# WIRELESS ELECTRIC VEHICLE CHARGING STATION

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## ABSTRACT

This paper deals with the designing of a wireless inductive charging circuit to demonstrate a wireless charging station. The wireless charging technique offers advantages over plugged-in charging techniques such as overheating issues and bulky architecture. Wireless charging technique effectively avoids sparking during plugging/unplugging ensuring safety to the user as well as the car. It provides future scope for dynamic charging of cars - charging while driving which will remove the limitations of electric drive range and battery dependency will be reduced greatly. This technique has been prioritised and implemented in major countries like the UK and Germany. This paper presents our attempt towards building an inductive charging station. The key wireless charging techniques are summarised and compared, such as a Capacitive wireless charging system, Permanent magnetic gear wireless charging system, and Inductive wireless charging system. By introducing Wireless power Transfer (WPT) in Electric Vehicles, the obstacles of charging time, range, and cost can be easily mitigated.

***Keywords: wireless charging, wireless power transfer, dynamic charging***

## INTRODUCTION

According to the numbers by the Indian Venture and Alternate Capital Association (IVCA), EV registrations have increased by ~168%, from 120,000 in 2020 to ~330,000 in 2021 including all forms of Electric vehicles even in the IC engine-dominated market[1]. Internal Combustion (IC) engines have a lot of drawbacks such as high dependency on fast-depleting fossil fuels, and carbon emissions as a side product which then contributes to global warming. The fast depletion of fossil fuels and increasing demand for vehicles further push up fuel prices. One of the ways to overcome this dependency is to switch over to pure electric vehicles which don't produce harmful emissions, reduce dependency on fossil fuels to a great extent, and are eco-friendly. However, the major drawbacks associated with EVs are that many of the EVs don't support quick charging[2] and lack charging infrastructure.

Wireless Power Transfer techniques are broadly categorised into three based on the way power is transferred from transmitter to the receiver. There are mainly three types of wireless charging techniques

1. Inductive Power transfer (IPT)
2. Capacitive Wireless Power Transfer (CWPT)
3. Magnetic Gear Wireless Power Transfer (MGWPT)

More references for Battery Operated Vehicles can be found from [4], [5], [6], [7], [8]

## INDUCTIVE POWER TRANSFER (IPT)

IPT has been used for a long time for power transfer in transformers, in which the primary coil and a secondary coil are inductively coupled. The most common way of IPT is when primary and secondary are inductively coupled [9] mainly using a permeable magnetic core or by transmission through the air in which primary and secondary are physically separated. This technique however is dependent on the air gap between the primary and secondary and the efficiency tends to decrease when the distance in the air is superior to the coil diameter. The efficiency of energy transmission is determined by the coupling factor and the quality of the inductors used.

## CAPACITIVE WIRELESS POWER TRANSFER (CWPT)

In CPWT, instead of using magnets or coils, coupling capacitors are used to pass power from the source to the receiver via a power factor correction circuit. The capacitive coupling of the CPWT system is generally represented as a pair of capacitors in series as shown in Figure 1 however due to the connection with the equivalent capacitor, it is difficult to analyse the primary as well as secondary sides of the circuit. Such systems are also exposed to leakages and cross-couplings between the capacitors which aren't accounted for in this representation. Complex models are used to overcome these drawbacks allowing deeper analysis on the primary and secondary sides[10]. This technique offers the following advantages: (i) The charging system can be placed horizontally, therefore, offering design flexibility, (ii) no heat generation is involved, and the battery is protected against heat when placed near the CWPT apparatus [11]. Owing to the low-cost structure and simplicity on a small scale, this technique is used in low-power techniques such as pacemakers, neurostimulators, etc.

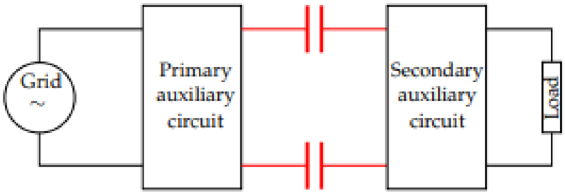



Figure 1: Capacitive Wireless Power transfer simple representation

## MAGNETIC GEAR WIRELESS POWER TRANSFER (MGWPT)

The Magnetic Gear Wireless Power Transfer (MGWPT), is also referred to as Magnetic Resonance WPT or Weak Coupling WPT. It was theoretically developed by the Massachusetts Institute of Technology in the year 2005. The electrical energy is transmitted through electromagnetic resonance between the transmitter and the receiver using the coil and a capacitor as a resonator[12]. The resonant frequency of two coils is matched which allows for electrical energy transmission. This method also provides flexibility of use as in CWPT.



Table 1. Comparison of Wireless Power Transfer Techniques

| | Capacitive | Inductive | Permanent Magnet |
|---|---|---|---|
| **Power Transfer Method** | Varying Electric Field | Varying MagneticField | Resonance between circuits |
| **Gap between Coils** | <1mm | >10cm | - |
| **Power Levels** | Low Power Application | Medium to High Power Application | High Power Application |
| **Medium** | Capable of passing through metals | Only through air | Objects, Materials |
| **For High Power Transfer** | Low Cost | High Cost | High Cost |
| **Coupler Area** | Less | High | High |
| **Eddy Current Loss** | NA | Large | Large |
| **Power Losses** | High | Low | Low |

## PROBLEM DEFINITION

A large segment of the Indian population has started transitioning from conventional Internal Combustion (IC) engines to electric vehicles owing to a large number of factors like adverse effects of IC engine exhaustion on the environment, Improved battery capacity and range of Electric Vehicles, Cost savings in longer duration of operations, increased costs of fossil fuels due to exponential depletion of fossil fuel resources across the globe.

The most basic infrastructure required for electric vehicles are charging stations. But these stations face a lot ofchallenges like high cost of installation, communication between the grid and charge station companies, the inter compatibility of chargers, last mile reach of the charging infrastructure, along with slow charging speeds. Our project found motivation in the wireless power transfer charging infrastructure and aims to overcome the drawbacks offered by the plugged in charging methods.

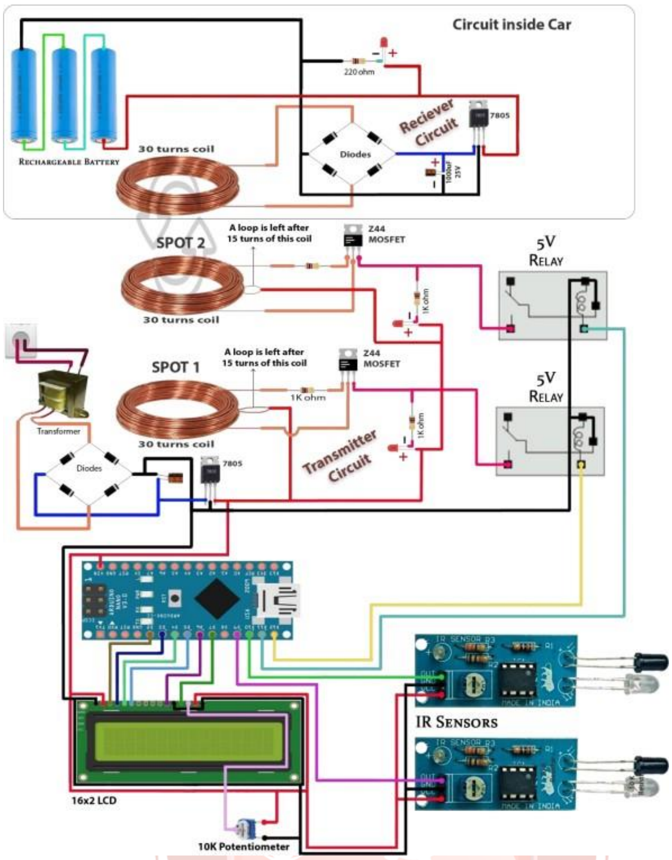
## METHODOLOGY

In our project, we have designed a two-coil (plate) system where one of the coils is mounted on the vehicle (receiver) whereas one of the coils is mounted on the charging station(transmitter). This reduces the need of plugging the external charger into the vehicle and the vehicle charges automatically when stationary at the charging point with reduced heat loss and increased efficiency. However, wireless charging achieves about 90%efficiency compared to traditional charging methods. For example, if the traditional way of charging takes 1 hour to charge fully, the wireless charging methodology made take about 1.11 hours to achieve the same charge(assuming an efficiency of 90%)[3]

The work starts with supplying incoming directly to the microcontroller used. The microcontroller acts as the main controlling unit for the setup and it handles the operations per the program. The microcontroller is connected to the LCD as well as the IR sensors that sense the presence of the car at the charging point. The IR sensors are used to detect the presence of the car at the station, and if the car arrives and is detected by the sensor it sends the signal to the microcontroller. Acting on this signal, the microcontroller operates the relay coil attached to that particular charging station, and current flows to the station coil. In the event the car moves out before charging, the IR sensor detects it and the relay cuts off the supply therefore avoiding exposure of the coil which may prove dangerous. In the event of successful IR sensor operation and relay operation, current flows inthe station coil, and due to mutual inductance between the station coil (transmitting coil) and the car coil (receiving coil), current is inductively transferred to the receiving coil.

On the car, the receiving coil is connected to a control switch which is used to switch between battery charging mode and battery usage mode. When switched to the battery charging mode, the coil output is fed directly to the battery. Once the charging is done, the button is used to toggle to the battery usage motor and hence the inductively charged battery is used to power the Electric Vehicle. The LCD is used to display the chagrin status of the stations and is controlled by the microcontroller as well.

Figure 2: Circuit Connection




## RESULTS

Figure 3 shows the observed battery discharge characteristics observed during the testing of the model. Figure 4 shows the rate discharge characteristics of the battery. The battery is used to power the electric vehicle and hence its proper charging is of utmost importance. The mode selection switch is available on the vehicle and is used to switch from battery charging mode to battery usage mode. The LCD is used to display the status of the charging stations. If the station is occupied by the vehicle (successful detection by the IR sensor), the display shows ON status, and by default, it has OFF status. Both the stations are shown individually on the screen. LCD receives the signal from the microcontroller which coordinates between the sensors, the relay, and the LCD. When the car arrives at the station and the IR sensor detects it, the relay switches to the ON position, and current flows into the station soil (transmitting coil), inductively charges the car coil (receiving coil) and the battery is successfully charged for further usage.

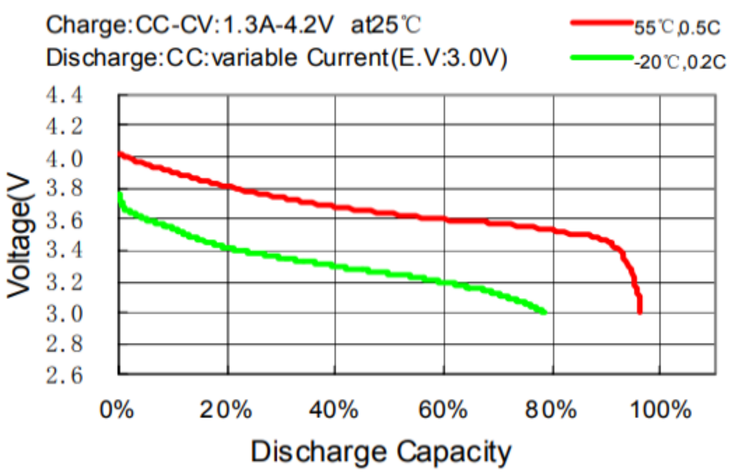


Figure 3: Battery Discharge Characteristics

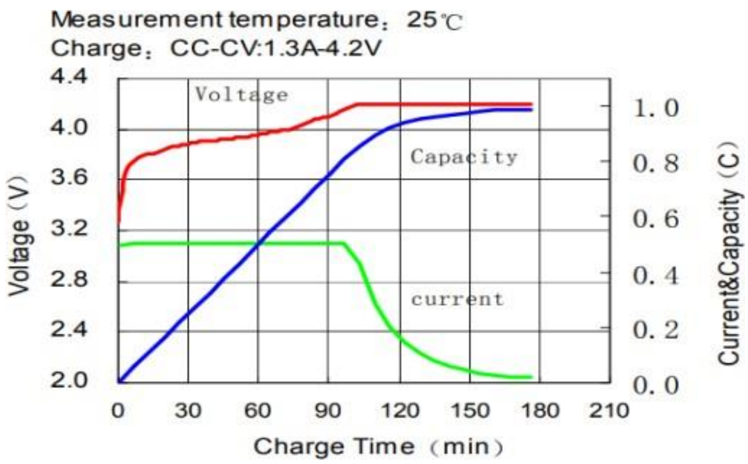



Figure 4: Rate Discharge Characteristics

## CONCLUSION

In conclusion, the emergence of inductive charging technology for electric vehicles (EVs) has brought about significant advancements in the EV charging infrastructure. Inductive charging stations eliminate the need for a physical connection between the charging cable and the vehicle, which makes charging more convenient and efficient. Although the technology is still relatively new and not widely available, it has the potential to become a game-changer in the EV industry. The convenience of wireless charging, coupled with the environmental benefits of EVs, may help to accelerate the transition towards a cleaner, more sustainable future.

However, there are still some challenges that need to be addressed before inductive charging can become the norm. These include increasing the efficiency of the charging process, improving the range of wireless charging, and reducing the costs of the technology.

Overall, the future of inductive charging stations for EVs looks promising, and we will likely see more and more of these stations popping up in the coming years. As technology advances and becomes more accessible, inductive charging could play a crucial role in making EVs more accessible and convenient for everyone.

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