An Autonomous Electric Car Using LIDAR Technology On E-Roads

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Abstract— **In this project a simple Autonomous electric car is designed and implemented. The concept of the project was inspired by the recent surge in automated car industry. The designed car was capable of detecting the road signals and taking the right turn accordingly. To implement the whole system, the body of the car was connected to the analyzer computer via Wi-Fi where the computer can analyze the feed video frame by frame. In a real car the analyzer computer can be simply mounted on board. The whole system was capable of taking right decision with excellent accuracy using LIDAR Technology. Cars that can drive themselves without any human input have not yet been deployed on the road. It's believed that the industry will take years to develop the technology necessary for fully autonomous vehicles. In a world where charging electric cars is a key point in boosting the energy transition, other solutions can come alongside electric charging stations. One such solution is wireless charging. Wireless car charging is an enhanced version of smartphone charging with several differences. "Wireless inductive charging allows an electric vehicle to automatically charge without the need of cables. A project that could recharge electric vehicle batteries by driving over special charging strips embedded in the road. The biggest grouse with owning electric vehicles is the cumbersome process of locating a recharging station when the battery runs low, and then spending a lot of time recharging it for a long journey ahead. This problem often crosses the mind of those wanting to make a switch to the non-polluting vehicles. This new research could pave the way to changing minds and increasing the adoption of electric vehicles. A technology for charging EVs wirelessly while the vehicles are in motion. This could help save time and improve productivity**.

Keywords— autonomous vehicles; sensors; perception; weather; camera; LIDAR; RADAR; GNSS

Nomenclature

Abbreviations

EV- Electric vehicle

WPT-Wireless power transfer

WR-Wireless recharging system

HEV-Hybrid EVs

AFE-Active front end

HF-High frequency

PEV-Pure EV

EMF-Electromagnetic field

SOC-State of charge

I. INTRODUCTION:

An autonomous electric car is a vehicle capable of sensing its environment and surroundings and operating without any human input & that runs with the help of electrical power. A human passenger is not required to take control of the vehicle at any time, nor is a human passenger required to be present in the vehicle at all. An autonomous car can go anywhere a traditional car goes and do everything that can experienced human driver does.

Every year, there are around 1.25 million deaths caused by road Accidents. That's equivalent to 3,287 deaths on daily basis! And there is ridiculous amount of traffic that we have to suffer through, which just Creates unnecessary frustration for most people. Autonomous cars have the potential in the future to reduce deaths and Injuries from car crashes, particularly those that result from driver Distraction.

Electrical vehicles (EVs) are promising for achieving a sustainable transport sector in the future, due to their very low to zero carbon emissions, low noise, high efficiency & flexibility in grid operation and integration. This chapter includes an over view of autonomous EVs technologies as well as associated energy storage systems and Electric Vehicle charging infrastructures.

2.EXISTING METHODOLOGY

IC ENGINES:

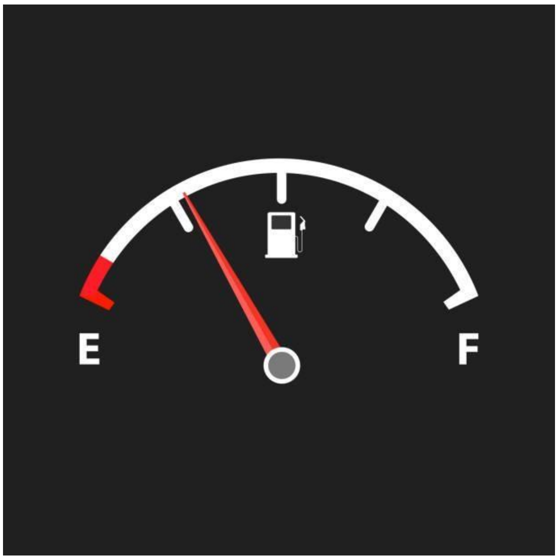
This is the present existing methodology i.e. still the Internal combustion (IC) engines i.e. petrol or diesel engines are still running and the Complete era of Electrical vehicles (EVs) is not yet started.

Results For Existing Methodology

1.Results in pollution

The use of IC engines will cause the environment pollution. Emitting CO_2 into the environment increases the global -mean surface warming and about 20% of all CO_2 emissions originate from road traffic.

2.Decrease in fossil fuels



Today fossil fuels supply more than 80 percent of all the energy consumed by the industrially developed countries of the world.

Hence there is a need to conserve the fossil fuels for the future generations.

Low *Efficiency*

The average efficiency of today's combustion engines, namely the way how effectively they operate with consumed fuels, is between 25 percent & 35 percent.

3. PROPOSED METHODOLOGY

ELECTRIC VEHICLES(EVs):

To overcome the drawbacks of the existing methodology a new methodology is proposed

i.e. Electric Vehicles (EVs). As the new era of the automobile, the industry is rapidly transforming from an IC engine vehicle to an electric vehicle. The demand for an electric vehicle is increasing day by day.

Electric vehicles have low running costs as they have fewer moving parts for maintaining and also very environmentally friendly as they don't use fossil fuels (petrol or diesel).

Results for Proposed Methodology

1. No fuel, No emissions

This is the key point that attracts many people to use electric cars. If we want to decrease your personal impact on the environment through transport, then an Electric Vehicle (EVs) is the way forward. The Electric Vehicle (EVs) doesn't emit any of the gases often associated with global warming. No petrol or diesel is needed in a fully electric vehicle, which is great for your carbon footprint.

2. Running Costs

Because you're not paying for petrol or diesel to keep your car running, you can save a lot of money on fuel.

3. Low Maintenance

Petrol and diesel engines can require expensive engine maintenance over their lifetimes – electric vehicles don't.

In a traditional combustion engine there are hundreds of moving parts which can potentially go wrong, whereas an electric motor has fewer than 20. This means that your EV is likely to have lower long-term maintenance costs than other vehicles.

4. Performance

Electric cars are lighter, and – as all of their power is generated from a standing start – their acceleration capability can surprise.

EVs are more spacious than conventional cars due to the lack of a large engine; they also offer a smoother drive with lower levels of noise.

5. Recharge Time

Charging electric vehicles does take longer. Estimates show that 80% of EV charges take place on a slow charge at home over night, which is sufficient for most purposes.

Unfortunately, there is no five-minute recharge for electric cars just yet. However, rapid charging is becoming more common, you'll just need to plan it into longer journeys as even a rapid charge takes 20 – 30 minutes.

This is the major disadvantage (i.e. charging time) of Electric Vehicles (EVs).

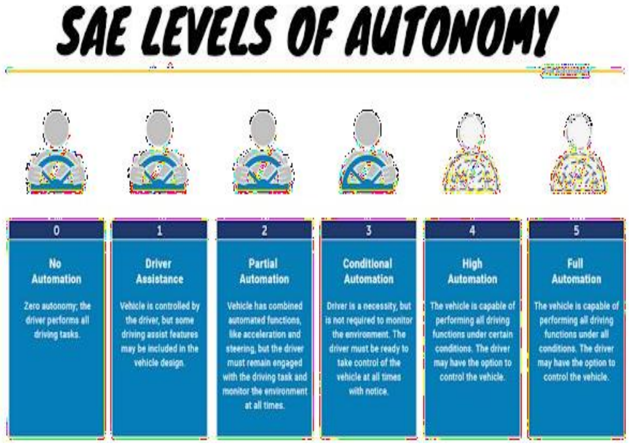
4.MODIFIED PROPOSED METHODOLOGY:

We have a proposed methodology i.e. Electric Vehicles (EVs). The main problem with the normal Electric Vehicles (EVs) is these are not accurate and there may be chances of crashes as those Electric Vehicles (EVs) are driven by humans. Now we are modifying the proposed methodology i.e. making the Electric Vehicles (EVs) fully Autonomous so that they don't require any human input.

A self-driving car, is also known as autonomous vehicle (AV), driver less car, or robotic car (robo car), is a car incorporating vehicular automation, that is a ground vehicle that is capable of sensing its environment and moving safely with little or no human input.

An autonomous electric vehicle combines a variety of sensors to perceive their surroundings such as thermographic cameras, radar, lidar, GPS, odometry and inertial measurements units. Advanced control systems interpret sensory information to identify appropriate navigation paths as well as obstacles and relevant signage.

Society of automotive engineer's automation levels:



SAE International Releases Updated Visual Chart for Its "Levels of Driving Automation" Standard for Self-Driving Vehicles:
which range from Level 0 to 5. Let's take a brief look at each stage.

- **Level 0** does not feature any self-driving tech at all.
- **Level 1** cars offer at least one system that helps the driver brake, steer, or accelerate, but if there are multiple systems, they are not capable of communicating with each other.
- **Level 2** cars can simultaneously control steering and speed, even if the driver is not driving, for short periods of time. Think lane-centring technology combined with advanced cruise control, as an example.
- **Level 3** vehicles are fully autonomous but require driver attention. These cars aren't yet available but are being tested by some tech start-ups.
- **Level 4** cars, once programmed to a destination, will not need driver input, but the controls are available should the driver wish to intervene.
- **Level 5** cars will be fully autonomous without any driver input.

Core Technologies Used in Self Driving Cars:

Autonomous Vehicles Sensors Ecosystem:

This section presents the most representative sensors that make up AVs sensors ecosystem: RADAR, LiDAR, ultrasonic, global navigation satellite system (GNSS), and cameras. These sensors measure wave sources and detect various physical phenomena. They have distinct properties that enable them to perform different tasks under specified conditions.

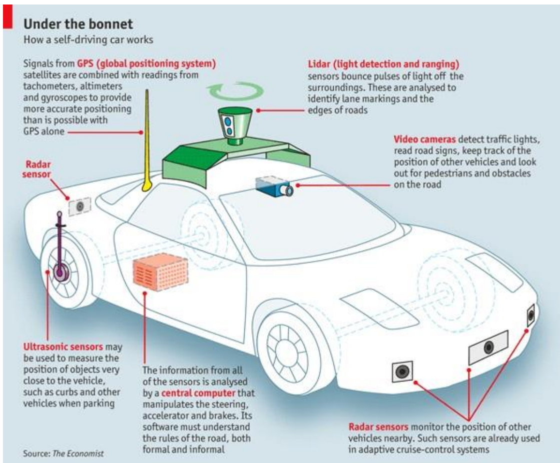


Fig. Autonomous vehicles sensor ecosystem (Image source: The Economist).

LiDAR and RADAR:

In order to improve the accuracy of navigation, it also uses a set of sensors such as Light Detection and Ranging, commonly referred to as LiDAR. A LiDAR works by measuring distance to a target by illuminating the target with pulsed laser light and measuring the reflected pulses with a sensor. Differences in laser return times and wavelengths are then used to make digital 3-D representations of the target. A LiDAR can give an accuracy of up-to 2.5 cm. Multiple LiDAR modules throughout the body of the car help in creating an accurate map of the entire surroundings and avoiding blind spots. LiDAR and RADAR play an important role in collision avoidance as well. LiDAR can detect micro-topography that is hidden by vegetation which helps archaeologist to understand the surface. Ground-based LiDAR technology can be used to capture the structure of the building. This digital information can be used for 3D mapping on the ground which can be used to create models of the structure.

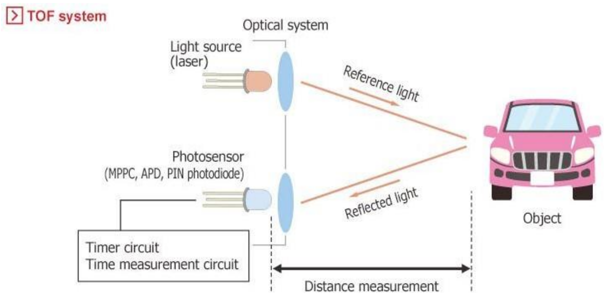


Fig: High-level block diagram for time-of-flight LiDAR system (Image source: microcontroller tips).

Ultrasonic Sensors:

Ultrasonic sensors are suitable for many detection tasks in industrial applications. They have the capability to detect objects that are solid, liquid, granular, or in powder form. Ultrasonic sensors rely on sonic transducers to transmit sonic waves in the range of 40 kHz to 70 kHz for automotive applications. This frequency range is beyond the audible range for humans, which makes it safe for human ears. This is an important factor given that a cars' parking system can generate more than 100 dB of sound pressure to assure clear reception, which is equivalent to the audible sound pressure from a jet engine.

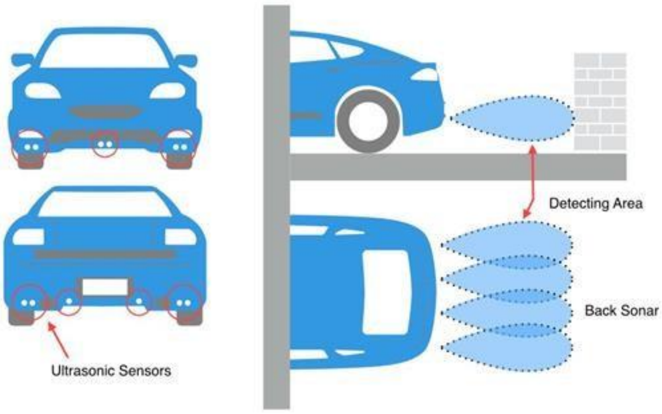


Fig: Application of ultrasonic sensors in vehicles (Image source: parking network).

CAMERAS:

Camera Self-driving vehicles may rely heavily on cameras to perceive the surrounding environment. According to the electromagnetic spectrum, most cameras can be classified as visible (VIS) or infrared (IR). VIS cameras (e.g., monocular vision and stereo vision) capture wavelengths that ranges from 400 to 780 nm, similarly to human eyes. They are mostly used due to their low cost, high resolution, and their capability to differentiate between colours. Combining two VIS cameras with a predetermined focal distance allows stereo vision to be performed; hence, a 3D representation of the scene around the vehicle is possible. However, even in a stereoscopic vision camera system, the estimated depth accuracies are lower than the ones obtained from active range finders such as RADARs and LiDARs. IR cameras work with infrared wavelengths ranging between 780 nm and 1 mm. They can be extended to the near-infrared (NIR: 780 nm–3 mm) and the mid-infrared (MIR: 3–50 mm; known as thermal cameras) for certain applications.

GPS:

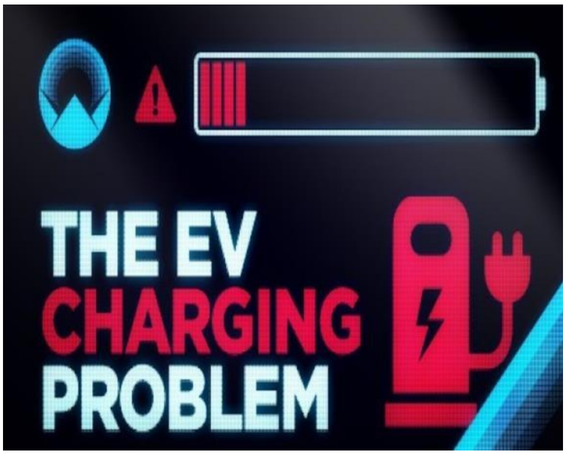
However, an image of the surroundings is not enough to drive safely around the streets of a city. A GPS system is also present to help the car position and navigate itself. But the accuracy of commonly available GPS is about 4-meter RMS.

Feature	LiDAR	RADAR	Camera	Ultra sonic
Primary Technology	Laser beam	Radio wave	Light	Sound wave
Range	~200m	~250 m	~200 m	~5 m
Resolution	Good	Average	Very good	Poor
Affected by weather conditions	Yes	Yes	Yes	Yes
Affected by lighting conditions	No	No	Yes	No
Detects speed	Good	Very good	Poor	Poor
Detects distance	Good	Very good	Poor	Good
Interference susceptibility	Good	Poor	Very Good	Good
Size	Bulky	Small	Small	Small

Table: Summary of autonomous vehicles' sensors.

5.Charging Solutions to Electric vehicles (EVs)

The main disadvantage of Electric Vehicles (EVs) is the charging time and efficiency limiting factor.



Now in this project we are focusing on this problem i.e. EVs charging problem.

The following are the two possible solutions to overcome this EVs charging problem:

1. Installing the solar panels on the electric vehicles.

2. Dynamic wireless charging on electric roads (E-Roads).

<u>1.Installing the solar panels on the Electric vehicles:</u>

This is one charging solution i.e. installing the solar panels on the roof electric vehicles. The efficiency of semiconducting semi-conducting silicon solar panels is 15-20%.

To increase the efficiency gallium phosphate, gallium arsenide solar panels is used whose efficiency is about 34%.

We can see self-charging solar vehicles becoming more and more practical as the solar cells gets more and more efficient.

"A future solar technology with efficiency is about 50 to 60% would be a game changer".

And there is a lot of research is going on to improve the solar efficiency.

<u>2.Dynamic wireless charging on electric roads (E-Roads):</u>

In this project, a wireless charging system is used to charge the vehicle wirelessly via inductive coupling. we just simply need to park the car on the charging spot. The transmission of electrical energy from source to load from a

distance without any conducting wire or cables is called Wireless Power Transmission.

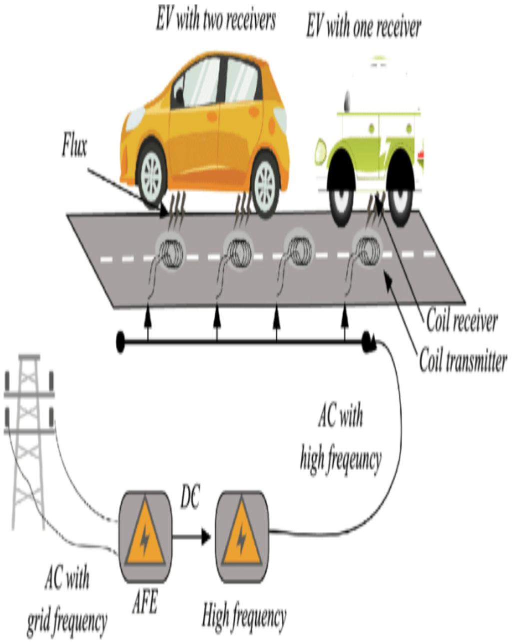


Fig: Wireless transmission system

Fig: Construction of the electric roads

(E-Roads)

The above fig shows the construction of electric roads under the road the transmitter coil is installed and the receiver coil is fixed at the bottom of the electric vehicles. The power supply to the transmitter coil is applied through the grid. when the electric vehicle comes near to the transmitter coil the power is transmitted to the receiver coil through the magnetic resonance inductive coupling. Here we are not preferring the inductive coupling for wireless power transmission because the efficiency of the inductive coupling is very low so that's why we are using the magnetic resonance coupling.

Fig: Autonomous electric vehicle moving on E-Roads

Once this electric road is constructed now the electric vehicles are ready to move on this electric road.

When the electric vehicle moving on the electric roads the transmitter coil under the electric road contacted the receiver coil wirelessly which is fixed at the bottom of the electric vehicle.

Fig: Wireless power transmission between transmitter and receiver coils.

Through the magnetic resonance inductive coupling the power is transmitted from transmitter coil to receiver coil and this receiver coil is connected to battery through a bridge rectifier. This bridge rectifier converts AC into DC and this dc is stored in the battery so that the battery gets charged.

This solution provides continuous charging to the electric vehicles as we drove on the electric roads.

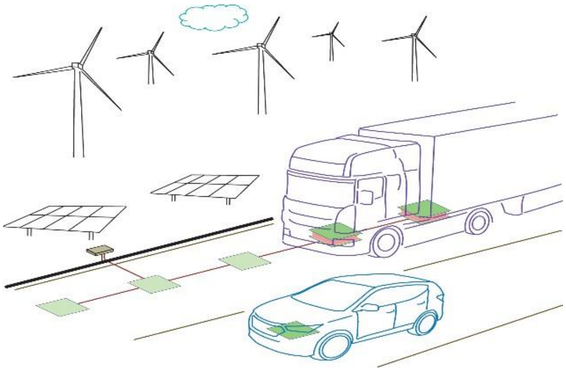
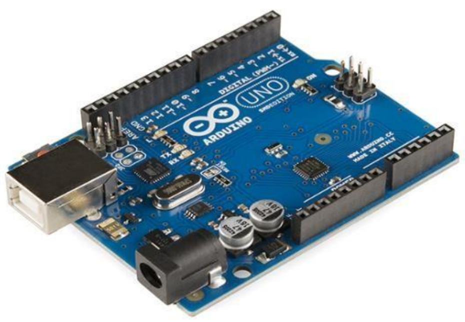


Fig: The future of Electric Vehicles (EVs) charging infrastructure.

6.Components Required to Design Prototype Model:



Arduino Uno

The Uno with Cable is a micro-controller board base on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs); 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button.

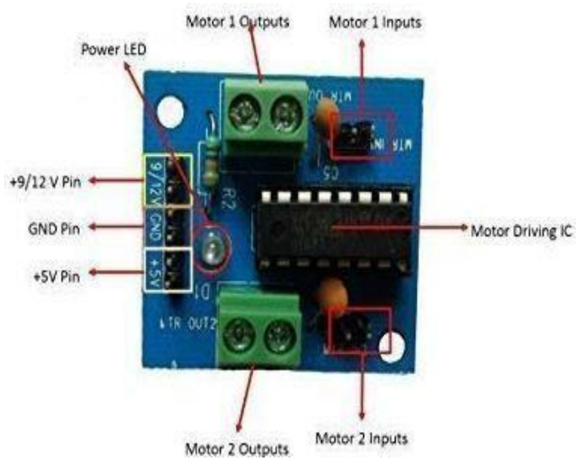
It contains everything need to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

Ultrasonic sensor

An ultrasonic sensor transmits ultrasonic waves into the air and detects reflected waves from an object. There are many applications for ultrasonic sensors, such as in intrusion alarm systems, automatic door openers and backup sensors for automobiles.

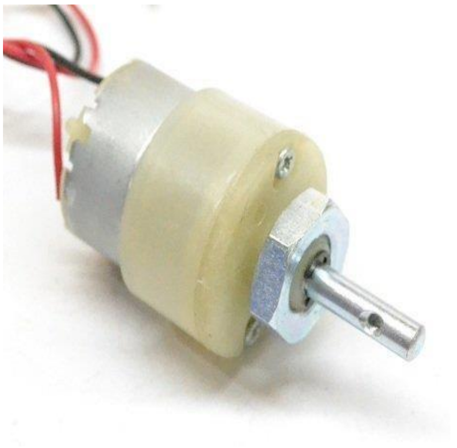
IR Sensor

An infrared (IR) sensor is an electronic device that measures and detects infrared radiation in its surrounding environment. Infrared radiation was accidentally discovered by an astronomer named William Herschel in 1800. While measuring the temperature of each color of light (separated by a prism), he noticed that the temperature just beyond the red light was highest. IR is invisible to the human eye, as its wavelength is longer than that of visible light (though it is still on the same electromagnetic spectrum).



Motor Driver

L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC. Dual H-bridge *Motor Driver integrated circuit* (*IC*).

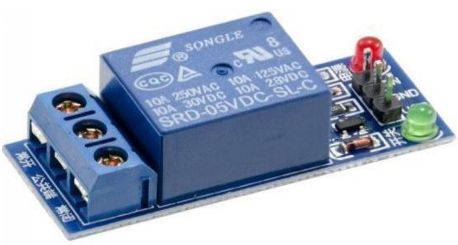


DC MOTOR

A machine that converts D.C power into mechanical power is known as a DC motor. Its operation is based on the principle that when a current carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force. The direction of this force is given by Fleming's left-hand rule and magnitude is given by;

F = Bill newton's

Basically, there is no constructional difference between a D.C. motor and a D.C. generator. The same D.C. machine can be run as a generator or motor.



Relay

A relay is an electromagnetic switch that is used to turn on and turn off a circuit by a low power signal, or where several circuits must be controlled by one

Pin Number	Pin Name	Description
1	Coil End 1	Used to trigger (On/Off) the Relay, normally one end is connected to 5V and the other end to ground.
2	Coil End 2	Used to trigger (On/Off) the Relay, normally one end is connected to 5V and the other end to ground.
3	Common (COM)	Common connected to one End of the Load that is to be controlled.
4	Normally Close (NC)	The other end of the load is either connected to NO or NC. If connected to NC the load remains connected before trigger.
5	Normally Open (NO)	The other end of the load is either connected to NO or NC. If connected to NO the load remains disconnected before trigger.

Wireless Power Transmission Coils

The 5V 2A Large Current Wireless Charger Module Transmitter Receiver Charging Coil Module is for a variety of small electronic products, wireless charging, power supply development, and design, with a small size, easy to use, high efficiency, low price characteristics.

12V battery

A rechargeable battery is an energy storage device that can be charged again after being discharged by applying DC current to its terminals.

Rechargeable batteries allow for multiple usages from a cell, reducing waste and generally providing a better long-term investment in terms of dollars spent for usable device time. This is true even factoring in the higher purchase price of rechargeable and the requirement for a charger.

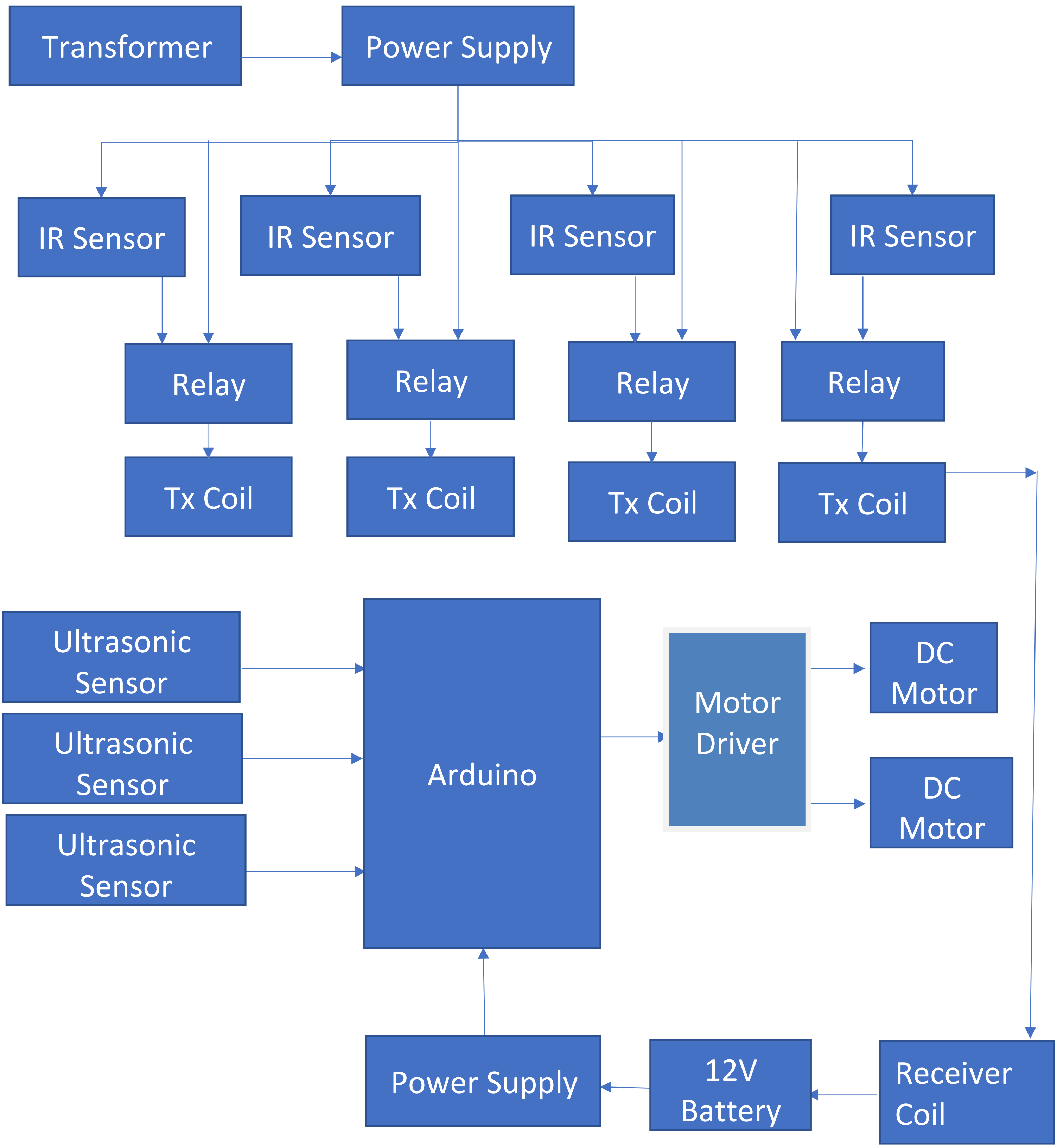
Advantages:

- No more charging batteries
- No messy cords
- Reduces the use of disposable batteries
- Reduces energy loss
- Never run out of battery power in wireless zones
- Power transfers more efficiently than through wires

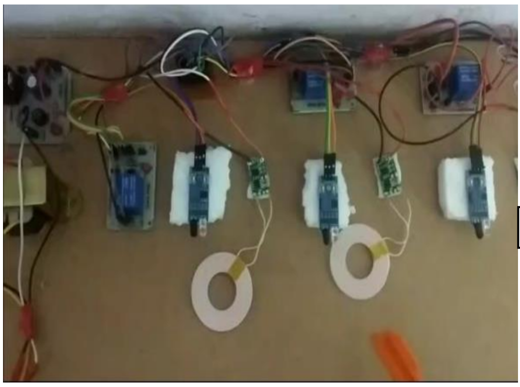
Applications:

- In industries
- Subsea applications
- Charging mobile devices, unmanned aircraft, home appliances and electric vehicles.

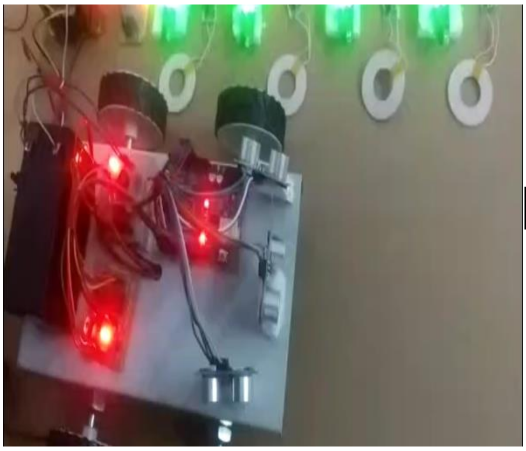
BLOCK DIAGRAM OF PROTOTYPE MODEL:



DESIGNED PROTOTYPE MODEL:



Transmitter, Relay and IR Sensors



Autonomous Electric Car on Electric Road

Dynamic Wireless Charging of Autonomous Electric Car on Electric Road

Working:

The input 230v AC applied to the stepdown transformer which will step down the 230 v AC into 12v AC. The 12v AC is then applied to the Power Supply board it is used to convert AC current to DC current using bridge rectifiers and by using this 7805 Voltage regulator We are getting the output 5v DC, that 5v is given to the all other components of the transmission side and here the transmission side is arranged on Electric roads(E-Roads).

Here we have transmitter side and receiver side. In transmitter we interface IR Sensors with transmitter coils. On receiver side an electric vehicle will be moving and also it is an obstacle avoidance vehicle (i.e. Autonomous vehicle). Based on obstacles it will move and When the Vehicle is detected by IR Sensor the corresponding Transmission coil will ON and the receiver which is attached to the Vehicle will get charge and that will charge the battery of the electric vehicle which is moving on the Electric Roads(E-Roads). From the battery which is charged through the dynamic wireless power transfer the power is supplied to the Arduino and this Arduino will drive the motor driver. L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC. Dual H-bridge *Motor Driver integrated circuit* (*IC*).

An ultrasonic sensor transmits ultrasonic waves into the air and detects reflected waves from an object and this reflected waves then applied to the Arduino based on the received signals the Arduino will control the movement of the vehicle so that it will implement the obstacle avoidance that means without any human input the vehicle takes its own decisions and moves accordingly.

Conclusion:

The goal of this project was to design and implement a wireless power transfer and wireless charger for low power devices via resonant inductive coupling. After analyzing the whole system step by step for optimization, a circuit was designed and implemented. Experimental results showed that significant improvements in terms of power transfer efficiency have been achieved. It was described and demonstrated that resonant inductive coupling can be used to deliver power wirelessly from a source coil to a load coil and charge a low power device. The Wireless Power Transmission would replace the conventional technology. The main Purpose of this project is to make the Electric Vehicles (EVs) fully autonomous and provide charging solutions to the Electric Vehicles (EVs) through Dynamic Wireless Power Transmission System.

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