
- Electrical Distribution Module (EDM)
- Current Sense Module (CSM)
- Battery Management and Controls
- Pack Enclosure Systems with Integrated Cooling (if needed)

Prismatic Module

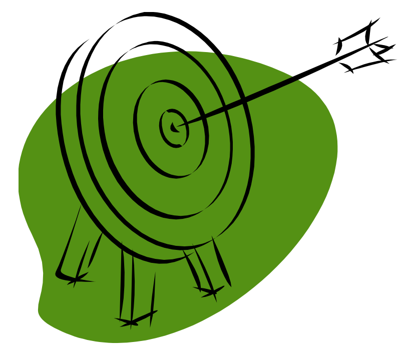
+

EDM+CSM

+

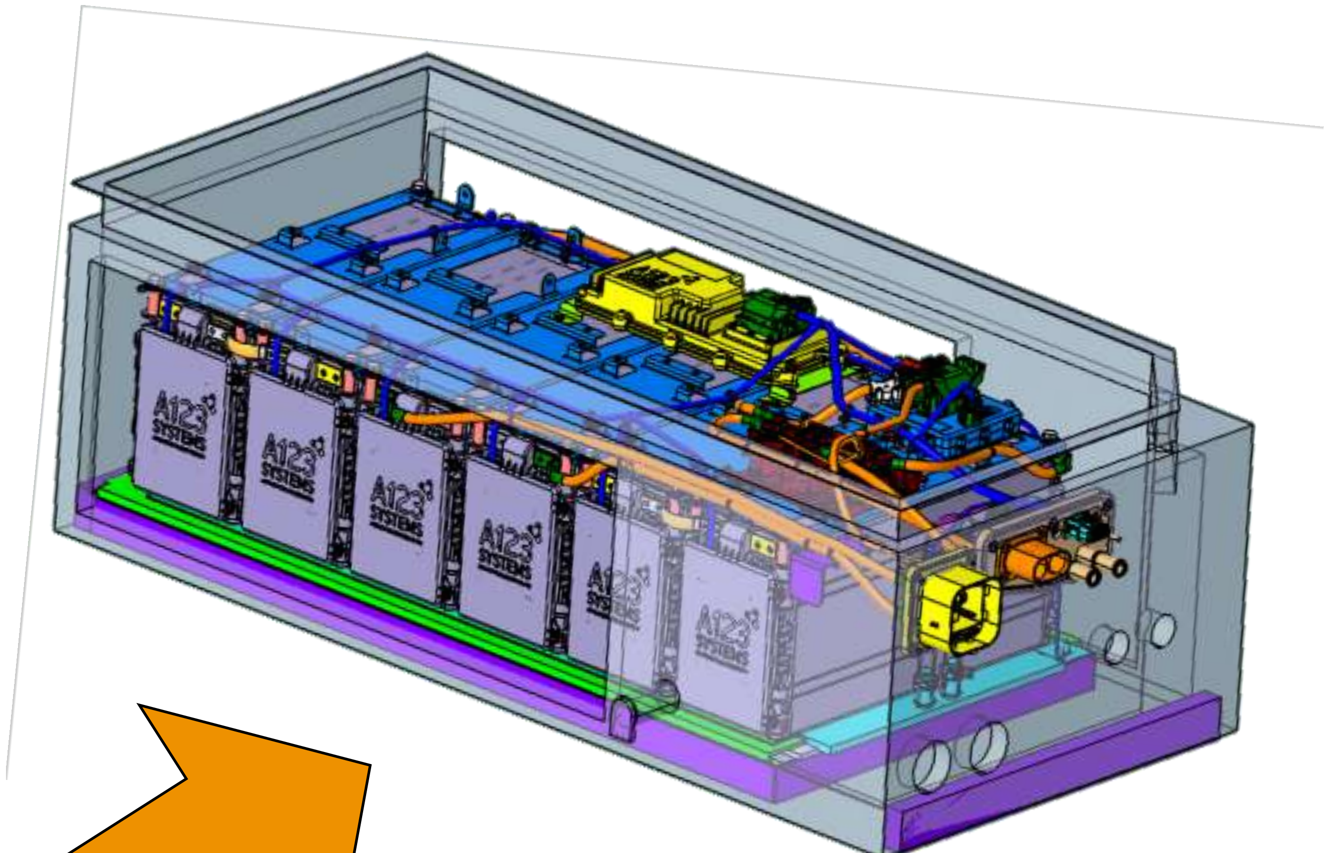
BCM

=



XM1124 Pack Upgrade

A123 XM1124 “Gen 2” Battery Pack

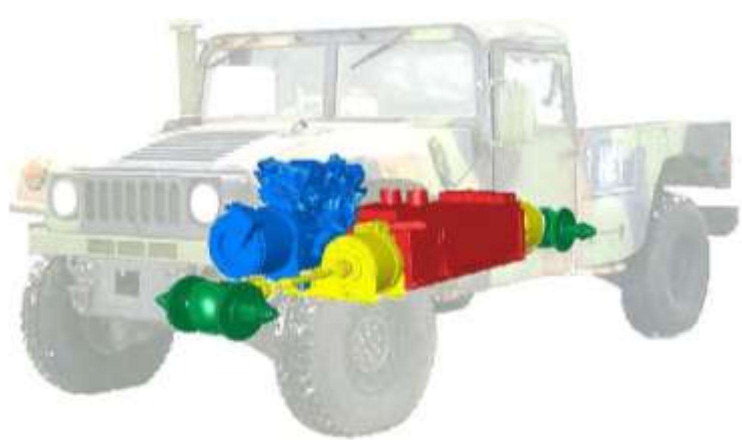


A123 prismatic modules integrated into existing XM1124 battery tray

Pack Characteristics

Performance with and without liquid cooling

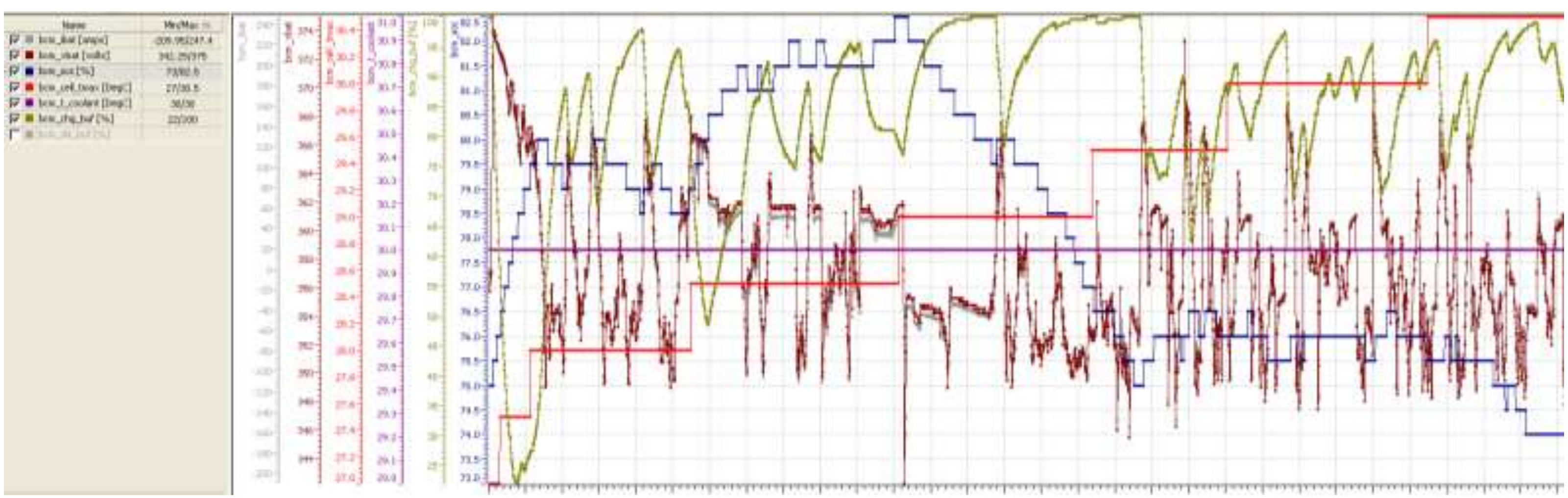
	No Liquid Cooling				With Liquid Cooling			
	CHARGE		*DISCHARGE*		*CHARGE*		*DISCHARGE*	
Duration	*CONT*	*10-sec*	*CONT*	*10-sec*	*CONT*	*10-sec*	*CONT*	*10-sec*
Test Pack Power (kW)	-22	-67	21	61	-22	-113	61	184
Pack Vmax	389	389	389	389	389	389	389	389
Pack Vnom	350	350	350	350	350	350	350	350
Pack Vmin	270	270	270	270	270	270	270	270
Min Pack Energy (kW-Hr)	19.8				19.8			
Test Current (A)	-60	-180	60	180	-60	-300	180	600
Test Temperature (DegC)	25	25	25	25	25	25	25	25
Test SOC (%)	50	50	50	50	50	50	50	50



Pack Characteristics

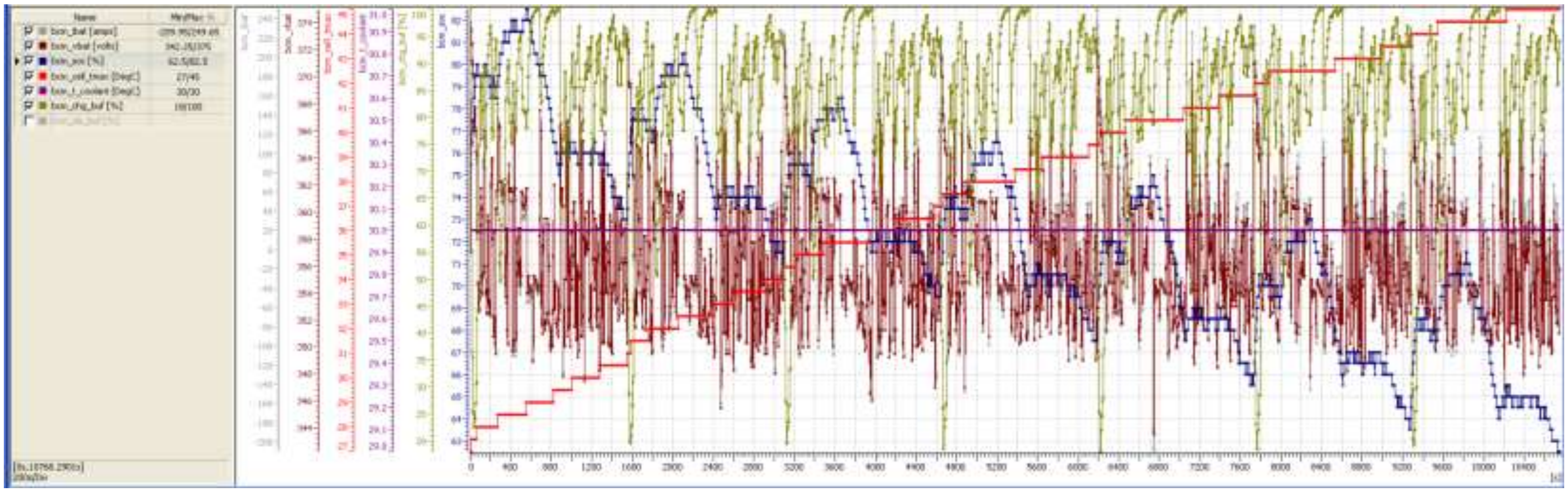
Preliminary Simulation Results

- Duty cycle requirements taken from Gen1 pack during testing used to simulate Gen2 battery performance for various scenarios
- Aberdeen duty cycle
  - Over 25 minutes of battery usage, with no cooling
  - Pack met all performance requirements
  - Battery temperature rise less than 4 deg C



Pack Characteristics
Preliminary Simulation Results

- Repeating Aberdeen cycle for 3 hours still shows pack meeting performance and not exceeding cell temperature limits (without applying cooling)



Current Status

Running Gen 1 profiles from testing on battery cycler to compare performance with Gen 2 pack

Pack to be delivered to DRS in Jun 2011

Conclusion

- HE vehicles are becoming commonplace in commercial market; anticipate the same for Military Markets in years to come
- The “Generation 1” A123/DRS/TARDEC pack worked very well in bench and vehicle testing
- An upgraded prismatic pack would enhance the overall performance at a reasonable cost
- Preliminary simulation and testing shows increased performance over “Generation 1 pack”
- In-Vehicle testing will begin this summer

Special Thanks

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