Brent Morris

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Class of 2027

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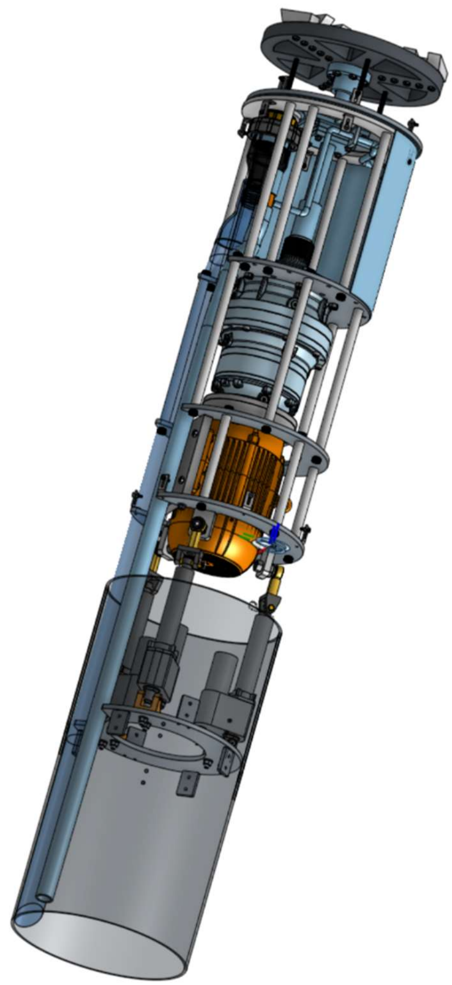
WatDig



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 the team decided to pursue the full-scale competition and design a full-scale tunnel boring machine (TBM) to dig a 50cm diameter tunnel 30m in length. I officially joined the WatDig team in May 2024 at the very beginning of the design of the full-scale TBM, however I helped resolve a few electrical issues for the team from January to March 2024.

I joined the team for my electrical knowledge; however, the detail of my initial electrical design was severely limited when I joined as the team was starting from scratch and did not know their electrical loads. My role on the team is currently extremely multidisciplinary as I am involved with the design of the majority of the components in the design. I want to help the team make a functioning TBM, regardless of what work that requires. Some of the odds and ends work I have contributed to includes

- Proposition and research of an auger cutter face design as opposed to scrapers
- Proposition and research of a winch-based tunnel jacking system, as opposed to hydraulic jacks
- Calculation of thrusting forces required to advance tunnel lining segments and TBM
- Development of project management procedure and project schedule for all sub teams in Office Libre (freeware clone of Microsoft Project)
- Consultation in the design of the hydraulic system for pipe jacking system
- Electrical controls architecture

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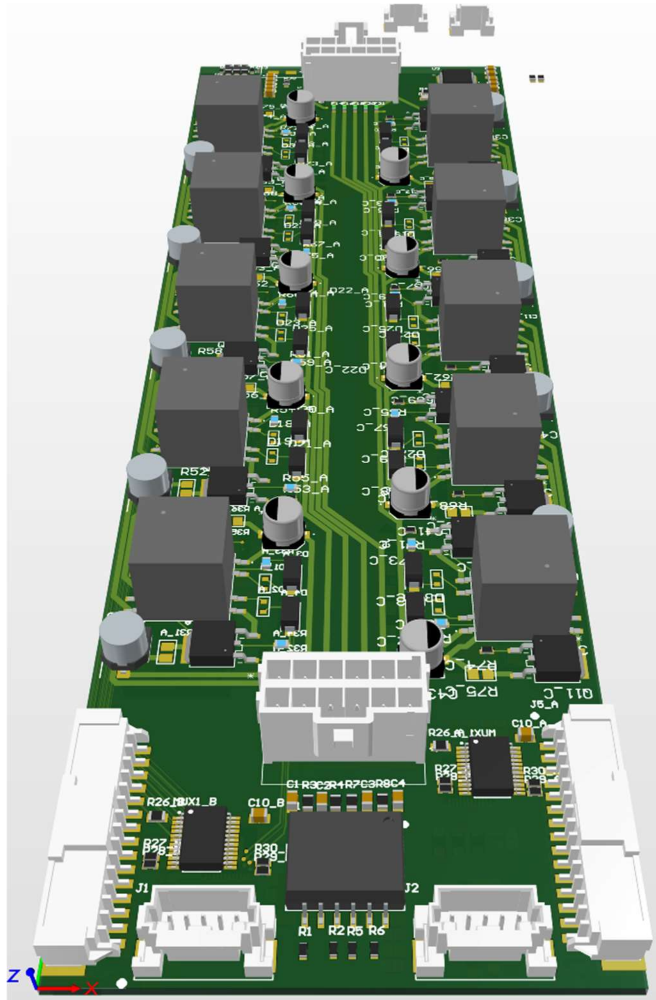
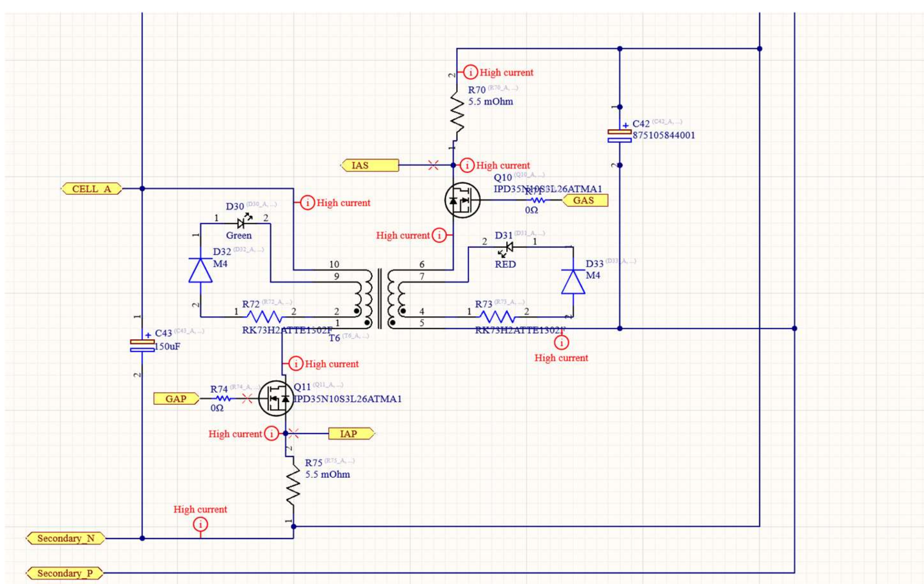
Active Accumulator Management System



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 charging faster than the others.

The active accumulator management board I designed used a synchronous flyback transformer topology to transfer charge between individual group 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 had already been implemented

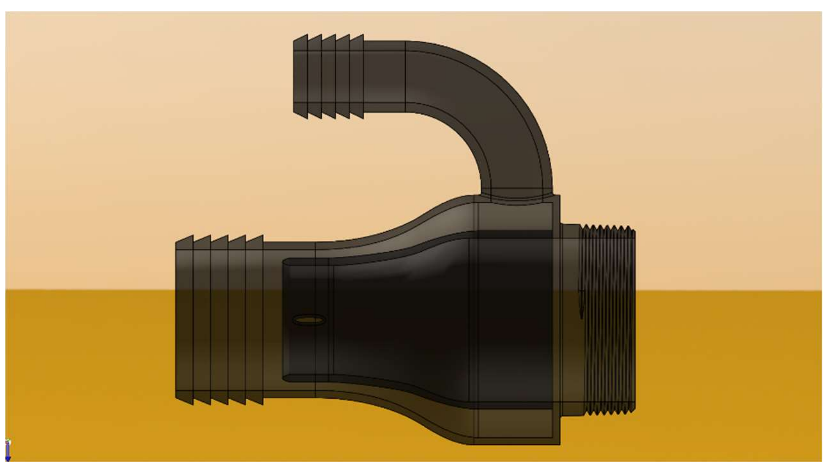


with the previous boards. The board was designed in Altium designer.

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 canceled 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



Electrical Engineering at the University of Waterloo dose not cover fluid mechanics, nevertheless I am responsible for designing the muck excavation system for the tunnel boring machine (TBM). I have taught myself all the necessary fluid mechanics concepts to complete this project.

Our TBM is digging in clay soil with no reported large rocks, as a result our TBM is designed to pass solids with a maximum diameter of 2in. We are using a Jet pump and slurry line for muck excavation due to the small scale of our design 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 2inch in diameter. I settled on injecting the high-pressure water around the circumference of the slurry line so the pump could pass 2inch diameter rocks through the center while keeping the outside dimensions to a minimum.

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

The geometry of the pump was modeled in SolidWorks. I am preforming 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.

Due to the required manufacturing tolerances, durability requirements and geometry of the part we are manufacturing it using selective laser sintered plastic (SLS) 3-D printing technology.

WatDig Electrical

As the University of Waterloo is in Ontario, Canada we are governed by the Ontario Electrical Code. This means our electrical equipment must be designed and installed in accordance with CSA-SPE-1000-21 to legally energize our machine in Ontario.

The current power systems design consists of a splitter with a lockable fuse disconnect on each branch circuit to a motor controller, be it a ACS550 VFD or a soft starter. The only loads on the 480VAC splitter are motor controllers which monitor line voltage and current, therefore the current draw and line voltage of the generator are monitored at all times buy the sum of the current draw of all motor loads. The motor controllers communicate to our control system through Modbus.

The above image shows an outdated electrical plan at a time when we were using 240V three phase power with a main breaker and exclusively Eaton equipment where possible.

The full details of the power systems design have not yet been finalized as I am finishing the Jet Pump design for the team first. After the power systems design is completed, I will shift my primary focus to the control and software components of the tunnel boring machine.

Website

I wrote my portfolio website brentmorris.ca using HTML, CSS and Java script. I chose not to use a framework such as React for the website as I felt the added overhead was not worth the investment for such a small project. I prepared a mock up of the UI in Figma prior to development. The website is hosted with GitHub pages.