Conceptual Design Draft

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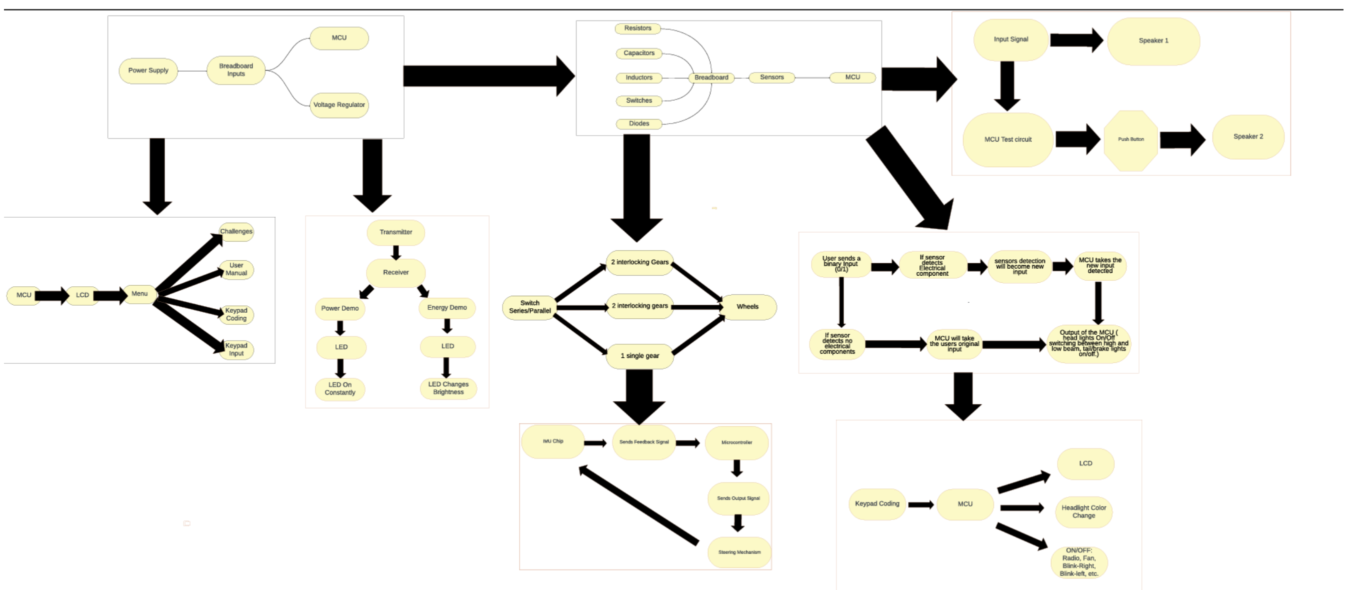

Figure 1. Main System

I. 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:*

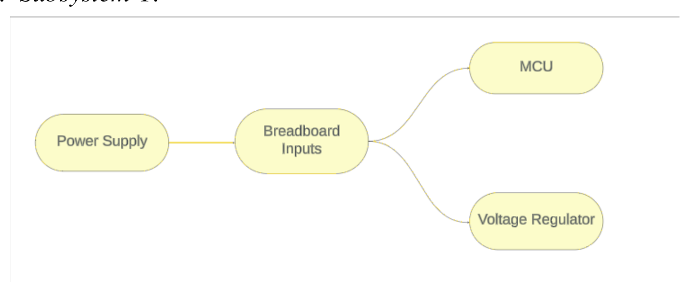

Figure 2. Power Subsystem

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:

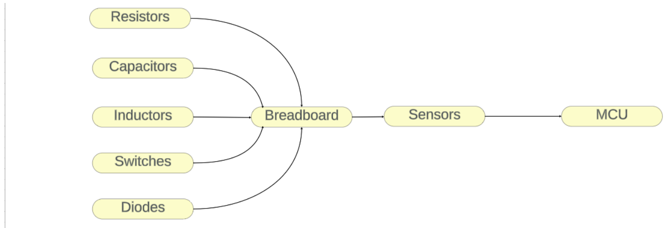

Figure 3. Breadboard/Input Subsystem

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:

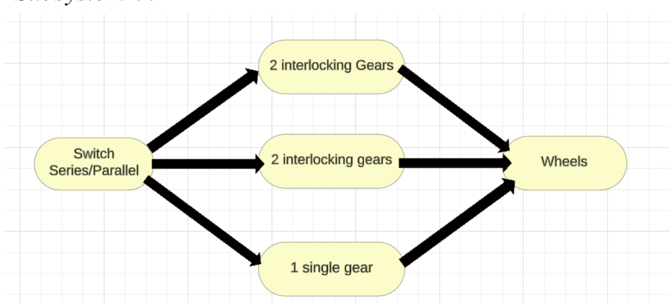

Figure 4. Gears/Logic Gates Subsystem

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 [4] 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, making 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:

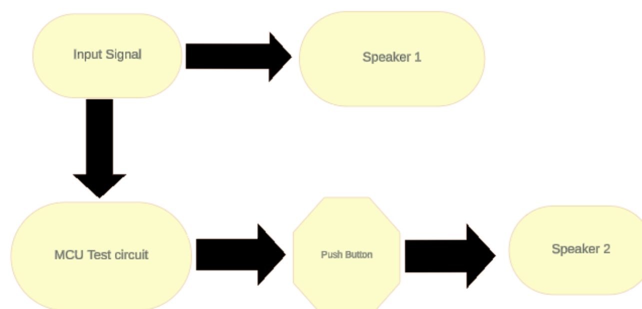

Figure 5. Noise Cancellation Subsystem

The noise cancellation subsystem gives students the opportunity to practice with building circuits that include op amps. Which allows the students to understand how noise cancellation works in cars or headphones. In addition, students can construct circuits that will amplify 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:

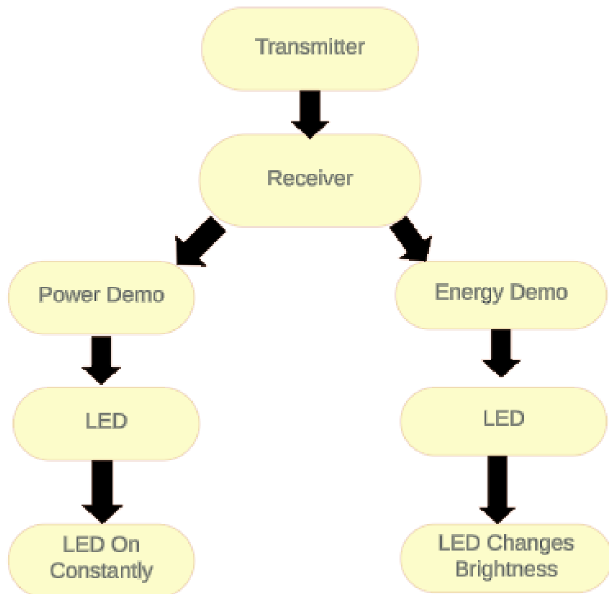

Figure 6. Wireless Power Transfer Subsystem

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 [3]. 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:

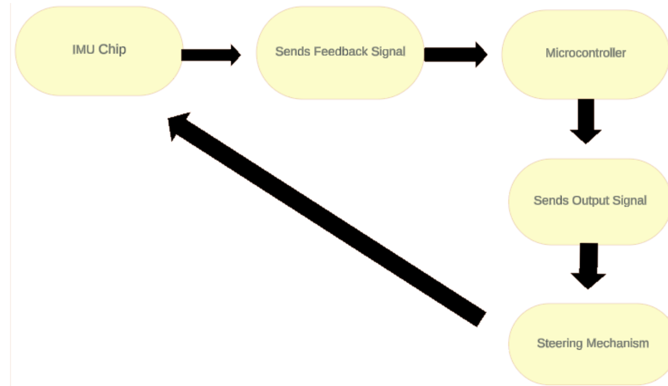

Figure 7. Direction sensor subsystem

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 [6]. 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:

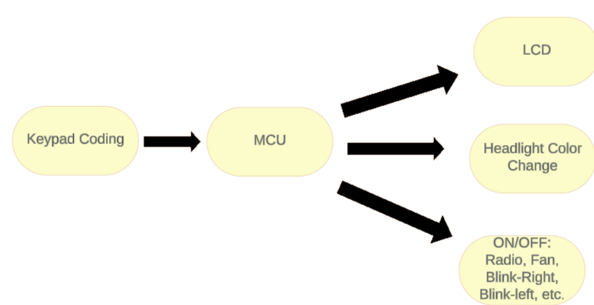

Figure 8. Keypad block subsystem

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 control send control signal to change the head lights color change, 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 student will be able 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:

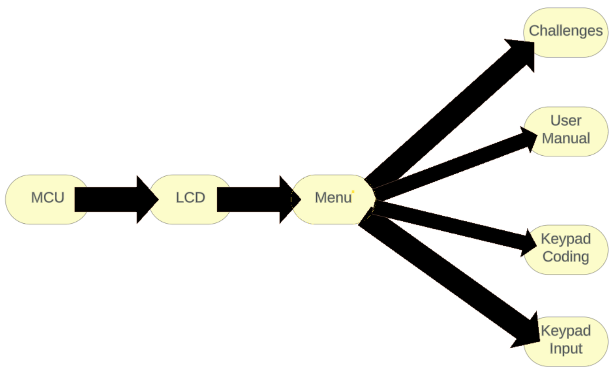

Figure 9. LCD block Subsystem

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:

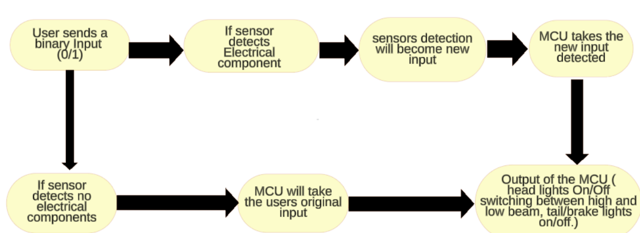

Figure 10. Vehicle Lights Subsystem

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 to show 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. 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 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 can range in different 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 shall all work on 2.0 volts as that is the most common voltage for each LED since they can all use 2.0 volts [5].

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[5] What are the forward voltages of different leds?. CircuitBread. (2024, January 12). https://www.circuitbread.com/ee-faq/the-forward-voltages-of-different-leds

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