Higher Colleges of Technology
Department of Engineering

ENG4003: Design Project I

FINAL REPORT

Project title: Smart street (wireless Parking)

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Executive Summary

Electric cars are the future of transportation without pollutions. Electric cars industry start to grow fast, but this cars facing some problems like, low speed and the car take long time to fully charge. The aim of this project is to solve the charging problem by creating charging field around the parking. The transmitter and the receiver range will be expand around the vehicle and the parking permitting the vehicle to charge faster.

As wireless technology advances and adds more and more features, till it reached the electric cars. With this development, these vehicles do not require wires for charging, however charging still demands tying up these devices to a cord.

Wireless power aims to cut these cords and transmit power to these electric cars wirelessly. This is done by transmitting power from source to the receiver that attached in vehicles with the form of a magnetic field.

In this report, we study the technological landscape of this charging method technology. We find that the majority under this technology has occurred in inductive coupling technology for charging a vehicle.

Toyota and Nissan developed this charging method in Toyota RAV4 and Nissan Leaf. There are not only this two companies in this technology domain. There are BMW, Tesla and Mercedes Benz, but Toyota and Nissan are more advanced than the other companies.

Acknowledgements

This thesis was conducted as a part of Wireless Power Transfer Parking project at the group of composed of the following team members: Salama Abdulla, Abdulrahman Ahmad, Kaltham Obaid and Yousuf Abdulraoof.

We wish to express thanks to our supervisor Dr. Sandor Piros for his support and guidance. Whose ideas and huge knowledge have make us possible to continuous learning and having better points of view to tackle the problems. His wide support will made this project possible, saving us a lot of time by helping us in simulations.

Finally, we want to thank all faculty of electronics engineer for their valuable help.

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Introduction

In this project we will use Inductive resonant charging as a method of transferring power wirelessly. The power producing from the source system its can be AC voltage from grid or DC voltage from renewable energy sources. An electromagnetic field is generated between the two coils and power will be transferred. We will use Radio Frequency Identification (RFID) as a communication transfer method.

The idea first started in UK (electric bus) and it's developed in some countries as we can see it now in Dubai. According to "Saeed Mohammed Al Tayer", MD and CEO of DEWA, said: "The Green Charger initiative grid will substantially contribute to introducing electric vehicles in Dubai, boosting the use of energy resources and reducing the Emirate's carbon footprint. These stations are at DEWA's head office, the Sustainable Building, Al Wasl, Al Hudaiba, Burj Nahar, Umm Ramool and Jebel Ali (Tayer, 2016).

Wireless charging system are not alternative of wire charging system,

Currently, the most conventional method is plug-in charging, where a connected copper cable forms the power link. The charging power level varies from level 1 over 1kW to level 2 up to 19.8kW. It generally takes an overnight charge to bring an empty battery up to full charge. There are several disadvantages to this method, which have led to the exploration of inductive charging technology.

Inductive charging (or Inductive Power Transfer [IPT]) uses time changing magnetic fields to transfer in the air gap of a car and wirelessly recharge a vehicle parked over a transmitter. The advantages of inductive charging over plug-in systems can be summarized as follows:

- Convenience – Inductive power transfer system can be completely self-directed. Vehicles start to charge right away when they are parked over a charger, if the user has balance. This was found to be really helpful for users.

- Weatherproof – Inductive power transfer system can be fixed underground, eliminating issues related to exposure to rainy, snowy, or freezing environments

- Anti-vandalism – Public plug-in systems are likely to damage such as stealing of the copper cables. Because possible criminals and thieves cannot easily see Inductive power transfer system casing, it seems far less likely they will dig under the road to target it.
- Low risk of hazards – the wire used in a plug-in system may be a probable trip hazard for people; given that in a public setting the charging environment is usually close to the road, the level of danger forced by another vehicle hitting someone is not tiny.

We are really motivated when we look at the idea. Also, it is a new thing and it will benefit us in the future. There are many ideas about how to charge the car wirelessly like put transmitter at the front or back of the car but we will put the transmitter around the parking. In UAE there is one park in the silicon that charges the car so maybe in the future, it will be possible to make it and companies will produce more electric cars. It will take a long time to apply this idea because explaining to people will take time, and they will know that it will benefit us.

Problem/Project

Definition

Problems faced	Solution
Did not have time to prepare task 1, so we had to fix the mistakes in task 1	We try to sit weekly meeting with our advisor, so he can monitor the progress
Our goal is to transmit more than 100 watts if it possible	We still try to find a way to overcome this problem
Creating a block diagram	Searching online for e-books and checking the components needed with the advisor
Incorrect RFID Tag (Extended)	Replacing it by (WISP) RFID tag
Finding the component for our project	Found what we will use for next semester
Understand how the project will work	Understand it by searching and the advisor explanation
Project was new thing so we didn't know how to do it	We made a lot of researches about the project so now we know how to do it
Doing the coding was difficult because some code we didn't learn	We ask teachers to give us some brief idea about the program we use
finding coils size and how it would fit in the car, how can I connect it and make it receive from the coil that is located on the floor, and how many coils should I use for a single car	The solution of this problem I took the size of the length and width of the parking spot, and then searched for a different size of coils that can fit perfectly in the parking spot and the EV

Literature Review

Nowadays electric cars can be charged wirelessly. By getting rid of the plugs and cables, there are some parking areas that can charge the electric cars wirelessly. This kind of parking's have a wall-mounted power adapter and on the underside of the vehicle is a receiver that will charge the car wirelessly. The current plug less model is 3.3 kW that will charge the vehicle from empty to full in about eight hours, but they are working on increasing the power adapter power from 3.3 kW to 7.2 kW and it will cut Leaf charging time in about half, to four hours. Charging electric vehicles wirelessly has 2 years of selling a product (LAKSMAN, 2016).

Nowadays and in the near future it's hard to save the environment, and it's also harder for the owners of electric vehicles that requires plug and unplug in and out the charging port. So, researchers tried hard and found that charging electric vehicles wirelessly would make it easier for the owners of these cars. There are many modern vehicles which feature wireless charging, for example, Mercedes S550e, Chevrolet Volt, Tesla, and Nissan Leaf. Researchers did a research and found out the reason behind consumers owning electric vehicles is that they can be charged wirelessly, they changed from vehicles that run on gas to a modern vehicle with more technology (Roberts, 2016).

• A wire carrying an electric current produces a magnetic field around the wire by using (Ampere's Law).

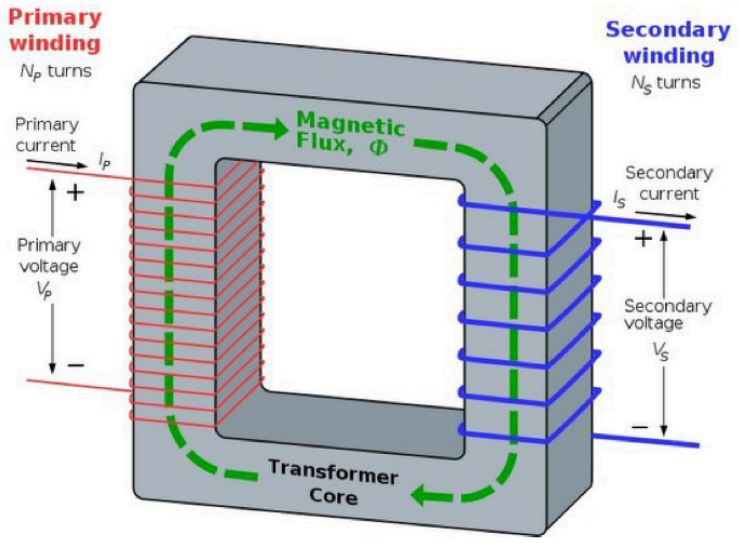
• A coil intersecting a magnetic field produces a voltage in that coil by using (Faraday's Law).

• Electromagnetic power transfer between electrical circuits across an air gap can be achieved using magnetic field coupling at resonance by (Tesla).

When the power supply produces an alternating electric current in the primary coil embedded in the parking (similar to the primary coil of an electric transformer, as shown on the right), which, in turn, produces a time-changing magnetic field. This variable magnetic field induces an electric current (producing a magnetic field) in the secondary coil spin mounted under the vehicle floor. The induced AC and voltage are then converted to Direct Current (in an inverter) to recharge the battery in the vehicle.

The Rechargeable Energy Storage System onboard the vehicle may also include an ultra-capacitor completing the battery. Since the former can more quickly charge or discharge. When a transmitter radio frequency magnetic field matches the receiver frequency this is the way the vehicle battery will be charged.

In a transformer, the primary and secondary coils are connected by a magnetic core that traps the magnetic flux. Figure 2-1 shows how a magnetic field produced by the primary loop (transmitter) embedded in the pavement induces a current in the secondary coils (receiver) to charge the battery.



The resistances of some magnetic sensors might change when exposed to a magnetic field. By selecting higher gains for the magnetic sensors to be more sensitive, the resistance of magneto-resistive elements will decrease, making them more sensitive during changes in the temperature. If the resistance of the magneto-resistive elements changes by the temperature, reading of the sensor (which directly corresponds to the resistance of the resistors) varies without a change in the magnetic field. Sensors show more sensitivity in regard to temperature noise.

The performance of short-range wireless systems is limited to the environmental effects such as involvement effects, shadowing, multipath fading and temperature noise.

One solution to this issue is to increase the sample rate or repeat data and transmit the same data several times. However, increasing the sample rate will cause higher power consumption (Martin O'Malley, 2013).

Electric cars might take over most driving requirements tomorrow, per a gaggle of scientists at the Massachusetts Institute of Technology, however, they'll want the assistance of burning engines to try to it. Using travel surveys and international positioning information, the university team has evaluated the potential widespread use of electrical cars and has found that grids might simply support today's low-cost electrical cars, which the cars themselves will already meet drivers' needs nearly nine-fold out of ten. The group's projected answer to it a downside is twofold: Trancik aforesaid her team was engaged in developing the information they compiled into AN app that might predict once a driver can want AN old style petroleum-burning automobile to urge from purpose A to purpose B and residential once more over the course of every day. The prediction would be supported factors like distance, the number of your time spent traveling at high speeds on highways, and whether or not the weather would require plenty of warmth or air-con.

Secondly, Trancik aforesaid, a neighborhood company or a neighbor may give easy accessibility to a standard automobile. "We still want a bit little bit of business model innovation, with community automobile sharing, or automobile sharing [businesses] wherever you may perhaps order one the night before a thereon tiny range of terribly high-energy days." Whether or not drivers ever take that dreamed-of road trip from one finish of I-40 to the opposite, the university team admits the restricted vary of powered electrical vehicles may be a major barrier to entry. "The image I actually have is of plenty of individuals owning electrical cars then again having the ability to terribly handily get an enclosed combustion engine vehicle to require that long road trip," Trancik afore said. "That has to be as simple as obtaining an uber." But the requirement for electrical cars is pressing, within the estimation of the university team, and therefore drag-racing guys in 1964 Mustangs don't shape the majority of the injury to the atmosphere shaped by fuel vehicles. "Transportation accounts for twenty-eighth folks energy use and thirty-fourth folks greenhouse emission emissions, the bulk returning from light vehicles creating personal visits – individuals commutation to figure, driving to social events, and playacting errands in cars and lightweight trucks," wrote the report's authors. (Thielman, 2016)

Charging an EV is a difficult process. The owner has to find a charging point, connect up their cable and leave the car for some hours. It's inconvenient, and cables can easily get lost or damaged. Wireless power transfer technology was developed decades ago, but low efficiency meant it was restricted to industrial settings, providing power for robotic vehicles and cranes, for example. That is finally changing. The wireless system relies on the well-known principle of electromagnetic induction. A magnetic field generated by an alternating current in a primary coil induces a current in a nearby secondary coil. What is new is technology that allows for an energy-transfer efficiency of 90 percent or higher. (newscientist, 2016)

The wireless power made a huge development in the recent years with many inductive technologies and it's become available widely .For example, Samsung is building a wireless receiver into phones. Also a large number of transmitters from a company like Air charge. The resonant technology presents the future of wireless charging. The factors that will increase the wireless charging and it needs to be considered for the consumers in the future are:

The speed (Is it going to charge more and faster?), Multiple devices charging Efficiency, Alignment, power level (including higher power devices (>10W), Design, Safety, and interface.

Resonant presents a wireless charging future with greater performance and flexibility. (Mishriki, 2015)

Evaluation of Alternatives

We had many ideas about the project for example, control house with a phone like an open door or open the light or put timer so it automatically opens the light as you choose the time. Another idea was when car moving at night, and a car reach the street light before 3 KM the light open and it close when the car moves. The last idea was to charge electric cars wirelessly so the idea is for electric cars only. The different form our idea is the original idea is that we charge the car wirelessly so the user doesn't need to get out of the car to charge it. It charges using a cell phone. Another idea was easy to do so we chose our idea because it's challenging. The advantage of our Idea is electric automobile may be a good way for you, as a client, to save lots of plenty of cash on gas. However, there area unit such a lot of completely different reasons why you ought to invest in an electrical automobile within the modern-day of technology.

1. No Gas Required: electrical cars area unit entirely charged by the electricity you give, which means you don't have to be compelled to obtain any gas ever once more. Driving fuel based mostly cars will burn a hole in your pocket as costs of fuel have gone all-time high. With electrical cars, this price is avoided as a median tank spends $2000 – $4000 on gas every year. Although electricity isn't free, an electrical automobile is much cheaper to run.

2. Savings: These cars are fuelled for the bottom costs, and lots of new cars can supply nice incentives for you to induce a reimbursement from the government for going inexperienced. Electrical cars may be good thanks to saving cash in your own life.

3. No Emissions: electrical cars area unit 100% eco-friendly as they run on electrically supercharged engines. It doesn't emit cytotoxic gasses or smoke within the setting because it runs on clean energy supply. They're even higher than hybrid cars as hybrids running on gas manufacture emissions. You'll be causative to a healthy and inexperienced climate.

4. Popularity: EV's area unit growing in quality. With quality comes all new varieties of cars being placed on the market that area unit every distinctive, providing you with a wealth of decisions moving forward.

5. Safe to Drive: electrical cars endure same fitness and checking procedures test as different fuel supercharged cars. Just in case associate degree accident happens, one will expect airbags to open up and electricity provides to chop from the battery. This could forestall you and different passengers within the automobile from serious injuries.

6. Price Effective: Earlier, owing an electrical automobile would price a bomb. However, with additional technological advancements, each price and maintenance have gone down. The production of batteries and offered tax incentives have more brought down the value, thus, creating it way more price effective.

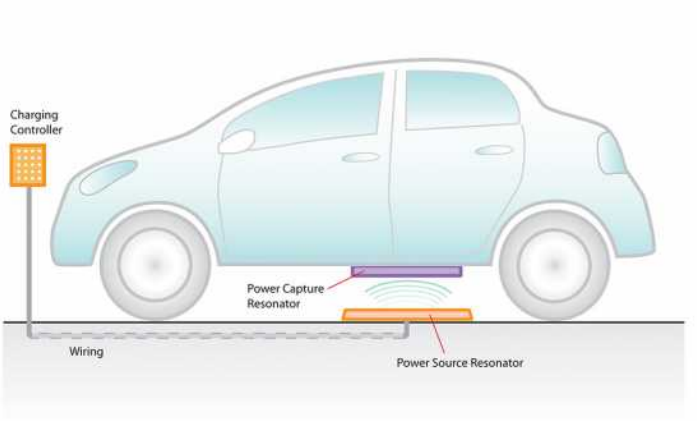
7. Low Maintenance: electrical cars runs on electrically supercharged engines and thus there's no have to be compelled to lubricate the engines. Different dearly-won engine work may be a factor of past. Therefore, the upkeep price of those cars has return down. You don't have to be compelled to send it to station typically as you are doing a traditional petrol supercharged automobile.

8. Reduced Noise Pollution: electrical cars place a curb on pollution, as they're a lot of quilters. Electrical motors area unit capable of providing the sleek drive with higher acceleration over longer distances. (Rinkesh, 2016).

Also, wireless charging provides a convenient, safe, and reliable because of charge and power ample electrical devices reception, inside the point and in business. By eliminating the utilization of physical connectors and cables, wireless charging provides sort of efficiency, worth and safety blessings over the quality charging cable. From smartphones to hand-held industrial devices and industrial instrumentality applications, wireless power maintains safe, continuous, and reliable transfer of power to form positive every kind of devices and instrumentality unit charged and ready to travel at a moment's notice. (charging, 2016)

Design approach

This technique will enlarge the freedom of the electric car choosing the parking spot and the position of the parking for the reason it stays within reasonable acceptable distance from the transmitter. The wireless charging might use the principle of "electromagnetic induction" this technology allows efficiency in energy transferring by 90% or higher. Adding more than transmitter or receiver coils to aim less time charging.
The smart street wireless parking will contribute economically in decreasing the wiring and preventing complex wiring looms with less reliance on plugs. Environment friendly so it does not cause pollution and motivate drivers to use the electrical cars.



The first part includes the transmitter circuit that would be placed in the parking surface while the other part is the receiver circuit installed at the bottom of the vehicle. This method is already exist but our aim is to improve and develop the efficiency of transmitting in order to charge the electric car in less time that will be convenient for the users. The wireless charging provide safety specially for removing the need for complex wiring looms and temperature changes that may lead to corrosion due to elements such as oxygen and water. Moreover this technology can work even if any object (pets) passed above the transmitting area.

To achieve our objectives we need to consider all the steps starting from data analyzing, writing a program using embedded system that would help us for the connection between the EV and the wireless charger. Moving all the way in configuring ways to develop the idea by classified the equipment, RFID, Coil, transmitters and receiver. Ended up by combining all the elements and techniques for testing the program and the equipment in order to insure the success of the project.

Developing this idea can help in improving the transportation infrastructure economically and environmentally. Encouraging the people changing their thoughts about the electrical vehicles.

Table 1: Performance of Inductive and Resonant Wireless Charging Technology

	Inductive *(in market)*		Resonant
Performance factors	**Inductive Qi (V1.1)**	**PMA**	**Resonant Qi** *(DRAFT)*
Fast charging speed *(same as wired)*	No	No	Yes
Multiple devices	No	No	Yes *(Scalable, incl. multiple types)*
Efficiency	Excellent	Very Good	Excellent *(over 70% demonstrated)*
Spatial Freedom (X/Y axis)	Limited	Poor	Excellent *(any position & orientation)*
Spatial Freedom *(Z Height)*	None	None	Very Good
Power Level	Limited *(<4W)*	Limited *(<4W)*	Yes *(Up to 20W)*
Human safety *(RF exposure)*	Excellent	Very Good	Excellent
Interference *(within EMI/EMF limits?)*	Compliant	Compliant	Compliant
Interoperable *(with current Qi devices)*	Yes	No	Yes

Design Narrative,

Detailed description of the design

The wireless parking chargers allow the electric car to charge easily and freely. Basically, there are two parts in this technology. The communication designing part includes transmitting and receiving using a WISP (RFID tag) one will be on the ground and the other tag will be attached to the car so it detects the car and checks the credit .while the second part is power transfer using resonant coupling technology to transfer the power between two coils. We need high-frequency rectifier, inverter, smooth capacitor and transformer for safety in order to build the transmitting part.

The new in our project is to rise up the efficiency of transmitting by adding more than one transmit and receive coils. This technique will help the user to park as the way he likes without being a worry if the receiver coil in the car will match the transmit coil.

The Communication part design

The transmitter will be connected to a power supply connected to the microcontroller system Using wireless Identification sensor platform to read the data and transmit it to the receiver (kind of RFID Tag).The receiver tag will be in the car receiving the signal from the transmitter. This procedure will detect the car and give signal shows the status of the car to start charging or not.

Facts about the WISP(RFID) design

WISP (RFID) implementation:

- Board with power harvesting circuitry
- Demodulator
- Modulator
- Microcontroller
- External sensors
- EEPROM and LED

Features

- Up to 10ft range with harvested RF power
- Ultra-low power MSP430 microcontroller
- 32K of program space, 8K of storage
- Light, temperature and 3D-accelerometers
- Backscatter communication to reader
- Reader to WISP communication (ASK)
- Real-time clock
- Storage capacitor
- Voltage sensor
- Extensible hardware
- HW UART & GPIO for external connections
- Works with select EPC Class 1 Gen 2 readers
- WISP software to sense and upload data
- Reader application to drive WISP

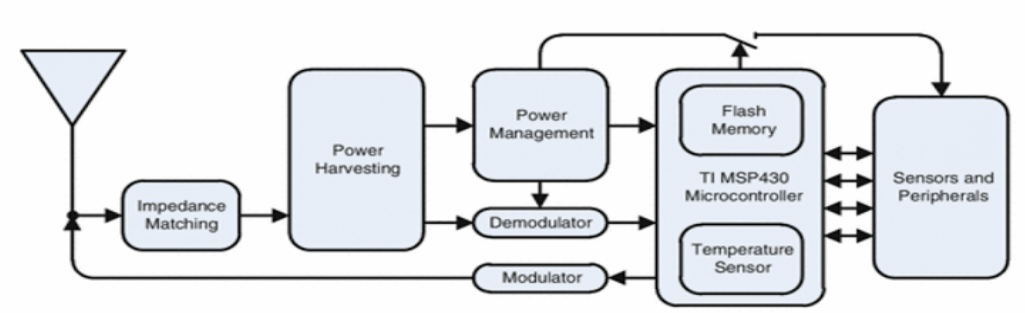


Fig. 1 Block diagram of the WISP

How The Transmitter and Receiver work in RFID

The main design of the transmitter part in the RFID examiner includes an oscillator performing at the frequency of interests, voltage or power amplifier, and the tuning circuit to peer with the impedance of the transmitter of the antenna characteristic. Moreover, to produce the radio frequency signal to energize the transponders, some interrogators transmit commands to the transponder. Besides they can be able to write new data into the memory of the transponder's memory.

The Transmitter in a RFID system must produce reliable and exact radio frequency signal during reducing the spurious radiation that they energize. Spurious radiation is similar to all transmitter.The amount of energy that drop outside the desired transmission band. Also, they have to be as logical as possible to minimize the amount of energy abandoned as heat. Heat exceed limit can reduce the life spam of electronics components and must be decreased to a suitable level.

In case of (read-only) transponders, the interrogators continuously transmit radio frequency and receive the response from the transponders. This action mode called (Tag Talks First).

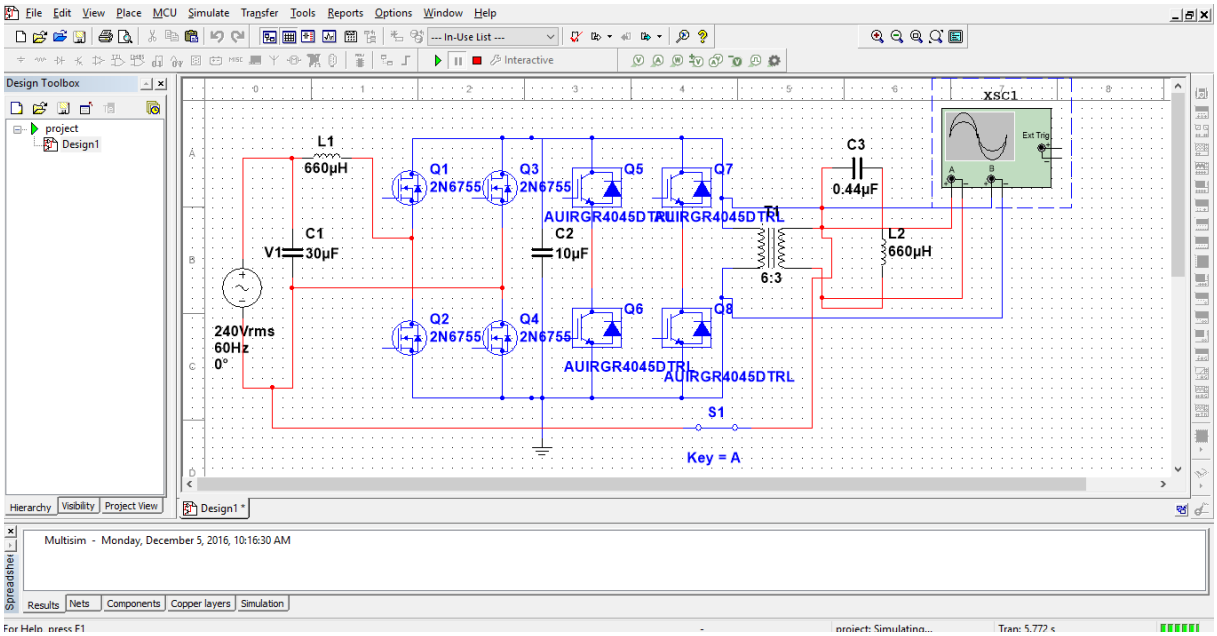
The other case is (read/ write) transponders are used for integrators should send the command either for reading or writing them.

If we use a Microchip the communication will start by sending specially timed gap pulse called (Fast Read Request) and (Fast read by pass) that will be operating by the interrogator.

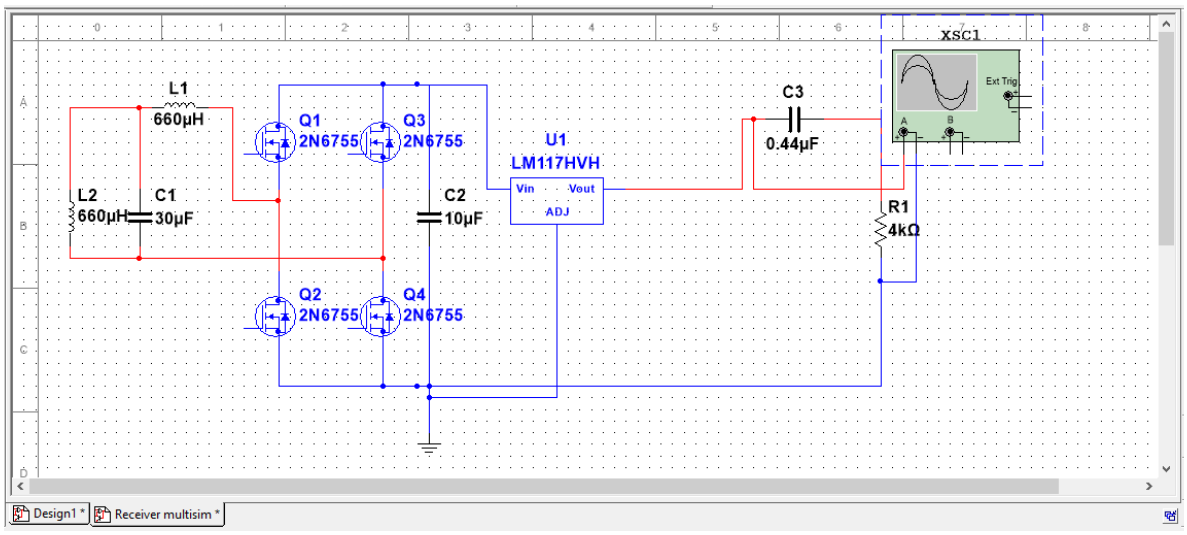
The power transfer design

Power supply for feeding the circuit. We program the microcontroller to give the order to transmit. Signal will transfer to receiver circuit to identify the vehicle. Data will be stored in data control before it sends to transmit circuit. In order to test the power transfer, we create a simulation circuit in the Multisim.

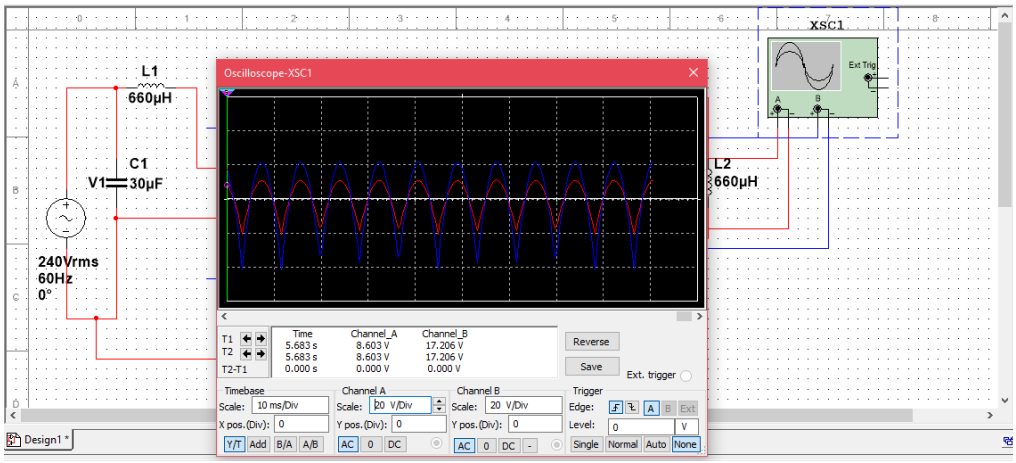
This is the transfer circuit



This is the receiver circuit

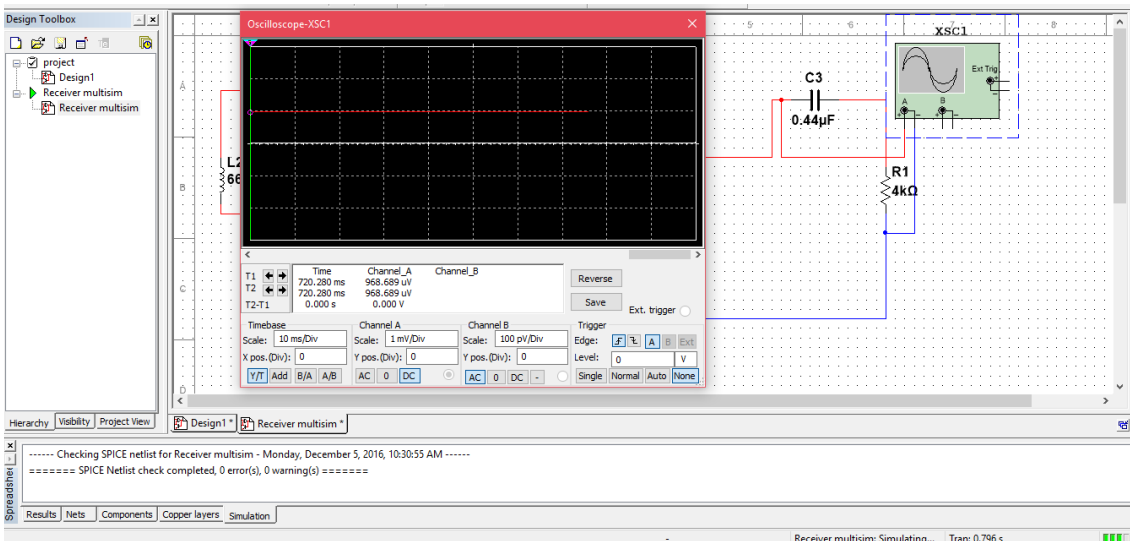


Testing in Multisim



The red line the signal in the transmitter coil.

The blue line shows the output of the inverter.



The graph shows the output voltage that will enter the battery.

Design verification and testing

In order to evaluate the reader (RFID) to be fine - tuned, we need to consider the following:

- Forward capability with future tag protocol
- Tenability
- Flexible power output
- Clean RFID Output
- Antenna programmability

The basic steps for setting up our RFID reader and antenna is as follows:

1. Mount the reader
2. Mount and connect the antenna
3. Power up the reader
4. Test the interrogation zone for RF path

For satisfying the power transfer we need to consider:

- Coil size and how it would fit on the car.
- How can I connect it and make it receive from the coil that is located on the floor.
- How many coils should I use for a single car.

Professional and Societal Concerns,

The coils cost is near 40 AD and we need two coils so it will cost 80 AD.

The RFID tag (WPT) will cost near 600 AD.

The battery will cost nearly 350 AD.

The microcontroller (Arduino) will cost nearly 30 AD.

Other components like sensor, diode, breadboard, resistors, etc. Will cost nearly 160AD

So the total cost of the project is 1,220 AD.

Wireless charging is a big step in electric vehicles industry. It will allow the customers to feel free with the way they will park their cars, so the vehicle can be charged the car without considering the car position.

Our system will be an automatic charge. It will start charging only in one case which is, If the user have credit and the battery is not full, then the system will start charging.

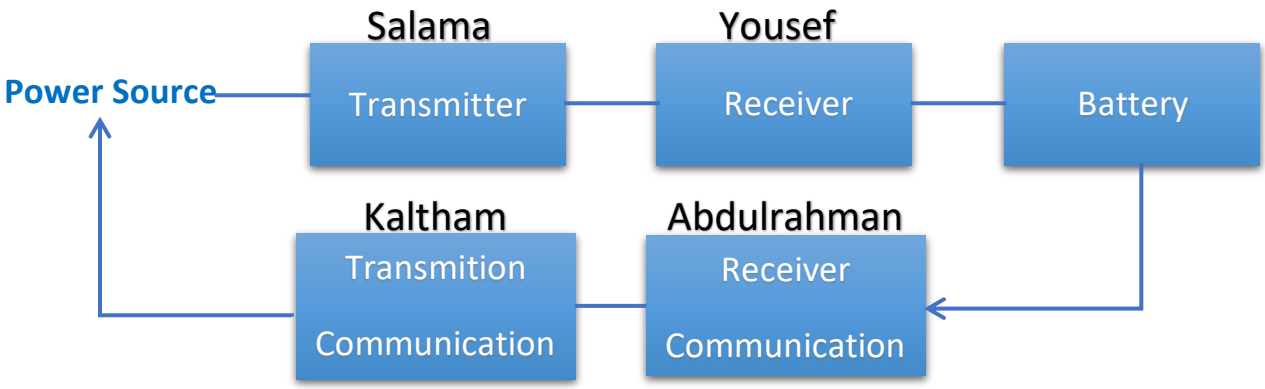
If the user have credit and the battery is full, the system will not charge.

If the user don't have credit and the battery is low, the system will not charge.

This will help the customers who forget to plug in their cars. It also will not have to take on mind the wires damages.

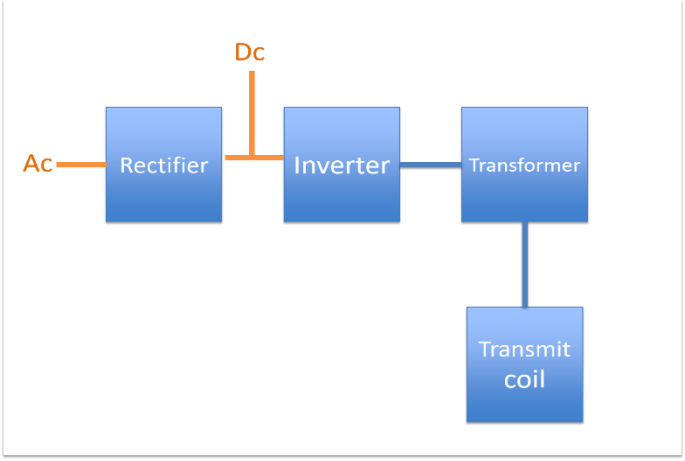
Discussion

Group block diagram



Block diagram

Transmitter:

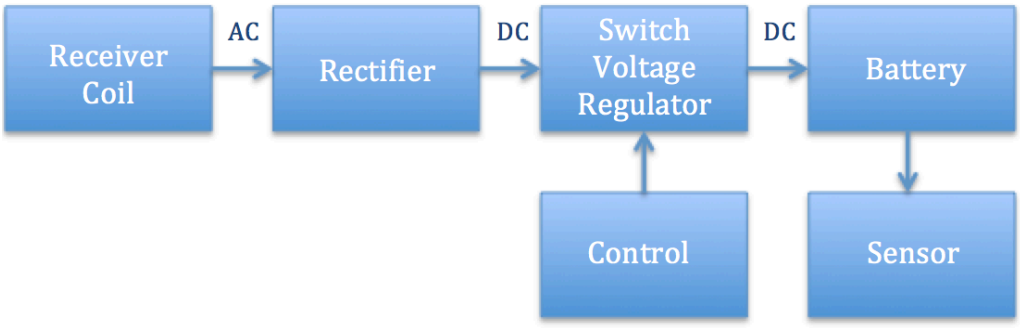


An active front-end rectifier with power factor correction is used as an interface between the AC grid and the DC input to the high-frequency inverter.

Transformers adjust the voltage coming into the appliance to the proper level, and pump the electricity through the appliance to keep it operating properly.

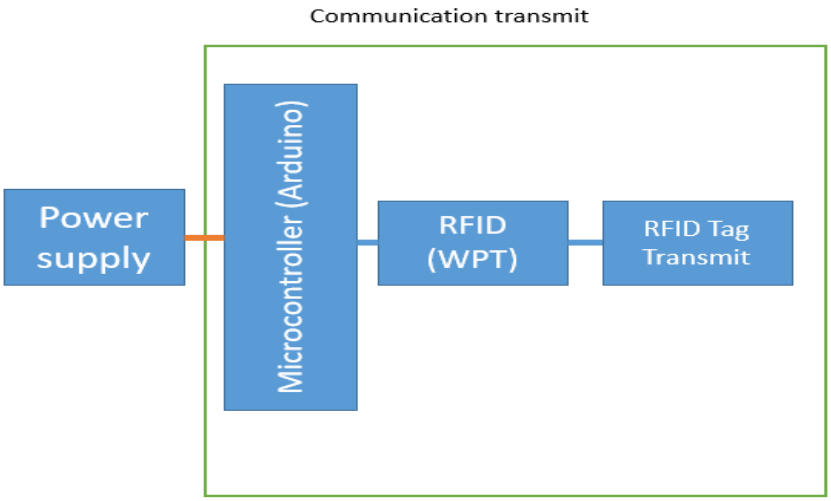
The transformer is used in order to provide galvanic isolation and safety on the primary side while improving the inverter efficiency with higher voltage input. High-frequency current through the primary coupler generates a magnetic field and is then applied to the secondary which induces a voltage on the receive side.

Receiver:



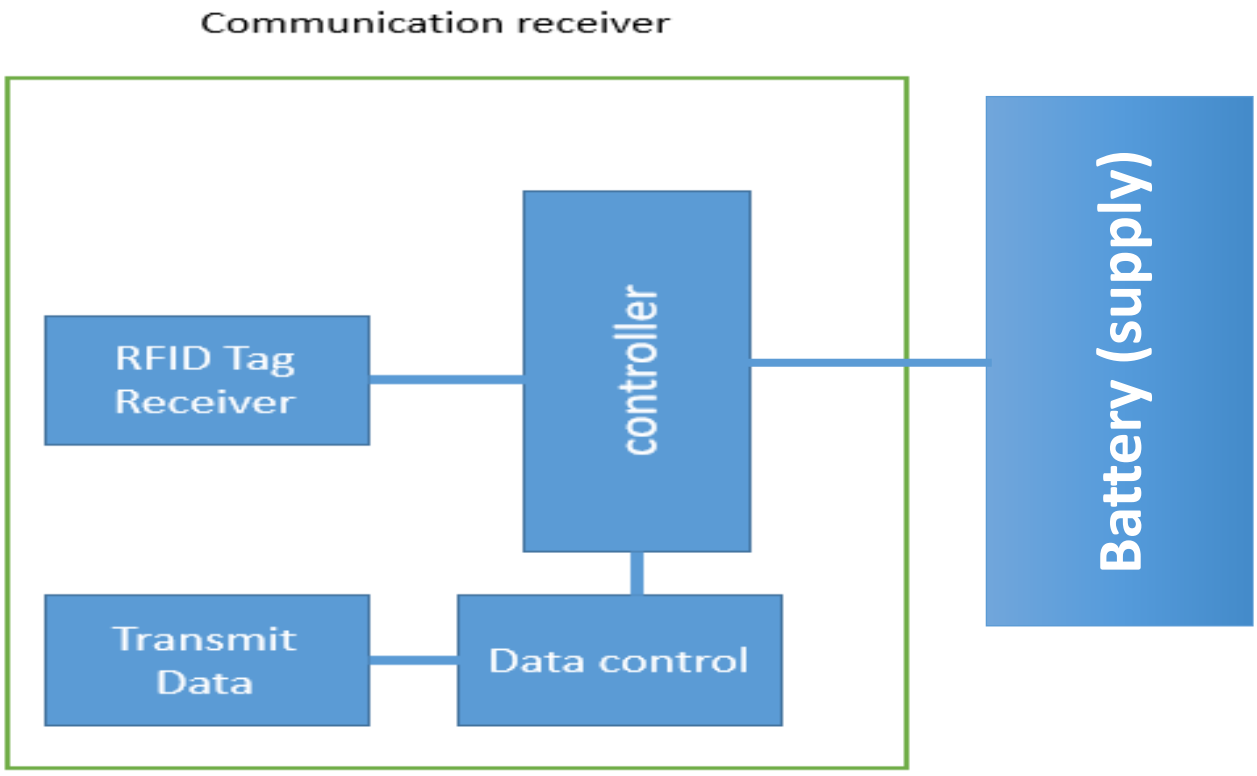
The Receiver coil will the receive energy from the transmitter coil, and so on the Rectifier will convert the AC to DC. The Switch Voltage Regulator will control the Input energy to let the battery receive the energy it needs, after that the sensor will decide if the battery needs more energy so it will send data to the controller to send to the power supplier.

Transmitter communication



The transmitter will be connected to a power supply Connected to the microcontroller system which will be programmed using wireless Identification sensor platform to read the data and transmit it to the receiver (kind of RFID Tag). The receiver tag will be in the car receiving the signal from the transmitter. This procedure will detect the car and give signal shows the status of the car to start charging or not.

Receiver communication:



The receiver coil will receive data from the transmitter then it will go to the controller and the controller will get data from the battery then it will check if the car in the position of the coil, then it will go to the data control it will analyze the data and process it then it will transmit it again to the transmitter.

Conclusions and Recommendations

Our project is charging electric cars wirelessly, it's a difficult project to do but finally, we will do it and difficult projects are challenging so the student should challenge them self's to learn more. Also, our project is something we will use in the future, I recommend a student to choose their project they know how to do it and choose challenging project and project that people will be interest to see and will benefit from. Also, choose a group that they comfortable working with.

The Best group action that has been made

- Developing the block diagrams for all the components and the process
- Choosing the suitable tag and the steps for implementing
- Calculation of the power transmitted throw the coils (Resonant inductive coupling)
- Simulation of the transmitter and the receiver coil using Multisim
- Estimating the cost of the whole project components

Action needed and recommendation

- Ordering the components that are needed
- Programming (Arduino / Microcontroller)
- Testing the power transferring on site
- Calculating the desired frequency
- Choosing the most suitable coil

References/ Citations