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Development of High-Power Density Dc-Dc Converters for Electric Vehicles

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Abstract

The mid-19th century saw the initial introduction of electric vehicles, or EVs. Because the EV's batteries were disposable, there were a lot of dead batteries. By the early 1900s, as home electricity increased, advances in rechargeable battery technology were made, and EV batteries began to be charged instead of having dead batteries dumped. After being taken out of the car, the batteries were taken to the charging station to be charged. Later, General Electric installed weatherproof, water-resistant, and telephone box-like public chargers in the US's largest cities. Even though DC chargers are fast chargers, frequent use of fast chargers or chargers with higher capacity rates than batteries shorten the battery's lifespan. As a result, on-board charging is better than using a fast charger. This study presents a fuzzy control method for bi-directional multi-input single-output DC-DC conversion for electric vehicle (EV) power management.

Keywords: Fuzzy Algorithms, EV, DC-DC Converter.

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Introduction

Energy is currently the foundation of a wide range of industries and services, including manufacturing, digital services, hospitality, defense, and transportation. Fuel, which is typically coal or oil, is needed to generate energy. The transportation sector is one of the biggest consumers of oil as an energy source. Nearly half of the world's oil consumption and 25% of its greenhouse gas emissions are attributable to the transportation sector. Over the last twenty years, there has been a significant increase in carbon dioxide (CO2) emissions worldwide, with the transportation sector playing a significant role in this increase. Both the demand for automobiles and the energy required to power them are steadily rising. It is anticipated that the number of vehicles will increase by at least double during the next ten years. As energy use rises, fossil fuels will swiftly run out and the environment will deteriorate due to the release of harmful chemicals. Vehicles that don't have any negative environmental effects require a reliable energy supply to operate. For the transportation industry, electric energy is turning out to be the finest substitute for oil energy (Kim et al., 2016). The climate has changed significantly as a result of the rise in pollutants and the greenhouse effect. Much progress has been made in battery technology. As a result, global electric vehicle (EV) manufacturers have been influenced to release more EV models due to technology advancements and concerns about protecting the environment and fossil fuels (Martinez & Cortes, 2013). Compared to internal combustion engine (ICE) versions, electric vehicles (EVs) release significantly fewer greenhouse gases (Lai, 2016). The majority of nations are offering EV users unique incentives, such as tax breaks and designated parking spaces, in an effort to encourage EV adoption. The user's main worry is that fully charged batteries have a limited range. EVs typically have a range of 100–700 kilometers. The larger the battery, the greater the range. The charger's type and charging capacity also affected how well the battery charged. In general, chargers are divided into two groups based on the charging current they produce: AC chargers and DC chargers. DC is required to charge EV batteries. In order to charge the EV via the Battery Management System (BMS), the AC charger transforms AC electricity from the AC outlet into DC (Jia et al., 2015). For charging, the battery receives DC power directly from the DC charger. In addition, chargers can be categorized as either on-board or off-board depending on where they are installed. An AC charger that is on-board often has a smaller size and a lower output. Two subcategories can be further distinguished within the On-Board Charger category. Hand-held or integrated AC charger. The integrated charger is already installed in the EV, so all that is required to begin charging it is power from the AC supply. It does this by converting AC to DC inside the EV. The car comes with a handheld charger that charges the EV by converting AC power into DC outside the vehicle's body when it is linked to an AC supply. Depending on the combination employed, an onboard charger with a power output of 3 KW to 22 KW can charge a car from 30 kWh to 60 kWh in 6 to 14 hours. DC chargers, often known as off-board chargers, are typically faster than AC chargers. The charger is a wall-mounted or fixed charger that charges the car by sending AC current straight to the BMS. High output power chargers are what the off-board chargers are. The output power is between 40 and 200 kWh.

Materials and Methods

To optimize the battery's capacity, an EV battery charger is essential. Efficiency, dependability, weight, cost, charging time, and power density are characteristics of a trustworthy charger (Zhou et al., 2020). These features depend on the parts, switching, and control algorithms that were utilized in the charger's microdesign and implementation. There are two steps to the charger. AC grid electricity is first transformed into DC with a low total harmonic distortion and a high-power factor (Liu & Tan,2023). Depending on the charging technique, the charging voltage and current are controlled at the second stage. Both unidirectional and bidirectional chargers are possible (Yang, 2014). Unidirectional charging, sometimes referred to as grid to vehicle (G2V), involves charging a car from a grid. Bidirectional chargers, on the other hand, can both charge and provide power to the grid from a vehicle or a power outage at the grid (Ahmed & Li, 2019). Vehicle to Grid (V2G) is the method in question.

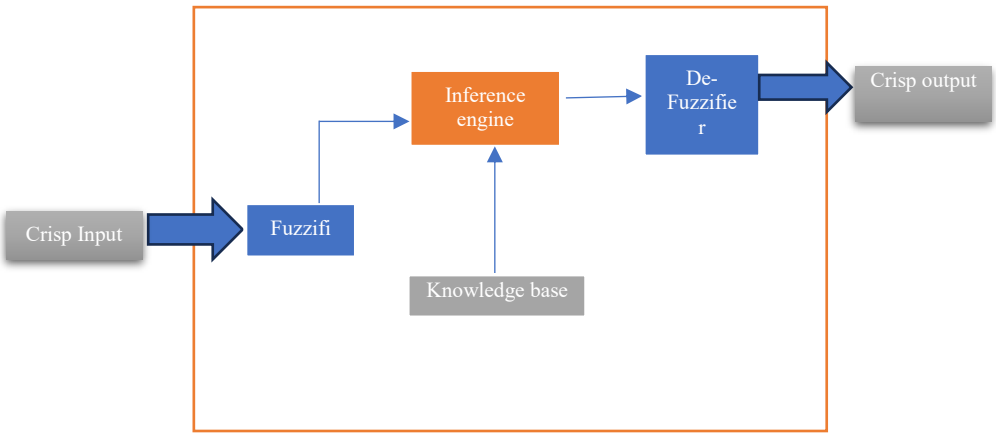


Fig. 1: Proposed Flow

Fuzzy reasoning is known as a fuzzy inference system (FIS). Fuzzy logic controller, fuzzy expert system, fuzzy model, and fuzzy associative memory are some other names for it. There are three stages involved: Fuzzification, Rule Evaluation, and Defuzzification. FIS implements a nonlinear mapping from the input space to the output space. A number of fuzzy if-then rules are applied to this mapping. Mamdani and Sugeno are the two main fuzzy inference techniques used.

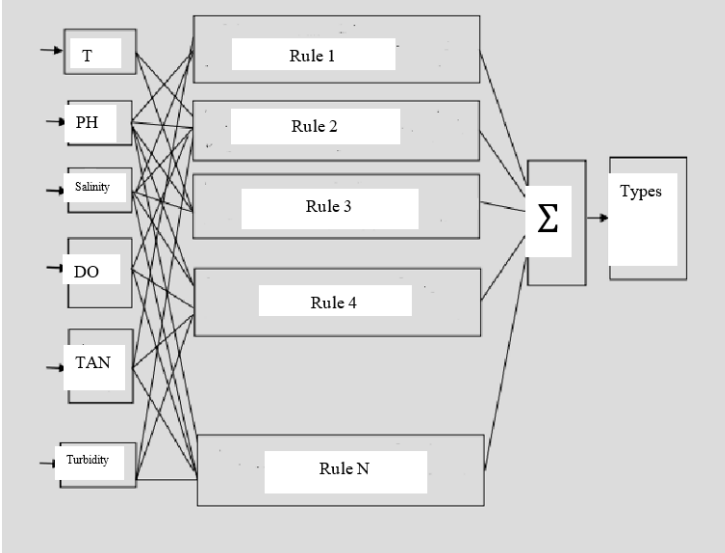
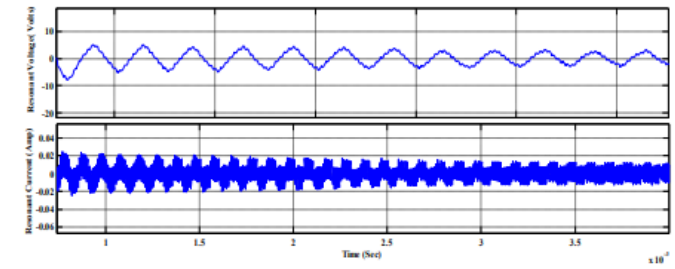


Fig. 2: Fuzzy Classifier

The most popular method is the Mamdani fuzzy inference methodology. Defuzification, rule evaluation, rule output aggregation, and input variable fuzzification are the four stages of the Mamdani process. Once the inputs have been fuzzified, the result is achieved by fulfilling the antecedent component of each rule. At least two enrollment values from the fuzzified input factors must be available in order to run the fuzzy operator. Here and there, the standards should be coordinated in order to make a decision based on the rules of a fluffy derivation framework. Conglomeration is the most popular method of combining all of the fluffy set criteria that deal with the results into a single fluffy set.

Results and Discussions

Both active and passive strategies can be used to smooth out the short but intense current pulses that travel through switching power supply without power factor correction. By lowering the input RMS current and additional perceived current, these methods raise the power factor. We refer to this method as power factor adjustment (PFC). The PFC modifies the input current such that the output receives the highest amount of power possible.



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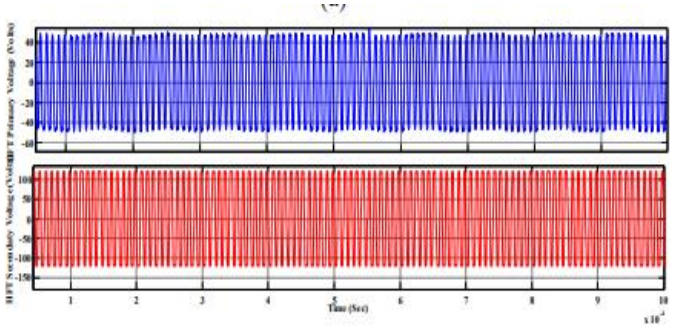

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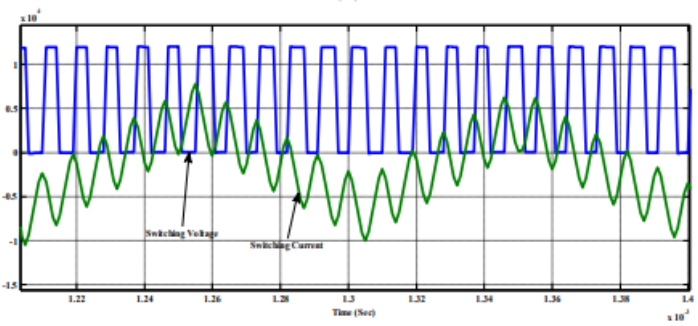

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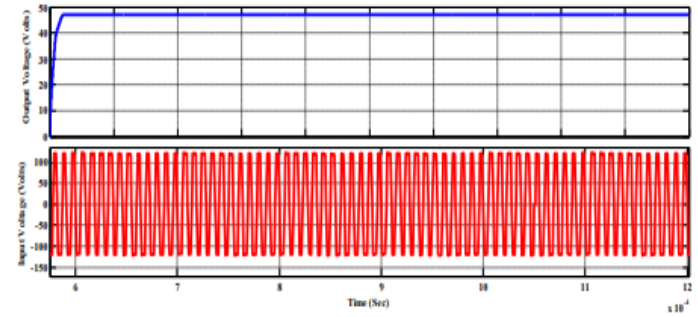

(d)

Fig. 3: Simulation Response of Proposed Converter in Discharging mode (a) Resonant Tank Voltage, and Current (b) Primary Side and Secondary Side Voltage (c) Zero Voltage Switching of Secondary Side of the Switches (d) Input Voltage of Converter, Output Voltage of Converter.

Although this is not often the case in practice, the load at the supply should ideally be as pure as a resistor, meaning that there should be no reactive power and the current and voltage waveforms should be in phase with one another. When the current and voltage waves are out of phase with one another, some power is lost during transmission, making

it almost impossible to use all of the AC provided to the circuit in a productive manner. Consequently, in order to meet demand, power producing companies must generate more power than is necessary and accept the cost of transmission losses. Users eventually bear the expense, which also contributes to global warming. Since the PFC circuit is designed to have a desirable power factor of 1, or even 0.95 in the majority of applications, power factor correction is extremely important in this situation. PFCs are often separated into two groups: passive and active.

Conclusion

A feedback loop is used in constant current mode to regulate the voltage and keep the output current constant. Even in the event that the current drops to zero, the voltage is kept constant in constant voltage mode. To determine the mode of operation, software communication takes place between the EV and charger. Battery life can be preserved and the charging rate regulated by adjusting the current in CC mode. When they are first purchased, chargers with low efficiency and a low power factor are inexpensive, but they waste a lot of electricity and end up costing more money and effort. MATLAB-SIMULINK will be used to simulate the current model and methods. SIMULINK will be used to create a new developer module for electric vehicle chargers with various PFCs. The experimental studies will also be conducted on Proteus. Comparative studies will be conducted and state-of-the-art prototypes will be developed. The performance of the suggested circuit will be shown, and conventional sensors and circuitry will be constructed, tested, and put into use because IoT is crucial to our research. Alongside it, the conceptual elements that have been implemented thus far, including the use of IoT in the construction of an EV charger with various PFCs, will be put into practice. To demonstrate the accomplishment of the aforementioned goals, the suggested and current models will be contrasted based on compactness, output effectiveness, charging time, per unit price, and gross margins.

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