Brent Morris

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2B Term - Class of 2027

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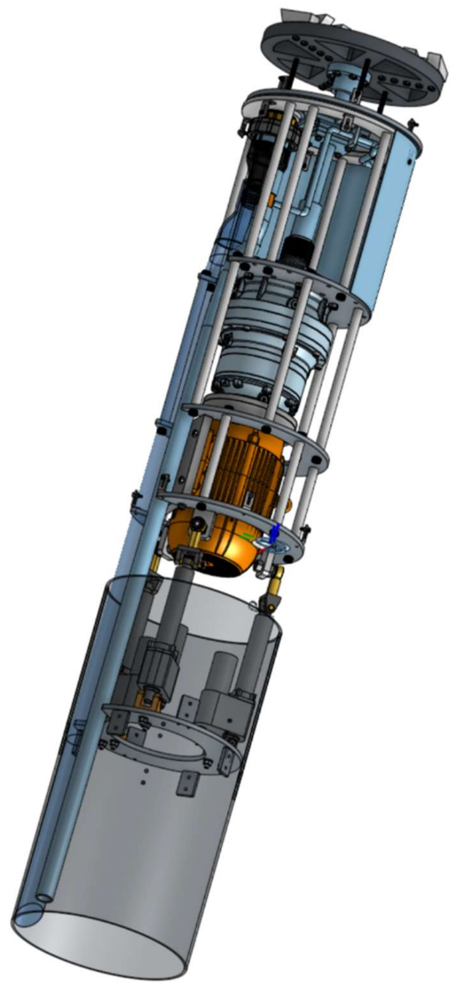
WatDig



WatDig is the University of Waterloo's student design team competing in the Not-a-Boring Competition. The team was founded in Fall 2023 and competed in the navigation mini competition in Bastrop, Texas in March 2024. After winning the navigation award with the Hermes I rover, the team decided to pursue the full-scale competition and design a tunnel boring machine (TBM) to dig a 50cm diameter tunnel 30m in length. Though I formally joined the WatDig team in May 2024 at the beginning of the design of the full-scale TBM, I helped resolve electrical issues for the Hermes I rover from January to March 2024.

While I am officially responsible for the electrical design of the TBM, the mechanical design must come first. My role on the team is currently extremely multidisciplinary as I am involved in the design of the majority of the components of the TBM. I want to help the team make a functioning TBM, regardless of what work is required. The work I have contributed to includes

- Researching and proposing an auger cutter face design as opposed to a scraper cutter face design
- Researching and proposing a winch-based tunnel lining jacking system, as opposed to hydraulic jacks
- Calculating thrusting forces required to advance tunnel lining segments and the TBM
- Designing 480VAC motor control system
- Developing a project management procedure and project schedule for all subteams in Project Libre (a freeware clone of Microsoft Project)
- Consulting in the design of the hydraulic system for the pipe jacking system
- Electrical controls architecture

Please feel free to ask me anything about WatDig's design.

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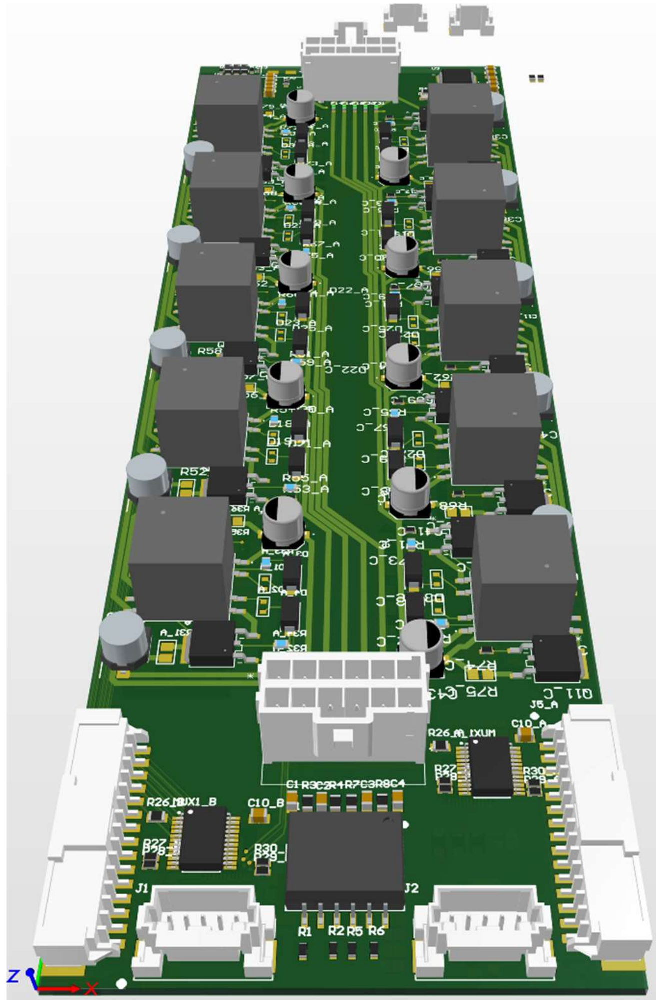
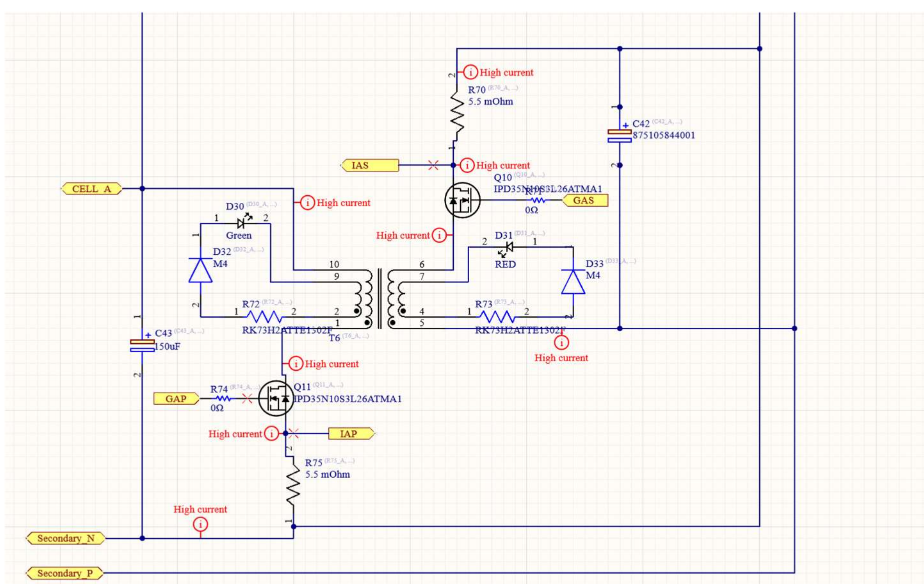
Active Accumulator Management System



As a member of the University of Waterloo Formula Electric Design team I was tasked with designing an active cell balancing board for our accumulator. At the time I joined the team our existing AMS board was responsible for monitoring the temperature of the cylindrical LiPo cells within the accumulator as well as the voltages of all parallel cell groups. The existing board employed passive cell balancing which discharged a cell that was charging at a rate faster than the surrounding cells through a MOSFET and high-power resistor. The existing design was based on the LTC6804 chip.

The existing board was only used during the charging phase to balance cells, while the cells were discharging there was no way to redistribute charge throughout the cells if one cell was discharging faster than the others.

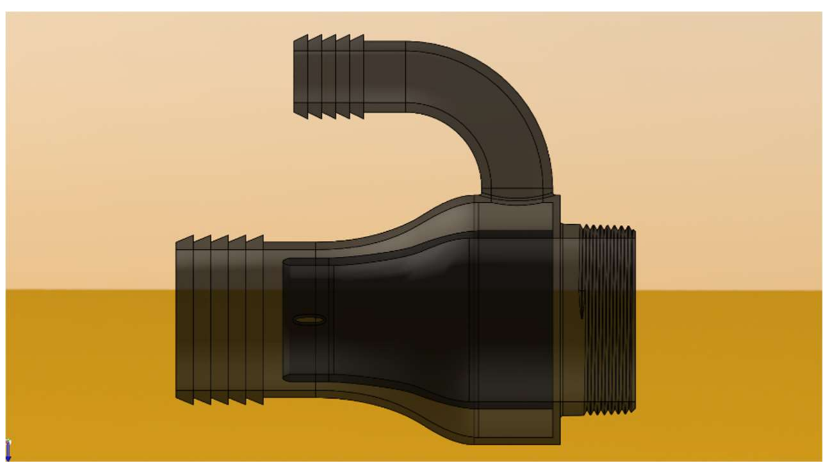


The active accumulator management board I designed used a synchronous flyback transformer topology to transfer charge between individual groups of parallel cells and the rest of the battery stack. The LTC3300 chip was used for this design as it supported ISO SPI communication that was already implemented with the previous boards. The board was designed in Altium Designer.

The new AMS boards were required to fit inside the accumulator box; however, the team did not want to rebuild the accumulator to accommodate a larger AMS board, therefore the active AMS board was required to have the same board space as the passive balancing board. This required a clever high-density component layout.

This project was cancelled 70% of the way through the design phase when the formula electric electrical team lead realised the internal resistances of the LiPo cell composing our accumulator were sufficiently similar that active cell balancing was not worth the development time and cost.

Slurry Jet Pump



Though fluid mechanics is not part of the Electrical Engineering curriculum at the University of Waterloo, I am responsible for designing the muck excavation system for WatDig's tunnel boring machine (TBM). I have taught myself all the necessary fluid mechanics concepts to complete this project.

Our TBM Is designed to pass solids with a maximum diameter of 2in since it will be digging in clay soil with no reported large rocks. We are using a jet pump and slurry line for muck excavation due to the small scale of our TBM and the mechanical simplicity of a jet pump. A typical jet pump injects high pressure water in the center of a pipe to transfer the kinetic energy of a high velocity water jet to the slurry in which the jet is immersed. In our case this design would require an unreasonably large jet pump to pass solids up to 2in in diameter. I settled on injecting the high-pressure water around the circumference of the slurry

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line so the pump could pass 2in diameter rocks through the center while keeping the outside dimensions to a minimum.

I am modelling the clay mixed with water and a soil conditioning surfactant agent with the Herschel-Bulkley model. Though I have preliminary values for Herchel-Buckley parameters, I am scheduled to test a treated soil sample in the University of Waterloo's soils laboratory, under the advisement of Professor Mark Knight, to experimentally determine the Herschel-Bulkley parameters of our slurry.

The geometry of the pump was modelled in SolidWorks. I am performing the CFD simulation in Ansys Fluent. The CFD simulation is not a straightforward process as there are no accurate CFD models for turbulent flow of non-Newtonian fluids other than direct numerical simulation (which is too computationally expensive to be practical). As of August 15th, 2024 I am currently investigating how to simulate the performance of the pump before manufacturing.

We are manufacturing the pump using selective laser-sintered plastic (SLS) 3-D printing technology due to the pump’s required manufacturing tolerances, durability and geometry.