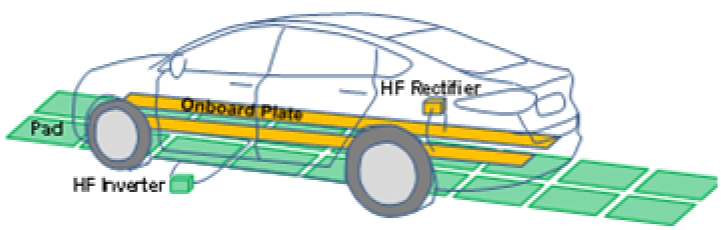
Wireless Capacitive EV Charging Proposal



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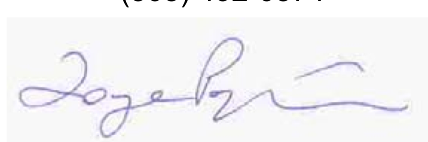

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1. Introduction

The past few decades have seen an increase in the demand to lower our society's environmental impact, and a push has been made to use electric vehicles. Electric vehicles, however, are expensive, inconvenient, and have a low range. Electric vehicle technology has been increasing at an exponential rate, but the issue of charging convenience is rarely addressed. We propose the research and development of a wireless power system that will charge an electric vehicle from under the very road it drives on. Additionally, charging would occur in moving vehicles as well as in stationary vehicles, and power usage could be tracked, and charged for accordingly.

Our work will occur on the University of Colorado at Boulder campus and take place until the end of the spring semester in 2015. Off-site research may include testing on a real car. As students, we desire to supplement our own personal and academic exploits with a concrete, realistic, and marketable project that we can take with us beyond our time at school.

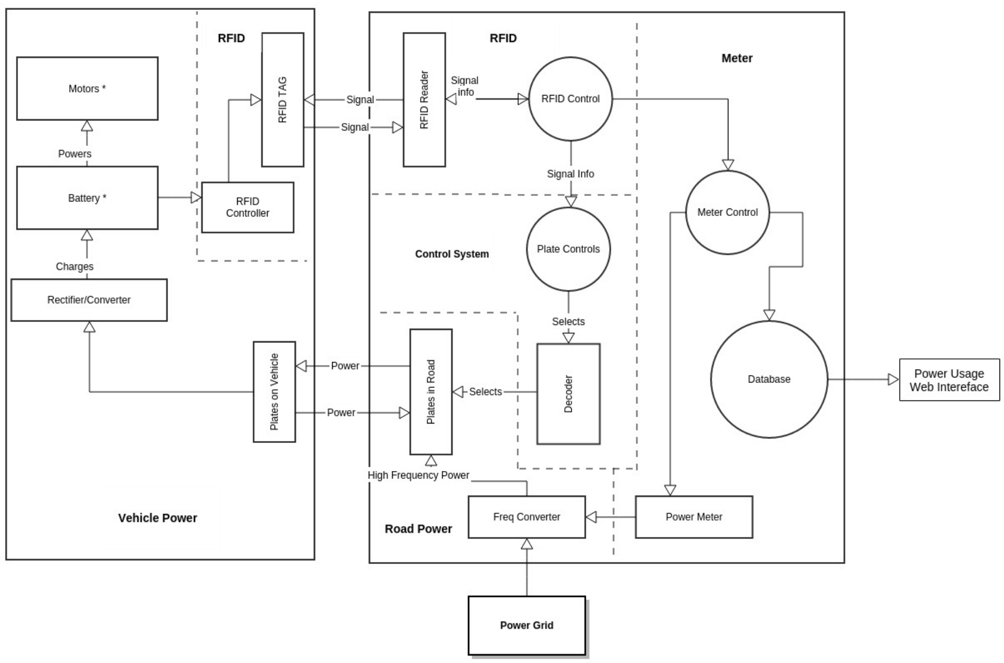
2. Background

The electric vehicle market in the United States has the potential for rapid growth. However, electric vehicles currently have a 0.6% market penetration[4]. This low market share is largely due to the fact that electric cars have limited range and long charging times. Wireless capacitive charging allows for the possibility to charge large amounts of moving cars in densely populated areas. This will allow electric vehicle users to have both longer operating ranges and reduced charging time after a trip has been completed.

Currently, all charging of electric vehicles in the United States is done by plugging in the vehicle either at a driver's home or at one of a few charging stations. Wireless charging of electric vehicles would reduce the inconvenience of finding a charging station or cutting a trip short due to lack of charge capacity. Wireless charging of busses is currently being done in South Korea[1]. The Korean system uses inductive charging instead of capacitive charging. Capacitive charging can theoretically be more scalable for vehicles that are in motion instead of being stationary over a charging pad.

3. Methods

In order to complete this project while satisfying our own, and our institution’s standards, we will use a series of design methodology tools. We have begun our project by creating system diagrams, outlining requirements, and decomposing the various subsystems into their functional components. The current version of the system diagram can be seen below:



Our design process is laid out to be adaptable, short-term, and efficient. We will complete deliverable milestones on a periodic basis, and hold short meetings four times a week. In this way, we plan to keep ourselves on schedule and constantly making progress toward our design goals instead of stagnating.

Our group consists of five talented engineering students with backgrounds in a wide variety of electrical engineering sub-disciplines. Among the five of us, we have specialists in power electronics, control systems, computer systems, signal processing, and embedded systems. We believe the variety of our skillset will be helpful for a project of this magnitude.

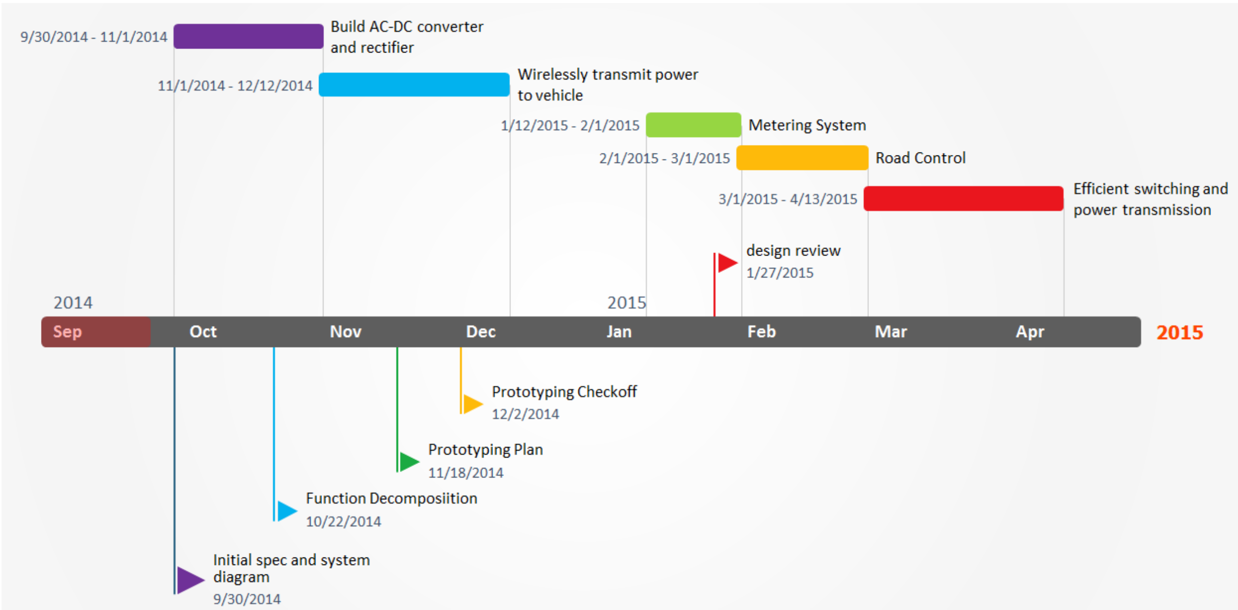
This project is unlike many others in that all of the circuit designs are going to be made mostly from scratch, and although we will have the assistance of the faculty at our university, this is not the sort of project for which you can order all the parts online and immediately use them in the system. This means that we must make and test small components of the system using a trial and error type approach. Each component will be tested until the component functionality is verified -- then we can move on to the next task. This is where our design methodology becomes most useful. We will not use a single long design phase followed by a build phase as we believe this will be risky if the initial design turns out to not function as desired. Instead, we will first design, then build, then repeat, any number of times.

Our research will consist of our own circuit analysis coupled with frequent meetings with our faculty sponsor, Professor Zoya Popovic. Much of what we are doing has not been fully realized in any existing or prior projects, so having support from a knowledgeable faculty member will be necessary to complete the project.

All our software will be in a public repository on the web and reversion control will be utilized. The boards and parts will be, for the most part, custom built by ourselves, the only exceptions being a possible web service hosted by a small linux computer. All of the functionality will be implemented on a small radio-controlled car and track that will be much easier and less dangerous to experiment with than a full-size vehicle would have been. A scale prototype will give us all of the information we will need for the full scale project.

We would like to get started with technical research and development work as soon as possible. This way we could keep on track with our goals and expectations, while also meeting the expectations of the capstone class. All circuits will be designed and simulated in using standard software tools before ordering parts or assembling the system. Most importantly, we take safety seriously and will use our better judgement when handling the most dangerous components in our system such as high-voltage electrical systems.

4. Time Schedule



5. Budget Justification

5.1. Introduction

The project budget is outlined below and summarizes how we will use UROP Grant funds, if awarded. We have determined necessary parts and costs using a top-down design approach, resulting in multiple levels of functional decompositions. We investigated standard prices from reliable component retailers in order to determine the item prices listed below.

5.2. Budget Breakdown

Item Name/Description	Unit Price	Quantity	Total Cost
Radio Controlled Car	$200.00	2	$400.00
ARM M4 Microcontroller	$50.00	2	$100.00
Metal sheet for capacitor plates	$300.00	1	$300.00
Capacitor Plate Connector	$3.33	10	$33.33
Ferrite Cores	$3.56	5	$17.80
Inductor Bobbin	$1.13	10	$11.32
Inductor Clamp	$0.41	10	$4.10
Power Connector	$1.12	10	$11.21
Ceramic Capacitor 4.7uF	$0.76	20	$15.26
Film Capacitor 55uF 700V	$15.83	2	$31.66
Aluminum Capacitor 100uF	$0.44	10	$4.39
Ceramic Capacitor 1uF 630V	$5.02	30	$150.66
Schottky Diode	$0.87	40	$34.80
Ceramic Capacitor 10uF	$2.06	10	$20.60
Ceramic Capacitor 2.2uF	$0.66	10	$6.63
Ceramic Capacitor 1uF 16V	$0.08	20	$1.62
GaN FETs	$5.22	10	$52.20
Gate Driver	$3.11	10	$31.14
Rgate	$0.09	10	$0.90
Aluminum Capacitor 47uF 450V	$2.04	10	$20.42
RFID Reader (125kHz)	$34.95	4	$139.80
Active RFID Tag	$26.95	4	$107.80
Raspberry Pi	$35.00	1	$35.00
		Total	$1530.64

References

1. Barry, Keith. "In South Korea, Wireless Charging Powers Electric Buses | WIRED." *Wired.com*. Conde Nast Digital, 05 Aug. 0013. Web. 25 Sept. 2014.

2. Kelion, Leo. "Road Charges Vehicles Driving on It." *BBC News*. N.p., n.d. Web. 25 Sept. 2014.

3. Afridi, Khurram, and Zoya Popovic. *Efficient In-Motion Capacitive Wireless Power Transfer System for Electric Vehicles*. Working paper.

4. "Electric Vehicle Market Share in 19 Countries." ABB Conversations Electric Vehicle Market Share in 19 Countries Comments. N.p., n.d. Web. 27 Sept. 2014.