ECE Kit Project Proposal

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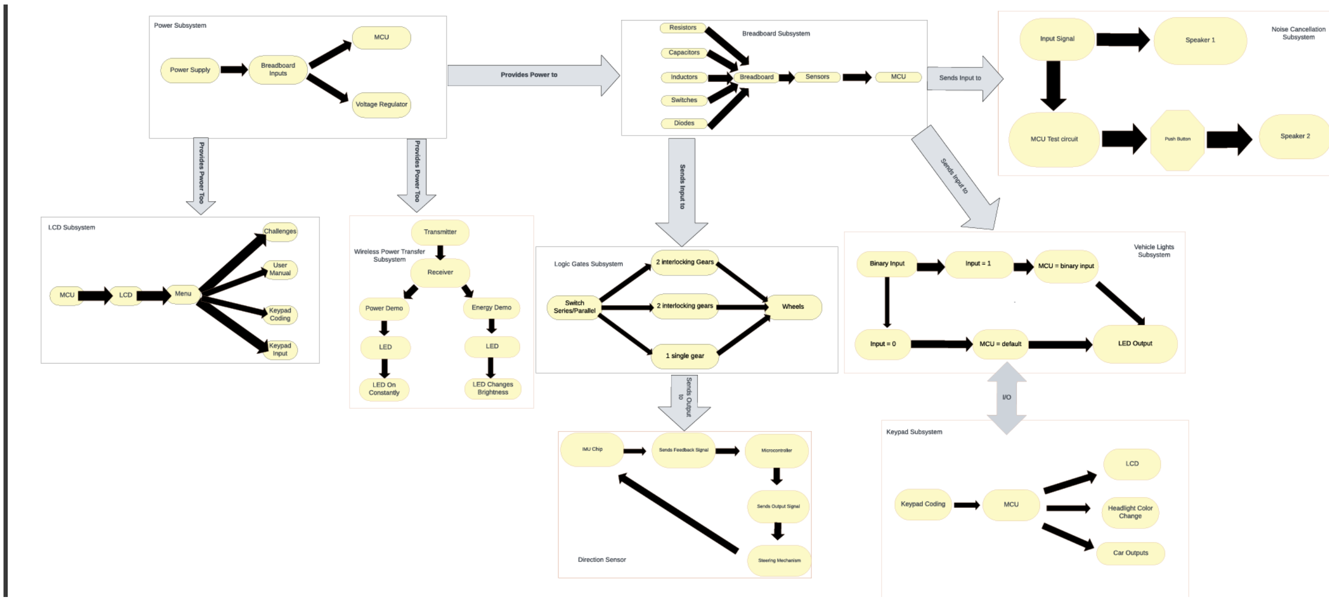

Figure 1. Main System

I. Introduction

The purpose of this document is to give a more in depth understanding and explanation of the electrical and computer engineering kit which has the goal of creating a better way of learning for highschoolers or incoming freshman students. The different conceptual designs are explained within the block diagram section, and within the block diagram section, the main system is highlighted and broken down into nine subsystems which are explained in depth. The purpose of these explanations is to show what the kit will do and not how it will be accomplished. By showing what the system will do, the team will be able to lay out the fully formulated problem and how this problem will be solved using the ECE kit. Using multiple sections within the document, the specifications and constraints will be explained to give a better understanding of the capabilities of the kit and any background information needed will be documented in the background section. A general timeline will also be provided to give a good idea of when certain objectives will be met. Furthermore, the goals of the stakeholder will be shown as met by explaining what the kit's abilities are while also abiding by the constraints which will be provided to maximize safety. Along with that, the team will attempt to minimize risk by defining unknowns and other possible setbacks. Lastly, the team will identify how to minimize cost and utilize the consumption of resources.

II. Fully Formulating the Problem

Incoming students with desires of majoring in electrical/computer engineering come with varying background knowledge regarding the field. Some students may have a better understanding of electrical properties compared to peers, so it vital for other students to have the same understanding to be successful in the engineering courses. Some of the main reasons students drop out of engineering are because of the fear of failure or lack of understanding conceptual properties that cannot be seen [4]. For example, things like voltage, current, resistance, or capacitance are concepts that cannot be seen. The problem is when students do not grasp a strong base understanding of electrical properties early, students tend to fall behind in the next level of classes.

Designing something that can physically represent these concepts will bridge the gap for students lacking understanding. This design will be used as an instructional tool that delivers a hands-on learning experience that will physically represent electrical properties and demonstrate circuitry in a safe yet immersive way. With hopes of stimulating students early with interactive learning in the electrical/computer engineering program to pursue a career in STEM. Designing a model vehicle with integrated experiments that show electrical properties allows the students to get familiar with unknown properties by learning how to use circuitry to demonstrate and control these properties. With the rise of EV and knowing almost all incoming students are familiar with cars, it is a great way to represent these properties through the operations of a vehicle. With the use of a vehicle-based learning kit, students see real world applications from these electrical properties. Ensuring safety even if students wire a circuit wrong gives the students the ability to learn from failure and grow their engagement in said concepts. This unique design showcases real world applications of electrical properties in an approachable way for incoming students to learn and retain a better understanding of electrical properties.

Considering the fact that the targeted users will likely have no safety training;

1) : The kit shall operate at safe voltage levels for educational purposes.

2) : The kit shall possess safety features such as short circuit protection and overcurrent protection.

3) : The kit shall be water resistant or still work after an exposure to water

4) : The kit's speed shall be limited to a max of –3 to 3 mph, since higher speeds may cause the car's motor to overheat.

5) : The kit shall respect the voltage limitations set by the manufacturer to avoid overheating the battery on the charger and prevent fires [9].

6) : The kit shall follow safety requirements and standards relevant to educational materials used in the kit. To ensure that users can easily assemble and operate the kit without any confusion or difficulty;

7) : The kit shall define clear instructions, labeled components, and a user-friendly interface.

8) : The kit shall allow the student to assemble and disassemble components, promoting hands-on learning. As the goal of the kit is to provide a hands-on learning experience that is both educational and engaging for all users;

9) : The kit shall include comprehensive learning materials including manuals, background information, and step by step guidance for each experiment.

10) : The kit shall be made with durable components that last over a school year.

11) : The kit shall include cost considerations, so it is easily accessible for educational institutions.

12) : The kit shall follow safety requirements and standards relevant to educational materials used in the kit. To ensure the kit's usage longevity and make sure the kit is always usable,

13) : The kit shall include extra components in case a replacement is needed.

14) : The kit shall have safety features which shall allow its functionality even if components are misplaced.

15) : Since the kit ultimately a car, The kit shall be movable and allow users to conduct experiments in various locations.

III. Ethical, Professional, and Standards Considerations

A. Ethics

To ensure ethics are taken into account, the team will use parts for the kit that are affordable yet reliable to the customer to ensure the product is consistent and accurate. While doing so, the kit will be able to be used and purchased by many other users who are interested in the ECE curriculum. The goal of this is to ensure that there are less limitations on who the user is by making the kit affordable to not only universities but anyone who may be interested in learning about electrical and computer engineering. Furthermore, the team will ensure that all information given and displayed will be true and accurate to the best of their abilities. The team strives to provide a learning experience which teaches accurate information, refraining from giving or allowing any false information.

B. Standards

The standards of electrical and computer engineering design will also impose some constraints on the project. As listed in the project proposal, any radio signals being used in the project will be constrained to frequencies under 9 kHz. According to Section 15.3 of the FCC guidelines, "An incidental radiator is an electrical device that is not designed to intentionally use, intentionally generate or intentionally emit radio frequency energy over 9 kHz" [3]. The standards for batteries and power supplies will constrain our power subsystem design as well as what microcontrollers we can use. The design has no high voltage requirements, so all components can have basic shielding.

C. Broader Implications

Originally, the team was going to make a kit using electrical components to show the functionality of different car parts such as headlights, air conditioning and tire rotation. The customer wants the car to move so this might cause the price of the kit to increase due to the added specifications. The goal is to construct a kit involving a moving car with different parts of the car demonstrating electrical properties. By making a specified requirement to make a moving car, all the parts are built in together and nothing strays out on its own. This gives the kit a better user-friendly interface. To ensure the kit will be on time, the team has decided to first complete and order the power system subsystem since it feeds into all other subsystems. This will give the team the ability to first optimize the power subsystem, so each other part will have a safe power input.

IV. Block Diagrams

The system has been broken down into nine subsystems. While some of these subsystems overlap, a few of them are mainly by themselves. The first subsystem is power. The power subsystem will be responsible for powering every aspect of the system and will be described more in detail in "Subsystem 1." The second subsystem is the block inputs. This subsystem will be responsible for allowing the user to use different circuitry components and see the outcome. It will be described below in "Subsystem 1." The third subsystem will use logic gates and gears to control forward or backward direction of the car. It will be explained in detail in "Subsystem 3." The fourth subsystem will be responsible for noise cancellation. It will be found in detail in "Subsystem 4." The fifth subsystem is wireless power transfer demonstrating power and energy. It will be found in "Subsystem 5." Subsystem 6 is responsible for correcting the direction of the car using a closed loop system. It is explained in "Subsystem 6." Subsystem 7 will demonstrate the use of a keypad interacting with the user. It is found in "Subsystem 7." Subsystem 8 will demonstrate outputs using an LCD. It is found in "Subsystem 8." Subsystem 9 is responsible for showing output using lights on the car. It is found in "Subsystem 9."

A. Subsystem 1:

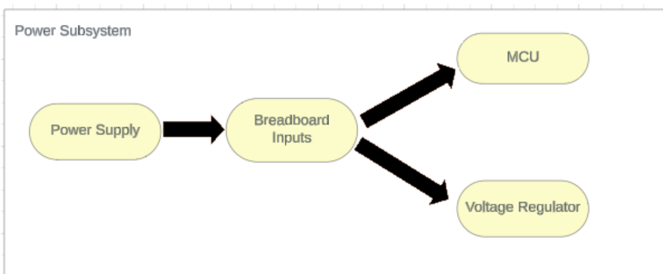

Figure 2. Power Subsystem

The Power Delivery Subsystem is responsible for supplying and maintaining all power for the whole project. Because this system needs to be mobile, the main power source will be a battery or some other portable form of power. For powering the Microcontroller, the voltage input ranges from 3.3 to 5 volts [1]. With this in mind, the power supply needs a max of at least 3.3, ideally 5, volts. Also in this subsystem, there will need to be voltage regulators. Some components will need varying levels of input voltage and current, so a regulator that can manage all of these differing values will be necessary for operation of the kit. Lastly, there will need to be hard-wired kill switch. This switch is connected in series directly behind the source. This allows this switch to cut off all power to the rest of the kit in the event of an emergency or if the unit is to be turned off for storage.

B. Subsystem 2:

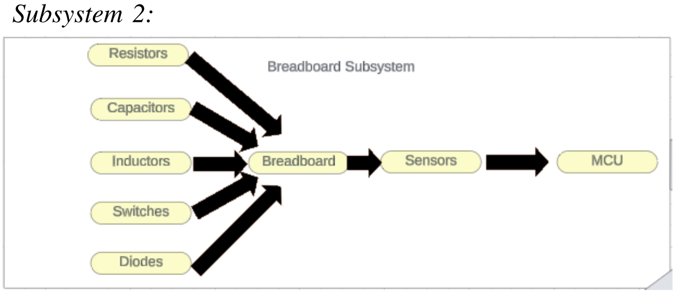

Figure 3. Bread Board subsystem

The breadboard subsystem serves as a method for the user to interact with the project. The user will be given several circuit components, ranging from resistors, capacitors, and inductors to other components such as switches and speakers. The amount of block slots will range from 0 to 5. This means that the outputs will have a "default" value for operation that the blocks will alter based on what's inside them. These blocks will be connected to a device that can detect these components through sensors. These sensors will be able to gather data on what component is connected, how they are connected to each other, and the value of the component. This sensor data is then gathered and sent to the Microcontroller, which takes this data and uses it for outputs. The breadboard will need to be separate from the body of the car unit so that no adjustments to a moving car will be necessary. This connection can simply be a wire, and it would be wise to stick the power system in this as well, as a kill switch needs to be the first in line following the power source.

C. Subsystem 3:

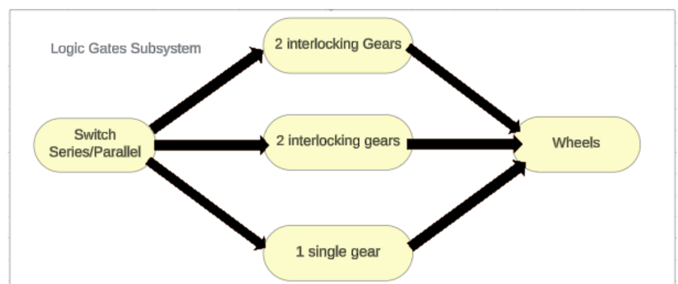

Figure 4. Logic gates/Gears Subsystem

The logic gates subsystem's main purpose is to show the functionalities of AND, Or, and NOT logic gates. The system will take the user's input to move the car forward and backward as needed. The first part of the system will consist of 2 switches in series, connected to two interlocking gears [6] to conceptualize the AND logic gate. When both switches are on, the output, more precisely the wheels, will be turning. When at least one switch is off, the wheels will stop moving and the car will come to a stop. The second part of the system will also consist of 2 switches in parallel connected to 2 interlocking gears that represent the OR logic gate. When at least one switch is on, the output will be on, the wheels will turn, and the car will move forward. When both switches are off, the output will be off, and the car will come to a stop. The third and last part of the system only includes one switch which output will be inverted to match the NOT gate logic gate function, letting the car go backward when the switch is on. In conclusion this subsystem will interact with the user, get his input, and provide a hands-on understanding of the most common logic gates.

D. *Subsystem 4:*

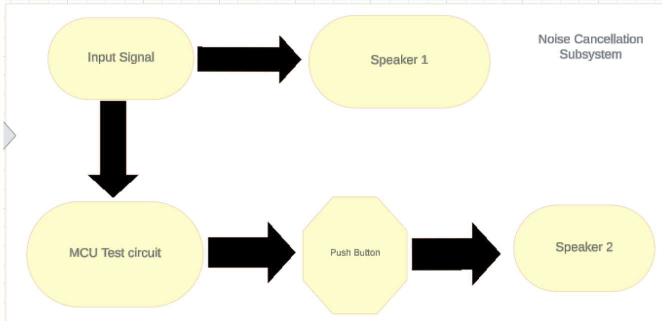

Figure 5. Noise Cancellation Subsystem

The noise cancellation subsystem gives students the opportunity to practice with building circuits that include op amps. This subsystem will demonstrate the electrical concepts of filtering, noise cancellation, and noise amplification. The subsystem will also interact with the breadboard input subsystem to gather the signals input. This is because students can construct circuits that will amplify or cancel the output sound. To do this, one speaker will output the original signal, and a second speaker will output the signal after it passes through the circuit the student built on the breadboard. Using the micro controller to test the circuit's gain allows the second speaker to output the desired signal. A push button will be used to easily toggle the second speaker to hear the difference between the signals. For this sub system, an op amp will be necessary for the students to build an inverting and non-inverting circuit for the second speaker to show noise cancellation or amplification. Giving students practice with op amps and using sound to physically represent how the gain effects the signal is the goal of this subsystem.

E. *Subsystem 5:*

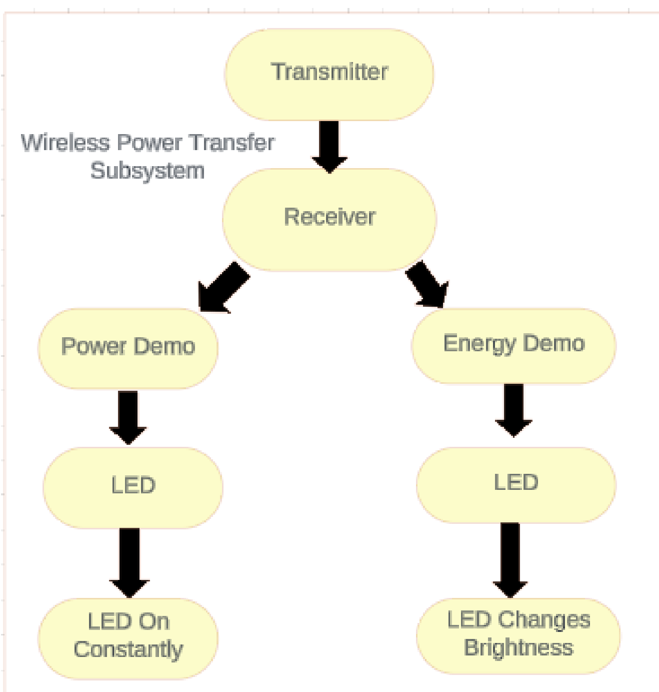

Figure 6. Wireless transfer power Subsystem

The wireless power transfer subsystem will be responsible for specifically making the car move. The wireless power transfer will consist of two main "pads" or housing containing a transmitter and receiver. These "pads" or housings will be placed on the bottom and inside of the car's housing to work properly. The transmitter and receiver shall be placed in these "pads" or housings to add a factor of safety to the project. This shall be designed and placed in the most feasible position based on the current needed for the vehicle to function. For this project, the transmitter will require 9 V – 12 V to operate and will have the capability of producing up to but no more than 500 mA [5]. Furthermore, this subsystem shall demonstrate the difference between power and energy. The power shall be demonstrated by allowing the user to run one side of a wire that will be pre-placed from the source to anode of the LED. Accordingly, the LED will light up when power is simply connected. As for the energy demonstration, the concept will be similar, except the LED will change brightness depending on the time the car is moving or even the speed of the car. The movement of the car will act as a manual hand crank, showing how power over time increases the flow of current in this case. Mainly, energy will be shown as a function of power and time, hence the changing of brightness.

F. *Subsystem 6:*

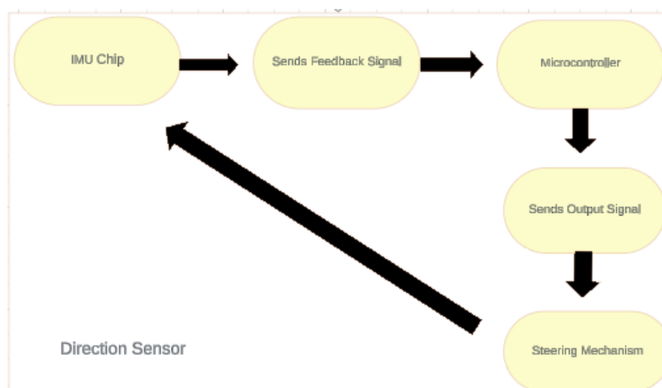

Figure 7. Direction sensor Subsystem

This subsystem is a self-stabilizing closed loop control system for the car when it runs. When the car moves forward, the wheels are free to move in any direction. To keep the car running dead straight, something must be implemented. This is where an IMU chip comes into play. An IMU chip is a sensor that can measure specific gravity and consists of gyroscopes, accelerometers, and magnetometers [8]. So it can continuously measure the alignment of the car. The process starts with the IMU chip detecting a signal that the car's gone off track due to the wheel or wheels turning a direction. This signal is immediately sent to the microcontroller. For the microcontroller, there will be a program that receives the signal, reads it, then corrects the signal. This corrected signal is then sent to the steering mechanism allowing the wheels to be straightened. This design is a closed loop because of the feedback. If the car were to go off track again or for a second time, the same process would start with a signal being sent to the IMU chip. So the system continuously receives feedback from the car and makes adjustments to keep driving straight.

G. Subsystem 7:

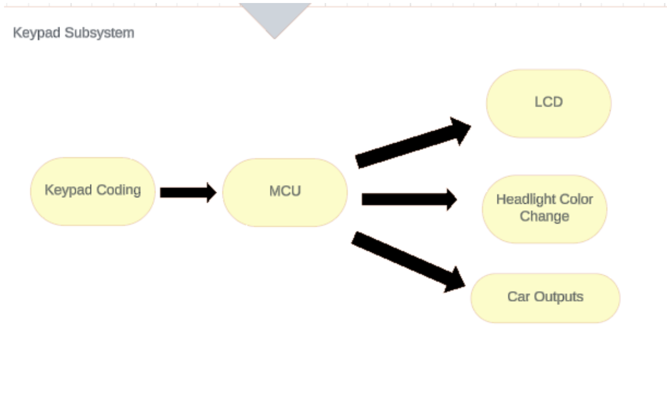

Figure 8. Keypad Subsystem

The Keyboard Coding subsystem shall basically be a system design to implement or introduce users to the aspect of coding, hence introducing the computer engineering side of ECE. This system will pretty much receive inputs from the user using a keypad or keyboard. Then based on these inputs, the MCU will generate an output or display the resulting instructions on an LCD. Simultaneously, the MCU shall send a control signal to change the headlight color, turn ON or OFF the radio, turn ON or OFF the fan, turn ON or OFF the blink-right, turn ON or OFF the blink-left. The general view is that students will be able to write code instructions like "turnONFAN = 1;" to turn the fan ON and "turnONFAN = 0;" to turn OFF the fan. The LCD will be used to display the code and the MCU shall turn the fan OFF or ON.

H. Subsystem 8:

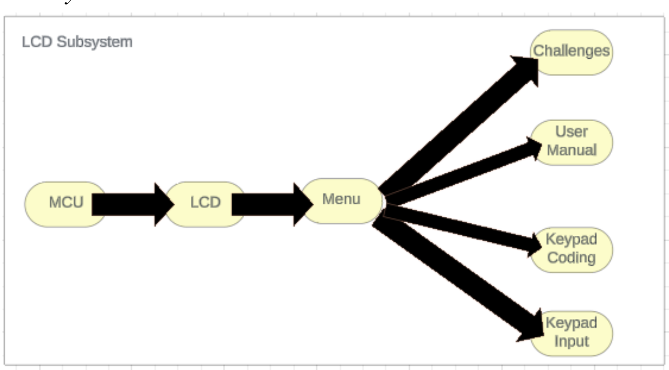

Figure 9. LCD Subsystem

The LCD and User Manual shall basically be a system design to interact with the LCD. This subsystem shall interact with the MCU at all times and shall be one of the main ways to interact with the users. The system's output will be on the LCD, which will contain a main Menu. The main Menu will have items such as an actual User Manual, a button to input a code using the keypad (Subsystem 8), a list of challenges to the user like "Have you tried changing the color of the headlight to Red?", and as a bonus some type of interactive game like Birduino (an Arduino Game Project, a Replica of Flappy Bird for Arduino). [2]

I. Subsystem 9:

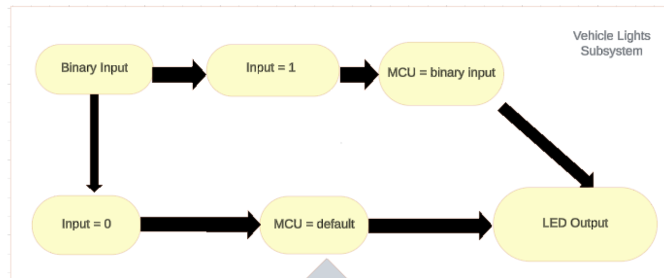

Figure 10. Vehicle Light Subsystem

This subsystem will be what we shall implement to operate the car headlights, taillights, and brake lights. The output of this subsystem shall show these car components' functionality such as turning the lights on and off and switching between low and high beams, while also teaching the concept of binary (zeros/ones) and showing the different output changes of electrical components. The subsystem will include taking a binary user input, sending it through a sensor checking for any electrical components that may affect the input sent to the microcontroller, if the sensor detects that there is an electrical component that will represent one. The input sensors shall detect what the component is and the value of that component so that the correct input is sent to the microcontroller. If there are no components detected, then the input of the user originally selected will not be affected representing a zero since there were no components placed and will be sent straight to the microcontroller. The microcontroller shall take the user's original, or sensor-detected input and control the output based on what the user has selected it to do. The output of this subsystem will be LEDs (red taillights/brake lights, yellow headlights, orange) which will also show zero or one by being on or off (1 being on and 0 being off). The different LEDs listed above can range in values of voltage. The voltage range for a red LED shall be 1.6 - 2.0 Volts (forward voltage), for a yellow it shall be 2.1 - 2.2 Volts (forward voltage), and orange shall be between 2.0 - 2.1 Volts (forward voltage). All the LEDs used in this subsystem are below 2.2 Volts and above 1.6 Volts. The LEDs can be adjusted to all work on 2.0 volts as that is the most common voltage for each LED since all of them are around 2.0 volts [7].

V. TIMELINE

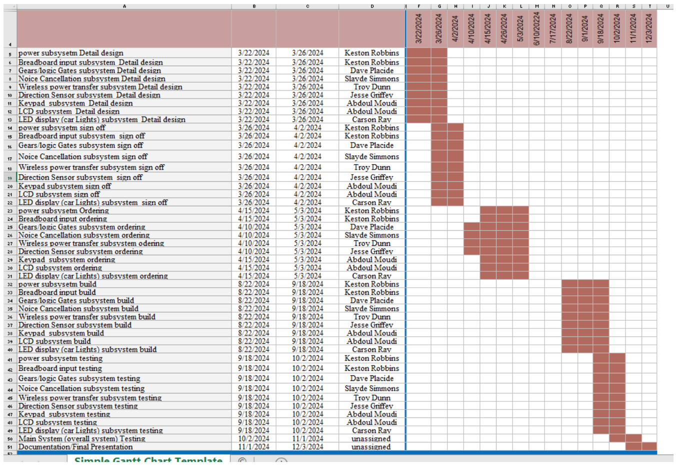

Figure 11. Timeline Gantt chart detail design

The main block diagram (Figure 1) outlines the main system for the project. Each line connecting the subsystems has a short description of each interaction. The system is divided into 9 subsystems, which will be described, explained, and laid out in the coming paragraphs. As listed in the schedule, each subsystem is handled by one person.

Subsystem 1 (Figure 2) is the responsibility of Keston Robbins. This subsystem will deliver power to the rest of the project. What that entails includes but is not limited to: voltage regulation, fail safes, power switches, etc. This system is vital to the rest of the project and is listed first chronologically because all other systems are essentially paper weights without the appropriate power delivery and maintenance.

Subsystem 2 (Figure 3) is also the responsibility of Keston Robbins. This system is also vital to the project, as these inputs will be interpreted by the microcontroller and sent to the various output subsystems. Without this subsystem in place before the others, the various output subsystems will be impossible to lay out and program for.

Subsystem 3 (Figure 4) is the responsibility of Dave Placide. This subsystem is necessary because it will represent basic logic circuits with gate stand-ins. This system will work in tandem with the wheel outputs and is vital to the project.

Subsystem 4 (Figure 5) is the responsibility of Slayde Simmons. This system interacts with the input signal coming from the microcontroller and has connections with the car's speakers for its outputs. This subsystem will demonstrate the electrical concepts of filtering, noise cancellation, noise amplification, and other various signal-based concepts. This system will also interact with the breadboard input subsystem to gather its input signal data.

Subsystem 5 (Figure 6) is the responsibility of Troy Dunn. This system will communicate with the microcontroller and specialized LEDs on the roof of the car. This system's goal is to demonstrate wireless power transfer. This system is particularly difficult to integrate due to the wireless transfer pads needing minimal separation, but that will be handled appropriately by its presiding team member.

Subsystem 6 (Figure 7) is one of the most important subsystems. It will be the responsibility of Jesse Griffey. This system will communicate with a specialized gyroscope-based sensor and with the microcontroller for both sending and receiving data on the car's location, speed, and orientation. This system is vital for two reasons. For one, it is a suitable demonstration for closed-loop control systems design, and it will have a practical use for the project as well, as it will make the car's traversal across the testing area much safer.

Subsystem 7 (Figure 8) is the responsibility of Abdoul Modi. This subsystem is important to the project because it represents key computer engineering concepts rather than electrical engineering concepts. It will interact with the keypad for input, the microcontroller for input analysis, and several of the output systems as well.

Subsystem 8 (Figure 9) is also headed up by Abdoul Modi. This system is closely related to subsystem 7, as it will house that subsystem inside of it. Also, this system is vital because it will control many aspects of the vehicle. As a result, this system is one of the most interconnected ones in the project and will need extensive planning and testing to be utilized effectively.

Finally, subsystem 9 (Figure 10) is LED output subsystem. This subsystem is the responsibility of Carson Ray. This system is connected to several others, as it maintains the LED outputs for the whole car minus the wireless power transfer LED. This system is also important, as this will be one of the main ways the users will see the results of the inputs from the bread board subsystem and the keypad.

VI. CONCLUSION

In conclusion, the electrical and computer engineering kit has been described and laid out in detail above. Among college engineering students, it is a common idea that there is a better way to begin learning key concepts in electrical and computer engineering. The team's goal is to recreate the way these concepts are first taught to better the understanding of these intangible ideas for incoming college students or people who may be interested in the ECE curriculum. The team has worked towards a substantial solution to this problem and is working on a reliable strategy to ensure the project has a sufficient outcome. Furthermore, the main system is broken down into nine subsystems. The first subsystem is power, responsible for supplying power to each subsystem. The other subsystems consist of the MCU, wireless power transfer, "breadboard" inputs, gears, steering, noise cancellation, keypad, and led display. Some of these subsystems directly correlate to other subsystems while others work on their own. However, all subsystems will come together to display the general ideas of electrical and computer engineering. Overall, this kit will demonstrate the basic ideas of electrical and computer engineering using electric vehicle displays to show intangible ideas as something that can be easily observed.

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