Formula SAE Electric Vehicle Project Proposal Draft

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***Abstract*—This project aims to assist Tennessee Tech's Formula SAE club by designing the powertrain, controls, and power systems for the club's first electric vehicle. This project, for both the design team and the Formula SAE Club, serves as an introduction to the development of electric vehicles by exposing new engineers to the development of this area of automotive engineering.**

****CRITICAL: Do Not Use Symbols, Special Characters, Footnotes, or Math in Paper Title or Abstract*. (***Abstract***)**

Keywords—component, formatting, style, styling, insert (*key words****)***

I. Define Problem

A. Background

The goal of this project is to design the power system and powertrain system of an electric formula car for Tennessee Tech's Formula SAE club, herein referred to as Formula Club. This will be the club's first electric car, so it is crucial that these systems are designed to comply with the rules, specifications, and constraints of the Formula SAE guidelines which will be discussed in their own section.

Since this is the Formula Club's first electric vehicle much research and collaboration with the Formula Club is necessary. It is also important to note that these vehicles are very iterative and are modified and adjusted over the course of multiple years. This will be considered when designing the systems this project aims to complete.

This project, and the Formula SAE Electric competition, gives new engineers exposure to the rapidly developing field of electric automotive engineering. With more engineers being introduced to the field the potential for innovation increases. Innovations that could have a positive impact on society. These potential effects will be discussed later in its own section.

B. Objective

The main goal of this project is to design the powertrain and power system for the electric vehicle, so that it meets the specifications and constraints set by Formula SAE. These systems, and any related subsystems should be in a state so that the Formula Club can continue to develop the rest of the vehicle.

C. Benefits

The main benefit of this project its relation to the Formula Club. Completing this project will help the club enter the electric vehicle into the Formula SAE Electric competition. This will expose current and future members to the field of electric automotive engineering. Students and faculty of all engineering disciplines will learn more about electric vehicles and contribute new ideas to the field.

D. Challenges/Obstacles

This project presents several key challenges that must be carefully managed to ensure its success:

1. **Compliance with Formula SAE Regulations**:
The primary constraint is adhering to the rigorous rules and specifications set forth by the Formula SAE competition. All design decisions must align with these regulations to ensure the vehicle is eligible to compete. This requires a thorough understanding of the Formula SAE guidelines and frequent consultation to avoid violations.
2. **Limited Control Over the Vehicle's Structure**:
As this project focuses on the powertrain and electrical systems, the team has limited ability to modify or redesign the physical structure of the vehicle. The Formula SAE club is responsible for building the car, meaning that we must work within the constraints of their design choices. Any proposed modifications to the vehicle must be communicated clearly to the club, and we may need to persuade them to adopt changes that will optimize system integration.
3. **Collaboration with External Teams**:
Another challenge is the need to coordinate with a separate group of mechanical engineers who are not directly involved in this project. Their expertise and availability will significantly affect our team's ability to integrate the powertrain and electrical systems. Communication and collaboration will be key, but potential differences in priorities and schedules could limit efficiency and introduce delays.
4. **Iterative Development**:
Given that this is the Formula Club's first electric vehicle, we anticipate a learning curve and a process of continuous iteration. The systems we design will likely be refined and adjusted in subsequent years, making it essential that we provide flexible and modular solutions that future teams can build upon.

E. Availability

Availability of resources, personnel, and time will be a significant factor in this project's success. The design and development of the powertrain and power system must be coordinated within the schedules of multiple teams and stakeholders. One key challenge will be working with mechanical engineers not directly involved in this project. Their availability will dictate how quickly certain aspects of the design can be integrated into the vehicle.

Additionally, the Formula SAE club members may have competing commitments that could limit their availability for collaboration, requiring careful planning and clear communication to ensure the project progresses smoothly. Our team will need to remain flexible and adaptable, balancing tight deadlines and resource constraints while ensuring that the systems are delivered on time and meet the required standards. To mitigate availability issues, we plan to establish a regular communication schedule, prioritize tasks, and set clear milestones to keep the project on track despite potential delays or scheduling conflicts.

F. Stakeholders

The stakeholders involved in this project are:

5. **Formula SAE Club**:
   As the primary recipient of the powertrain and electrical systems, the Formula SAE club at Tennessee Tech will benefit from a working electric vehicle that meets the competition's specifications. Our work will empower the club to compete in future Formula SAE Electric competitions and pave the way for further development in electric vehicle technology.
6. **Tennessee Tech University**:
   The university itself is also a key stakeholder, as successful competition outcomes could bring increased recognition and funding. Additionally, this project can generate greater interest in engineering programs, particularly in electric vehicles and renewable energy technologies. The university stands to benefit from both the academic and practical experiences gained by students working on this innovative project.

II. Specifications and Constraints

- This Formula SAE Electric powertrain shall comply with all rules and regulations specified in the Formula SAE rule book [1]
- This electric powertrain shall have enough performance to be comparable to Tennessee Tech Motorsports internal combustion engine car.
- This electric powertrain shall be designed around the budget allotted by the engineering department.
- This electric powertrain shall be designed around the time available for the Capstone senior design group.

III. Identify Relevant Literature (Patents)

Patents are important for a Formula SAE electric car because they protect the unique technologies and innovations developed, like improved battery systems and electric powertrains. Securing patents ensures that the team behind the car has exclusive rights to their work, preventing others from copying it without proper permission. This not only helps safeguard their hard-earned research and investment, but it also opens doors for potential licensing and commercial opportunities beyond the field of motorsports.

IV. Set Goals and Measurements

The specifications of this project are defined in the Formula SAE Rules [1]. This powertrain shall be comparable in power to Tennessee Tech Motorsports' (TTM) internal combustion (IC) engine currently used in their Formula SAE competition car.

We will measure our success by testing the powertrain to ensure that it is compliant with every Formula SAE rule. An example is the Electronic Throttle Control (ETC) system that the SAE organization requires. If the two Accelerator Pedal Position Sensors (APPS) read values that have a 10% or greater difference for a duration of 100 milliseconds, the powertrain must disable itself automatically. To test a specification like this example, an oscilloscope would be connected to the APPS sensors, and the throttle output. The inputs and outputs of the ETC system could then used to prove that the system is rule compliant, and a goal of the project has been completed. All tests of rule compliance shall be run until the powertrain is in accordance with the Formula SAE Electric rules

Additionally, success shall be measured by placing the operational electric powertrain on TTM's dynameter table to check if the performance is similar to TTM's IC engine.

V. Estimate Resources and Timeline

A. Design Cost:

The Formula SAE Club has many parts and materials for us to use, but there will be parts and materials that we will have to purchase. The following table details an itemized list of parts or other materials needed for the completion of the electrical portion of this project:

TABLE I – COST OF MATERIALS

Item/Material	Description	Cost (USD)

B. Skills Needed:

The skills required for this project are more hardware based than software based. Hardware skills for this project include… Collaboration with the Formula SAE Club is necessary for knowing what will be required. Software skills may include being able to program a micro controller such as an Arduino to track certain metrics and give a response based on said metrics. As for hardware-based skills, being able to understand and follow wiring diagrams is crucial to the success of this project as we will be using components from different sources to connect the battery and motor. There is plenty of documentation online that could be helpful in making progress with this project. Being able to scan through and find relevant information is also a skill that is good to have.

C. Timeline:

A broad look at the current timeline of events is as follows:

- August – December 2024: Design Project
- January – May 2025: Build project

A more detailed look at the current timeline of events is as follows:

2024:

- October 28: Conceptual Design Finished
- November 30: Detailed Design Finished

2025:

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VI. BROADER IMPACTS

Developing a fully electric Formula SAE car under proper standards could drive significant advancements in technology, particularly in battery performance, energy efficiency, and materials science. These innovations could, on a broader scale, vastly improve the range, charging speed, and energy management of EVs. Additionally, it would promote sustainable engineering practices, reduce carbon emissions, and support the transition toward cleaner transportation. The ripple effects could include potential job creation in green industries, as well as further investments in electric mobility infrastructure. Overall, this shift could influence the automotive industry and inspire public interest in sustainable industries.

REFERENCES

The template will number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in [3]—do not use "Ref. [3]" or "reference [3]" except at the beginning of a sentence: "Reference [3] was the first ..."

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the abstract or reference list. Use letters for table footnotes.

Unless there are six authors or more give all authors' names; do not use "et al.". Papers that have not been published, even if they have been submitted for publication, should be cited as "unpublished" [4]. Papers that have been accepted for publication should be cited as "in press" [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [6].

[1] Formula SAE, "Formula SAE Rules 2024 Version 1.0", fsaeonline.com, https://www.fsaeonline.com/cdsweb/gen/DownloadDocument.aspx?DocumentID=369d01c0-589d-4ebe-b8d4-b07544f4a52b (accessed Sep 14, 2024)

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[3] I. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

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[7] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.