International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 06 | June - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Impact of Ultra-Sonic Coil Alignment Sensors on Electric Vehicles

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Abstract- For improving power transfer efficiency, perfect alignment between primary and secondary coil is required. In this paper alignment scheme using four ultra sonic sensors help to maintain perfect alignment. Sensors are laced symmetrically around the midpoint of primary coil. Algorithm design helps to decide the movement of vehicle required for coil alignment. Identical outputs are found when coils are aligned. Based on this, driver can align vehicle correctly

Keywords- -Electric Vehicle (EV), Ultra Sonic Sensors.

I INTRODUCTION

The convenient and secure method of charging is the wireless charging system. In the inductive power transfer method for wireless power transfer, the coils are placed some centimeters distance apart. Leakage impedance is high compared with magnetizing impedance.

The inductive power transfer in EV contains a primary coil in the charging pad kept on the ground and secondary coil in the vehicle pad placed at the bottom of the EV. Cable hazards and rainy conditions are avoided. Less maintenance required because of no wear and tear of cable and plug. Automatic control system helps to charge EV at the right time. Due to magnetic leakage, there is a reduction in power efficiency which can be compensated for by using proper alignment between primary and secondary coils. The misalignment of 10cm error is a challenge to the drivers.

When misalignment increases slowly. the power transfer efficiency largely reduces. When airgap distance between two coils is half the dimeter of primary coil, power transfer efficiency reduces from 80% to 30%. Hence alignment between primary and secondary coil is very important in the design of charging system.

The charging pad consists of a suitable sensor system and driver mechanism for the movement of charging pad automatically. The alignment technique with manual operation employs sensors to detect the position of electric vehicle and alert drivers to align.

The position sensing methods depends on camera system, rotary movement, radio system and global positioning system. Weather conditions are challenging factor to this method.

In general, wireless systems have a transmitter – receiver unit. Frequency and wavelength of these waves are important. A battery is used to power electric vehicles. Faster charging of DC EV chargers is demand in the market as charging time is reduced. Wireless charging system for light weight electric vehicle is designed, built and tested. Some sensing methods are with the radio alignment technique and magnetic positional control. To have higher power efficiency, large number of turns in coils are used which can increase the inductance of the coil. When the coils are loosely coupled, inductance increases. The charging station contains a constant voltage charging through a dc- dc converter. The power converters can use recent renewable energy resources so that efficiency can be increased.

Wireless power transmission depends on efficiency, distance of transmission, power level and size. In dynamic wireless charging, a special charging lane is used with transmitter coils under the surface of road and receiver is placed below EV. The transmitter coil receives power from the AC supply system. Voltage pulse transmitted from transmitter is received in receiver and converter converts into DC and is stored in battery.

Under resonance, Power transfer is maximum. Voltages on both sides will be compensated with the aid of series-series combination. The efficiency of wireless power transmission depends on the speed of EV and airgap between the coils. In low-Speed EV maximum power is transferred as receiver cuts maximum flux. Flux cutting is reduced in high-speed EV and power is minimum

The charge stored in battery management system is used to store collected power and it helps EV to go further distance if it is not running over the charged lane. Stored energy is used in horn and multimedia in EV. When a vehicle stops charging, stored energy in the battery management system is transferred to the motor which in turn causes electric vehicle movement. Compensation networks are provided in the transmitter and receiver side so as to improve the pulse transmitted or received. Thereby output and efficiency is increased. Conventional Series- Series compensation networks are commonly used. The self and mutual inductance of coils is significant in improving efficiency of the system. With the knowledge of mutual inductance between the two coils, the range of electric vehicle for wireless charging system can be determined. Circular shaped coils are more cost-effective and power transfer capability. The radius of conductor pitch, inner and outer circle of col and number of turns can affect the performance of circular coils

Therefore, modification in the vehicle side is important.

The travelling range of EV is dependent on total flux cutting in the coils. Two receivers implemented in electric vehicles can improve the flux cutting during the dynamic condition. Efficiency is improved with two receiver coils. The recommended airgap between the coils is 150- 300mm so that dynamic charging is not possible with heavy duty vehicles

In this paper, optimal and highly sensitive sensor system for EV alignment is discussed. For that Ultra Sonic sensor-based configuration isused and it senses the distance between the two coils. In the driver circuit, the direction to which EV has to align is obtained with the knowledge of sensor output. It reduces complexity as the minimum hardware unit to be incorporated with existing hardware in the EV charging system. In this cost-effective method, sensor system is not dependent on vehicle. Human exposure to unwanted magnetic waves is avoided. Results of numerical study and the subsequent experimental studies conducted are also discussed.

II LITERATURE SURVEY

Growth of electric vehicle market is high due to high fuel cost of petrol and diesel cars globally. Climatic condition and zero carbon emission helps in free marketing EV. The long charging time of EV batteries causes diminish in market. Wireless power transfer method helps charging of electric vehicle in optimal way for dynamic charging method, electric vehicle is powered during driving. High frequency operation as to meet desirable power and efficiency condition. Resonant frequency are air cored coils are used. Radio frequency identification technologies can be implemented for wireless systems. This transmission requires no wires and is useful for power electrical devices.

Two primary types of wireless charging: inductive and conductive. Inductive coupling transmission is widely used. Here electromagnetic waves are used for power transfer through gap between the coils and into the device battery to meet the safety regulations, the frequency and magnitude of leakage magnetic field should be controlled. Larger the airgap between the coils will produce high leakage magnetic field.

WIRELESS POWER TRANSFER

The basic principle behind wireless power transmission is the transmission of electrical energy without wires. Based on the electromagnetic field produced in transmitter device, power is caught by receiver unit. Power from the field is supplied to an electrical load. This technique provides safety and convenience of all components for the customer. The secondary coil generates voltage pulses due to the flux cutting in the magnetic field. As circular shaped coils are used as primary and secondary, power transfer capability is improved. A suitable plate core helps in the performance of the system.

Basic classification of Wireless power method mainly fall are near field and far-field. Either inductive or capacitive coupling is used in the near field for short distance power transmission. The widely used power transfer is through inductive coupling which can be used in electronic devices such as micro phones and electric toothbrushes, kitchen cooking, and medical devices like pacemakers or electric vehicles. Power transfer through electromagnetic beams is used in far fields. Here the receiver is kept a long distance from the transmitter. Far-field techniques are used in solar power satellites and powered drone aircraft.

In electric vehicles and automatic controlled vehicles wireless power transmission is used because of reliability, safety economical and convenience. Proper alignment is a major factor deciding power transfer capacity. Due to reactive power transfer, large electric stress is experienced which lead to system failure. The performance can be improved by checking the alignment of coils before charging initiates. The distance between the vehicle and the station from front, back and all sides are checked. Output from sensors is high with proper alignment. With the aid of algorithm, driver can align the vehicle perfectly aligned with received sensor outputs

III.. PROBLEM STATEMENT

The working of wireless electric charging for vehicles is similar to wireless smart phone charging. Here distance is in centimeters instead of millimeters. When car is parked such as proper alignment between coil occur, electric power is transferred from coil through air gap to another coil fitted on the car.

Wireless chargers can be chargers with charging pads with closely coupled coils which are non-radiating. Another type is charging bowls or surface type chargers with small coupling coefficient. They are radiative resonant chargers. Third type is uncoupled chargers with radio frequency whose charging capability is with few feet distance. The fundamental principle in all three types is electromagnetic induction. First coil transmits time varying magnetic field which induces electric potential in second coil by mutual induction. Resonant chargers are used to transmit power efficiently at greater distance under resonant condition. For this, capacitors are inserted in both coils so that they resonate at frequency of magnetic field.

Skin effect resistance can be minimized by using movable coils on an elevating plat form and receiver coil is made of aluminum or silver plated copper. The size of the coils has effect on distance where power is to be transmitted. Greater distance of power transfer capability is possible when bigger coil or large number of turns are used. Large diameter coils are used to transfer power over long distance in EV chargers.

The problems that could arise due to ineffective charging are: -

Device take more time to charge for same power due to smaller efficiency and slow charging. Driver circuit and coils increases cost and complicated system. When mobile devices are charged through cable system, it can be moved over limited range.

So, we came up with an idea of using four ultrasonic sensors and 3 IR transceivers to overcome the problem faced by MR sensor-basedcoil alignment system. Which we can implement with further low cost as well as increase accuracy. The Ultrasonic sensors measure the distance of the cars from each of the 4 sides of the charging station where the coil is placed.

If the position measured by 2 sets ofsensors are equal the coils are aligned else if the values are not samefor each pairs the driver need to steer and correct the vehicle. As today's technologies are advanced and electric vehicles have AI, the sensor data can be given to the parking assistant of the vehicle whereit can automatically adjust the vehicle till sensors measurement are corrected as required.

Also, the details are fed into the vehicle infotainment system to inform the driver. Also, we have implemented an IR transceiver for the purpose one is to confirm the alignment so only the charging starts second is to detect any large foreign objects along the wireless transmitter. Also, for confirming the linked voltage a voltage sensor is connected in secondary also to confirm the alignment and efficiency of charging. The charging timerequired for each vehicle according to the linked voltage is also shown.

System used here is an ultrasonic based coil alignment sensing system in Arduino platform. Distance error are displayed in LCD. Details are sent to vehicle information system so that driver can move easily for proper alignment. Simulation using Arduino gave promising result. When distance between transmitter and receiver is increased, current induced due to change of flux is reduced.

IV WORKING OF ULTRA-SONIC BASED COIL ALIGNMENTSENSING SYSTEM

An efficient transfer of energy must be maintained between the wireless charging coils to reduce loss of energy as well as animportant aspect that needs to look after i.e., time taken to completely charge the vehicle. So, to maintain the wireless energy transfer effective the coils must be aligned properly. So, the system proposed here is an Ultrasonic based coil alignment sensing systemin the Arduino platform. vehicle, so the coils get aligned makingthe ultrasonic data equal on either side and front and back.

The Ultra Sonic sensors measure the distance between the vehicle and the station on either side and the front and back. If the distance sensed from 2 sets of sensors i.e., front and back, left and right are unequal we can confirm that the coils which are placed center of the vehicle and charge station are misaligned. These distance errors are sent to an LCD display whichis placed in the station in our prototype but in practice, the details must be sent to the vehicle infotainment system wirelessly where the driver can easily see them. Now the driver can manually steer the

We also thought of mechanically adjusting both coils, but it seems to be costlyas well as mechanical parts wear over use. As manually steering the vehicle to adjust is difficult, newer AI-based electric vehicles can adjust the vehicle automatically in accordance with obtained data. To further confirm that the coils got aligned so as to only allow to charge flow three IR transceivers are used in which the transmittersare placed in station and receivers are placed in cars.IR sensors as another benefit that if the sensors are blocked by any objects aroundthe coil the charging is not started. So, the objects around the stationmust be cleared. Now if all got corrected then charging takes place showing the driver the voltage of charging and time taken forcharging. For practical working of the proposed system, every car manufacturer must adopt to make the charging section of the car in accordance with the proposed charging station.

V BLOCK DIAGRAM

The station set consists of 2 individual circuits:

1) **PRIMARY COIL SET**: -

In this circuit, there is a supply that is dc and converted to ac tosupply the coil in the coil set circuitry.

2) **SENSOR SET**: -

This set mainly consists of 2 operational stages. Sensing, Processing.

a) SENSING STAGE: It consists of 4 ultrasonic sensors, which are used to measure the distance between the car and each side of the station. It emits high frequency sound waves These signals are transmitted and reflected pulse from vehicle send to receiver

b) PROCESSING STAGE: Then the signal received from the 2 sets of sensors are applied to the Arduino nano board which is the processing part of the system.The input signals are compared i.e., the front and back set and the left and the right set with respect to the program, if any displacement is there the data is shown to the driver via LCD display. So accordingly,the driver can adjust the vehicle position. Also, IR transmitters are also powered by the Arduino The vehicle set also has 2 operational stages sensing and processing.

i. SENSING STAGE: The voltage linkage between the primary and secondary is sensed in the secondary coil

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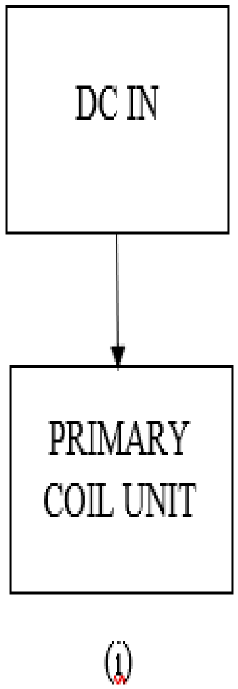
using a voltage sensor and applied to the Arduino. Also, the IR receiver data in which the IR receiver gained by the IR beam emitted by station IR transmitters.

ii. PROCESSING STAGE: The Arduino processes this information's and the details like voltage linked and time required for charging is shown in the vehicle LCD display.

Fig.1 Block Diagram for station i) Primary coil set
ii)Sensor set



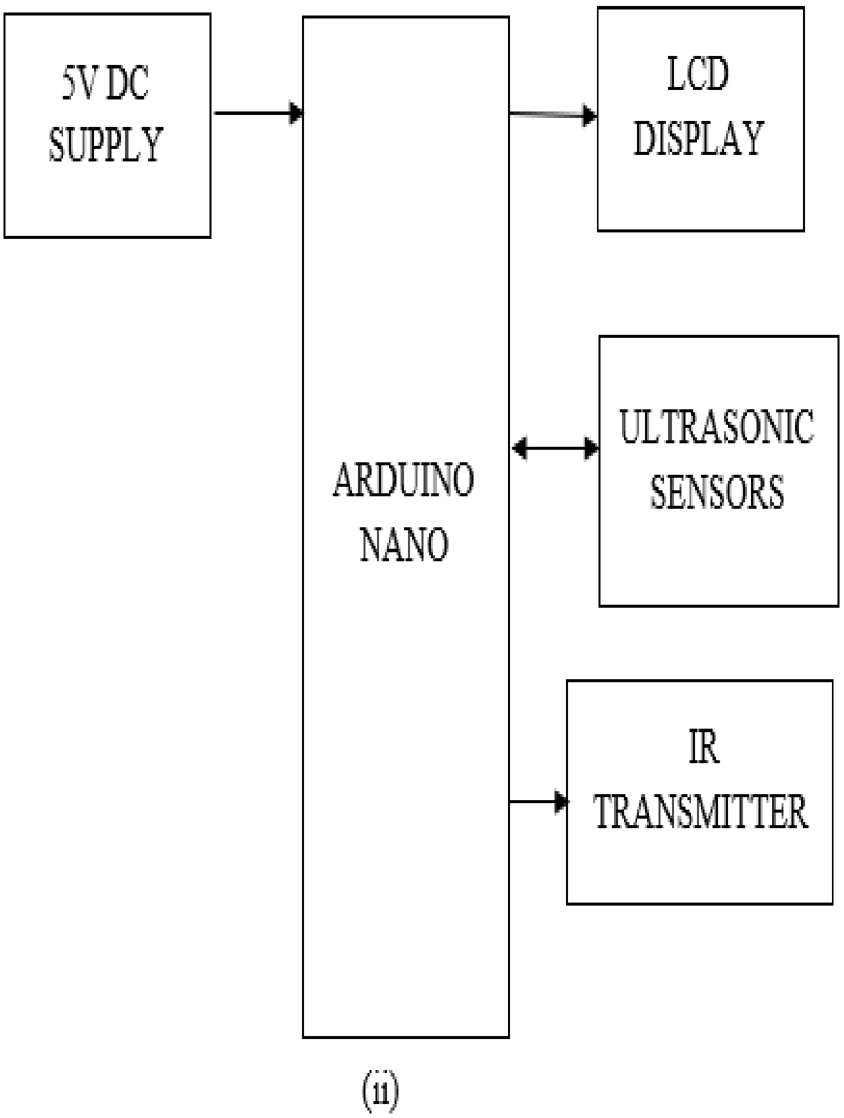


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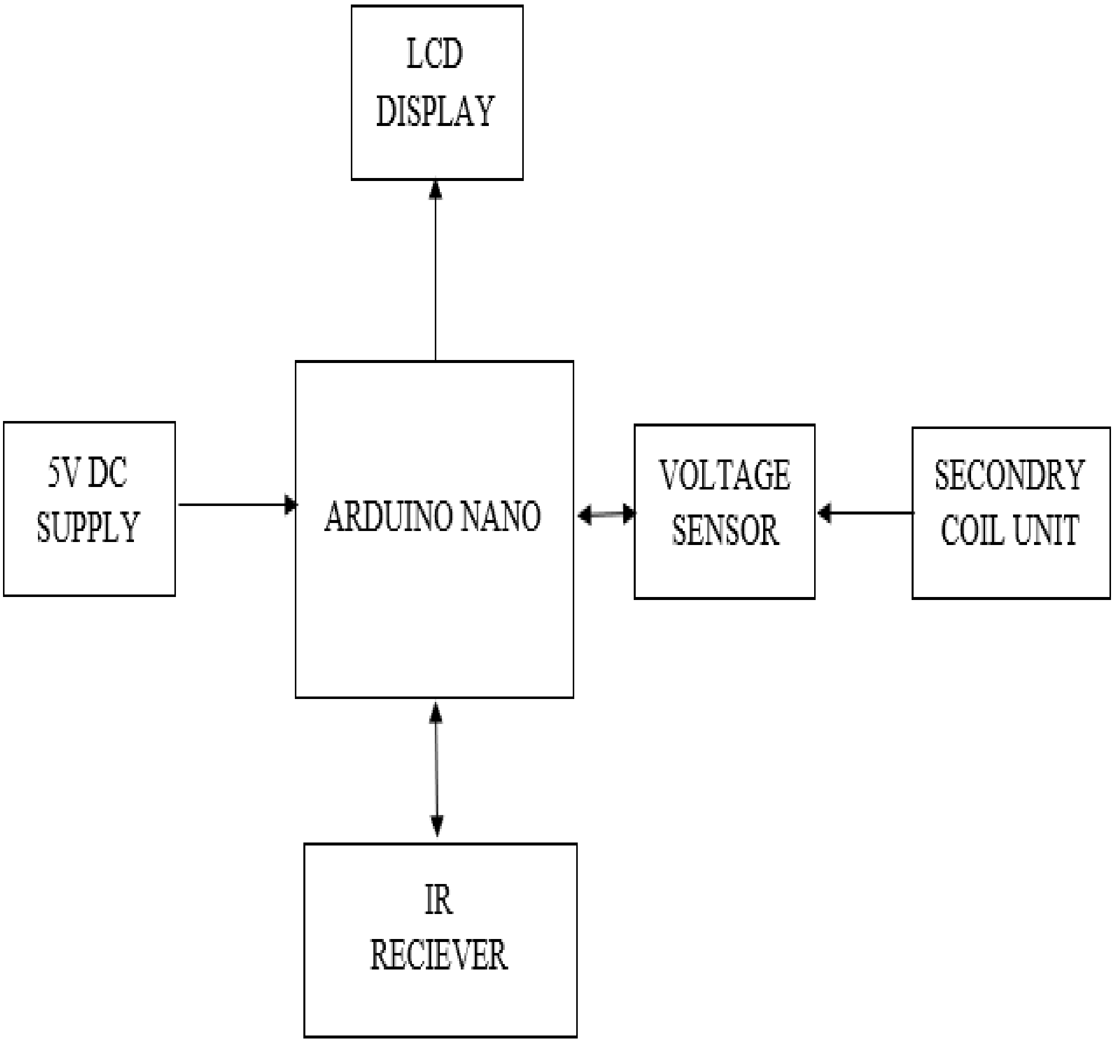
Fig.2 Block Diagram for Vehicle Set



Block diagram of Vehicle set

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VI IMPLEMENTATION PROCESS

The above shown circuit is installed in the charging station. It consists of four ultra-sonic sensors to locate the correct position of receiver coil by sensing the distance between the vehicle and the charging station. Also, here infrared led are used to double verify if the two coils are perfectly aligned. This circuit diagramshows the set-up inside the vehicle part. Here there is a voltage sensor unit to monitor the amount of electricity passing through thesecondary coil (receiver). Also here there is the infrared receiver ledto cross check and ensure if the coils are actually aligned or not. Thevalue of voltage being received in the secondary coil is shown in thedisplay.

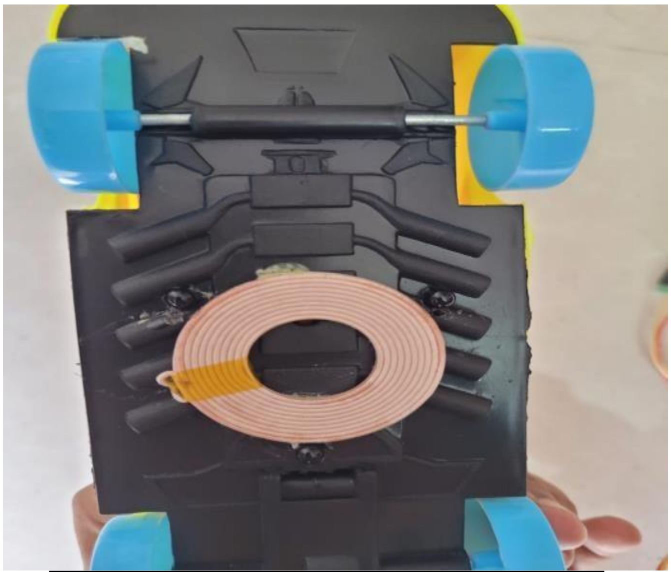

Fig:6 Secondary receiver coil on vehicle

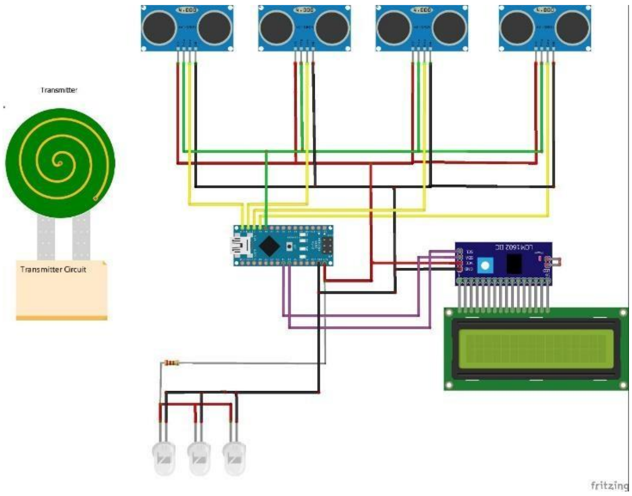

Fig.3 Circuit diagram (Transmitter)

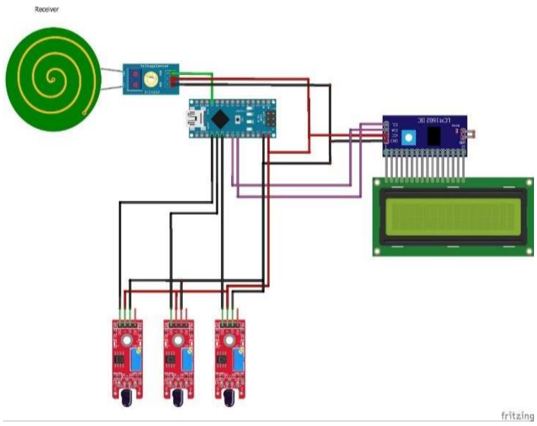

Fig.4 Circuit diagram (Receiver)

VII FABRICATION OF PHYSICAL PARTS

Hardware of the prototype was developed in the FabLab at SCMS School of engineering and technology and at a professional workplace called Mepitz in Ernakulam. The station has a dimension of 30x30 cm which holds the transmitter coil. Italso has ultra-sonic sensors located in the midpoint of the station onall 4 sides. Also, it holds the infrared-transmitter l LED's, a 16x2 LCDdisplay and an Arduino-Nano board to control all the units. The receiver coil is mounted to the vehicle which has a dimension of 19x7 cm. The vehicle unit holds the voltage sensor unit, IR receiverLED's and a 16x2LCD display to see the charging information. Also the vehicle contains an Arduino-Nano board to control all the sensorsand units.

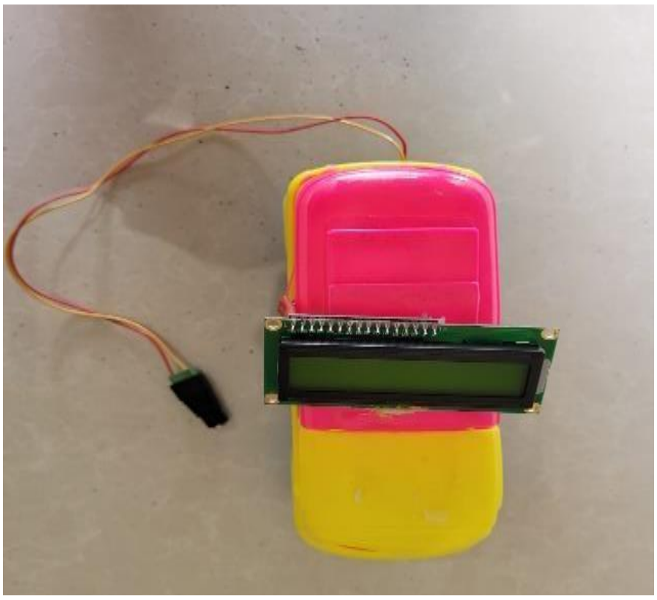

Fig.5: vehicle unit

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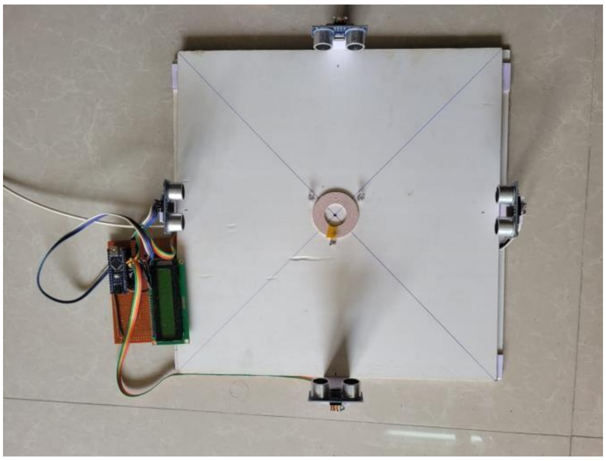

Fig.7: Top view of charging station

VIII FIELD TESTING

We have tested the prototype at SCMS school of engineering and technology. Below figure shows the testing of our prototype. Here etested the ultra-sonic sensors to measure and detect the accurate distance from an object to the sensor.

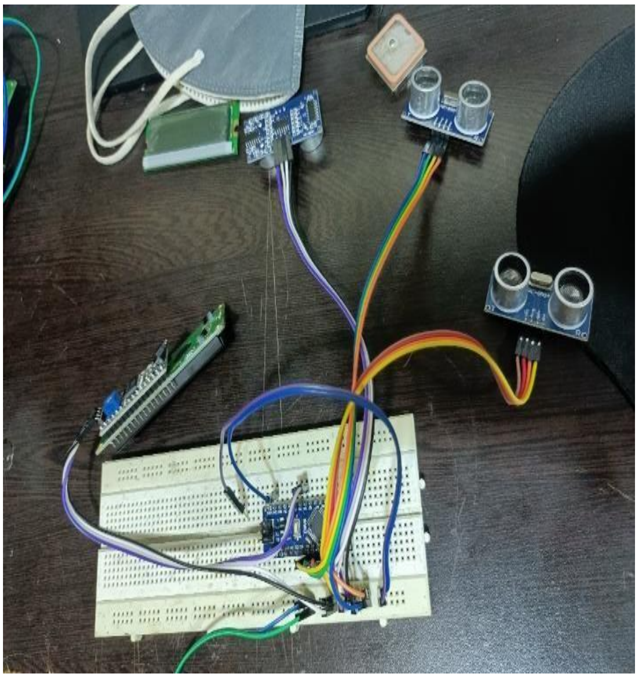

Fig.8: Testing of ultra-sonic sensors

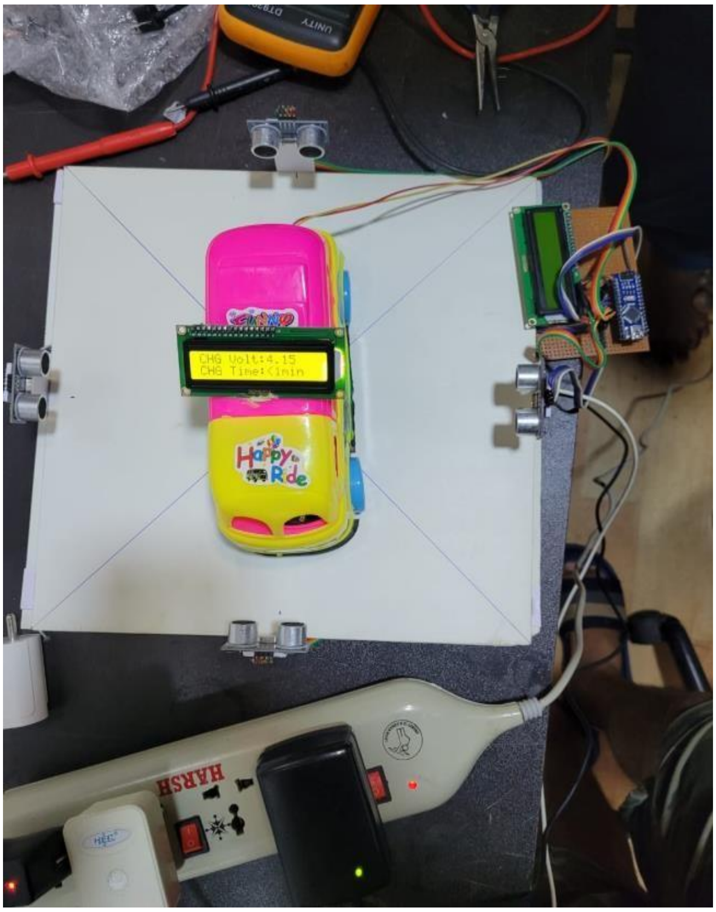

Fig.9: Testing of unit

The above shown figure shows the testing of the unit consisting of the vehicle and charging station with coil alignment system. Here the object is the vehicle and the distance between the vehicle and sensoris measured. When the two pairs (front and back, left and right) of ultrasonic sensor gives unequal measured the coils are not aligned. So, we manually place the vehicle until the sensor pair measured values are equal. This gives perfect coil alignment. To confirm this alignment, we use IR transceivers.

IX RESULTS AND DISCUSSION

In the proposed scheme, four ultra- sonic sensors are placed on primary coil. The direction in which electric vehicle has to be driven is determined which depends on perfect alignment between primary and secondary coil. When two coils are perfectly aligned, excitation is given Power is saved as the continuous search by primary coil is avoided. No further modification is required in the electric vehicle as the entire sensor systems assembly is done over the primary coil. Charging efficiency is improved.

X ACKNOWLEDGEMENT

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