

The SAE Clean Snowmobile Challenge

Electric Drivetrains for Zero Emissions
Over-Snow Transportation

What is the Clean Snowmobile Challenge?

- The newest competition in the SAE International collegiate design series. Others include Formula SAE, Baja and others.
- Challenges engineering students to improve on existing snowmobiles to reduce emissions and noise and improve public perception.
- Events include: emissions bench test, in-service emissions, noise, handling, static display, cold start, endurance run, range, draw bar pull, acceleration.
- Hosted by Michigan Technological University, Keweenaw Research Center, Houghton, MI past eleven years.
- Zero Emissions category funded by NSF Arctic Program for past six years
- I serve as a technical inspector, judge, event coordinator, sit on the rules committee and evaluate papers and presentations

Clean & Quiet Does Not Mean Slow



The faster IC sleds in the 2013 competition hit >60mph in the ¼ mile acceleration event.

Benefits

- Teaches students real-world engineering skills
- Innovations transfer to snowmobile industry
 - Direct injected 2-stroke engines
 - Better overall fuel economy and lower noise levels
- NSF gets to use zero emissions sleds at Summit Station, Greenland
- Rapid advances in electric drive snowmobiles has resulted

IC Emissions Testing



Static (dyno) and in-service emissions tests are performed.

Diesel Engines

SUNY Buffalo shoehorned a 3-cylinder diesel engine into their machine and won the emissions event!



Zero Emissions Category

- Added to CSC in 2006 in response to NSF need for motorized access to atmospheric sampling sites in Greenland
- Fastest growing category in the competition
- Meets a real need and may ultimately result in another transfer to snowmobile industry
- Truly ZE: All the energy used for charging ZE sled batteries over the week is more than offset by a 2kW PV array over the course of the year.

Electric Drive Trends

- Lithium ion batteries in universal application
- Different flavors result in different energy densities and performance characteristics
- LiFePO₄ seems to be favored due to inherent stability
- Some require a BMS to prevent any unwanted “Thermal Events”, but all benefit from cell balancing
- AC induction motors seem favored due to greater efficiency – but DC is less expensive
- Direct belt drive to jack-shaft common due to power characteristics of electric motors
- Higher voltages = smaller wires

Safety First!

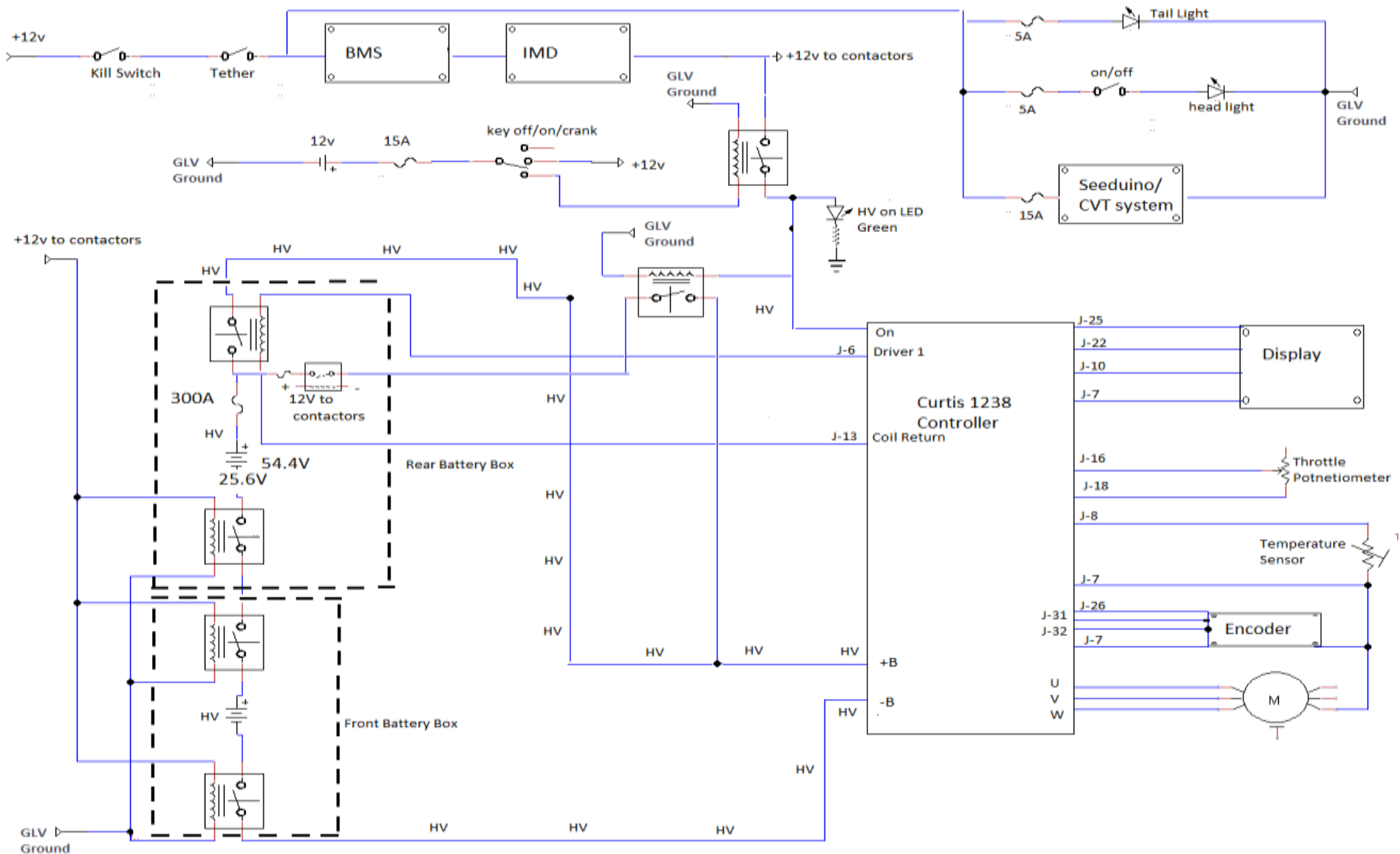
Raising The Bar

- Lots of energy on board – up to 8kWh
- New rules to better match other SAE competitions
- New electrical safety form
- Significant attrition in 1st year of tougher rules:
 - Seven ZE teams registered
 - Five made it to the competition
 - Two made it through technical inspection to compete

Technical Inspections



Technical Design Papers



ZE Events



Acceleration With Load

- Representative of utility type application of electric drive snowmobiles, yet still competitive and fun
- Note PV array in middle left – truly a ZE event

Cold Start Event



Not much drama for the ZE machines, which just quietly power up and pull away.

Objective Handling



Draw Bar Pull



UAF won the draw bar event with >500lbs pulling force.

Range Event



Current record is ~21 miles on a charge



Technological Evolution



Electric Drive Snowmobile for Summit Station, Greenland

- Built for NSF by Cross Chasm Technologies
- Still expensive, but 2.5X less than quote from three years ago.
- Built to specifications:
 - 10 mile range
 - 800 lb towing capacity
 - Reliability/servicability paramount



Acceptance testing in Montreal in February



Hybrid design snowmobile for Canadian Armed Forces

Conclusions:

- Electric drive snowmobiles are a viable zero emissions transportation alternative
- Suitable for supporting scientific research and other niche applications
- Barring a major energy storage breakthrough, they will remain very range limited
- Wheeled vehicles are potentially more efficient if ground pressure can be optimized
- Even more than most electric vehicles, the overall efficiency is very good at Summit due to generator waste heat recovery and use of renewable energy



Questions?