

Clarkson Electric Snowmobile Team

defy convention.



Clarkson
UNIVERSITY
defy convention

Overview

- Design Goals
- Specifications
- Ergonomics and Emissions
- Drive System
- Battery Choice
- Battery Management
- Charging
- Maintenance
- Lifetime Cost
- Conclusion



Design Goals

- Zero emissions
- High towing capacity
- Low-temperature operation
- Comparable rider comfort and performance
- Safety
- Reasonable range
- High efficiency



Specifications

- 2011 Polaris IQ Shift 550
- 42 hp / 37kW motor
- Zero Emissions
 - Powered by 816 LiFePO₄ cells
 - 6.8kWh Capacity
- Can perform as low as -40°C
- Pulling force: 737lbs (on grass)
- Estimated Range: 18 miles
 - 10.5 miles in poor conditions
 - 13 miles in good conditions with ~3/4 charge

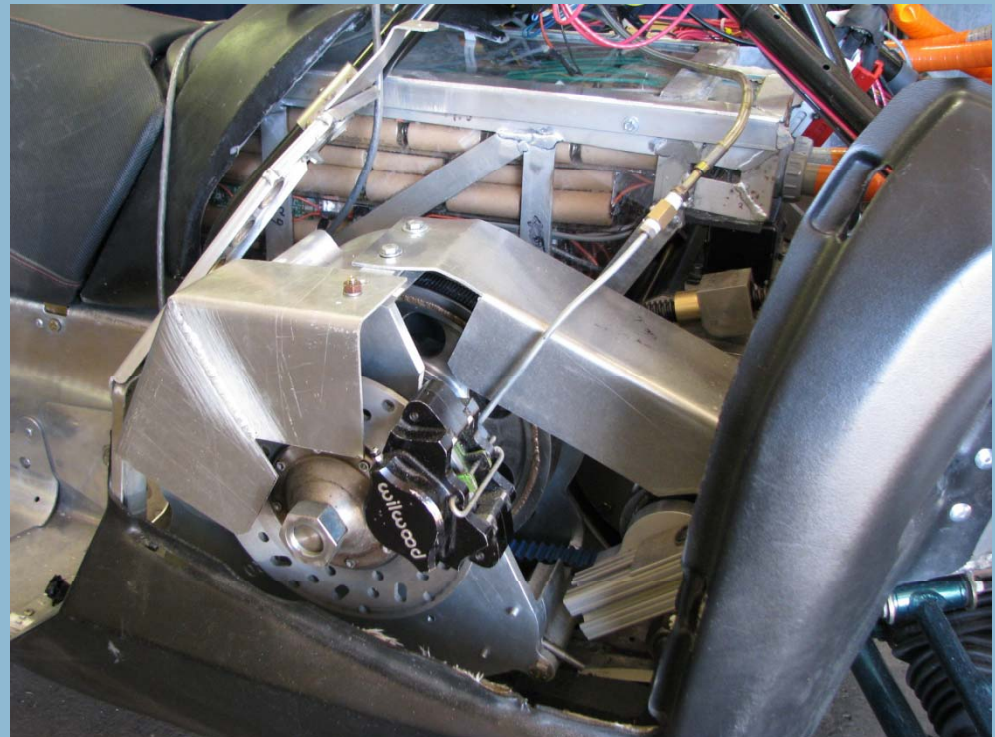


Ergonomics and Emissions

- Ergonomic Design
 - No changes to stock seat
 - Minimal changes to physical appearance
 - Stock comfort features
 - Adjustable skid frame
- Sound emissions
61dB
- Zero air emissions
 - No adverse health effects
 - No affect on pristine environments

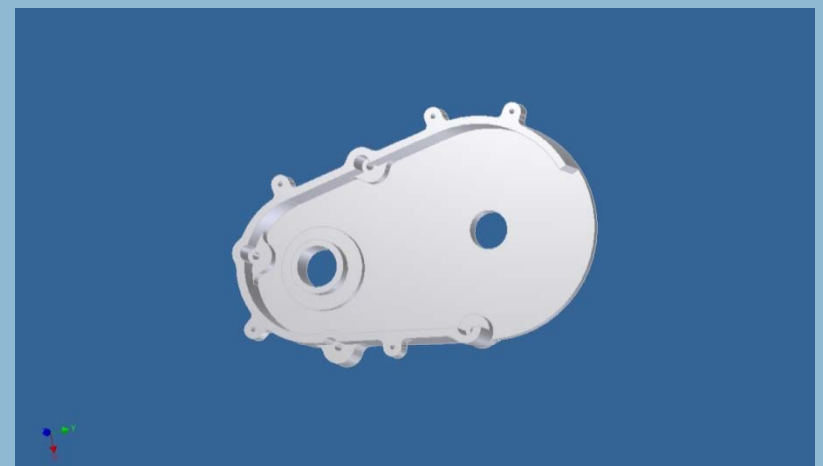


DRIVE SYSTEM



Drive Train

- Direct Drive
- Gates Polychain belt
- Aluminum belt case
- 4:1 Gear Ratio



BATTERY CHOICE



LiFePO₄ (Lithium Iron Phosphate) Batteries

Per Cell

- Energy Density: 103 Wh/kg
- Power Density: 795 W/kg
- Nominal Voltage: 3.2 V
- Energy: 8.32 Wh
- Cell Weight: 80.5 g
- Cell Life: >2000 cycles

Battery Pack

- Number of Cells: 816
- Total Pack Voltage: ~160V



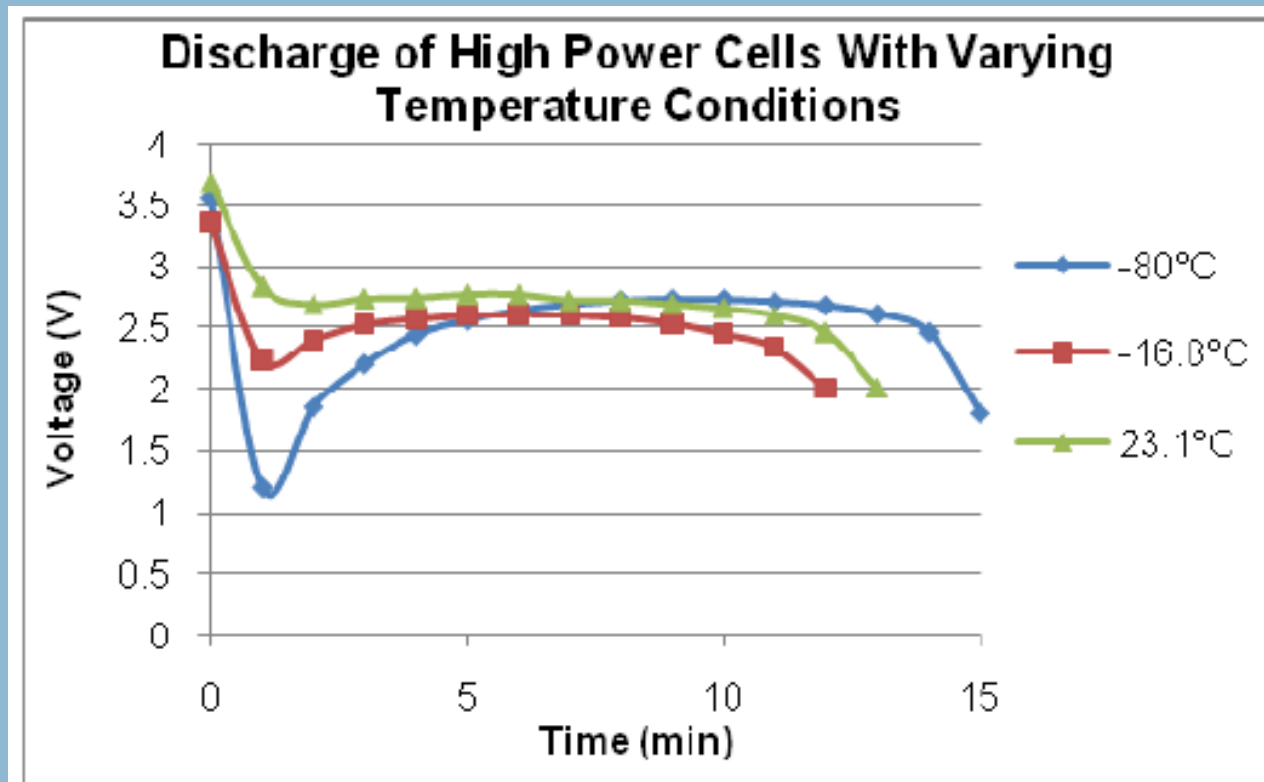
Safety and Reliability of the Batteries

- Proven safe without circuit board protection by:
 - Department of Energy
 - UL
 - Sandia National Labs
 - UN/DOT
- Patented thermal runaway protection



Battery Test Results

- Low temperature data
- Greenland use



BATTERY MANAGEMENT SYSTEM (BMS)

Elithion Lithiumate BMS

- Features
 - Resistive balancing
 - Communication ports
 - Interfacing with the motor controller
 - Displays temperature, battery life, faults



CHARGING

- Custom
- 8 hour charge time
- 89% Efficiency
- 12V Power to BMS
- Automatic Shutoff



Maintenance

Mechanical

- Belt System Requires little if any lubrication (bearings)
- Replace worn belts

Electrical

- BMS
 - Monitor cell health throughout life of snowmobile
 - requires minimal software (PUTTY and drivers)
 - Can identify any problems that the packs have.
- Pack Lifetime >5.5 years if discharged once daily

Cost

- MSRP: \$20,122
- Batteries store 12.2MWh during 2000 cycle lifespan – costs \$1335 at 9.83 cents/kWh
- Equivalent to \$3,907 in gas at \$3.19 per gallon
- Stock 2011 Polaris IQ Shift 550 MSRP: \$6,199
- Net Lifetime cost: \$11,352 more than stock

Marketability and Conclusion

- Meets Design Requirements of NSF
 - Towing Capacity
 - Range
 - Temperatures
- Good for utility applications
 - Ski resorts
 - Wildlife photographers
 - Biologists

Questions?

