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Design Of Wireless Power Transfer System Including Dynamic Charging for Electric Vehicle Applications

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Abstract

An electric automobile should have a Wireless Power Transfer (WPT) system visible when it has the appropriate ground clearance. This thesis uses the Archimedes optimization algorithm (AOA) to describe a wireless power transfer system with dynamic charging for electric car applications. In order to accomplish wireless charging of electric vehicles, the next stage in the regularization of modern cars and electric vehicle chargers is to do away with the need for wires connections sandwiched between the vehicle and charger. Because this state-of-the-art technology does not require user intervention, it may be utilized with any electric vehicle (EV). One of the biggest obstacles to wireless charging is ground clearance, which lowers power transfer efficiency. The concept of WPT for variable ground clearance is explained and the related cordless charging device is analyzed. It was demonstrated that the cordless charger device could deliver about 45 volts of energy and had a maximum ground clearance of 20 cm. For charging an electric car, a 3.8KWh super capacitor (SC) and a 4.5KWh battery are adequate.

Keywords: Archimedes Optimization Algorithm; Wireless Power Transfer System; Electric Vehicle

How to Cite This Article

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Introduction

Wireless charging and inductive charging electric vehicles(EVs) are a new type of EVs that remotely charge their batteries using a wireless charging technology [1]. Unlike conventional plug-in EVs, the wireless charging EVs do not require power cable connection for charging Wireless charging EVs are classified as either stationary or dynamic charging EVs. One of the first commercially available EVs using stationary charging was the General Motor EV, for which the primary transducer was a paddle and the secondary transducer a vehicle charger port [2-3]. The topology of the charging system was introduced. Stationary charging transfers energy more efficiently than dynamic charging due to better alignment between the transducers.The trade market of electric vehicles (EVs) has gradually begun to grow [4]. To revive the vehicle within a short span, high power charging devices or charging stations are required by the existing conductive charging method [5].

Additional inconvenience is caused by incompatible plugs receptacles between different EV models. Charging infrastructure can be shared by different EV models as for the wireless charging technologies [6]. The deployment of 85 million autonomous vehicles, is expected by 2035, hence establishment of wireless charging is needed, to incorporate in such vehicles [7-8]. Numerous studies have reported that one of the benefits of dynamic charging is that it allows smaller and lighter batteries to be used, due to frequent charging using power tracks embedded under roads [9-10]. However, none of these studies analyzed by how much battery size could be reduced and what the cost saving of reducing the battery size [11-12]. A true quantitative benefit analysis of dynamic charging has not yet been reported. As a result of numerous stances of vehicles and ground clearance magnetic coupling is varied. This succumbs the power efficiency. To specify this significance, using of high reactive power and resonant elements is strongly recommended in both transmitter and receiver side. By using Power conversion technique, the contactless coupler and the power electronics system the battery is charged. The proposed system location in EV [13]. The current charger for EV is mainly plugged-in, usually located at home, at work, or centralized charging stations. However, plugged-in chargers make inconvenience, easy to electric leakage. Wireless charging is based on, which makes using EVs more convenient and safer [14-15]. Wireless charging has two categories, that is static wireless and dynamic wireless charging. In the system, when charging, electric vehicles must be parked in alignment with the transmitter to receive power from the transmitter. However, the capacity and energy density of batteries limit the development. In the DWC system, EVs can charge while it is moving. Therefore, EVs can move longer, battery capacity and weight may be smaller, and transportation efficiency improves Therefore, DWC system research and development can promote the development of EV in the future. However, the movement of EV creates many challenges for the design and control system.

The design of the magnetic coupler is considered one of the most important factors in the system. In the DWC system, the magnetic components are composed of a transmitter lane, which is usually under the road and a receiver coils, which is mounted under an EV. The transmitter lanes in the systems can be classified into two main types, either long-track transmitters or short-track transmitters. The long-track transmitter structures have high inductance, low coupling coefficients, and low resonant frequency. These transmitter lanes have low efficiency and high electromagnetic interference. Short track transmitters used to reduce EMI and increase efficiency [8]. Each short-track transmitter can be the same size as a pad in the SWC. The transmitter lane is formed by arranging multiple short-track transmitters together. Each transmitter coil has a separate compensation circuit, so it is very flexible to design and expand the transmitter line. Besides, each short-track transmitter can be switched ON/OFF according to the EV position. Therefore, the efficiency and EMI of this transmitter lane are higher. However, this system is complexity, as it requires a large number of compensation circuits, power converters, EV position detection circuits.

The characteristics of coupling coefficients according to positions when EVs moves in the misalignment direction have not been reported. It is an important feature for the design and control a system. Furthermore, the design of compensation circuits does not consider the impedance matching problem then the maximum efficiency is difficult to obtain.

This paper proposed a method for calculating compensation circuit parameters according to the optimum load value to maximize transfer efficiency. Therefore, if the load impedance is always kept equal to the optimum load value, the transfer efficiency reaches the maximum value over a wide frequency range. Furthermore, the frequency can be controlled around to improve inverter efficiency, such as zero phase angle tracking control. A dynamic charging system prototype with a power of 1.5 kW is constructed. The average value of efficiency during dynamic charging is 89.5%. The variation of the output power. The contribution of this paper is as follows:

- To propose a wireless power transfer system for electric vehicle dynamic charging using Archimedes optimization algorithm (AOA).
- To reduce the number of inverters so that the efficiency can be increased.

This paper's remaining sections are organized as follows. The work's component modeling and methodology are provided in Section II. Experiments and simulations are given in Section III and IV concludes with findings.

Proposed Methodology

The proposed block diagram of wireless power transfer in electric vehicle is represented in fig. 1. The transmission of energy from one place to another without using wires. But,the wireless transmission is made possible by using various technologies. WPT is achieved through the affordable inductive coupling between two coils termed as transmitter and receiver coil. In EV charging applications, transmitter coils are buried in the road and receiver coils are placed in the vehicle. Transmission of electrical energy from power source to an electrical load without using wires. Alters the input low frequency AC to DC supply. Then by using the principle of mutual induction, the ac supply is transferred from primary winding of linear transformer to the secondary winding. The received AC supply is fed to the rectifier, to convert into DC supply for suppling the batteries. The converted DC supply is provided to the battery by means of super capacitor. Here the super capacitor plays the role as source for the battery, in order to reduce the battery damages. There is separate control system is enrolled for auto tapping the number of turns based on different ground clearance.

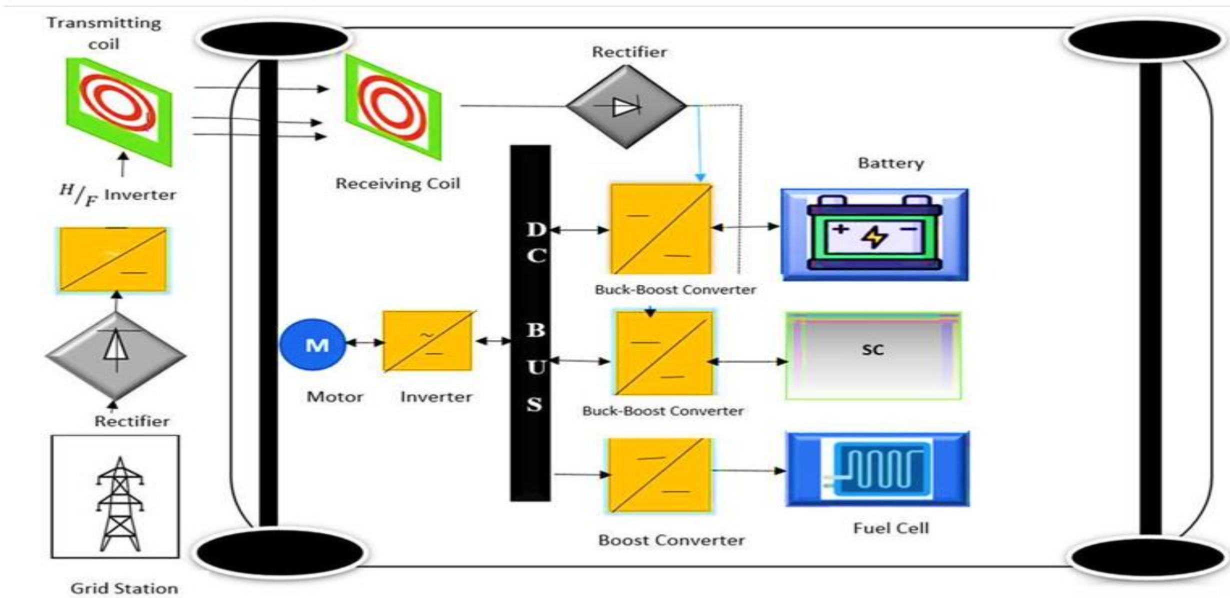


Fig. 1. *Proposed block diagram of wireless power transfer of electric vehicle applications*

The principle used in this project is Faraday's Law of Electromagnetic induction. Due to the Principle of Faraday's Law of Electromagnetic induction, the induced emf energizes the receiver coil. On account of magnetic field, the variations in the coupling factor k which is calculated by,

$$K = \frac{M}{L_1 L_2} \qquad (1)$$

Modelling of AOA

The population-based algorithm known as AO. Individuals in the objects serve as the absorbed substances in the suggested approach. The search procedure for AO Algorithm begins with an initial population of objects (candidates), just like other population-based metaheuristic algorithms. solutions) with erratic accelerations, densities, and volumes. Each object is initialised at this point with a random spot in the fluid. AO Algorithm performs iterations until the termination circumstance is met after assessing the basic population's efficiency. The density and volume of each item are updated by AO Algorithm after every iteration. Depending on whether an object collides with any other nearby objects, its acceleration is changed. The new position of a population is calculated by the revised dimensions, intensity, and speed. The exact mathematical representation of the AO Algorithm stages is represented below.

Algorithm 1: Archimedes Optimization (AO) Algorithm

Procedure

AOA (population size N, maximum iterations t_{max},C_1, C_2, C_3 and C_4)

Create a population of objects with random placements, velocities, and dimensions using the appropriate methods.

Choose the beginning population with the highest fitness value after evaluating the others.

Set iteration counter t=1

Whilet $\leq t_{max}$ do

for each object i do

Data updates for each object's dimension and intensity

Update transfer and intensity decreasing factors $TFand\ d$ correspondingly.

if TF ≤0.5 then

Increase and normalise acceleration data

Updata position

else

Updata acceleration and normalize acceleration

Updata direction flag F

Updata position

end if

end for

Choose the object with the highest fitness value after evaluating each item.

Set $t = t + 1$

end While

Set all objects' positions to zero using (2):

$$O_i = lb_i + rand \times (ub_i - lb_i); i = 1,2, \ldots..N \qquad (2)$$

For iteration t + 1, the density and volume of object i are changed with (3)

$$den_i^{i+1} = den_i^t \times (den_{best} - den_i^t) \qquad (3)$$

$$vol_i^{i+1} = vol_i^t \times rand(vol_{best} - vol_i^t) \qquad (4)$$

When A uniformly distributed random number is called a rand, $volt_{best}\ and\ den_{best}$ are the density and volume corresponding to the best population so far discovered.

This is accomplished in AO Algorithm with the aid of the transfer operator T F, specified in (5), which changes search from exploration to exploitation:

$$TF = \exp\left(\frac{t - t_{Max}}{T_{Max}}\right) \qquad (5)$$

Similar to how it helps AOA with local to global search, density reducing factor d. It gets smaller over time utilising (6):

$$d^{t+1} = \exp\left(\frac{t_{Max} - t}{t_{Max}}\right) - \left(\frac{t}{t_{Max}}\right) \qquad (6)$$

When an item collides with another if T F< 0.5, For iteration t+1, alter the object's acceleration using (7):

$$acc_i^{t+1} = \frac{den_{mr} + vol_{mr} \times acc_{mr}}{den_i^{t+1} \times vol_i^{t+1}} \qquad (7)$$

Update the population's acceleration for iteration t + 1 by (8) if T F > 0.5, which indicates that there is no object collision:

$$acc_i^{t+1} = \frac{den_{best} + vol_{best} \times acc_{best}}{den_i^{t+1} \times vol_i^{t+1}} \qquad (8)$$

To determine the percentage of change, normalise acceleration using (9):

$$acc_{i-norm}^{t+1} = u \times \frac{acc_i^{t+1} - \min(acc)}{\max(acc) - \min(acc)} + 1 \quad (9)$$

where u and l, which are fixed to 0.9 and 0.1, correspondingly, are the normalisation ranges. The percentage of steps that each agent will alter is determined by the acc_i^{t+1}.

$$x_i^{t+1} = x_i^t + C_1 \times rand \times acc_{i-norm}^{t+1} \times d \times (x_{rand} - x_i^t) \quad (10)$$

where C1 equals a constant of 2. In the absence of this, if T F > 0.5, the items upgrade their positions using (11).

$$x_i^{t+1} = x_{best}^t + F \times C_2 \times rand \times acc_{i-norm}^{t+1} \times d \times (T \times x_{best} - x_i^t) \quad (11)$$

where a constant called C2 = 6. T is defined by T = C3 T F and rises over time while being proportionate to the transfer agent directly. T primarily deducts a fixed percentage first from best possible position and grows with time in the range [C3 0.3, 1]. Starting with a low percentage results in a significant gap amongst the optimal and the present position, which causes the random walk's step size to be high. This percentage gradually rises as the search goes for reducing the distance is necessary between the ideal position and the present position.

Results And Discussion

The proposed wireless power transfer for electric vehicle applications with AOA using MATLAB Simulink software.

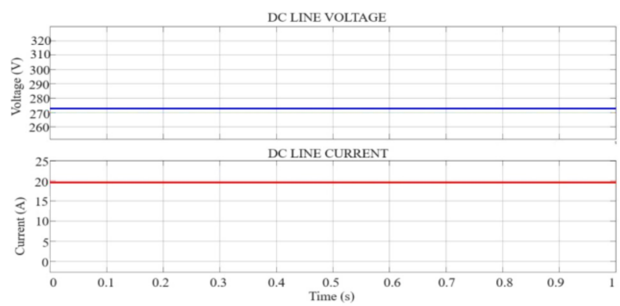


Fig. 2. *DC link voltage and current*

In the figure 2 represent the characteristics cure of DC link current that drawn between the time and current. In the current reaches the peak value in 20A after the peak time the current flows through constant.

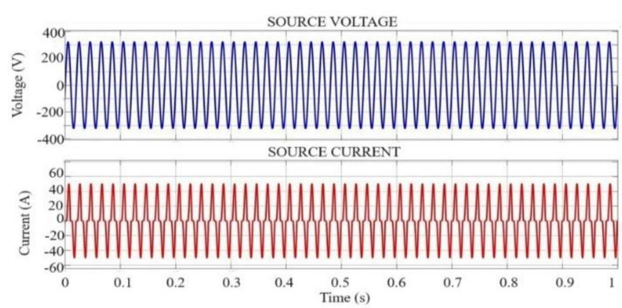


Fig. 3. *Source voltage and current*

In the figure 3 represent the characteristics cure of Source voltage that drawn between the time and current. In the current reaches the peak value in 40A after the peak time the current flows through same.

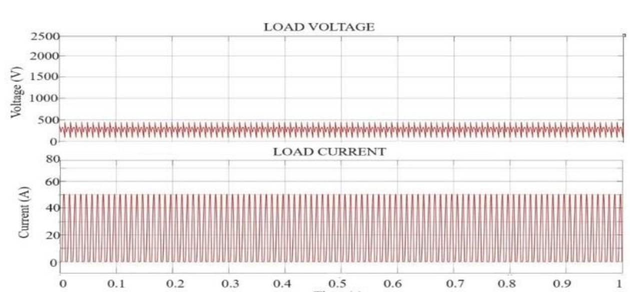


Fig. 4. *Load voltage and current*

In the figure 4 represent the characteristics cure of current that drawn between the time and current. In the current reaches the output current to load after the peak time the current flows through constant.

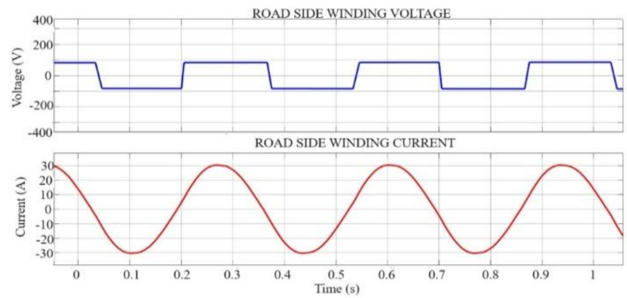


Fig. 5. *Road side winding voltage and current*

In the figure 5 represent the characteristics cure of road side winding voltage and road side winding voltage that drawn between the time and current. In the current reaches the peak value in 3.5A after the peak time the current flows through constant.

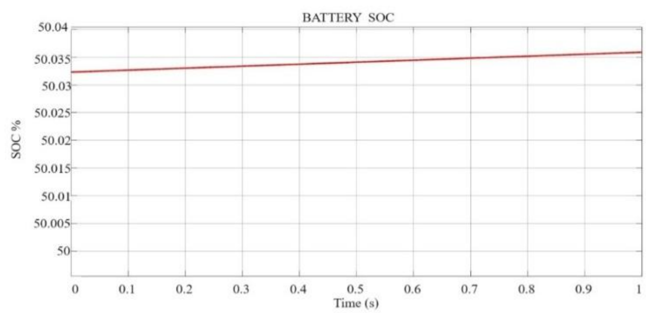
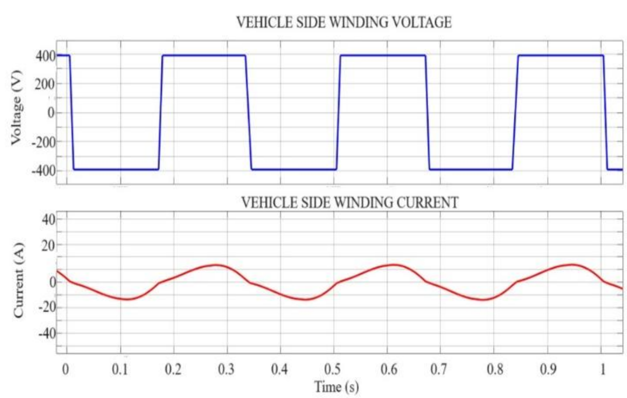


Fig. 6. *Battery of SOC*

In the figure 6 represent the characteristics of SOC battery. The range of SOC is 50.04%.



Fig, 7. *Vehicle side winding voltage and current*

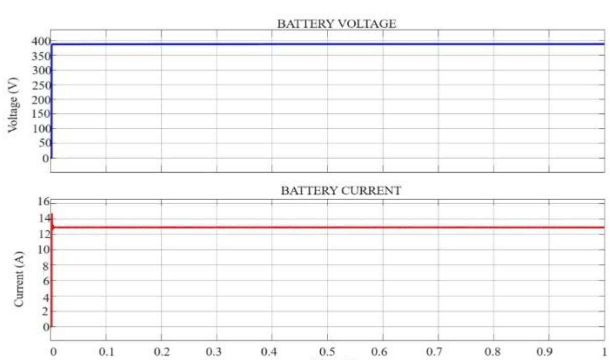


Fig. 8. *Battery voltage and current*

In the figure 8 represent the characteristics cure of Battery current and voltage that drawn between the voltage and current. In the current reaches the input voltage to load after the peak time the current flows through constant.

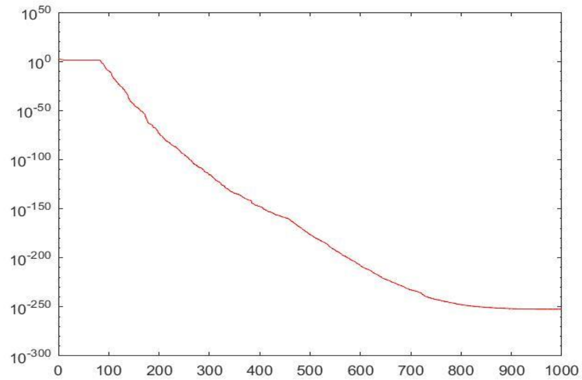


Fig. 9. *Optimization results.*

Figure 9 shows the results of Archimedes optimization algorithm, where the number of iterations is mentioned in x axis and the position is mentioned in y axis. The result of optimization gives high efficiency when compared to existing methods.

Conclusion

This paper proposed the Design of a wireless power transfer system including dynamic charging for electric vehicle application. several simulations were Performed. Regardless of previous studies, we inspected with some real-world charger placement limitations in the surveillance area such as walls, ground clearance. The above delivered system is economical and highly beneficial because it uses inverters, rectifiers and filters to handle a different coupling factor. Separate control system is enrolled, where, the transmitter coil is automatically tapped for transferring the power to the battery based on the ground clearance within 200mm. Eventually, this paper contributes to the typical hindrance of varying ground clearance. The wireless charger was procedurally verified for the battery at 4.5 kWh, super capacitor at 3.8KWh with a peak efficiency. The maximum transfer efficiency simulation result reaches 94.6% that is consistent with the analysis.

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