Regenerative Braking Electric Skateboard

Team Members:

Ryan Hawkins - Electrical Engineering

Fawzi Al Hadrab - Electrical Engineering

Brad George - Mechanical Engineering

Brendan DeJonge - Mechanical Engineering

Advisors and Mentors:

Faculty Advisor - Ali Pezeshki

Entrepreneurship Advisor - Ian Bernstein

EIR Advisor - Robert Thelen

Summary:
The electric skateboard has exponentially increased in popularity, quality, and capability in recent years, proving itself valuable to everyone from college commuters to professional racers. We believe we have identified two areas where electric skateboards can be improved.

First, most electric boards with regenerative braking don't allow the rider to brake when the battery is full (bad for starting a commute down a hill) or when too much current is generated (bad for steep hills). Our team seeks to resolve this issue by designing an electronics system that will redirect the excess current under braking away from the main battery.

The next issue concerns the trucks (which control steering sensitivity). Normally, a rider must manually adjust the skateboard trucks. If the trucks are loose, the board will be highly maneuverable at low speeds, but will be incredibly unstable at high speeds. Conversely, if the trucks are tight, the board will be stable at high speeds, but hard to maneuver at low speeds. Our team seeks to resolve this by developing a system that will autonomously adjust the trucks while riding according to the speed of the board or input of the rider.

We plan to build two prototype boards. One board will focus on the construction and understanding of individual parts, while the second board will use market ready parts to focus on the entrepreneurship aspect of our project. This board will focus heavily on the improvements that we mentioned above.

Why is This Project Important:
While electric boarding is thrilling and practical, it can be very dangerous. In 2012 alone, 5 people in the US and Canada died from electric skateboarding accidents. Furthermore, many riders have been seriously injured from the inability to brake down hills and from improper steering sensitivity in the trucks. This

project, if implemented well, has the potential to vastly improve the safety of electric boards by addressing the above problems, which could literally save lives.

Revision History

Date	**Description**	**Revision Num**	**Approved By**
9/17/21	**Initial Rough Draft**	**1.0**	**Team**
9/26/21	**Budget Revision**	**1.1**	**Ryan**
10/8/21	**Objective Revision**	**1.2**	**Team**
10/15/21	**Risk Analysis and Contingency Plan**	**2.0**	**Team**

Project Timeline:

Task	Assigned for	Assigne d on	Due by	Dependencies	Completion Status
Design (mechanical)	Brendan DeJonge & Brad George	09/16/2 021	10/20/2021	None	Complete
Design (electrical)	Fawzi Al Hadrab & Ryan Hawkins	09/16/2 021	10/20/2021	None	Complete
Select and Order Individual Longboards	Brendan DeJonge	09/16/2 021	10/25/2021	Design (mechanical and electrical)	Complete
Electrical Components Ordering	Fawzi Al Hadrab	09/16/2 021	TBD	Design (mechanical and electrical)	In-progress
Mechanical Components Ordering	Brad George	09/16/2 021	TBD	Design (mechanical and electrical)	In-progress
ESC Assembly	Ryan Hawkins & Fawzi Al Hadrab	10/8/20 21	11/15/2021	Design and component ordering	Complete
Controller Design and Assembly	Team	10/8/20 21	11/15/2021	Design and component ordering	In-Progress

ESC Assembly	Ryan Hawkins & Fawzi Al Hadrab	10/20/2021	Dependent on Parts	Soldering and building custom ESC	Waiting on Parts
Assembling 1st Board	Team	10/20/2021	11/13/2021	Complete an initially functioning electric skateboard	Waiting on Parts
Manufacturing and Machining	Brendan DeJonge	09/16/2021	11/20/2021	Design (mechanical and electrical)	Incomplete
3D Printing	Brad George	09/16/2021	11/30/2021	Design (mechanical and electrical)	Incomplete
Testing individual components	Team	09/16/2021	12/10/2021	Ordering components, manufacturing parts and 3D printing	Incomplete
Electrical Assembly	Ryan Hawkins	09/16/2021	01/15/2022	Testing individual components	Incomplete
Mechanical Assembly	Brendan DeJonge Brad George	09/16/2021	01/15/2022	Testing individual components	Incomplete
Insulating	Fawzi Al Hadrab	09/16/2021	01/25/2022	Electrical and mechanical assembly	Incomplete
Programming and Coding	Fawzi Al Hadrab & Ryan Hawkins	09/16/2021	01/25/2022	Electrical assembly	Incomplete
Entrepreneurship Improvements	Team	10/8/2021	02/20/2022	Programming and Coding	Incomplete
Physical Testing	Team	09/16/2021	02/20/2022	Programming and assembly	Incomplete
Fixing Testing Failures	Team	09/16/2021	03/1/2022	Physical testing	Incomplete

Testing

Battery Pack and BMS

This phase of testing will have the main focus of ensuring the efficiency, water and dust resistance, battery discharge and battery charging safety. After the battery pack is connected to the BMS the voltage output of each cell will be measured using a voltmeter. Using the data gathered, the output values will be compared with the data acquired by the BMS. This initial phase of testing will determine if the circuitry of the custom battery pack is connected correctly.

Furthermore, the charging capabilities must be tested by analyzing through the BMS's oscilloscopes. First we have to ensure that all batteries are being charged in a balanced manner, while reaching a battery capacity of only 90% then automatically cut off charging. Overloading the battery pack will cause the batteries to dissipate increased amounts of thermal energy. Thus, monitoring the temperature of the battery pack while charging is crucial as we should expect the battery pack to rise in temperature about 10°F but no more, as a drastic increase in temperature will cause the batteries to start a fire.

Enclosure Testing

Afterwards, we need to consider the normal operating temperature of electronics in the enclosure to guarantee that the enclosure won't deteriorate from heat. The enclosure will be 3D printed using ABS filament because of its higher heat resistance ability when compared to other materials like PLA or PVA. ABS filament can withstand temperatures reaching 100 degrees celsius and is also water and impact resistant. Temperature sensors will be required for testing the temperature of the battery packs during optimal charging conditions. Lithium-ion batteries typically range from 40-50 degrees celsius which is well under the requirement for the enclosure to keep its shape; however, using a 12s2p battery pack could increase the ambient temperature above the threshold especially if there is not proper ventilation within the enclosure. Temperature sensors can be used to monitor the real-time temperature of the battery pack as it is charging under standard charging conditions. During the test, the temperature of the cells will be monitored while charging the battery pack from 0-90% and additional sensors will be placed at critical points on the enclosure and monitored to ensure the temperature doesn't exceed 95 degrees celsius to be conservative. In the case of excessive temperatures during the test and the possibility of lithium-ion battery explosions, the test will have to be carried out in an open space with hardware installed that will be able to stop the charging process at any point. Should any of our temperatures exceed the requirements, the test will be terminated, the enclosure will be removed, and the system will be air cooled until it is stable. The battery charging voltage will then be altered and the test will begin again. The battery temperature and ambient temperature inside the enclosure should always be lower due to air cooling during riding; therefore, the temperature during charging is the only temperature testing required for the enclosure.

6355 180kV Motors

A relatively common failure mode within electrical skateboard systems is the sudden termination of motor power due to high temperatures. As data for the cutoff temperature of these motors cannot be found, testing will be required to determine what that temperature is in order to develop a system that will consistently keep the motors from exceeding this limit. Additionally, to keep debris from affecting the drivetrain, we plan on using ABS filament to 3D print additional parts that will shield the pulley system from small rocks and other debris that will also need to be kept at temperatures below 100 degrees celsius. Using temperature sensors to monitor the motor temperature at maximum power over a period of time will give us a better understanding of the limitations we will face in the future. If the cutoff temperature is well below our threshold of 100 degrees celsius, no further design changes will be necessary; however, additional air cooling will be required if the motor consistently exceeds the limitations. Using the temperature data from previous results, we can simulate the heat transfer from the motors to the ambient air at different relative wind velocities, air temperatures, and motor RPM using computational fluid dynamics. The enclosure geometry may also be altered in order to maximize the velocity of air flowing over the motors to increase the rate of heat transfer. This method of testing will be time-consuming and iterative, but will be necessary to prevent sudden discontinuation of a vital component of the system during rides and to ensure the motor covers protect the drivetrain.

Performance Requirements

The first performance requirement we will be testing for is the top speed of the board. This parameter will give us a direct comparison to other boards that are already on the market. Our target speed will be between 30 and 35 miles per hour, with a minimum speed of around 20 miles per hour. The next performance requirement we will be testing for is the torque of the motors. This will determine the rate of acceleration of the board. This parameter will help us determine if our motors are operating at peak efficiency, or if we need more power towards the motors. We can also test the weight of the board, but this won't be easily changed once the prototypes are built. The last important factor will be the range of the board. This will be another excellent comparison to other boards on the market. The efficiency and the size of the battery pack will be the main contributing factor for this parameter.